PHENOTYPIC AND GENETIC CHARACTERIZATION OF INDIGENOUS CHICKEN POPULATIONS IN NORTHWEST ETHIOPIA

Phenotypic and genetic characterization of indigenous chicken populations in Northwest Ethiopia

By

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DECLARATION

I declare that the thesis hereby submitted by me for the degree of Philosophiae Doctor in Agriculture at the University of the Free State is my own independent work and has not previously been submitted by me to another University or Faculty.

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DEDICATION

I dedicate this work to my beloved mother Aznolgne Fentie and my late father

Hassen Mogesse and brother Adem Hassen who were at my side to add courage.

CHAPTER 1

GENERAL INTRODUCTION

Poultry production has undergone rapid changes since the nineteen forties when modern intensive production methods were introduced together with new breeds, improved biosecurity, and preventive health measures (Permin & Pedersen, 2000). Poultry is now by far the largest livestock species worldwide (FAO, 2000a), 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 year 2015 poultry will account for 40 % of all animal protein. Indigenous chickens are widely distributed in the rural areas of tropical and sub-tropical countries where they are kept by the majority of the rural poor. Indigenous chickens in Africa are in general hardy, adaptive to rural environments, survive on little or no inputs and adjust to fluctuations in feed availability. Chickens largely dominate flock composition and make up about 98 % (Gueye, 2003) of the total poultry numbers (chickens, ducks and turkeys) kept in Africa.

Ethiopia has about 60 % of the total chicken population of East Africa (Mekonnen *et al.,* 1991), and play a significant role in human nutrition and as a source of income. The distribution and density of birds vary from place to place, but they are found in most parts of the country suitable for human settlement. The local chickens, which are basically non-descriptive types, vary widely in body size, conformation, plumage colour and other phenotypic characteristics. According to Teketel (1986), the productivity of indigenous birds which is expressed in terms of egg production, egg size, growth and survivability of chicks under the rural production systems was reported to be very low. This low productivity may be attributed to lack of improved

poultry breeds, the presence of predators, the incidence of chicken diseases, poor feeding and management factors (Alemu, 1995; Alemu & Tadelle, 1997).

The local chicken genetic resources in the Amhara region of Northwest Ethiopia are becoming seriously endangered owing to the high rate of genetic erosion resulting from chicken diseases, specifically Newcastle disease and predation. Furthermore, the extensive and random distribution of exotic chicken breeds by both governmental and non-governmental organizations is believed to dilute the indigenous genetic stock. If this trend continues, the gene pool of the indigenous chickens could be lost in the near future, before they are described and studied. This threat is in line with the FAO report (FAO, 1999), which states that animal genetic resources in developing countries in general, are being eroded through the rapid transformation of the agricultural system, in which the main cause of the loss of indigenous AnGRs is the indiscriminate introduction of exotic genetic resources, before proper characterization, utilization and conservation of indigenous genetic resources.

Genetic variation is the basis of animal breeding and selection. The genetic characterization of domestic animals is the first step in considering the sustainable management or conservation of a particular population. It is important to know how unique or how different it is from other populations (http://www.arc.agric.za/home.asp?pid=567). In the early 1990's, molecular markers have played a leading role in the characterization of diversity, which provide relatively rapid and cheap assays in the absence of quality phenotypic measures (Toro *et al*., 2006). As a result the classification of genetic resources based on geographical location needs to be supported by molecular data to provide or obtain unbiased estimate of genetic diversity (Pimm & Lawton, 1998) for the purpose of genetic resource conservation and utilization. The genetic

characterization of breeds requires knowledge of genetic variation that can be effectively measured within and between populations.

The genetic characterization of the domestic animals is part of the FAO global strategy for the management of farm AnGRs. This strategy places a strong emphasis on the use of molecular methods to assist the conservation of endangered breeds and to determine the genetic status of breeds. Throughout the world microsatellite or DNA markers have a preferred technique to establish the genetic distances among breeds and/or populations (FAO, 2004a). Microsatellites are simple sequence-stretches with a high degree of hypervariability and are abundant and well distributed in eukaryotic genomes (Tautz, 1989; Cheng & Crittenden, 1994). The sequence consists of short segments of DNA with motif repeats of up to six base pairs (bp). Microsatellite markers have been shown to be appropriate tools for linkage mapping, identification of quantitative trait loci and parentage testing (Bruford & Wayne, 1993). Microsatellites are also useful for the estimation of genetic relatedness and diversity in chickens (Crooijmans *et al*., 1996; Takahashi *et al*., 1998; van Marle-Köster & Nel, 2000; Wimmers *et al*., 2000; Weigend & Romanov, 2001; Tadelle, 2003; Chen *et al.,* 2004; Olowofeso *et al.,* 2005). It is also suitable for measurement of genetic parameters such as number of effective alleles as well as the Polymorphic Information Content (PIC) in populations and can detect rare alleles (Bartfai *et al.,* 2003).

In Ethiopia, limited attention has been given to the characterization and classification of indigenous non-descriptive chicken types and research is at its rudimentary stage for the identification, description and evaluation of these genetic resources. Tadelle (2003) studied five indigenous chicken ecotypes up to 18 weeks of age, which was selected from different parts of

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the country. The short comings of this study was that the production potential for traits such as meat production and productivity (IBC, 2004) as well as cataloging, body weight growth curves, egg production and egg composition have never been covered. Therefore, this investigation was carried out in Northwest Ethiopia with the following specific objectives:

♦ to carry out a systematic survey in order to generate information on village based indigenous chicken utilization, management practices, opportunities and challenges;

♦ to identify, characterize and describe the phenotypic variation of indigenous chicken populations;

♦ to provide preliminary data on the genetic variation of indigenous chicken populations using microsatellite markers;

♦ to compare and evaluate the growth, egg production, reproductive performances, as well as the rate of survival of indigenous chickens under intensive and extensive management levels.

CHAPTER 2

LITERATURE REVIEW

2.1 Origin and domestication of chickens

The domestic chicken (*Gallus gallus,* 2n = 78) 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 sonnerrati* (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 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 X 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 Overview of poultry production in Ethiopia

The word poultry refers to all domesticated birds that are reared for the production of meat and eggs for human consumption as well as for economic benefits. It includes chickens, turkeys, ducks, geese, quails, guinea fowls and other domesticated birds (Singh, 2000). In Ethiopia, however, the word poultry is synonymously used with the word chicken. Turkeys and ducks, which at present are rare, were introduced to Ethiopia by foreigners (EARO, 1999). There is no recorded information which indicates when and by whom the first batch of exotic breeds of chickens were introduced to Ethiopia. It is widely believed that missionaries imported the first exotic breeds. However, over the past few decades, many exotic breeds, including the White leghorn (WLH), Rhode Island Red (RIR), New Hampshire and Cornish have been introduced into the country by different government and non-governmental organizations and/or institutes. These breeds were kept for egg and meat production and were also used to upgrade the indigenous chickens (http://www.telecom.net.et/~ibcr/Animal%20Genetic.htm, 2001). Despite a number of intensive production systems with modern strains for egg and broiler production, up to 98.5 % and 99.2 % of the national egg and poultry meat production (AACMC, 1984) is still obtained from traditional chicken production systems, with an average annual output of 72300 metric tones of meat and 78000 metric tones of eggs (ILCA, 1993).

2.2.1 Chicken management systems

The terminology used to describe chickens is confusing, as they are referred to as "indigenous", "native", or "local". According to the Oxford Dictionary (1990) these terms are defined as;

- Indigenous: living naturally in an area; not introduced
- Native: belonging by birth to a specific area, country
- Local: native inhabitant. Hence, for the purpose of this study it was decided to use the word "indigenous" for the characterization of chickens.

Poultry production in Ethiopia is categorized into traditional, small and large-scale 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). The rural poultry sector constitutes about 99 % of the total chicken population and managed under the traditional village poultry production systems. Regular census of farm animals are not available in Ethiopia, especially for chickens; hence the most recent progress available indicate that at national level they are raised in small flocks of six birds of varying ages (AACMC, 1984) under a traditional scavenging system. They are characteristically an integral part of the farming systems requiring low-inputs, low-output and periodic destruction of a large portion of the flock due to outbreaks of diseases. Major causes of mortality for these chickens are Newcastle disease, Coccidiosis, Salmonellosis, Chronic respiratory disease as well as nutritional deficiencies and predation (Ashenafi *et al.*, 2004).

The main feed resources under this system are the household wastes. Provision of other inputs such as housing, additional feed and health care vary considerably among and within regions depending on the socio-economic circumstances of the farmers.

2.2.2 Production and productivity performance of indigenous chickens

Regarding the production potential of indigenous birds, studies carried out at Wolita Agricultural Development Unit (Kidane, 1980; M.O.A., 1980) indicated that the average annual egg production of the indigenous chicken was between 30-60 eggs under village based production conditions. A study at Asela livestock farm revealed that the average egg production of local birds was 34 eggs/hen/year, with an average egg weight of 38 g (Brannang & Pearson, 1990).

The AACMC (1984) reported that local males should reach a live weight of 1.5 kg at 6 months of age and the females should weigh 30 % less. Teketel (1986) found that the local stocks reached 61 % and 85 % of the body weight of White leghorn (WLH) at 6 months of age and maturity, respectively. In a study, Abebe (1992) found that the local birds in Eastern Ethiopia attained 71.5 % of the body weight of WLH at 6 months of age. The carcass weight of the local and WLH chickens at the age of 6 months was 559 g and 875 g, respectively (Teketel, 1986). Estimates based on human and livestock populations in Ethiopia showed that village chickens provided 12 kg of poultry meat per inhabitant per year, whereas cattle provided 5.3 kg per inhabitant per year (Teketel, 1986), indicating that village chicken products are often the source of animal protein for resource poor households.

Comparatively little research and development work has been carried out on village chickens, despite the fact that they are more numerous than commercial chickens. Even though, some research has been done in the area of breed evaluation and supplementary feeding (Brannang & Pearson, 1990; Abebe, 1992; Negussie & Ogle, 2000; Tadelle & Ogle, 2001) these studies are not tangible enough to show the relative effect of genetic and non-genetic factors on the

performance of the local chickens (Alemu & Tadelle, 1997). Improving the poultry productivity would improve protein nutrition and could increase the income levels of the rural population. In addition, consumers prefer meat from indigenous chickens, because of its leanness. They also like the multi-coloured plumage of these birds. The productivity of indigenous chickens can be improved by providing appropriate housing, disease control and good nutrition (Ndegwa & Kimani., 1997).

2.2.3 Challenges and opportunities of chicken production

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. Chickens also play a complementary role in relation to other crop-livestock activities. Indigenous chickens are good scavengers as well as foragers and have high levels of disease tolerance, possess good maternal qualities and are adapted to harsh conditions and poor quality feeds as compared to the exotic breeds. In some communities, village chickens are important in breaking the vicious cycle of poverty, malnutrition and disease (Roberts, 1992).

In Ethiopia, however, lack of knowledge about poultry production, limitation of feed resources, prevalence of diseases (Newcastle, Coccidiosis, etc) as well as institutional and socio-economic constraints (EARO, 1999; Ashenafi *et al*., 2004) remains to be the major challenges in village based chicken productions. Adene (1996) has also reported that Newcastle disease (ND), Infectious Bursal disease (IBD) or Gumboro, Marek disease (MD), Fowl typhoid, Cholera, Mycoplasmosis and Coccidiosis are major diseases that have been predominantly identified in

commercial poultry in most African countries. Chaheuf (1990) argued that the most devastating disease in village chickens in Cameroon is ND, whereas in commercial poultry, Coccidiosis, MD and IBD are more prevalent. Research work in Mauritania (Bell *et al.,* 1990), Burkina Faso (Bourzat & Saunders, 1990), Benin (Chrysostome *et al.*, 1995) and Tanzania (Yongolo, 1996) supports the argument that ND is the most devastating disease threatening village chickens. This forced the owners to sell and purchase chickens with the lowest and highest prices during the beginning of the rainy and dry seasons, respectively. This results the consumers to have an abundant and scarcity of chicken products during the rainy and dry seasons, respectively.

2.3 Characterization and conservation of chicken genetic resources

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 (Scherf, 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 databases and guidelines for better characterization, utilization and conservation of animal genetic resources. Such programmes are important because the AnGR have been 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).

The rural poultry population in most African countries accounts for more than 60 percent of the total national poultry population (Sonaiya, 1990). However, inadequate attention has been given to evaluating these resources or to setting up realistic and optimum breeding goals for their improvement. As a result some of the animal genetic resources of Africa are endangered, and unless urgent efforts are taken to characterize and conserve, they may be lost even before they are described and documented (Rege & Lipner, 1992). It is also stated that an increasing loss of genetic diversity has been observed for all agriculturally used species (Frankham, 1994; Hammond, 1994; Ollivier *et al.*, 1994) and poultry genetic resources are considered to be the most endangered (Crawford, 1990; Crawford & Christman, 1992; Romanov *et al.*, 1996).

Globally over 6379 documented breed populations of some 30 species of livestock have been developed in the 12,000 years since the first livestock species were domesticated (FAO, 2000b). The majority of livestock genetic diversity is found in the developing world where documentation is scarce and risk of extinction is highest and increasing. More particularly, it is estimated that 35 % of mammalian breeds and 63 % of avian breeds are at risk of extinction, and that two breeds are lost every week (FAO,2000a; www.cgiar.org/pdf/livestockgeneticresources).

The current breeding strategies for commercial poultry concentrate on specialized production lines, derived by intense selection from a few breeds and very large populations with a great genetic uniformity of traits under selection (Notter, 1999). However, there are numerous local chickens that are characterized by medium or low performance and maintained in small populations (Gueye, 1997). These local chickens face genetic erosion which may lead to the loss of valuable genetic variability in specific characteristics. The local breeds contain genes and alleles pertinent to their adaptation to a particular environments and local breeding goals (Romanov *et al.*, 1996).

Ethiopia is endowed with varied ecological zones and possesses diverse animal genetic resources. There is a long history of trade with Asian and Arab countries across the Red Sea. The waves of trade and physical movement of people and animals have influenced the genetic make up of domestic resources, including chickens (Workneh, 1992). These indigenous animal populations are generally named either after the area they occupy or ethnic group or clans keeping them (www.telecom.net.et).

Characterization, conservation and use of indigenous animal resources under low levels of input in the tropics are usually more productive than is the case with exotic breeds. The locally adapted animals are also more readily available to resource-poor farmers and they can be productive without high disease-control inputs. 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.

2.4 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 (van Zeveren *et al.*, 1990; Gueye, 1998; Weigend & Romanov, 2001; Msoffe *et al.*, 2001; 2004).

2.4.1 Phenotypic and biochemical markers

Morphological and biochemical (protein) polymorphisms are among the first to be used to determine the relationship between breeds (Moiseyeva *et al*., 1994; Romanov, 1994; 1999). 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. 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).

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). Limited reports have addressed the genetic diversity of the indigenous chickens (Horst, 1988; van Marle-Köster & Nel, 2000; Wimmers *et al.*, 2000; Tadelle, 2003) with the primary aim to understand the extent of genetic variation within and among populations.

2.4.2 Molecular markers

During the last two decades several DNA markers such as RAPD, AFLP, 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).

Microsatellites are tandemly repeated loci with a core motif of 1 to 6 bp repeated several times (Vanhala *et al.*, 1998). The application of microsatellite markers are currently thought to be more useful than the other markers, since they are numerous and randomly distributed in the genome, seem highly polymorphic and show co-dominant inheritance (Smith & Smith, 1993; van Zeveren *et al*, 1995; Crooijmans *et al.,* 1996; Laval *et al.*, 2000; Martinez *et al.,* 2000). 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). 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). 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). 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 2.1 Microsatellite markers used in estimation of the genetic relationship and distinctness of chickens

Title	Origin	Name of chicken population & number of chickens 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 *et al*. (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)	
	Bolvia	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)

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2.4.3 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). The standard genetic distance (Ds) of Nei (1978), is formulated as:

$$Ds = (1 - J_{xy})^{-1/2} \{(1 - J_x) + (1 - J_y)\}$$

Where: $J_X = (2n_x \sum x^2_i - 1) / 2n_x - 1$

$J_y = (2n_y \sum y^2_i - 1) / 2n_y - 1$

$J_{xy} = \sum xy$

n = Number of individual sample size per population

XiYi = Allele frequencies for x^{th} allele in population x and y.

This remains to be the most commonly used method to measure the genetic distances between populations.

CHAPTER 3

STUDIES ON VILLAGE BASED INDIGENOUS CHICKEN PRODUCTION SYSTEMS IN NORTHWEST ETHIOPIA

3.1 Introduction

Indigenous chickens, which are managed under extensive systems account for 99 % of the total chicken population in Ethiopia (AACMC, 1984). This indicates that traditional chicken keeping is practised by virtually every family in rural Ethiopia in general, and in Northwest Ethiopia in particular because they provide protein for the rural population, create employment and generate family income. Furthermore, the indigenous chickens are good scavengers and foragers, well adapted to harsh environmental conditions and their minimal space requirements make chicken rearing a suitable activity and an alternative income source for the rural Ethiopian farmers. In addition, the local chicken sector constitutes a significant contribution to human livelihood and contributes significantly to food security of poor households. Horst (1988) considered the indigenous fowl populations as gene reservoirs, particularly of those genes (naked neck) that have adaptive values in tropical conditions. Despite the important roles of local chickens, rearing them can be considered as aside line agricultural activity. However, the indigenous chicken populations have been neglected by conservation and development programmes. Instead high-input high-output exotic commercial chicken breeds are introduced and supported by the government.

Knowledge and understanding of the chicken production systems, opportunities and constraints are important in the design and implementation of indigenous chicken-based development programmes, which can benefit rural societies (Gueye, 1998). There are many complex and

varying constraints to chicken production systems, which in turn influence their production and productivity potential. Such type of studies are lacking in Northwest Ethiopia. Hence, this investigation was carried out to generate information on village based indigenous chicken utilization, management practices, opportunities and challenges.

3.2 Materials and methods

3.2.1 Description of the region

Amhara National Regional State (ANRS) is one of the constituent states of the federal democratic republic of Ethiopia. It lies between 09^0 20' to $14^0 00$' North latitude and $36^0 20$' to $40^0 20$' East longitude. The state is divided into 11 administrative zones, including the capital city of the region, Bahir Dar and the zones are further sub-divided into districts. The region covers an area of 170150 km^2, which is 11 % of the total area of the country (Figure 3.1) (UNECA, 1996). Topographically, the region is divided into highland, midland and lowlands. The total population of the region is 16.5 million, which is about 25 % of the total population of the country (http://www.ada.org.et/).
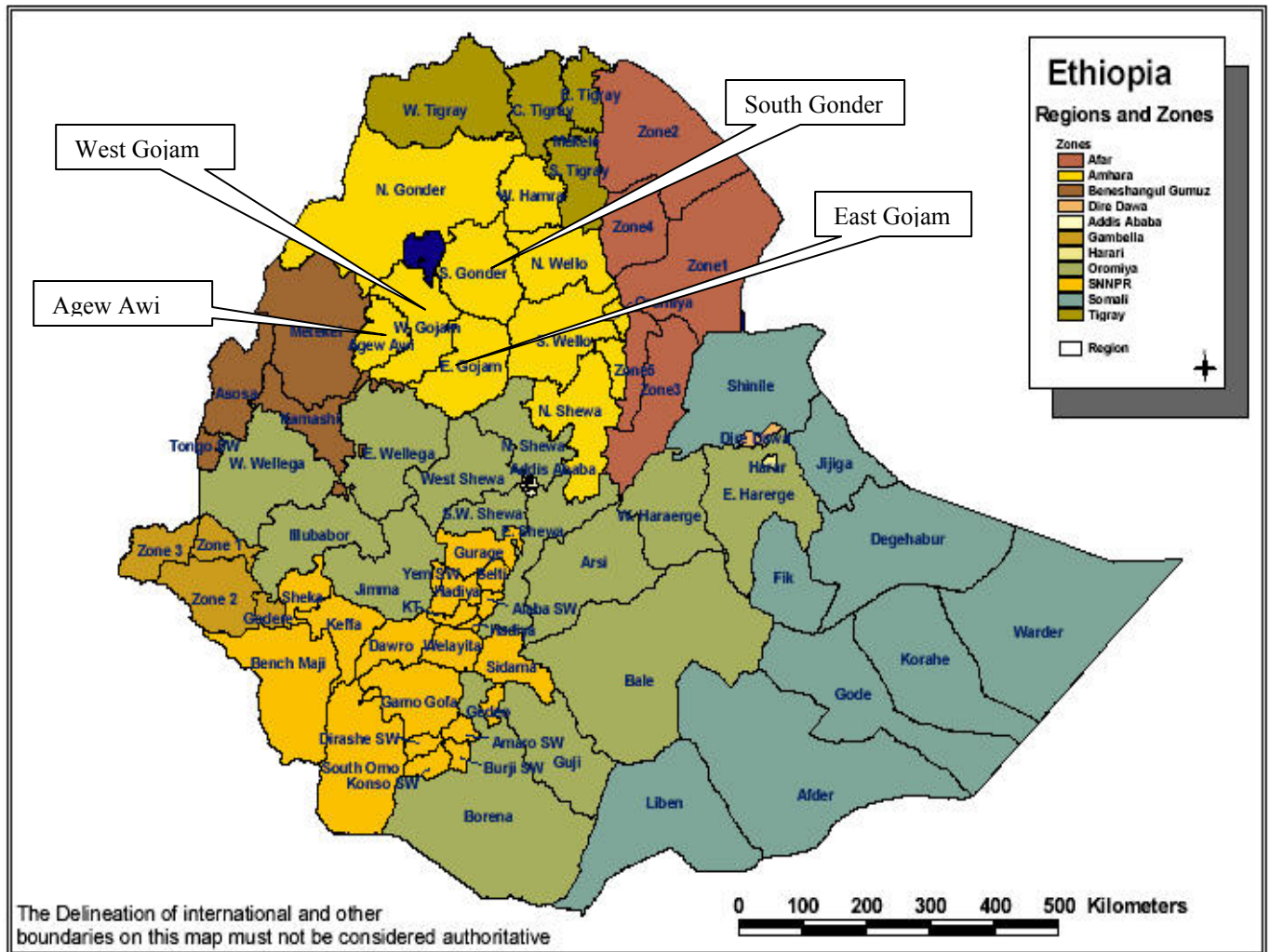
Figure 3.1 Map of Ethiopia indicating the study zones (South Gonder, Agew Awi, West and East Gojam) of the Amhara region

3.2.2 Selection of the study area

The study areas were selected from 11 zones found in ANRS, namely: East Gojam, West Gojam, Agew Awi and South Gonder (Figure 3.1). These administrative zones were chosen based on purposive sampling method (Workneh & Rowlands, 2004). The study areas were also selected after consultation of key informants (elders), agricultural officers at bureau of agriculture, zonal and district levels, comprehensive literature review and existence of known indigenous chickens. In addition, an informal rapid field survey was conducted using a checklist

with the specific objective of exploring the available knowledge about the type, distribution, importance, management systems, morphological and phenotypic characteristics of indigenous chickens in Northwest Ethiopia.

Apart from visual appraisal of the appearance of the chickens observed, random open-ended discussions were held with elders and agricultural officers using a checklist (Appendix 3.1). Based on the outcomes of the informal field survey and agro-ecological coverage (high altitude, mid altitude and low altitude), a total of eight districts were purposely chosen from four zones representing Northwest Ethiopia. Within each locality, peasant associations, villages and households were further selected based on random sampling methods. Data on distribution of chickens for each of the selected districts were collected from the CSA (2001).

Some zones found in Northwest Ethiopia was purposely excluded in this study because of the high number of exotic chicken breeds distribution in the form of day-old, fertile eggs and three months old pullets and cockerels by the Ministry of Agriculture (M.O.A.) (North and South Wello), inaccessibility and poor infrastructure availability (North Gonder, Wag Hamra, North Shewa). Besides, the capital city and the seat of the national regional government, Bahir Dar, was excluded in this study.

3.2.3 Nature of questionnaire and data collection

An informal and formal field surveys were conducted on the selected sites to explore the available knowledge about the type, distribution and utility of chicken types in the region. The structured questionnaires were pre-tested in the selected districts. The technical staff members of ALRC were involved in data collection and in each sampling site farmers were briefed about the objective of the study before starting the data collection. In total, 300 households were

participated in the interviews (Table 3.1), which were conducted using a structured questionnaire (Appendix 3.2). The interviews were conducted at the farmers' residences with the assistance of local extension officers. Information was collected on the socio-economic characteristics of the farmers, chicken types, chicken production systems and farming support services provided by the MOA. Visual appraisal of the appearance of the indigenous chicken types was undertaken for morphological description. The history, origin, and distribution, typical features and types of the local chicken found in the area were recorded by consulting the farmers and the agricultural officers of each locality.

3.3 Statistical analysis

Descriptive statistics such as mean, range, frequency and percentage were used to analyse the data using Statistical Package for Social Sciences (SPSS, 1996).

3.4 Results and discussion

3.4.1 Socio-economic status of farmers

This study is the first attempt to describe village-based chicken production systems in Northwest Ethiopia. The survey results indicated that the keeping of chickens is widely practised in Northwest Ethiopia. It is used as a source of income for immediate household expenses such as purchasing salt, coffee and clothes. The majority of the respondents were female (74.16 %) (Table 3.1). This indicated that most of the time the women in male-headed and /or female headed households are responsible for chicken rearing, while the men are responsible for crop cultivation and other off- farm activities. This is in agreement with the research results reported by Mcainsh *et al.* (2004). Gueye (1998) found that approximately 80 % of the chicken flocks in a number of African countries were owned and largely controlled by women. In the male-

headed households the wife and husband were co-owners of the chickens. Sometimes children owned some birds in the flock and were allowed to use their chickens for expenses at school or to purchase clothes.

As indicated in the present study (Table 3.1), the average farm per household is very small (1.28 ha), while the average family size (5.39) is quite large. About 82.12 % of the farmers were illiterate and the rest were just able to read and write. Similar results on illiteracy were reported in the Kwale district of the South coast of Kenya (Njenga, 2005). There should be a focus on the education and training of women as they are playing a dominant role in the improvement of village poultry production systems. Improving the education of women will also improve the overall socio-economic status of the family and the society through family management and family planning. Village-based rural poultry production requires less space and investment and can therefore play an important role in improving the livelihood of the family.

Table 3.1 Socio-economic characteristics of the respondents in village chicken production system

Parameters	Study zones								Over all mean
	South Gonder	West Gojam			Agew Awi	East Gojam			
		Districts							
	Farta	Dembecha/ Gelila	Mecha	Tilili	Guangua	Basoliben	Bebugne	D/Elias	
Sample size (no.)	86	32	46	13	37	31	45	10	
Sex of the respondent (%)									
Male	46.50	40.60	15.20	0.00	18.90	43.30	42.20	0.00	25.84
Female	53.50	59.40	84.80	100.00	81.10	56.70	57.80	100.00	74.16
Age of the respondent (years)	37.79	45.81	32.89	44.62	34.22	40.83	33.64	30.00	37.47
Education level (%)									
Illiterate	76.70	84.40	89.10	61.50	94.60	77.40	73.30	100.00	82.12
Read & write	23.30	15.60	10.90	38.50	5.40	22.60	26.70	0.00	17.88
Mean land size (ha)	0.95	1.18	1.03	1.17	1.46	1.38	1.08	2.00	1.28
Family size (no. of persons)	4.99	5.22	5.39	5.77	6.54	5.94	5.42	3.90	5.39

3.4.2 Husbandry practice

3.4.2.1 Flock size

In the present study, the overall average flock size per household for chicks and cocks and for hens/pullets was 4.73 and 2.40, respectively, with a total flock size of 7.13 (Figure 3.2), which is in line with the report by Gueye (1997), who reported that the flock sizes generally ranged from 5 to 20 fowls per African village household. An average flock size of 16 birds was also reported in the central parts of Ethiopia and in the Kwale district of the South coast Kenya (Tadelle *et al.,* 2003; Njenga, 2005). In the present study, the respondents stated that flock size varies between seasons mainly due to the availability of feed, the occurrence of diseases, the presence of predators as well as the economic status of the owners.
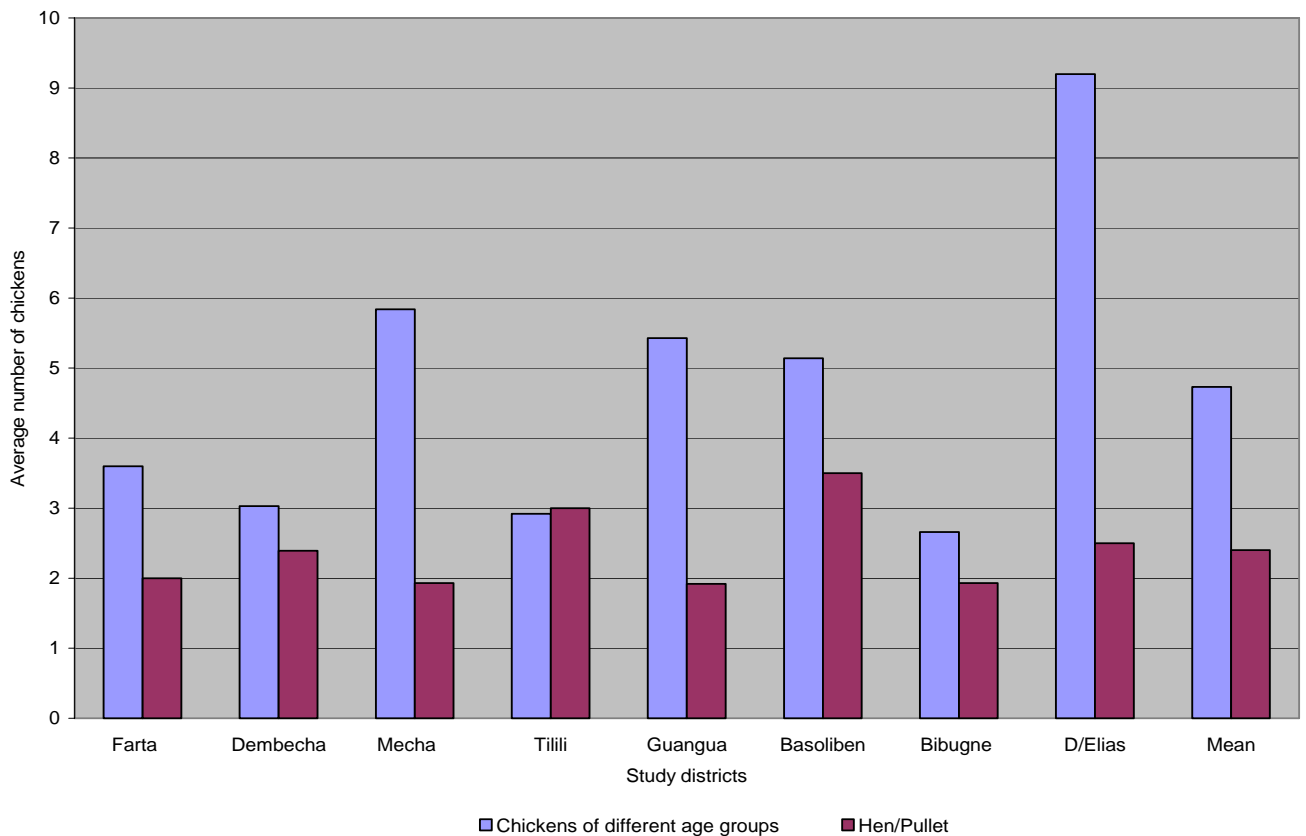
Figure 3.2 Average numbers of indigenous chickens per household

3.4.2.2 Feeds and feeding

After hatching, the chicks were allowed to forage and roam freely with their mothers in open areas near the home and surroundings (Figures 3.3 and 3.4). It is clear from the results that nearly all (99.27 %) the chickens are managed under a traditional or extensive chicken management system (Table 3.2). Almost all (99.28 %) the farmers in Northwest Ethiopia provided supplementary feeding to their chickens and chickens of different age groups were fed together. However, the type and amount of feed depended on the crops grown in the area as well as the seasons. The majority of the farmers who practised supplementary feeding systems (mostly once per day) used maize, barley, wheat, finger millet and household waste products to feed their chickens. This result is similar to the results of work done in Zimbabwe by Mapiye & Sibanda (2005), who reported that 96.8 % of the farmers supplied partial supplementation of feeds and 95.5 % of the feed was produced locally. Only 3.74 % of the chicken owners supplied the supplementary feed in a container or feeder, while the remaining threw the feed on the ground (Table 3.2). Mcainsh *et al.* (2004) observed that half of the farmers interviewed about traditional chicken production in Zimbabwe used feeders or containers to feed their chickens. At the beginning of the planting season the free roaming of chickens for scavenging was restricted to certain areas or they were kept in the main house and /or kitchens in order to prevent scavenging of newly planted seeds.

Figure 3.3 Indigenous chickens in the Mecha area, West Gojam zone of Northwest Ethiopia

Figure 3.4 Indigenous chickens in the Melo-Hamusit area, South Gonder zone of Northwest Ethiopia

3.4.2.3 Housing

The survey indicated that almost all farmers provided night shelter (Table 3.2) for their chickens either in part of the kitchen (1.36 %) or in the main house (39.07 %), in hand-woven baskets (7.29 %), in bamboo cages (1.51 %) or in separate sheds purpose-made for chickens (50.77 %). These shelters were made of locally available materials such as Eucalyptus poles and branches. This is an indication that the owners are aware of the importance of housing. In Botswana 35.8 % of the indigenous chicken farmers provided housing of some kind (Badubi *et al.,* 2006). It was further indicated that chickens were confined only during the night and that 74.02 % of the households cleaned their chickens' housing once per day, while 11.66 % of the owners cleaned it twice per day (Table 3.2). About 99.45 % of the farmers in the study area provided water for their chickens in plastic, wooden or clay bowls, and 31.52 % of the respondents cleaned the bowl daily (Table 3.3). In many cases the bowl was filled once per day.

Table 3. 2 Chicken management systems in Northwest Ethiopia

Parameters (%)	South Gonder	West Gojam			Agew Awi	East Gojam			Over all mean
	Farta	Dembecha/ Gelila	Mecha	Tilili	Guangua	Basoliben	Bebugne	D/Elias	
Type of chicken management									
Extensive	94.20	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.27
Semi-extensive	5.80	-	-	-	-	-	-	-	0.71
Supplementary feeding									
Yes	96.50	100.00	100.00	100.00	100.00	100.00	97.80	100.00	99.28
No	3.50	-	-	-	-	-	2.20	-	0.72
Chicken feeding									
Supply feed in containers	2.40	3.10	2.20	-	5.40	13.30	3.50	-	3.74
Thrown on the ground	97.60	96.90	97.80	100.00	94.60	86.70	96.50	100.00	96.26
Type of shelter for overnighting									
In the kitchen	2.40	6.30	-	-	-	-	2.20	-	1.36
Perch in the main house	34.50	50.00	45.60	38.50	62.10	9.70	42.20	30.00	39.07
Hand-woven basket	14.30	9.40	4.30	-	10.80	12.80	6.70	-	7.29
Bamboo cages	2.40	3.10	-	-	-	6.50	-	-	1.51
Purpose-made house	46.50	31.30	50.00	61.50	27.00	71.00	48.90	70.00	50.77
Cleaning of the shelter									
Once per day	100.00	91.70	93.80	16.70	90.00	100.00	100.00	-	74.02
Twice	-	-	-	83.30	10.00	-	-	-	11.66
None	-	8.30	6.20	-	-	-	-	100.00	14.32

Table 3.3 Provision of water to chickens, the type and frequency of cleaning of water containers

Parameters (%)	Study zones								Over all mean
	South Gonder	West Gojam			Agew Awi	East Gojam			
	Districts								
	Farta	Dembecha/ Gelila	Mecha	Tilili	Guangua	Basoliben	Bebugne	D/Elias	
Provision of water to chickens									
Yes	100.00	100.00	100.00	100.00	100.00	100.00	95.60	100.00	99.45
No	-	-	-	-	-		4.40	-	0.55
Type of waterer									
Plastic	14.10	28.10	54.30	-	75.70	32.30	19.00	-	27.93
Made from wood	29.40	46.90	26.10	-	5.40	64.50	35.70	90.00	37.25
Made from clay	56.50	25.00	19.60	100.00	18.90	3.20	45.30	10.00	34.82
Frequency of cleaning of the waterier									
Once per day	40.60	37.50	43.20	-	54.00	30.00	46.90	-	31.52
Twice	14.10	9.40	-	16.70	2.70	-	-	-	5.37
When it gets dirty	28.10	3.00	24.30	83.30	16.20	13.30	21.90	-	23.77
Every provision	17.20	6.30	2.70	-	8.10	16.70	-	-	6.38
None	-	43.80	29.70	-	18.90	40.00	31.20	100.00	32.96

3.4.2.4 Culling

In the survey area, farmers have their own criteria and strategies of culling, depopulating and selecting birds that are unproductive at any time of the year. 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. In addition, the respondents cited productivity, old age, lack of capacity to manage large number of birds and the outbreaks of disease as major determining factors in culling and reducing the number of chickens (Table 3.4). 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 & 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).

Table 3.4 Purpose and reason for culling chickens

Parameters (%)	Study zones								Over all mean
	South Gonder	West Gojam			Agew Awi	East Gojam			
		Districts							
	Farta	Dembecha/ Gelila	Mecha	Tilili	Guangua	Basoliben	Bebugne	D/Elias	
Purpose for culling and selection of chickens									
Consumption	11.30	-	5.00	-	5.40	3.40	2.60	-	3.46
Trade	32.40	51.90	22.50	-	18.90	17.20	31.60	-	21.81
Sacrifice	4.20	-	-	-	13.50	-	-	-	2.21
Consumption and sale	46.60	-	72.50	100.00	62.20	79.30	65.80	-	53.30
Fear of disease	5.60	48.10	-	-	-	-	-	100.00	19.22
Reasons for culling chickens									
Poor productivity	23.70	25.00	2.70	-	29.40	-	2.70	-	10.43
Old age	28.80	10.70	8.10	-	11.80	10.70	21.60	-	11.46
Poor productivity, old age and\ or sickness	45.80	64.30	81.10	100.00	44.10	89.30	73.00	100.00	74.70
Unable to manage large number of chickens	1.70	-	8.10	-	14.70	-	2.70	-	3.41

3.4.3 Production and reproductive aspects

In this study production and reproductive aspects were evaluated under the husbandry practices as set out in questionnaire (Appendix 3.2). From the results it is clear that chickens are kept by these household as a source of income. It was found that about 61.56 %, 5.27 % and 33.17 % of the replacement stocks for layer chickens (Table 3.5) were obtained in the form of purchase, gift and hatched eggs, respectively. Similar results with regard to the purpose of using of chickens were reported by Veluw (1987). The main source of capital (59.31 %) to replace and to start chicken production was the sale of crops (Table 3.5).

Pullets and cocks reached sexual maturity (Table 3. 6) at an age ranging from 20 to 24 weeks; however, 31.92 % of the pullets and 20.07 % of the cocks in this study reached maturity at 28 to 32 weeks, indicating late maturity. Under intensive management systems at the ALRC, Ethiopia, using similar indigenous chicken lines in the same research project, pullets and cocks reached sexual maturity at 22 to 23 weeks of age (Chapter 6). It was also reported that sexual maturity of 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) and 25 weeks in Senegal (Sall, 1990).

Table 3.5 Source of replacement stock and finance to indigenous chicken production

Parameters (%)	Study zones								Over all mean
	South Gonder	West Gojam			Agew Awi	East Gojam			
		Districts							
	Farta	Dembecha/ Gelila	Mecha	Tilili	Guangua	Basoliben	Bebugne	D/Elias	
Source of replacement stock for layers									
Purchased	78.60	96.90	26.70	61.50	43.20	46.70	68.90	70.00	61.56
Inherited/gift	2.40	-	24.40	-	5.40	10.00	-	-	5.27
Hatched	19.00	3.10	48.90	38.50	51.40	43.30	31.10	30.00	33.17
Source of finance for establishing chicken unit[*]									
Sales of culled poultry	3.60	3.10	-	-	-	-	4.50	-	1.41
" " egg	4.80	-	-	38.50	-	-	2.30	60.00	13.21
" " crop	44.60	59.40	100.00	53.80	59.50	71.00	86.30	-	59.31
" " livestock	4.80	6.30	-	7.70	-	-	2.30	-	2.63
Income from off-farm activities	19.30	28.10	-	-	24.30	29.00	2.30	-	12.87
Sale of both crop & livestock	22.80	3.10	-	-	16.20	-	2.30	40.00	10.55

*- Please see Appendix 3.2 for more detail

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Table 3.6 Age at sexual maturity of female and male indigenous chickens

Parameters (weeks)	Study zones								Over all mean
	South Gonder	West Gojam			Agew Awi	East Gojam			
	Districts								
	Farta	Dembecha/ Gelila	Mecha	Tilili	Guangua	Basoliben	Bebugne	D/Elias	
Pullet reached point of egg lay									
20-24	64.80	65.30	43.90	100.00	76.50	14.30	59.50	100.00	65.62
28-32	25.40	26.90	56.10	-	23.50	85.70	37.80	-	31.92
above 32	9.80	7.60	-	-	-	-	2.70	-	2.46
Cock reached sexual maturity									
20-24	64.00	76.00	50.00	100.00	67.70	96.00	65.70	100.00	77.42
28-32	24.00	16.00	50.00	-	32.30	4.00	34.30	-	20.07
above 32	12.00	8.00	-	-	-	-	-	-	2.51

3.4.3.1 Egg production and incubation practice

In general, artificial incubation is not practised by the owners of indigenous chickens in Ethiopia. In this study it was observed that for hatching of chicken eggs, farmers depended on broody hens. The total number of eggs incubated using a broody hen varied from 8-18 (Table 3.7) out of 9-19 eggs laid/clutch/ hen. A comparatively high number of chicks were hatched (7-15) from the number of eggs set and out of the total number of chicks hatched, 6-12 chicks survived to adulthood (Table 3.7). From the present study, it is confirmed that productive hens have on average 9-19 eggs per clutch with a maximum of 2 to 3 clutches/hen/year as a result the total number of eggs produced ranged from 18-57 eggs/year/ hen, which is very low (Table 3.7). Similarly, Badubi *et al.* (2006) reported that on average 11 to 15 eggs were laid by indigenous hens and 6 to 10 chicks were hatched. 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.

Table 3.7 The fertility and hatchability of eggs from indigenous hens

Parameters	South Gonder	West Gojam			Agew Awi	East Gojam			Over all mean
			Districts						
	Farta	Dembecha/ Gelila	Mecha	Tilili	Guangua	Basoliben	Bebugne	D/Elias	
Number of eggs used for hatching (no.)	6-20	6-16	7-18	11-20	6-20	6-15	7-19	11-13	8 – 18
Number of chicks hatched per eggs set (no.)	6-18	6-12	7-18	11-15	6-17	6-14	6-15	10-13	7 – 15
Chicks surviving to adulthood (no.)	6-15	6-9	7-15	7-11	6-13	5-10	5-9	7-12	6- 12
Number of clutch per hen per year (%)									
One	2.90	11.10	13.60	-	3.00	10.70	21.20	-	7.83
Two	69.60	77.80	27.30	100.00	48.50	46.40	60.60	50.00	60.03
Three	20.30	11.10	54.30	-	24.20	42.90	15.20	50.00	27.26
Four	7.20	-	4.50	-	24.30	-	3.00	-	4.88
Number of eggs per clutch (no.)	8-15	9-18	7-20	13-16	10-20	9-23	7-22	13-20	9-19

3.4.4 Mortality

The major causes of death of chickens over the study area were seasonal outbreaks of chicken diseases, specifically Newcastle disease (locally known as "fengele"), followed by predation. The highest chicken death rate was observed during the rainy season and 90.86 % of the chicken owners reported occurrences of chicken diseases. However, there was a problem in identifying the real causes and the type of diseases that led to chicken deaths since most of the veterinary services given to the farmers were not supported with laboratory investigation. Only 6.66 % of the farmers had counseling on chicken diseases and health management. The majority of chickens (72.43 %) reported in Northwest Ethiopia were not properly examined and no health management services were provided (Table 3. 8). It was indicated that in Africa one of the major constraints to village fowl production is the prevalence of various diseases (Gueye, 1998).

Table 3.8 Factors contributing to the low production and reproductive aspects of indigenous chickens

Parameters (%)	Study zones								Over all mean
	South Gonder	West Gojam			Agew Awi	East Gojam			
		Districts							
	Farta	Dembecha/ Gelila	Mecha	Tilili	Guangua	Basoliben	Bebugne	D/Elias	
Disease outbreak									
Yes	77.40	100.00	90.90	100.00	89.20	90.30	78.60	100.00	90.86
No	22.60	-	9.10	-	10.80	9.70	21.40	-	9.14
Treatment of diseased chickens*									
Treated by the owner	5.30	28.10	61.90	-	18.90	6.90	2.70	-	15.47
Killed immediately	1.30	-	4.80	-	-	-	-	-	0.76
Consumed immediately	2.60	-	-	-	5.40	-	-	-	1.1
Sold by the owner	9.20	-	-	-	-	-	-	-	1.15
No intervention	77.60	71.90	-	100.00	59.50	75.90	94.60	100.00	72.43
Consumed or sold	3.90	-	-	-	16.20	-	-	-	2.52
Consulted veterinary Experts	-	-	33.30	-	-	17.20	2.70	-	6.66

*- Please see Appendix 3.2 for more detail

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3.4.5 Marketing

Indigenous chickens are kept for both egg and meat production. The eggs produced are used for brooding, trade 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 in village markets to sell in big cities or to owners of restaurants. The price of eggs was directly related to supply and demand as well as the orthodox Christian fasting months. The income derived from the sale of chickens and eggs is used to purchase consumable food items, for school fees, grain milling services, purchasing of improved seeds of maize, wheat and other expenses. Most of the consumers prefer to buy eggs and chickens from producers of indigenous birds, since they are considered to be tasty, are better suited to preparation of the traditional "Doro wot" (chicken sauce) and the dark coloured egg yolks are commonly favoured.

Birds were brought to the local market once or twice a week to be sold to local consumers, or to local traders. People carry their chickens to the market on foot as there is no access to transport. 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. Normally the average prices of medium size chicken ranged from US$ 0.70 to 1.71 and 0.81 to 1.50 for a cock and hen, respectively (Table 3. 9). The price of live birds is often lower during the periodical outbreaks of Newcastle and other chicken diseases. In Nigeria the market price for indigenous male birds was two to three times higher than for females and ranged from US$ 4.08-5.10 and US$ 1.63–2.04, respectively (Sonaiya *et al*., 1992).

Table 3.9 Factors affecting the marketing of live chickens and eggs in Northwest Ethiopia

Parameters	Study zones								Over all mean
	South Gonder	West Gojam			Agew Awi	East Gojam			
		Districts							
	Farta	Dembecha/ Gelila	Mecha	Tilili	Guangua	Basoliben	Bebugne	D/Elias	
Factors related with chicken marketing (%)									
Unstable price	37.90	56.30	50.00	46.20	45.70	41.40	63.70	100.00	55.15
Seasonal demand	29.80	18.70	9.00	-	-	10.30	11.30	-	9.88
Lack of good market place	1.40	-	2.30	-	5.70	-	6.80	-	2.03
Poor infrastructure	4.10	-	38.60	-	-	-	-	-	5.33
No problem	21.60	25.00	-	53.80	42.90	48.30	18.20	-	26.22
Sale of diseased chickens	5.40	-	-	-	5.70	-	-	-	1.39
Selling price of medium size *									
Male chickens (Eth. Birr)	5-15	6-14	5-15	7-18	7-13	6-13	5-15	10-15	6-15
Female " "	5-12	5-10	5-10	7-18	6-15	6-12	5-12	10-15	7-13

*- NB. 8.63 Eth. Birr = 1 US$ (February 2006)

3.4.6 Provision of extension services

Extension services to utilize improved agricultural technology for increasing crop and livestock production and productivity are provided to 52.51 % of the farmers in Northwest Ethiopia. About 70.6 % of the chicken growers obtained information about exotic chicken breeds and improved chicken management from market places, neighbours and extension officers (Table 3. 10). This indicates that the M.O.A. has given due attention to poultry production and considers it a viable enterprise towards boosting economy.

Table 3.10 Percentage of farmers reached by extension services of the government

Parameters (%)	Study zones								Over all mean
	South Gonder	West Gojam			Agew Awi	East Gojam			
	Districts								
	Farta	Dembecha/ Gelila	Mecha	Tilili	Guangua	Basoliben	Bebugne	D/Elias	
Provision of extension services									
Yes	57.00	37.50	35.60	46.20	64.90	51.60	52.30	75.00	52.51
No	43.00	62.50	64.40	53.80	35.10	48.40	47.70	25.00	47.49
Information for exotic chicken breeds and improved management									
Yes	77.10	73.30	51.20	46.20	63.90	85.70	67.40	100.00	70.6
No	22.90	26.70	48.80	53.80	36.10	14.30	32.60	-	29.4
Source of information for improved chicken production									
Extension officer Market, neighbours	63.10	19.00	3.40	15.40	50.00	50.00	35.50	-	29.55
and \ or extension officer	39.90	81.00	96.60	84.60	50.00	50.00	64.50	100.00	70.45

3.5 Conclusions

In general, the present study identified various major constraints such as chicken disease, predation, poor housing, poor nutrition and no attention given to the improvement of indigenous chicken stocks. Insufficient capital and a knowledge gap among smallholders also restrict poultry production. Disease and replacement of indigenous chickens by exotic chicken breeds are major threat in eroding and dilution of the indigenous genetic resources. There is, therefore, a need to design and implement a research programme to collect, conserve and improve the indigenous chickens in order to advance poultry production and productivity in the region.

CHAPTER 4

PHENOTYPIC VARIATION OF INDIGENOUS CHICKEN POPULATIONS IN NORTHWEST ETHIOPIA

4.1 Introduction

A substantial amount of phenotypic diversity for various traits in the indigenous chicken genetic resources of Ethiopia is expected because of diverse agro-climates, ethnic groups, socio-economic, religious and cultural considerations are amongst the reasons. In addition, the country has served as one of the gateways for domestic animals migration from Asia to Africa and this have led to a further impact on the diversity of Ethiopian chickens.

Indigenous chickens in Ethiopia are found in huge numbers distributed across different agro-ecology categories under a traditional family-based scavenging management system (Alemu & Tadelle, 1997). This indicates that they are highly important farm animals kept as a good source of animal protein and income to most of the rural populations. Furthermore, their widespread distribution indicates their adaptive potential to the local environmental conditions, diseases and other stresses. However, the phenotypic diversity of the local chicken resources in Ethiopia in general, and in Northwest Ethiopia in particular has not yet been sufficiently studied. Therefore, this study was carried out to identify, characterize and describe the phenotypic variation of indigenous chicken populations.

4. 2 Materials and methods

4.2.1 Selection of the study area

Please refer for detail explanation in the material and methods of Chapter three, 3.2.2.

4.2.2 Measurement of phenotypic traits

Informal and formal field surveys were conducted on selected sites to explore available knowledge about the type, distribution and utility of indigenous chicken types in Northwest Ethiopia. The interviews were conducted at the farmers' houses with the assistance of local agricultural extension officers. In the survey, information on the phenotypic characteristics of indigenous chicken types was recorded. Moreover, visual appraisal of the appearance of the indigenous chicken types and their typical features were collected from a total of 300 individual chickens (Table 4.1), using a structured questionnaire (Appendix 3.2) for morphological description (Batty & Francis, 1979). After the consultation with agricultural officers, key informants, and the carrying out of an informal rapid field survey, these indigenous chicken populations were chosen because of their unique morphological traits, economic importance to each locality and their development in a unique environment as described in Chapter 3. Hence, morphologically distinct indigenous chickens were sampled using the qualitative traits (plumage colour, comb type, shank feather, shank colour, ear lobe type and colour, comb shape and colour) and quantitative traits such as body weight, shank length and circumference following the standard descriptor (FAO, 1986). As a result seven indigenous chicken populations identified from four zones: Guangua (Agew Awi), Debre-Elias (East Gojam), Gassay and Melo-Hamusit (South Gonder) and Gelila, Mecha and Tilili chickens (West Gojam) and grouped according to these ecological zones. However, chicken types from Basoliben and Bebugne

districts were not included in the performance (Chapter 6) and genetic diversity (Chapter 5) studies since these are too small populations.

Eggs from each identified indigenous chicken populations (Table 4.3) were purchased in respective administrative village markets and hatched at the Andassa Livestock Research Centre, Ethiopia, in order to further evaluate their performances and to develop catalogue on their physical description. The names of the indigenous chickens were given from the place where they have identified. At the age of 22 weeks, sixteen birds (8 female and 8 male) from each chicken population were randomly selected to describe the qualitative and quantitative traits. Qualitative traits such as plumage colour, comb type, shank colour and earlobe colour and quantitative traits like body weight (g), egg size (g), wing span (cm), shank circumference and length (cm) were also measured.

4. 3 Descriptive statistics

The data collected from the quantitative variables such as body weight, wing span, shank length, shank circumference, age at first egg, egg weight, % fertility and % hatchability of fertile eggs were analyzed to obtain descriptive statistics, using GLM multivariate analyses (SPSS, 1996) & SAS (2006). Similarly, the qualitative parameters like comb type, head shape, shank colour, earlobe colour, shank feather and plumage colour were analysed using descriptive statistics and compared as percentages using the same software packages.

4.4 Results and discussion

4.4.1 Variation in qualitative traits

Qualitative traits such as plumage colour, comb type, shank colour and earlobe colour were evaluated in chicken populations. The results indicated that the predominant plumage colour of the local chicken populations in the respective administrative zones of Northwest Ethiopia is white (25.49 %) followed by a grayish mixture (22.23 %) and red (16.44 %) (Table 4.1). However, considerable numbers of chickens showed heterogeneity and have diverse plumage colour like black, multicolour, black with white tips, reddish brown and white with red stripes which accounted for 7.79, 3.62, 13.64, 6.67 and 4.03 %, respectively (Table 4.1) that aid for camouflage against predators. The presence of such large variations in plumage colours may be the result of their geographical isolation as well as periods of natural and artificial selections. This is in agreement with previous studies in Senegal (Missohou *et al*., 1998). Duguma (2006) also found similar results for the Horro, Tepi and Jarso indigenous chickens with regard to plumage colour. Variations were also observed in head shape and shank colour and the overall mean indicated that about 51.18, 64.42 and 50.72 % of the chickens had plain head shapes, yellow shanks and pea comb types, respectively (Table 4. 2). Similar results were reported in other countries (Mcainsh *et al*., 2004; Bhuiyan *et al*., 2005; Badubi *et al*., 2006).

Most of the indigenous chickens evaluated under intensive management systems had yellow, white, red, black and gray shanks, while the Gassay and Guangua chicken types did not have red and black shank colours, respectively. All hens laid light brown or cream coloured eggs. The Debre-Elias and Gassay chickens additionally laid white coloured eggs (Table 4.4). Similarly, it was reported that the indigenous chickens in Bangladesh laid light brown (67 %) and white (27 %) eggs (Bhuiyan *et al*., 2005). Similar variations in qualitative and quantitative traits were

reported in the indigenous chickens of Botswana (Badubi *et al*., 2006), Tanzania (Msoffe *et al*., 2001) and Zimbabwe (Mcainsh *et al*., 2004).

Table 4. 1 Phenotypic (plumage colour) variation of indigenous chicken populations in Northwest Ethiopia

Plumage colour (%)	Study zones									Over all mean
	South Gonder		West Gojam			Agew Awi	East Gojam			
	Districts									
	Farta		Dembecha/ Gelila	Mecha	Tilili	Guangua	Basoliben	Bebugne	D/Elias	
	Gassay	Melo-Hamusit								
Sample size	31	21	46	32	33	37	31	40	29	
White (Nech)*	9.10	27.30	25.10	15.20	-	24.30	32.20	20.00	50.00	25.49
Black (Tikur)	7.95	2.65	21.90	2.20	-	5.40	-	22.20	-	7.79
Red (Kiy)	10.58	3.53	6.30	26.10	38.50	29.70	-	6.70	10.00	16.44
Grayish mixture (Gebsema)	6.15	2.05	21.90	13.00	61.50	5.40	22.60	24.40	20.00	22.23
Multicolour (Ambesema)	6.23	2.08	-	4.30	-	5.40	6.50	4.40	-	3.62
Black with white tips (Teterma)	12.38	4.13	9.40	21.70	-	21.90	12.90	6.70	20.00	13.64
Red brownish (Kokima)	3.53	1.18	9.40	10.90	-	8.10	9.70	11.10	-	6.76
White with red stripes(Seran)	0.90	0.30	6.20	6.50	-	2.70	3.20	4.40	-	4.03

* -Names in parentheses are in Amharic, Ethiopian national language

Table 4.2 Morphological characteristics of indigenous chicken populations in Northwest Ethiopia

Parameters (%)	Study zones									Over all mean
	South Gonder		West Gojam			Agew Awi	East Gojam			
	Districts									
	Farta		Dembecha/ Gelila	Mecha	Tilili	Guangua	Basoliben	Bebugne	D/Elias	
	Gassay	Melo-Hamusit								
Head shape										
Plain (Ebab-eras)*	15.30	27.50	68.80	50.00	46.20	51.40	60.00	42.20	70.00	51.18
Crest (Gutya)	84.70	72.50	31.20	50.00	53.80	48.60	40.00	57.80	30.00	48.82
Comb type										
Rose	2.20	5.00	15.60	13.00	38.50	22.20	-	-	40.00	16.6
Pea	67.40	57.50	40.60	54.30	53.80	47.20	54.80	62.20	30.00	50.72
Walnut/strawberry	-	-	3.10	8.70	-	2.80	3.20	-	30.00	5.97
Single	4.30	5.00	21.90	13.00	7.70	22.20	19.40	17.80	-	13.34
V-shape	26.10	32.50	18.80	10.90	-	5.60	22.60	20.00	-	13.37
Shank feather										
Present	-	2.60	3.10	-	15.40	-	-	-	-	2.48
Absent	100.00	97.40	96.90	100.00	84.60	100.00	100.00	100.00	100.00	97.52
Shank colour										
Yellow	67.40	55.00	59.40	73.30	76.90	64.90	60.40	61.40	55.00	64.42
Black	13.00	12.50	9.40	2.20	-	8.10	13.30	13.60	15.00	9.61
White	15.20	15.00	12.50	17.80	15.40	16.20	13.30	6.80	10.00	13.99
Green	4.30	17.50	18.80	6.60	7.70	10.80	10.00	11.30	20.00	11.98

*- Names in parentheses are in Amharic, Ethiopian national language

4.4.2 Variation in quantitative traits

Body weight (g), shank length (cm), shank circumference (cm) (Table 4.3), egg weight (g) and other reproductive traits (Table 4.4) were measured for the different chicken ecotypes which were characterized at the ALRC under intensive management conditions. The Guangua cock lines were heavier than the other indigenous chicken groups (p<0.05), while the other indigenous hens were relatively similar in body size. On the other hand, both the male and female RIR chickens were larger (Table 4.3) than the indigenous chickens in this study.

In terms of shank lengths, the Melo-Hamusit and Gassay cocks had shank lengths of 11.3 cm and 10.83 cm, respectively at 22 weeks of age which is relatively long compared to the other chicken populations in this study. Among the local hens, chickens from Mecha (7.50 cm) had the shortest shank lengths. In both the male and female chickens, there was no significant (p>0.05) difference in shank lengths (Table 4.3), except for the Melo-Hamusit cock chickens, where as the cocks appear to be taller than the hens. Badubi *et al.* (2006) reported the shank length of the Tswana indigenous females and males as 7 cm and 8.5 cm, respectively. In Tanzania, five local chickens 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).

As to shank circumference, the Mecha local cocks and the Tilili hens had the largest shank circumferences of 0.87 and 0.70 cm, respectively, while the smallest was recorded for Gassay cocks (0.70 cm) and Debre-Elias and Gassay (0.53 cm) hens. Both the male and female chickens had a non significant (p>0.05) variation in wing length (Table 4.3).

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Other economical traits that showed morphological variations were body weight at day-old (25.55-29.26 g), age at point of lay (144-168 days), average egg weight (40.53– 46.68 g), fertility (85.1-100 %) and hatchability of the fertile eggs (50- 80.3 %) (Table 4.4). Similar day-old body weights were reported by Hoque *et al*. (1975) for the Deshi indigenous chickens under scavenging conditions.

Table 4. 3 Comparison of body weight, shank length, shank circumference and wing span at the age of 22 weeks among indigenous chickens

Parameters	Sex	Indigenous chicken populations							RIR	Over all mean
		Tilili	Gelila	Debre-Elias	Melo-Hamusit	Gassay/Farta	Guangua	Mecha		
Pre-slaughter body wt (g)	M	1131.33^c	1044.67^c	1141.33^{bc}	1292.00^{bc}	1057.33^c	1517.00^{ab}	1157.33^{bc}	1735.67^a	1259.58
	F	873.50^{ab}	848.67^{ab}	642.00^b	745.50^b	749.00^b	840.33^{ab}	794.33^{ab}	1263.33^a	847.77
Shank length (cm)	M	10.50^{ab}	10.33^{ab}	10.00^{ab}	11.33^a	10.83^{ab}	10.0^{ab}	10.00^{ab}	9.50^b	10.31
	F	8.50^a	8.33^a	8.00^a	8.50^a	8.00^a	8.30^a	7.50^a	8.17^a	8.14
Shank Circumference (cm)	M	0.80^{ab}	0.83^{ab}	0.77^{ab}	0.83^{ab}	0.70^b	0.80^{ab}	0.87^{ab}	0.93^a	0.82
	F	0.70^{ab}	0.63^{abc}	0.53^c	0.60^{bc}	0.53^c	0.63^{abc}	0.60^{bc}	0.73^a	0.62
Wing span (cm)	M	15.17^a	15.83^a	15.50^a	15.83^a	15.00^a	15.00^a	15.13^a	15.50^a	15.38
	F	14.00^a	13.83^a	12.83^a	14.00^a	12.67^a	13.17^a	13.33^a	13.50^a	13.36

[abc] Means with a different superscript in a row are significantly different (p< 0.05)

Table 4.4 Comparison of economically important traits (performance profile) among indigenous chickens

Traits	Indigenous chicken populations							RIR
	Tilili	Gelila	Debre-Elias	Melo-Hamusit	Gassay/Farta	Guangua	Mecha	
Day-old body wt (g)	27.17^d	27.85^c	27.14^d	26.26^e	25.55^f	29.26^b	27.88^c	35.24^a
Comb type	P,S,R	P,S,R,W	P,S,R,W	P,S,R	P,S,R,W	P,S,R	P,S,R	S
Shank colour	Y,W,R,B,G	Y,W,R,B,G	Y,W,R,B,G	Y,W,R,B,G	Y,W,B,G	Y,W,R,G	Y,W,R,B,G	R
Age at first egg (days)	157.33^{abc}	160.67^{ab}	143.67^c	168.33^a	158.67^{abc}	155.67^{abc}	153.00^{bc}	149.67^{bc}
Average egg weight (g)	44.64	40.53	41.21	41.42	41.07	46.68	44.56	53.4
Egg colour	LB, C	LB, C	LB, C,W	LB, C	LB, C,W	LB, C	LB, C	B
Fertility (%)	90.20	95.50	92.30	85.70	100.00	85.10	91.00	94.00
Hatchability (TES) (%)	49.00	56.70	46.20	61.90	70.90	62.30	73.10	62.70
Hatchability (FES) (%)	54.30	59.40	50.00	72.20	70.90	65.0	80.30	66.70

- Comb type-   Pea (P), Rose (R) Single (S), & Walnut/Strawberry (W)
- Shank colour- Black (B), Gray (G), Red(R), White (W) & Yellow(Y)
- Egg colour-   Light brown (LB),Cream(C), White (W)
- TES-   Number of chicks hatched per number of eggs set X 100
- FES-   Number of chicks hatched per number of fertile eggs X 100

4.4.3 Physical description of indigenous chicken ecotypes

4.4.3.1 Tilili chickens

Most of the Tilili males have predominantly light red plumage with rich brown on the back side. In some cases the breast of the male is black. The female has a partridge or black red colour and the tails in both sexes are black.

Figure 4.4.3.1 Tilili indigenous chickens

4.4.3.2 Gelila chickens

The males are multicoloured, the most common combination being bodies in varying shades of red with deep brown and black tails. Some have a green sheen to their black bodies and multicoloured wings and white striped tails. The plumage colour of females is brownish black or light brown with brown hackles. Both males and females have black or white tails. The experimental group also included a silky gray specimen and a few chickens with white and red plumage and reddish brown breasts.

Figure 4.4.3.2 Gelila indigenous chickens

4.4.3.3 Debre-Elias chickens

The predominant plumage colour for males is a reddish brown, with black tinted breasts, thighs and tails, or a medium to light brown with white speckles on the shoulders. Female birds are predominantly black-red (partridge) with golden hackles and black tails; also black with white feather tips. Also included in the experimental group were a few birds that were completely white.

Figure 4.4.3.3 Debre-Elias indigenous chickens

4.4.3.4 Melo-Hamusit chickens

The predominant plumage colour for both sexes is white, although, light gold coloured birds with cream coloured breast feathers and black tails with a green sheen also featured. The females are mainly red and white with white tails but black and brownish red birds with black tails also occur.

Figure 4.4.3.4 Melo-Hamusit indigenous chickens

4.4.3.5 Gassay/Farta chickens

The males come in brown or reddish brown colours; also white with red striped wings, red with light yellow hackles and golden body plumage with straw/light yellow coloured hackles and black breasts and thighs. The females have partridge, black and light golden feathering. In most cases both sexes have black tails. These chicken lines are commonly known as "Farta chickens".

Figure 4.4.3.5 Gassay /Farta indigenous chickens

4.4.3.6 Guangua chickens

The males are light brown with white speckles hackle, shoulder and breast parts. Most of both sexes are reddish brown with black tail or blackish brown with black spots on the breast, thighs and tail.

Figure 4.4.3.6 Guangua indigenous chickens

4.4.3.7 Mecha chickens

The main plumage colours of both sexes are red and white with red lacing on the breast and saddle feathers. Some of the males have a black and red pattern with light red on the hackle. Others have a brownish red colour with light red on the hackle. Some of the hens have a brownish black colour with white on the hackle and tail, while others have a light golden colour on the hackle part.

Figure 4.4.3.7 Mecha indigenous chickens

4.5 Conclusions

This study was the first attempt and has been found that the seven indigenous chicken lines showed distinct physical variations for both qualitative and quantitative traits under their respective production systems, as well as under intensive management conditions. It was observed that the local chickens are liable to genetic erosion and dilution resulting from natural disasters such as chicken diseases and man-made constraints such as extension of RIR and other introduced breeds. It is highly recommended to collect and improve the indigenous chickens so as to utilize these resources in a sustainable way.

CHAPTER 5

PRELIMINARY STUDY ON THE GENETIC VARIATION OF INDIGENOUS CHICKEN POPULATIONS IN NORTHWEST ETHIOPIA USING MICROSATELLITE MARKERS

5.1 Introduction

Genetic characterization contributes 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. Since the initiation of an integrated programme for the global management of genetic resources (Project MoDAD, http://www.fao.org/dad_is) on an international level (Scherf, 1995; Gandini & Oldenbroek, 1999) the conservation of farm animal resources has been emphasized by a number of authors (Mendelsohn, 2003; Shresta, 2004). Conservation of farm animals including poultry will be important for future designing of sustainable breeding programs (Toro *et al.,* 2006). Up to date no information is available on the genetic diversity of Northwest Ethiopian indigenous chickens, which are becoming important to design effective selection and conservation strategies. The production potential of indigenous chickens in village based production systems (Halima *et al*., 2007a), the phenotypic variation (Halima *et al.*, 2007b) and performance traits of these chickens have been also studied under intensive management conditions (Halima *et al*., 2006a; 2006b) and recommendations were made for efficient management, breeding and utilization.

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 for the Measurement of Domestic Animals Diversity (MoDAD) (FAO, 2004b), for application in diversity studies and detailed information on the microsatellite markers are available on the FAO website (www.dad.fao.org/en/refer/library/guidelin/marker.pdf).

Microsatellites are highly polymorphic tandem repeat loci with a core motif of 1 bp to 6 bp repeated (Tautz, 1989) and evenly distributed in the genome (Shahbazi *et al.,*2007). Microsatellites are widely implemented in exploring genetic variation and phylogeny between populations of same species (Buchanan *et al*., 1994; MacHugh *et al*., 1994). The usefulness of microsatellite markers in estimating genetic relatedness and diversity in chickens have been demonstrated in a number of indigenous breeds, inbred strains and in commercial chicken lines (Crooijmans *et al*., 1993; 1996; Ponsuksili *et al.*, 1996; Vanhala *et al*., 1998; Zhou & Lamont, 1999; van Marle-Köster & Nel, 2000; Romanov & Weigend, 2001; Zhang *et al*., 2002; Tadelle, 2003). These markers are co-dominant and highly reproducible.

In this study a limited number of DNA samples were available. The aim of the study was to provide preliminary data on the genetic variation of indigenous chicken populations using microsatellite markers.

5.2 Materials and methods

5.2.1 Chicken populations

Blood samples were collected from the seven indigenous chicken populations as described in Chapter 3. A total of 147 chickens representing seven indigenous chicken populations: Tilili (n = 22), Gelila (n = 23), Debre-Elias (n = 23), Melo-Hamusit (n = 14), Gassay/Farta (n = 19),

Guangua (n = 23) and Mecha (n = 23) were included in the sampling procedures. The Rhode Island Red (n= 30) breed was included as control. Blood samples from four South African chicken strains namely one commercial (White leghorn breed, n = 20) and three indigenous chicken lines (Ovambo, n = 25), (Koekoek, n = 25) and (Lebowa-Venda, n = 25) were obtained from ARC at Glen Agricultural Institute, Bloemfontein, South Africa and included as control populations.

5.2.2 Blood sample collection

Blood samples from Ethiopian chicken populations were collected in 2 ml tubes containing EDTA in the form of K3E, as anticoagulant and stored at $-70\ ^{O}C$ until DNA extraction, while blood samples from the South African chicken lines were collected from their combs using FTA cards and stored at room temperature.

5.2.3 DNA extraction

Genomic DNA was extracted from 50 µl of blood following Sambrook *et al.* (1989) DNA extraction method. The frozen blood was thawed at 37 ^{o}C for 15 minutes using a water bath. Seven hundred µl lysis buffer (10 mM Tris–HCl pH=8.0, 100 mM NaCl, 1 mM EDTA, pH= 8.0, 0.5 % Sodium Dodecyl Sulphate (SDS)) and 20 µl of 10 mg per ml Proteinase-K were added to the aliquot and incubated overnight at 42 ^{o}C with gentle shaking. Three hundred thirty µl Phenol, Chloroform and Isoamyl alcohol mixture at a ratio of 25:24:1, respectively was added to each sample, and centrifuged for 5 minutes at 12000 rpm at 4 ^{o}C. The supernatant from each sample was collected and added into newly labeled Eppendorf tubes. Three hundred sixty µl Isopropanol, stored at -20 ^{o}C, was added to the supernatant and centrifuged at 12000 rpm for 15 minutes at 4 ^{o}C. The liquid phase was then removed by gently inverting the Eppendorf tubes.

DNA samples were washed by adding 1ml of 70 % Ethanol, and centrifuged at 12000 rpm for 5 minutes. Ethanol was removed and DNA samples were dried at room temperature. Finally, DNA was diluted by adding 40µl of 1 x TE buffer, and concentration measured at 260 nm using a spectrophotometer.

DNA extraction from FTA cards was carried out following the method described by the WHATMAN Company (http://www.whatman.com). FTA cards containing blood samples were dried at room temperature. A 1.2 mm disc, containing the dried blood sample was punched out from FTA filter paper (Whatman Bioscience) using a hole punch and placed in a 1.5 ml micro centrifuge tube. The samples were then washed three times with 200 µl FTA purification reagent. Each time, the samples were stirred manually, vortexed and the liquid was removed with a sterile pipette. The samples were again washed two times with 200 µl TE buffer (10 mM Tris-HCl, 0.1 mM EDTA, pH =8.0) in a similar manner and then dried on a heating block at 65°C. The washed and dried FTA disks were used as DNA template for the PCR reaction.

5.2.4 Selection of microsatellite markers

A total of twenty-two microsatellite markers were donated by the Department of Animal Breeding and Genetics, Wageningen University, The Netherlands, via Department of Animal and Wildlife Sciences, University of Pretoria, South Africa. Markers were chosen based on the degree of polymorphism reported in the literature and further optimized and tested for polymorphism (Table 5.1).

Table 5.1 Characteristics of microsatellite markers used for the genetic analysis of 12 chicken populations (Source: Wageningen Agricultural University)

Markers	Repeat motif	Dye*	Annealing temp.(^{o}C)	Expected size range, bp
MCW 98	(TG)5 TT(TG)7	TET	55	260-262
MCW 103	(AC)5T(CA)8TT(CA)4GG(CA)4	TET	55	269-274
MCW 145	(GTTT)6 (GT)20	TET	55	164-212
MCW 154	(CA)11	FAM	55	171-192
MCW158	(GT) 26 (AT)9	FAM	55	164-224
MCW 160	(AC)8G(CA)10	FAM	55	206-226
MCW 208	(CA)11N8C16A12	HEX	55	228-239
MCW 213	(AC)25	FAM	55	293-311
MCW 214	(CA)9	FAM	55	244-291
MCW 216	(GT)9	TET	55	140-148
MCW 222	(GT)8	FAM	55	221-223
MCW 228	(GT)10	TET	55	222-240
MCW 238	(AC)21	FAM	55	187-217
MCW 243	(AC)21	FAM	55	193-232
MCW 248	(CA)9	TET	55	216-225
MCW 258	(CA)11	FAM	55	141-162
MCW 263	(CA)11	HEX	55	240-254
MCW 264	(CA)13C(CA)6	HEX	55	227-241
MCW 276	(TG)8(AG)5	TET	55	205-239
MCW 283	(AC)14A24	HEX	50	112-155
MCW 284	(TG)10	TET	50	238-246
MCW 289	(GT)5GC(GT)2GC(GT)12	TET	55	217-234

* - TET (Green), FAM (Blue), HEX (Yellow)

5.2.5 Polymerase Chain Reaction (PCR) preparation and amplification

A PCR reaction mixture with the final volume of 10 µl included 50 ng template genomic DNA, 1µl of Thermophilic DNA poly. 10 X Buffer, 2 µl of 100 mM dNTP, 0.5 µl of each (10 pmol/µl) forward and reverse primers, 0.2 µl of 5U/µl *Taq* DNA polymerase, 0.6 µl of 25 mM MgCl$_2$ and double distilled water were prepared.

The following program run for amplification: 1 min denaturation at 95 ^{o}C followed by 35 cycles of denaturation at 94 ^{o}C for 30 sec, annealing at 55 ^{o}C for 30 sec and extension at 72 ^{o}C for 30 sec, and a final elongation step at 72 ^{o}C for 10 min using a Thermo-Hybrid PX2 thermal cycler. Thereafter, a mixture of 1.5 µl of PCR products, 0.5 µl of ROX^{TM} 500 internal size standard and 24 µl Formamide was made, heat denatured at 95 ^{o}C for about 3 minutes. Each sample was prepared and performed as single runs and analyzed on POP-4 polymer using a 36 cm capillary with 55 injection at 15 KV and run for 28 minutes at 15 KV + 9 µA 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 ROX^{TM} 500 using the Gene Mapper ID version 3.2 and exported to Microsoft excel for preparation of input files for statistical analyses.

5.3 Statistical analysis

Statistical analyses were performed using POPGENE version 1.31 software package (Yeh *et al.*, 1999). The following estimations such as observed number of alleles, observed heterozygosity (H$_o$) and expected heterozygosity (H$_e$) per microsatellite marker were calculated using POPGENE software. Genetic distances between populations were calculated by Nei (1978) unbiased distance and similarity measures. 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), which was modified from NEIGHBOUR procedure of PHYLIP version 3.5. Polymorphism Information Content (PIC) values were calculated based on the method described by Botstein *et al.* (1980) using Power Stat version 12 software based on the following formula:

$$PIC = 1 - \left(\sum_{i=1}^{n-1} pi^2\right) - \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} 2 \, pi^2 pj^2$$

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

pi^2 and pj^2 = the population frequencies of the ith and j^{th} allele

5.4 Results and discussion

From an initial 177 blood samples, sufficient DNA from only 65 samples could be extracted. This was due to several factors influencing the quality of blood during transport from Ethiopia to Bloemfontein, South Africa. Although all the microsatellite markers were tested and optimized, only seven markers were applied in the final analysis due to the limited quantity and quality of the DNA available. These constrains limited the envisaged results and therefore only preliminary data are presented on a relatively small sample size.

The seven microsatellites used in this study were found to be highly (100 %) polymorphic. The observed numbers of alleles per chicken lines are presented in Table 5.2. The allele frequencies estimated for all loci and chicken populations is shown in Appendix 5.1. The highest number of alleles per locus (11) was observed for the Ovambo chicken population using MCW 214 locus, while the lowest number of alleles per locus (2) was recorded for Gassay, RIR and Lebowa-Venda chicken populations (MCW 214 and MCW 238) (Table 5.2). Amongst the Ethiopian

chickens, Gassay/Farta chicken population showed the highest number of alleles per locus (10) for the MCW 158 marker. From the Ethiopian chicken population, D/Elias chickens showed the highest mean number of alleles across all loci (6.29), followed by Melo-Hamusit (6.0), Tilili and Gassay (5.57). The average number of alleles across all populations in all loci was 6.04 (Table 5.2). Similar results with regard to the number of alleles were reported by Crooijmans *et al*. (1996); Cheng *et al*. (1995); Ponsuksili *et al*. (1996); Tadelle (2003); Olowofeso *et al.* (2005). Van Marle-Köster & Nel (2000) had also reported a mean number of alleles ranging from 2.3 to 4.3 in five chicken lines representing the "Fowls for Africa" program, which included the Koekoek, New Hampshire Red, Naked-Neck, Lebowa-Venda and Ovambo. In general, microsatellite markers are found to be medium to highly polymorphic when tested in various chicken lines (Vanhala *et al*., 1998; Romanov & Weigend, 2001; Osman *et al*., 2006). Wimmers *et al*. (2000) detected 2 to 11 alleles per locus for the local chickens from Africa, Asia and South America.

Heterozygosity was calculated to determine the genetic variation. However, heterozygosity values are directly influenced by sample sizes (Nei, 1978). In Table 5.3 the expected and observed H values are shown, but it is not recommended at this stage to draw any conclusions. Therefore, all Ethiopian lines (Tilili, Gelila, D/Elias, Melo-Hamusit, Gassay, Guangua and Mecha), local South African lines (Koekoek, Venda and Ovambo) and commercial (RIR and WLH) lines were grouped together and H was recalculated (Table 5.4). In general, the H values for the three groups were found to be high. Vij *et al*. (2006) reported mean observed heterozygosity values ranged from 0.381 to 0.977 for the Punjab brown chicken. The highest (0.97) and lowest heterozygosities (0.04) were observed for Peking ducks using microsatellite loci (Huang *et al*., 2005). Besides, Yu *et al*. (2006) also estimated mean heterozygosity values

of 0.747 to 0.778 for indigenous Chinese chicken populations. The levels of heterozygosity estimated in the present study is much higher than the previous results reported by Vanhala *et al*. (1998); Zhou & Lamont (1999); van Marle-Köster & Nel (2000); Wimmers *et al*. (2000), who reported mean heterozygosity values ranging from 0.29 to 0.67, 0.0 to 0.1, 0.31 to 0.61 and 0.45 to 0.71 using microsatelite markers, respectively. Zhang *et al*. (2002) have reported high heterozygosity values (0.63-0.86) on Chinese indigenous and commercial chicken lines based on microsatellite markers. In general, direct comparison of data from different studies is probably difficult due to the different genetic backgrounds of the chicken populations studied, sample sizes and the different microsatellite markers used.

Table 5.2 Observed number of alleles per chicken populations for the seven microsatellite markers

Populations	Actual sample sizes used for statistical analyses	Locus							Mean	St. dev
		MCW 145	MCW 154	MCW 158	MCW 213	MCW 214	MCW 228	MCW 238		
RIR	15	6	6	3	4	4	7	2	4.57	1.82
Tilili	7	3	6	6	7	4	7	6	5.57	1.52
Gelila	7	5	6	4	6	6	3	5	5.00	1.16
D/Elias	9	8	9	6	5	5	7	4	6.29	1.79
Melo-Hamusit	9	9	7	7	6	3	5	5	6.00	1.92
Gassay/Farta	8	5	6	10	5	2	6	5	5.57	2.37
Guangua	6	6	8	5	6	4	7	5	5.86	1.34
Mecha	4	5	4	5	5	4	8	3	4.86	1.58
Ovambo	9	7	7	9	9	11	8	8	8.43	1.39
Koekoek	8	9	9	7	8	6	6	5	7.14	1.58
Lebowa Venda	7	5	7	9	6	6	4	2	5.57	2.22
WLH	8	9	9	5	6	8	7	9	7.57	1.61
Mean		6.42	7.00	6.33	6.08	5.25	6.25	4.92	6.04	1.69

Table 5.3 Observed and expected heterozygosity values for twelve chicken populations using seven microsatellite markers

Populations	Traits	MCW 145	MCW 154	MCW 158	MCW 213	MCW 214	MCW 228	MCW 238	Mean	St. dev
					Locus					
RIR	H_o*	0.67	0.75	1.00	1.00	0.29	1.00	0.50	0.74	0.28
	H_e**	0.88	0.93	0.83	1.00	0.40	0.85	0.50	0.78	0.22
Tilili	H_o	1.00	0.67	0.80	0.67	1.00	0.60	0.85	0.80	0.17
	H_e	0.83	0.81	0.84	0.90	1.00	0.93	0.81	0.87	0.07
Gelila	H_o	1.00	0.71	1.00	0.83	0.60	1.00	0.67	0.84	0.17
	H_e	0.81	0.83	0.79	0.81	0.89	0.83	0.76	0.82	0.04
D/Elias	H_o	1.00	1.00	0.50	0.62	0.33	0.89	0.83	0.74	0.26
	H_e	0.87	0.88	0.80	0.77	0.54	0.86	0.74	0.79	0.11
Melo-Hamusit	H_o	0.85	0.83	0.71	0.67	0.33	1.00	0.67	0.72	0.21
	H_e	0.92	0.90	0.82	0.81	0.31	0.83	0.72	0.77	0.20
Gassay/Farta	H_o	1.00	0.80	1.00	0.60	0.20	1.00	0.67	0.75	0.30
	H_e	0.87	0.89	0.93	0.89	0.20	0.89	0.84	0.79	0.26
Guangua	H_o	1.00	0.83	0.80	0.80	0.40	1.00	0.67	0.79	0.20
	H_e	0.89	0.93	0.84	0.84	0.64	0.92	0.58	0.81	0.15
Mecha	H_o	1.00	1.00	0.75	1.00	0.75	1.00	1.00	0.93	0.12
	H_e	0.90	0.82	0.79	0.85	0.65	1.00	0.68	0.81	0.12
Ovambo	H_o	0.75	1.00	0.44	0.89	1.00	0.78	0.89	0.82	0.19
	H_e	0.88	0.85	0.90	0.89	0.95	0.83	0.83	0.87	0.04
Koekoek	H_o	0.75	0.71	0.60	1.00	0.83	0.50	0.50	0.70	0.19
	H_e	0.85	0.90	0.93	0.92	0.84	0.80	0.76	0.87	0.07
Lebowa Venda	H_o	0.83	1.00	0.85	1.00	0.50	0.50	0.00	0.67	0.36
	H_e	0.72	0.85	0.92	0.93	0.87	0.79	0.43	0.79	0.18
WLH	H_o	1.00	0.71	0.33	0.37	0.71	0.50	1.00	0.66	0.27
	H_e	0.98	0.90	0.79	0.82	0.91	0.83	0.93	0.88	0.06
Mean	H_o	0.90	0.83	0.73	0.79	0.58	0.81	0.69	0.76	0.23
	H_e	0.87	0.87	0.85	0.87	0.68	0.86	0.72	0.82	0.13

*Observed (H_O) heterozygosity and **expected heterozygosity (H_E) was computed using Levene (1949) based on Popgene computer software

Table 5.4 Observed and expected heterozygosity values for microsatellite markers tested
in three chicken groups

Locus	Chicken populations					
	Ethiopian indigenous		South African indigenous		Commercial	
	H_o	H_e	H_o	H_e	H_o	H_e
MCW 145	0.98	0.86	0.77	0.90	0.82	0.93
MCW 154	0.79	0.90	0.91	0.89	0.73	0.92
MCW 158	0.88	0.83	0.65	0.93	0.50	0.86
MCW 213	0.77	0.82	0.95	0.90	0.50	0.86
MCW 214	0.51	0.68	0.80	0.92	0.54	0.81
MCW 228	0.94	0.90	0.63	0.88	0.73	0.90
MCW 238	0.72	0.75	0.58	0.76	0.89	0.90
Mean	0.80	0.82	0.76	0.88	0.67	0.88
St. dev	0.16	0.08	0.14	0.06	0.16	0.04

5.4.1 Polymorphic Information Content (PIC)

The PIC values were estimated in order to assess how informative (polymorphic) the microsatellite markers are. The PIC values are calculated based on the number and frequency of alleles per marker at a specific locus (Botstein *et al*., 1980; Buchanan *et al*., 1994). The PIC values observed in this study were similar with the PIC values reported for the various chicken populations by Ponsuksili *et al*. (1996); Van Marle- Köster (2001); Tadelle (2003); Olowofeso *et al*. (2005); Vij *et al*. (2006); Yu *et at*. (2006). In the present study the average PIC value for the seven loci tested ranged from 0.58 for MCW 214 to 0.78 for MCW 154 with an average value of 0.71 overall the markers (Table 5.5), when these chicken lines grouped into Ethiopian, South African and commercial the PIC value ranged from 0.55 (MCW 214) to 0.91 (MCW 158) (Table 5.6).

Table 5.5 Polymorphic information content (PIC) for the twelve chicken populations using seven microsatellites

Population	Locus							Mean
	MCW 145	MCW 154	MCW 158	MCW 213	MCW 214	MCW 228	MCW 238	
RIR	0.78	0.79	0.55	0.70	0.35	0.78	0.30	0.61
Tilili	0.55	0.72	0.73	0.80	0.70	0.82	0.72	0.72
Gelila	0.77	0.74	0.63	0.72	0.77	0.55	0.64	0.69
D/Elias	0.80	0.81	0.72	0.68	0.49	0.80	0.62	0.70
Melo-Hamusit	0.84	0.81	0.73	0.72	0.27	0.73	0.62	0.67
Gassay/Farta	0.74	0.77	0.86	0.77	0.16	0.77	0.74	0.69
Guangua	0.77	0.85	0.72	0.73	0.54	0.83	0.50	0.71
Mecha	0.75	0.67	0.65	0.71	0.52	0.86	0.51	0.67
Ovambo	0.81	0.77	0.84	0.83	0.87	0.76	0.76	0.81
Koekoek	0.79	0.82	0.82	0.83	0.75	0.70	0.64	0.76
Lebowa Venda	0.62	0.77	0.84	0.79	0.76	0.63	0.30	0.67
WHL	0.87	0.82	0.68	0.73	0.83	0.74	0.85	0.79
Mean	0.76	0.78	0.73	0.75	0.58	0.75	0.60	0.71

Table 5.6 Polymorphic information content for microsatellite markers tested in three chicken groups

MCW	Chicken populations		
	Ethiopian Indigenous	South African indigenous	Commercial
MCW 145	0.85	0.86	0.87
MCW 154	0.88	0.87	0.87
MCW 158	0.83	0.91	0.80
MCW 213	0.87	0.87	0.79
MCW 214	0.55	0.88	0.70
MCW 228	0.88	0.87	0.88
MCW 238	0.71	0.71	0.84
Mean	0.80	0.85	0.82

5.4.2 Genetic distance

The genetic distances (Tables 5.7 and 5.8) were used to construct a neighbour joining tree (Nei, 1978) in Figures 5.1 and 5.2. Although, the Bootstrapping values are not very high, due to the small sample sizes, there is a tendency for the chicken populations from Northwest Ethiopia to group into two major categories (Gojam and Gonder) with distributions running generally consistent with their geographical locations and marketing places. All the populations collected from Gojam regions were grouped under one major cluster. The Tilili and Gelila populations from this cluster were further divided into different sub clusters. The two populations collected from Gonder region were clustered under the Gonder category, but into separate clusters, which is inline with the phenotypic data and the geographical location. The two South African local chickens (Ovambo and Lebowa-Venda) were clustered in the same group, while one of the local South African native chicken population (Koekoek) was grouped with WLH commercial breed under one major cluster, indicating that the Koekoek was bred from crosses between the Black Australop and the White Leghorn breeds (http:// www.arc. agric.za). Distances were recalculated by grouping these chickens into three groups such as the Ethiopian indigenous,

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local South African and commercial chickens and presented in Table (5.8). This indicates that the commercial chicken breeds (WLH and RIR) clustered with the local South African chickens. This suggests that the Ethiopian indigenous chicken resources are not still highly diluted by exotic breeds and therefore a complete study on their diversity should be undertaken in order to obtain conclusive evidence (Figure 5.2).

Table 5.7 Unbiased measures of genetic identity (above diagonal) and genetic distance (below diagonal) (Nei, 1978) of twelve chicken populations

Population	1	2	3	4	5	6	7	8	9	10	11	12
RIR(1)	***	0.470	0.385	0.404	0.172	0.337	0.373	0.418	0.462	0.486	0.479	0.324
Tilili (2)	0.756	***	0.748	0.770	0.550	0.689	0.758	0.742	0.594	0.419	0.546	0.580
Gelila (3)	0.955	0.290	***	0.778	0.744	0.559	0.828	0.793	0.527	0.408	0.660	0.539
Debre Elias(4)	0.907	0.261	0.251	***	0.752	0.819	0.873	0.925	0.512	0.438	0.670	0.487
Melo-Hamusit(5)	1.758	0.598	0.295	0.285	***	0.844	0.850	0.707	0.350	0.306	0.377	0.301
Gassay/farta(6)	1.087	0.373	0.581	0.199	0.169	***	0.823	0.740	0.450	0.390	0.401	0.375
Guangua (7)	0.986	0.276	0.189	0.135	0.163	0.194	***	0.883	0.480	0.358	0.443	0.448
Mecha(8)	0.872	0.299	0.232	0.078	0.346	0.301	0.124	***	0.601	0.339	0.650	0.448
Ovambo (9)	0.772	0.521	0.641	0.669	1.049	0.799	0.733	0.509	***	0.544	0.673	0.402
Koekoek(10)	0.721	0.871	0.897	0.825	1.183	0.943	1.026	1.083	0.608	***	0.476	0.521
L.Venda(11)	0.736	0.605	0.416	0.400	0.974	0.914	0.814	0.430	0.396	0.742	***	0.339
WHL (12)	1.126	0.545	0.617	0.720	1.200	0.981	0.803	0.803	0.912	0.652	1.083	***

Table 5.8 Unbiased measures of genetic identity (above diagonal) and genetic distance (below diagonal) (Nei, 1978) of three chicken groups

Population*	1	2	3
1	****	0.6286	0.5473
2	0.4643	****	0.6669
3	0.6028	0.4051	****

*-1- Indigenous Ethiopian chickens (Tilili, Gelila, D/Elias, Melo-Hamusit, Gassay, Guangua and Mecha chicken populations)
2- Local South African chicken lines (Koekoek, Lebowa Venda and Ovambo)
3- Commercial chicken breeds (RIR and WLH)

```
    +--------------------------------------------------------------RIR
    !
    !                                          +------------------------Tilili
    !                                          !
    !                                    +--5  +--------------------Gelila
    !                                    !  !  !
    !                                    !  +--4        +------------Debre-Elias
    !                                    !     !      +--1
   11                  +------------------6      +-----2  +------------Mecha
    !                  !                  !              !
    !                  !                  !              +---------------Guangua
    !                  !                  !
    !        +----------9                 !              +----------------Melo-Hamusit
    !        !          !            +--------3
    !        !          !                         +------------------Gassay/Farta
    !        !          !
    +---10             !                 +--------------------------------Ovambo
       !              +---------------7
       !                          +----------------------------------Lebowa Venda
       !
       !                  +-------------------------------------------------Koekoek
     +------------8
                      +--------------------------------------------------White Leghorn
```
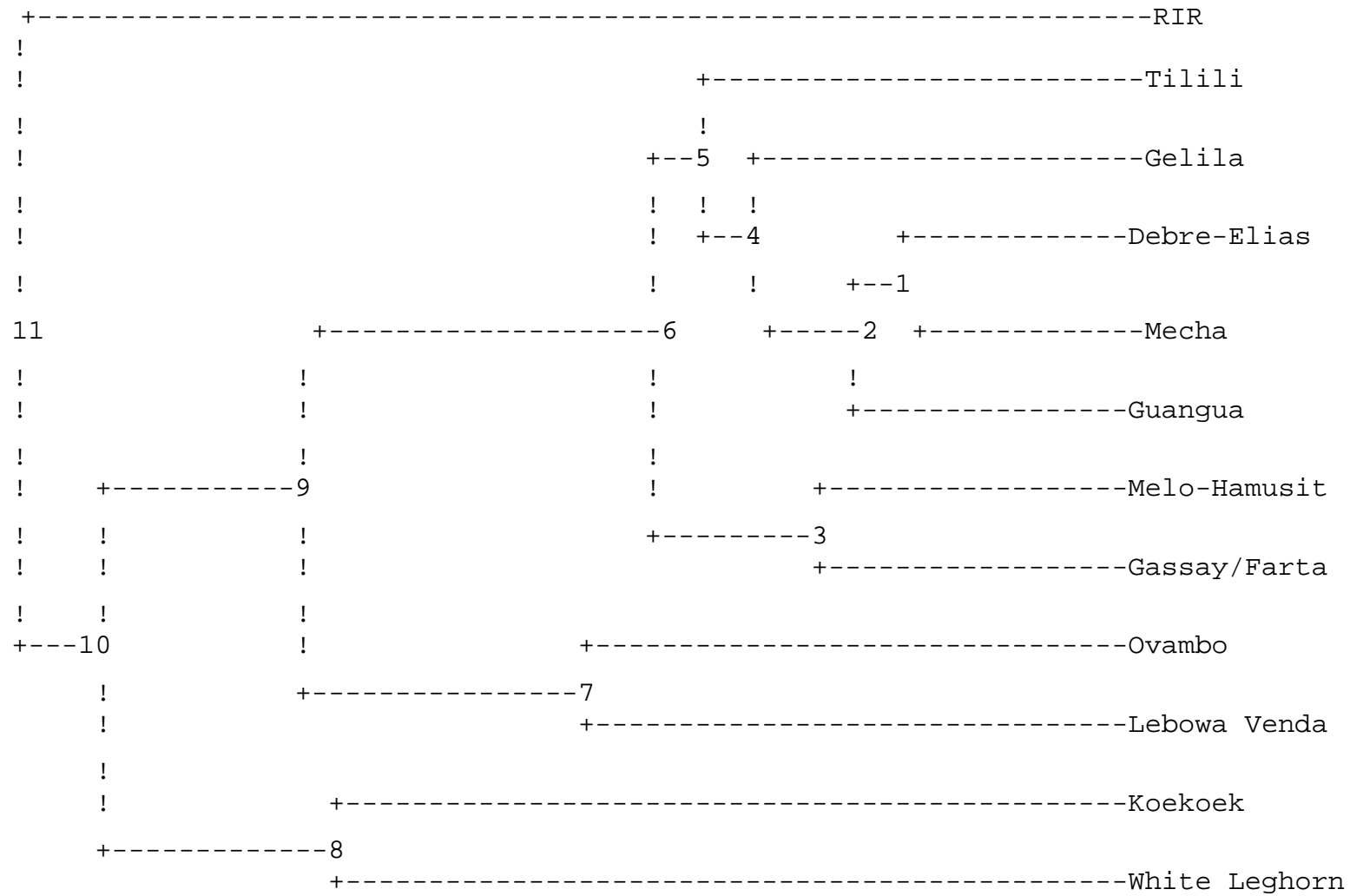
Figure 5.1 Dendrogram of relationships among 12 chicken lines using Nei's (1978) genetic distance and neighbour-joining methods

```
+-----------------------------------------------Ethiopian indigenous chickens
2
!          +---------------------------------------South African indigenous chickens
+---------1
           +---------------------------------------Commercial chicken breeds
```
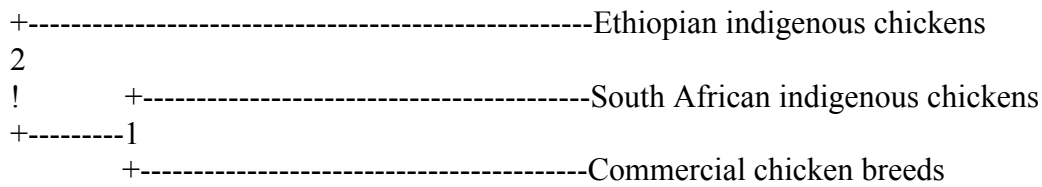
Figure 5.2 Dendrogram of relationships among three chicken groups using Nei (1978) genetic
distance and neighbour-joining methods

5.5 Conclusions

A major limitation of this preliminary study was the poor quality DNA. This let to several
complications as the sample size decreased and not all the microsatellite markers could be
tested. From the results it can be concluded that in the population tested as a group there is a
relatively high genetic variation as indicated by the high heterozgosity values. This also suggests
that the Ethiopian indigenous chicken resources are not still highly diluted by exotic breeds
(WLH and RIR) and therefore a complete study on their diversity should be undertaken in order
to obtain conclusive evidence. It can be confirmed that suitable microsatellite markers are
available for testing diversity for chickens.

These results indicate that further research is needed to catalogue and investigate for the genetic
characterization of Ethiopian indigenous chicken populations in each province. This should
form part of an international or national project to reduce over all investment by one group and
to overcome problems associated with the use of a small number of populations, sample sizes
and microsatellites for genotyping.

CHAPTER 6

GROWTH, EGG PRODUCTION AND REPRODUCTIVE PERFORMANCE OF INDIGENOUS CHICKEN POPULATIONS

6.1 Introduction

Indigenous chickens are well adapted to local environments with low-input low-output systems. There is evidence that chickens differ in their growth performance due to various genotypes (Bilgili *et al.,* 1992), nutrition, management and exposure to pathogens under prevailing conditions (Moran, 1977). For instance, under a village chicken management system, the annual egg production per bird ranged from 20 to 100 eggs, with an average egg weight ranging from 30-50 g (Gueye, 1998). The indigenous chickens in general have not attained their full production potential due to exposure to risks that influence against their survival and productivity under extensive management conditions. Even though, there are efforts to sustain exotic chicken breeds under intensive and village based production systems, documentation on the productivity and reproductive ability of indigenous chickens is not available in Northwest Ethiopia. Therefore, the purpose of this study was to compare and evaluate the growth, egg production, reproductive performances, as well as the rate of survival of indigenous chickens under intensive and extensive management levels.

6.2 Materials and methods

6.2.1 Study area

A performance evaluation trial was conducted at ALRC, Ethiopia, which is located at $11^{o}29'$ North latitude and $37^{o}29'$ East longitude with an elevation of 1730 meters above sea level. It receives an average annual rainfall of 1150 mm with temperatures ranging from 6.5-30 ^{o}C. It is

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about 22 km from Bahir Dar which is the capital city of the ANRS. On-farm evaluation of selected chicken types was also carried out in the rural villages near Bahir Dar and Andassa under a scavenging system.

6.2.2 Evaluation of chickens under intensive management

6.2.2.1 Method of egg collection and production of experimental chickens

The required number of eggs (about 1300 eggs in each group) from the identified seven indigenous chicken populations of four zones was purchased at various village markets across Northwest Ethiopia. The eggs were selected for artificial incubation according to size, shape, breakages and cleanliness, where either very small eggs or very large eggs, broken shells or dirty eggs were discarded. The selected eggs were incubated after fumigation with formalin and potassium permanganate at a ratio of 2:1, respectively. In addition, fertile eggs from the RIR breed kept at ALRC were included as control. These eggs were hatched using the hatchery units of the poultry division at ALRC following standard procedures of the Victoria setter and hatchery machines (www.victoria-srl.com). Chickens resulting from this incubation were studied in respect of growth, egg production as well as their reproductive performance under on-station (intensive) and on-farm (extensive) management systems at ALRC and around Bahir Dar and Andassa areas, respectively.

6.2.2.2 Management of experimental chickens

All the hatched chicks at day-old were vaccinated against Newcastle disease, using HB1 vaccine, while 21 and 60 day-old chickens were treated with LaSota vaccine according to the recommendations of the veterinarian. In addition, at day 45, all the chickens were vaccinated against Fowl typhoid as precaution. Based on the types and number of chicken populations

identified and hatched (Tables 6.2, 6.3 and 6.5), all the chicks were weighed separately, using a sensitive balance, and randomly allocated to the pens, using a Completely Randomized Design (CRD) with three replications. They were placed in deep litter pens, using dry grass as litter material and light was provided according to Bovans RIR breed management guide. Artificial lighting was provided for 24 hours starting from day-old and decreased in light hours at regular speed at weekly intervals till the natural day length was achieved at 20 weeks of age. While at laying phase the birds were given16 hours of day length (Singh, 2000).

All experimental chickens were offered standard starter and finisher rations for a period of 8 weeks, and thereafter, a commercial grower ration (Table 6.1) purchased from the Akaki animal feeds processing plant (Addis Ababa, Ethiopia) was given for an additional period of 14 weeks. Feeds and fresh clean water were provided *ad libitum*. During the growth and layer phases, chickens under intensive system were provided Coccidiostat (Coccimed and Amprolium) for Coccidiosis, Oxytetravit and Oxtetracycline for Infectious coryza and *E. coli* as occurred. In addition, Pantominovit was given in water as vitamin supplement. In general, antibiotics and vitamins were supplied for all chicken flocks under study when disease was also suspected in a pen.

Data on growth characteristics such as body weight at hatching and at 15 day intervals, feed intake on a daily basis, feed conversion ratio (feed: gain) and mortality rate were recorded. In addition, at the age of 22 weeks, six birds (3 female and 3 male) from each chicken population were selected, weighed and slaughtered to measure their carcass characteristics.

At the age of 22 weeks, the required number (Table 6.5) of both male and female chickens from each population was selected and randomly assigned to individual pens using the same

experimental design and experimental housing as used for the growth period. The chickens were given a commercial layer ration (Table 6.1) from 22 to 44 weeks of age and fed *ad libitum*. The body weight of all experimental birds were measured at the age of sexual maturity and then at 15 day intervals using a sensitive balance. Daily feed consumption was recorded by subtracting the feed remains from the feed given. The final body weight gain was calculated by subtracting the body weight of the birds at 22 weeks from the weight obtained at 44 weeks of age. Egg production and mortality rate were recorded daily and as it occurred, respectively. Hen-day egg production (%) was calculated on the basis of total eggs produced per day divided by total number of hens available on that day. Hen-housed egg production (%) was also calculated by using the total eggs produced by each chicken divided by total number of hens housed at the beginning of the experiment. Both hen-day and hen-housed egg production for the whole study period were determined by summing the daily hen-day and hen-housed egg production for each chicken population as stated by North & Bell (1990); Singh & Kumar (1994).

Table 6.1 Ingredients, proportion and nutritional values of the starter, grower and layer diets

Ingredients and nutritional value*	Chicken age group		
	Starter	Grower	Layer
Maize	60	59	45
Noug cake	18	17	26
Wheat bran	12	13	14
Fish meal	7	8	10
Salt	0.5	0.5	0.5
Lime stone	2	2.5	4
Pre-mix	0.5	0.5	0.5
DM	91.9	91.6	91.3
ME (Cal/kg)	2900	2750	2800
CP (%)	20	16	16
Ca (%)	1.2	1.2	4.0
P (%)	0.8	0.6	0.7
CF (%)	4.5	5.0	5.0

*- Source: Akaki Animal feed processing plant and ALRC, Ethiopia

6.2.2.3 Evaluation of egg quality characteristics

Evaluation of the external and internal egg qualities was performed using four eggs randomly purchased from each chicken population across their geographical origin in Northwest Ethiopia. Furthermore, 12 eggs from each chicken ecotypes laid by the hens managed at ALRC was evaluated for both internal and external egg qualities. Egg qualities of the parent stock (eggs purchased from representative village markets) and the first generation were weighed and measured using Egg Multi Tester-5200 (automatic egg quality measurer i.e. EMT-5200) and egg tester machine (TSS QCD instrument), respectively. Eggs were broken and immediately measured for shell weight by including the shell membrane using sensitive balance and the shell thickness was measured by excluding the shell membrane, using a digital micro screw gauge. The egg weight, albumen height, Haugh Unit (HU) and yolk colour of the parent stock were measured by using the EMT-5200 machine, while the yolk colour of the first generation was measured by adjusting the egg yolk with the Roche colour Fan. Moreover, the content of the egg was poured into a plate and measured on a tripod micrometer (calibrated in mm) to determine the albumen height. The albumen and the yolk were carefully separated and weighed separately on a triple beam balance to determine their respective weights. The HU value was taken from the TSS QCD Haugh Unit look-up table.

Eggs purchased from village markets of Northwest Ethiopia (6.2.2.1) and eggs laid by hens kept at ALRC were evaluated for percent fertility and hatchability. Fertility was calculated as the percentage of eggs that were fertile out of total number of eggs set at 18 days of candling. Furthermore, the hatchability (%) of eggs was measured as the total number of chicks obtained from the fertile eggs set and also expressed as total number of chicks obtained from the total number of eggs set (Singh & Kumar, 1994; Singh, 2000).

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6.2.3 Evaluation of chickens under extensive management

Indigenous and RIR chickens reared at ALRC were randomly selected at the age of six weeks (Table 6.6) and distributed to the selected farmers living around Bahir Dar and Andassa areas to evaluate their growth performance under village based chicken management systems, using CRD with three replications. Farmers were selected by consulting the local agricultural extension workers, as well as considering their superior chicken rearing experience. The scavenging period, housing, supplementary feeding and other husbandry practises were synchronized with each of the farmers' chicken management practises. Evaluations of body weight at 15 day intervals using a weighing balance and treatment of diseases as they occurred were carried out. However, after sixteen weeks, the study was discontinued because most of the experimental chicken populations had died (Table 6.6), mainly due to the occurrence of Coccidiosis, Streptococcus, Infectious Coryza and poor management conditions.

6.3 Statistical analyses

Analysis of variance, mean separation and other descriptive statistics was done using SPSS (1996); SAS (2006) software.

6.4 Results and discussion

6.4.1 Growth performance

6.4.1.1 Body weight and body weight gain

The least squares are presented in Tables 6.2, 6.3 and 6.4 for body weight, feed consumption, feed conversion ratio and survival rate from day-old to 4 weeks, from 5 to 8 weeks and day-old to 22 weeks of their growth period for the seven indigenous and RIR chickens. Significant body weight differences within the indigenous and between indigenous and RIR chicken populations

were obtained at hatching. It could be seen that the difference between the day-old chick weight of RIR (35.24 g) and the average (27.30 g) of the local day-old chicks was 7.94 g. The gap narrowed by the fourth week, with the RIR outclassing the local chickens only by 3.72 g. Furthermore, significant differences ($p<0.05$) in live body weight and body weight gain were observed between indigenous and RIR chickens at four weeks of age (Table 6.2). At four weeks of age the Gassay and Mecha indigenous chickens had the lowest and highest mean body weight gain of all the strains with average daily growth rate of 3.30 g and 4.20 g per bird per day in the starter growth phase, respectively.

From 5 to 8 weeks of age, the mean daily body weight gain ranged from 8.80 g in the Gassay chicken population to 11.50 g in the Mecha chicken population (Table 6.3). Similar results were reported by Hoque *et al*. (1975); North (1984); Najib *et al*. (1985); Mwalusanya (1998).

Significant body weight differences within and between the indigenous and RIR chicken populations were observed at the age of sexual maturity, with the highest body weight observed for the control (RIR) group. The average body weight of Tilili, Gelila, D/Elias, Melo-Hamusit, Gassay, Guangua, Mecha and RIR was 1191.25, 1186.29, 1054.38, 1222.43, 1038.42, 1249.10, 1256.80 and 1394.09 g, respectively at the age of 22 weeks (Table 6.4 and Appendix 6.1). These results are comparable with the South African indigenous chickens' average body weight at 11 weeks of age (van Marle-Köster, 2001), indicating the late maturity of the Ethiopian indigenous chickens.

The mean body weight of the indigenous hens at 44 weeks of age ranged between 1266.33 g for Gassay to 1597.00 g for Guangua chickens, while the RIR had a mean body weight of 1588.87 g. The indigenous cocks from Gassay had an average body weight of 1721.17 g and Melo-

Hamusit and RIR cocks had average body weights of 2430.33 g and 2314.00 g , respectively (Table 6.5 and Appendix 6.2). The result of this study is similar to the work reported by Shanawany (1987) who stated that differences in hatching weight may be attributed to differences in the age of the breeder flock, which have been reported to affect the subsequent growth performance (North, 1984). It was also reported that at egg laying stage, the mean body weight of Thai indigenous hens reared under intensive management systems was 1.45 kg (Bansidhi *et al*., 1988; Gongrattananun *et al*., 1992). The body weight growth curve for grower and layer phases (Figure 6.1) showed continued growth in both local and RIR chickens up to 44 weeks of age. These results also indicated the presence of a substantial amount of variation in growth rate among and between the indigenous and RIR chicken populations. The Melo-Hamusit, Guangua and Mecha chicken lines seemed to be the faster growers amongst the seven chicken populations identified in Northwest Ethiopia. Moreover, the growth performances of these lines are comparable to that of the RIR chicken breed, which can be explained by the effects of provision of good commercial feeds, better management, health care and environment.

The growth performance and rate of survival of the seven indigenous and RIR chickens were studied under a village based management system during the age of six to sixteen weeks and the results are presented in Table 6.6 and Appendix 6.5. At the age of six weeks significant (p<0.05) body weight differences were attained among the Gelila, Melo-Hamusit and Mecha lines, while there was no significant (p>0.05) variation in weight among the rest of the lines. At the age of sixteen weeks, mean body weight gain ranged from 65.93 g for Gelila to 190.37 g for RIR chickens (Table 6.6). However, when it is compared with the same chicken lines evaluated under intensive system at the age of eight weeks, the mean body weight gain per bird ranged from 247.10 g to 321.80 g (Table 6.3). The mean body weight gain at the age of twelve weeks

from the on-farm experiment in village based management system (Table 6.6) is comparable with mean body weight gain at eight weeks of age under favourable management conditions (Table 6.3). This indicated that provision of commercial feeds, housing and other related improved chicken management systems played a considerable role to express the genetic potential of the indigenous and exotic chickens in terms of body weight. Under the scavenging system, the non-genetic factors in particular poor nutrition and health care have much larger effects on production parameters than the genetic characteristics of the birds (Sazzad *et al.*, 1988). In this study, both the indigenous and RIR chickens did not adapt well and survived poorly in a village based management system. This was mainly due to the occurrence of Coccidiosis, Streptococcus, Infectious coryza and poor management conditions.

6.4.1.2 Feed intake and feed conversion ratio

Feed consumption from hatching to 4 weeks (Table 6.2) and 5 to 8 weeks (Table 6.3) as well as from hatching to 22 weeks of age (Table 6.4 and Appendix 6.1) show that there were significant variations in feed intake among the local chickens, and between the local and RIR chickens. At the age of four weeks, the lowest (23.40 g) and highest (34.20 g) daily feed intake were recorded for RIR and Debre-Elias chicken lines, respectively. From hatching to 22 weeks of age, the lowest and highest mean daily feed intake were 83.33 g for RIR and 98.46 g for Gelila chicken types (Table 6.4). The mean total feed intake at the end of their growth phase for Tilili, Gelila, D/Elias, Melo-Hamusit, Gassay, Guangua, Mecha and RIR breeds was 13799.45, 15162.19, 13438.12, 13248.86, 13812.77, 13356.38, 14111.89 and 12832.16 g, respectively. There was no significant (p>0.05) difference in total feed consumption for Tilili, D/Elias, Melo-Hamusit and Guangua chicken lines as well as for Gassay, Mecha and RIR chickens. However, a significant

(p<0.05) feed intake variation was recorded for the indigenous Gelila chickens as compare with the rest of the groups (Table 6.4).

Significant differences in feed intake were observed during the egg production phase among the different chicken genotypes with the lowest (143.49 g) and the highest (263.81 g) daily feed intake for Debre-Elias and Mecha chickens, respectively (Table 6.5 and Appendix 6.2). At all stages, there was a higher level of feed consumption by the identified indigenous chicken populations. This can be related to their pronounced selective feeding and feed scratching behaviour, which led to an overestimation of their feed intake during the growth and egg production period. The amount of feed consumed did not follow the same pattern as the bird's body weight (Tables 6.2, 6.3, 6.4 and 6.5). Solomon (2003) found the feed intake from hatching to maturity (defined at 5 months of age) was higher for local (14.46 kg) than for WLH (11.85 kg) chickens.

At the end of the growth period the feed conversion ratio (feed: gain) for the indigenous and RIR chickens varied from 9.50 to 13.87 (Table 6.4) for RIR and Gassay chicken lines, respectively. Solomon (2003) observed FCR during 8 and 12 weeks growth period in local and WLH chickens under intensive managements to be 13.40 and 6.60, and 11.10 and 7.90, respectively.

6.4.1.3 Mortality

Mortality from hatching to end of the growth period, i.e. at sexual maturity, varied substantially for all chickens (Tables 6.2, 6.3, 6.4 and Appendix 6.1). The results of this study showed that the lowest and highest rate of mortality from day-old to 4 weeks, 5 to 8 weeks and day-old to 22 weeks were 7.40 % for RIR and 49.73 % for D/Elias, 1.50 % for D/Elias and 6.20 % for

Gassay, 18.89 % for RIR and 82.41 for % D/Elias, respectively. The Debre-Elias indigenous chickens had significantly higher rate of mortality compared to the rest of the indigenous chickens. This suggests that the rate of survival of local chickens under intensive management condition was very low. In general, the RIR chickens suffered comparatively fewer deaths, and the peak mortality was observed in indigenous chickens from hatching to 22 weeks of age. The reason for the high rate of mortality under confined management was mainly due to Coccidiosis, *E. coli* (pathogenic level), Streptococcus, Infectious coryza and the fact that all chicken lines were also exposed for the first time to a confined environment. Brannang & Pearson (1990) evaluated the productivity of WLH, Yarkon (Y) and local (L) chickens at Assela and recorded a mortality rate of 12 %, 53 % and 93 % for WLH, Y and L chicks, respectively. In the same study, it was also indicated, the rate of mortality at maturity for WLH, Y and L chickens were 11 %, 14 % and 34 %, respectively. Amber (1994) studied the production performance of 22 different genetic combinations of both indigenous and exotic birds under intensive conditions and reported that RIR male x Fayoumi female, Deshi male x Fayoumi female, Fayoumi male x Deshi female and RIR male x Deshi female survived at a rate of 85.4 %, 85.0 %, 80 % and 86.9 %, respectively.

The rate of survival of both indigenous and RIR chickens under an intensive management system was much higher in the layer phase than the growth period. In general, the rate of mortality ranged from 1.00 % to 4.50 % and the major causes of death were cannibalism, egg bound, chronic cases of Streptococcus and Infectious coryza (Table 6.5). However, Choprakarn *et al*. (1998) found a total mortality rate of 28.2 % for Thai indigenous hens kept in individual cages and also 40.1 % in Thai indigenous chickens (TIC) reared on the floor (Gongrattananun *et al*., 1992).

Table 6.6 indicates a very high rate in mortality of indigenous and RIR chickens studied in a village based management system from six weeks to sixteen weeks of age. The occurrence of Coccidiosis, Infectious coryza, Streptococcus and poor management conditions were the major factors that impaired the rate of growth, and rate of survival of these experimental chickens. Indigenous chickens were considered highly adaptable to the local environments and resistant to diseases. However, the result of this study showed that both local and RIR chickens, when kept under traditional chicken management system, were inferior in terms of rate of growth and disease resistance as compared with an intensive management system. Furthermore, during the study period both the local and RIR chickens suffered a high rate of mortality which ranged between 58.4 % for Mecha to 86.90 % for D/Elias chickens. Makarechian *et al.* (1983) stated that both environmental and genetic factors contribute to the rate of mortality. Fessessework (1990) studied the prevalence rates of Coccidiosis in deep-litter intensive management and backyard extensive local chicken production systems in Debre-Zeit and its surroundings and found that to be 50.8 % and 11 %, respectively. Amin *et al.* (1992) reported the mortality percentage of RIR male x Fayoumi female and Deshi to be 50 % and 29 %, respectively in semi-scavenging conditions. Rahman *et al.* (1997) found the rate of mortality of RIR male x Fayoumi female under semi-scavenging conditions to be 18.07 %.

Table 6.2 Comparison of growth performance of indigenous and RIR chickens under intensive management system in Northwest Ethiopia from day-old to 4 weeks of age

Parameters*	Indigenous chicken populations							RIR	St.dev
	Tilili	Gelila	Debre-Elias	Melo-Hamusit	Gassay/Farta	Guangua	Mecha		
Sample size at day-old (no. of chicks)	338	263	404	388	328	395	376	446	
Mean day-old body wt/bird (g)	27.17^d	27.85^c	27.14^d	26.26^e	25.55^f	29.26^b	27.88^c	35.24^a	2.89
Mean 4 weeks body weight /bird (g)	134.00^c	125.70^d	127.00^d	137.50^{bc}	118.60^e	142.10^{ab}	146.00^a	136.70^{bc}	9.16
Mean body weight gain/bird (g)	106.80^{bc}	97.80^{de}	100.00^d	111.30^b	93.10^e	112.90^{ab}	118.10^a	101.50^{cd}	8.62
Mean daily body wt.gain/bird (g)	3.80^{cd}	3.50^{ef}	3.60^e	4.00^{ab}	3.30^f	4.00^{ab}	4.20^a	3.60^{de}	0.31
Total feed intake/bird (g)	697.50^{ab}	942.20^a	956.40^a	733.70^{ab}	806.90^{ab}	695.70^{ab}	719.50^{ab}	654.50^b	161.17
Mean daily feed intake/bird (g)	24.90^{ab}	33.60^a	34.20^a	26.20^{ab}	28.80^{ab}	24.80^{ab}	25.70^{ab}	23.40^b	5.76
FCR (feed: gain)	6.50^a	9.60^b	9.50^b	6.60^a	8.70^{ab}	6.20^a	6.10^a	6.50^a	1.85
Mortality (%)	27.30^{ab}	27.40^{ab}	49.73^a	14.17^b	20.75^{ab}	20.00^b	12.87^b	7.40^b	16.88

[abc] Means with a different superscript in a row are significantly different (p< 0.05), * See Appendix

Table 6.3 Comparison of the growth performance of indigenous and RIR chickens under intensive management system in Northwest Ethiopia between 5 and 8 weeks of age

Parameters*	Indigenous chicken populations							RIR	St. dev
	Tilili	Gelila	Debre-Elias	Melo-Hamusit	Gassay/Farta	Guangua	Mecha		
Sample size (no. of chickens)	233	145	156	240	247	267	317	389	
Mean body wt at 8 weeks gain/bird (g)	284.50[b]	272.10[bc]	254.20[cd]	277.30[bc]	247.10[d]	316.40[a]	321.80[a]	275.20[bcd]	28.30
Mean daily wt gain/bird (g)	10.20[b]	9.70[bcd]	9.10[cd]	9.90[bc]	8.80[d]	11.30[a]	11.50[a]	9.80[bcd]	1.02
Total feed intake/bird (g)	1173.90[ab]	1323.80[a]	1216.00[ab]	1195.10[ab]	1018.40[c]	1137.10[bc]	1063.50[bc]	1004.10[c]	124.31
Mean daily feed intake/bird (g)	42.10[ab]	47.30[a]	43.40[ab]	42.70[ab]	36.40[c]	40.60[bc]	38.00[bc]	35.90[c]	4.44
FCR (feed: gain)	4.10[abc]	4.90[d]	4.80[cd]	4.30[bc]	4.10[abc]	3.60[ab]	3.30[a]	3.60[ab]	0.62
Mortality (%)	5.80[a]	6.00[a]	1.50[a]	2.70[a]	6.20[a]	1.70[a]	5.30[a]	1.80[a]	2.91

[abc] Means with a different superscript in a row are significantly different ($p < 0.05$), * See Appendix

Table 6.4 Comparison of growth performance of indigenous and RIR chickens under intensive management system in Northwest Ethiopia from day-old to 22 weeks of age

Parameters*	Indigenous chicken populations							RIR	St. dev
	Tilili	Gelila	Debre-Elias	Melo-Hamusit	Gassay/Farta	Guangua	Mecha		
Sample size at day-old (no. of chicks)	338	263	404	388	328	395	376	446	
Mean day-old body wt/bird (g)	27.17^d	27.85^c	27.14^d	26.26^e	25.55^f	29.26^b	27.88^c	35.24^a	2.89
Mean final body wt /bird (g)	1191.25^{bc}	1186.29^{bc}	1054.38^c	1222.43^{abc}	1038.42^c	1249.10^{ab}	1256.80^{ab}	1394.09^a	136.05
Mean body wt gain/bird (g)	1163.98^{bc}	1158.45^{bc}	1027.24^c	1196.16^{abc}	1012.87^c	1219.84^{ab}	1228.92^{ab}	1358.85^a	134.15
Mean daily gain/bird (g)	7.56^{bc}	7.52^{bc}	6.67^c	7.77^{abc}	6.58^c	7.92^{ab}	7.98^{ab}	8.82^a	0.87
Total feed intake/bird (g)	13799.45^{ab}	15162.19^a	13438.12^{ab}	13248.86^{ab}	13812.77^{ab}	13356.38^{ab}	14111.89^{ab}	12832.16^b	1129.44
Mean daily feed intake/bird (g)	89.61^{ab}	98.46^a	87.26^{ab}	86.03^{ab}	89.69^{ab}	86.73^{ab}	91.64^{ab}	83.33^b	7.33
FCR (feed: gain)	11.89^{abc}	13.14^{bc}	13.10^{bc}	11.08^{abc}	13.87^c	10.97^{ab}	11.56^{abc}	9.50^a	1.85
Mortality (%) (day-old to 22 weeks)	67.03^{ab}	69.37^{ab}	82.41^a	53.68^{bc}	67.26^{ab}	64.01^{ab}	52.77^{bc}	18.89	12.05

^{abc} Means with a different superscript in a row are significantly different (p< 0.05), * See Appendix

Table 6.5 Growth performance of indigenous and RIR layer chickens in intensive management system during 22 to 44 weeks of age

Variables*		Indigenous chicken populations							RIR
		Tilili	Gelila	Debre-Elias	Melo-Hamusit	Gassay/Farta	Guangua	Mecha	
Mean day-old body wt/bird, (g)		27.17^d	27.85^c	27.14^d	26.26^e	25.55^f	29.26^b	27.88^c	35.24^a
Sample size (no. of chickens)		19.00	19.00	19.00	15.00	15.00	21.00	21.00	38.00
Mean mature body wt. at 22 wks (g)	Female	971.13^{bc}	1057.70^{abc}	845.67^c	900.00^{bc}	871.67^c	1032.40^{bc}	1124.33^{ab}	1259.53^a
	Male	1380.43^{bc}	1416.73^{bc}	1284.33^{bc}	1519.63^{ab}	1165.00^c	1538.00^{ab}	1396.33^{bc}	1762.60^a
Mean mature body wt. at 44 wks (g)	Female	1443.60^a	1288.43^a	1316.67^a	1427.50^a	1266.33^a	1597.00^a	1349.90^a	1588.87^a
	Male	2029.00^{abcd}	1943.10^{bcd}	1801.67^{cd}	2430.33^a	1721.17^d	2246.07^{abc}	2172.17^{abc}	2314.00^{ab}
Mean body wt. gain/bird (g)	Female	472.47	230.73	471.00	527.50	394.66	564.60	225.57	329.34
	Male	648.57	526.37	517.34	910.70	556.17	708.07	775.84	551.40
Total feed intake (kg)		31.30^{cd}	26.90^d	24.50^d	41.60^{ab}	38.40^{abc}	41.90^{ab}	45.10^a	33.30^{bcd}
Mean daily feed intake/bird (g)		182.76^{cd}	157.50^d	143.49^d	243.37^{ab}	224.50^{abc}	245.22^{ab}	263.81^a	194.57^{bcd}
FCR (feed: average egg mass)		10.50	10.60	15.30	15.20	16.20	12.00	15.00	7.10
Mortality (22- 44 weeks), %		1.67^{cd}	2.50^{bc}	2.00^c	3.00^b	1.00^d	2.33^{bc}	4.50^a	2.50^{bc}

[abc.]Means with a different superscript in a row is significantly different ($p< 0.05$), * See Appendix
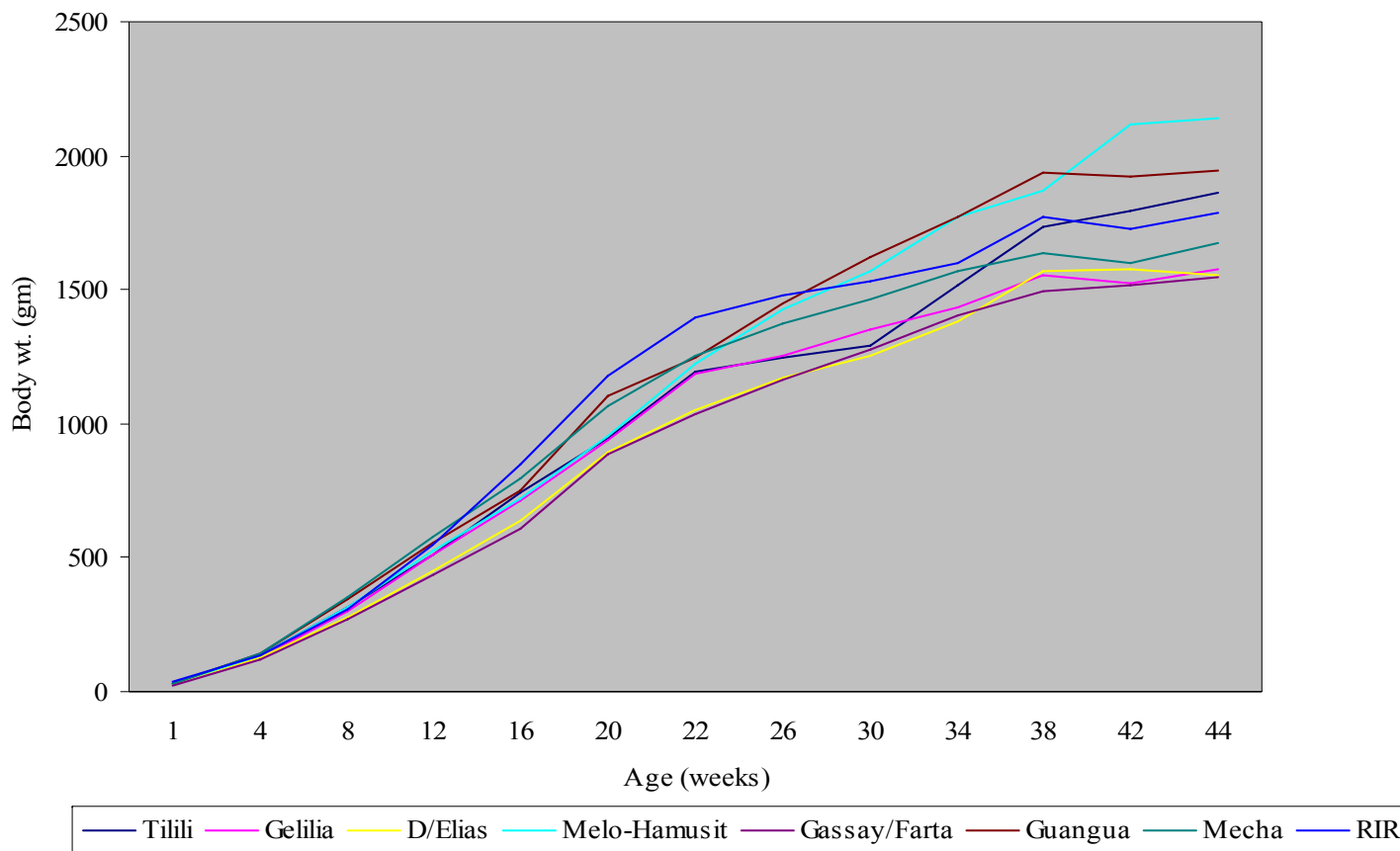
Figure 6.1 Body weight growth curve (day-old to 44 weeks) for indigenous chickens of Northwest Ethiopia under intensive management

Table 6.6 Comparison of the growth performance of indigenous and RIR chickens under a village based management system

in Northwest Ethiopia from 6 to 16 weeks of age

| Traits* | Indigenous chicken populations | | | | | | | RIR |
	Tilili	Gelila	Debre-Elias	Melo-Hamusit	Gassay/Farta	Guangua	Mecha	
Day-old body wt (g)	27.17^d	27.85^c	27.14^d	26.26^e	25.55^f	29.26^b	27.88^c	35.24^a
Sample size (no. of chickens)	81.00	32.00	45.00	96.00	97.00	123.00	143.00	221.00
Mean body wt. per bird at six weeks (g)	199.03^{ab}	170.00^b	193.11^{ab}	211.44^a	176.68^{ab}	201.43^{ab}	211.06^a	198.68^{ab}
" " " eight " "	216.59^a	184.24^a	204.70^a	245.04^a	197.11^a	237.61^a	229.49^a	231.33^a
" " " ten " "	229.19^a	194.52^a	227.75^a	271.33^a	208.74^a	256.33^a	242.26^a	247.98^a
" " " twelve " "	280.16^a	220.22^a	297.75^a	308.01^a	255.46^a	303.67^a	300.39^a	286.74^a
" " " fourteen " "	321.63^a	250.90^a	355.70^a	346.44^a	306.34^a	358.60^a	349.25^a	334.39^a
" " " sixteen " "	338.36^a	235.93^a	349.25^a	356.52^a	307.32^a	342.54^a	369.26^a	389.05^a
Mean body wt gain/bird (g)	139.33^b	65.93^c	156.14^{ab}	145.08^b	130.64^b	141.11^b	158.20^{ab}	190.37^a
Mortality (%) (6 to 16 weeks	67.77^a	70.77^a	86.93^a	64.67^a	74.10^a	79.53^a	58.43^a	70.33^a

[abc] Means with a different superscript in a row are significantly different ($p < 0.05$), * See Appendix

6.4.1.4 Carcass characteristics

The effects of chicken lines and sex on carcass yield at the age of sexual maturity are presented in Tables 6.7, 6.8, Appendix 6.3 and 6.4. A higher live slaughter weight of 1517.00 g and 1735.67 g was attained for Guangua indigenous and RIR commercial male chickens, respectively. The pre-slaughter weight of the local chickens ranged between 1044.67 g for Gelila to 1517.00 g for Guangua, with a dressed weight of 694.33 and 955.33 g, respectively. In addition, a relatively higher dressed weight, 1039.33 g and 955.33 g was recorded for RIR and Guangua male chickens, respectively. The dressing percentage of the indigenous cocks ranged between 53.33 to 66.67 %, while that of the RIR cocks was 60.00 % (Table 6.7). The indigenous hens, Gelila and Mecha, had relatively higher dressing percentage of 67.33 and 73.33 %, respectively (Table 6.8). A report by AACMC (1984) indicated that the local chickens may reach 1.5 kg live weight at 24 weeks of age. Teketel (1986) has also reported carcass weights of 0.56 and 0.87 kg for local birds and Leghorn breed, respectively at 24 weeks of age in Southern Ethiopia. The result of the present study indicated that the local chickens had a higher dressing percentage than the RIR chickens. There are a few reports related with the carcass weights and its percentage mainly due to the fact that the available literatures were carried out on the chemical composition of the various organs of the slaughtered chickens. As a result it was difficult to compare and contrast the present result with other findings.

Table 6.7 Mean values for carcass and organ characteristics of male finisher indigenous and RIR chickens at the age of 22 weeks

Parameters* (g)	Indigenous chicken populations							RIR
	Tilili	Gelila	Debre-Elias	Melo-Hamusit	Gassay/Farta	Guangua	Mecha	
Pre-slaughter weight	1131.33^c	1044.67^c	1141.33^{bc}	1292.00^{bc}	1057.33^c	1517.00^{ab}	1157.33^{bc}	1735.67^a
Thigh & drumstick	197.70^c	222.70^{bc}	213.30^{bc}	261.00^{abc}	194.00^c	311.00^{ab}	234.00^{abc}	334.30^a
Breast & wings	231.60^c	2550^{bc}	283.30^{abc}	324.70^{abc}	245.30^c	363.30^{ab}	289.30^{abc}	382.00^a
Back	104.00^a	108.70^a	102.70^a	117.00^a	104.30^a	147.00^a	107.00^a	156.70^a
Neck	37.00^d	48.70^{bcd}	42.30^{dc}	58.30^{abc}	33.00^d	61.30^{ab}	44.30^{cd}	69.00^a
Heart	6.00^c	6.70^c	6.70^c	7.30^{bc}	7.30^{bc}	9.70^b	7.30^{bc}	14.00^a
Gizzard	27.00^{bc}	28.30^{bc}	27.30^{bc}	30.30^{abc}	24.00^c	37.30^{ab}	30.00^{bc}	42.00^a
Liver	22.00^b	24.30^b	24.70^b	27.70^b	21.00^b	25.70^b	31.70^{ab}	41.30^a
Dressed weight	625.33^c	694.33^{bc}	700.00^{bc}	826.67^{abc}	629.00^c	955.33^{ab}	743.67^{bc}	1039.33^a
Dressing (%)	53.33^a	66.67^a	61.00^a	64.00^a	59.67^a	63.00^a	65.33^a	60.00^a

[abc] Means with a different superscript in a row are significantly different (p< 0.05), * See Appendix

Table 6.8 Mean values for carcass and organ characteristics of female finisher indigenous and RIR chickens at the age of 22 weeks

Parameters* (g)	Indigenous chicken populations							RIR
	Tilili	Gelila	Debre-Elias	Melo-Hamusit	Gassay/Farta	Guangua	Mecha	
Pre-slaughter body wt	873.50[ab]	848.67[ab]	642.00[b]	745.50[b]	749.00[b]	840.33[ab]	794.33[ab]	1263.33[a]
Thigh & drumstick	147.50[ab]	168.00[ab]	114.70[b]	132.50[b]	117.00[b]	147.00[ab]	158.70[ab]	215.30[a]
Breast & wings	210.00[ab]	238.90[ab]	164.00[b]	181.30[ab]	166.30[b]	204.00[ab]	241.00[ab]	314.00[a]
Back	64.50[b]	82.30[ab]	49.70[b]	59.50[b]	60.30[b]	74.30[ab]	76.00[ab]	110.70[a]
Neck	28.00[b]	25.00[b]	21.00[b]	24.00[b]	20.30[b]	29.00[b]	32.70[b]	49.30[a]
Heart	5.50[ab]	5.70[ab]	5.00[ab]	5.50[ab]	4.30[b]	8.00[ab]	4.70[ab]	8.30[a]
Gizzard	32.00[ab]	27.00[ab]	17.00[b]	22.00[ab]	22.70[ab]	22.00[ab]	31.30[ab]	36.30[a]
Liver	26.00[abc]	23.30[abc]	15.70[c]	23.00[abc]	16.70[bc]	33.70[a]	26.00[abc]	33.00[ab]
Dressed weight	513.50[ab]	570.33[ab]	387.00[b]	448.00[b]	407.67[b]	518.00[ab]	570.33[ab]	767.00[a]
Dressing (%)	59.00[a]	67.33[a]	60.00[a]	60.50[a]	56.33[a]	60.67[a]	73.33[a]	60.67[a]

[abc] Means with a different superscript in a row are significantly different (p< 0.05), * See Appendix

6.4.2 Age at point of lay and egg production traits

The data on age at point of lay and egg production traits for the indigenous and RIR chickens are presented in Table 6.9 and Appendix 6.6. Age at point of egg lay ranged between 144 to 168 days and 150 days for the indigenous and RIR chickens reared under favourable conditions, respectively. The finding of this study is in line with the report by Soltan & Ahmed (1990); Sazzad (1992); Ali *et al*. (2003). However, literature reviewed by Mebratu (1997) showed that age at first egg production for local chickens ranged from 166 to 230 days. Similarly, Rahman *et al*. (1997) reported 231 days for RIR male x Fayoumi female chickens to reach sexual maturity.

Egg mass, hen-day (%) and hen-housed (%) egg productions showed significant (p<0.05) variation within the indigenous and between the local and RIR chicken populations. Cumulative egg production for the indigenous chickens ranged from 91.70 to 175.50 eggs per hen per year (Table 6. 9), which is higher than the previous report by Teketel (1986) regarding indigenous chickens in Southern Ethiopia. The local chickens under conventional management systems produced fewer eggs as indicated in Chapter 3 of this study, which happened due to the variation in management, health care and feed types. Sazzad (1986) indicated total egg production of about 64 eggs/hen/year from indigenous birds under intensive management conditions, one reason for this being a pronounced brooding instinct. In Malaysia, Jalaludin (1992) reported 45-60 eggs/hen/year under a conventional system. In Nigeria, 20-30 eggs per hen per year were reported under a scavenging system (Bessei, 1987). North (1984) reported a hen-day egg production of 73 %. In the present study, some of the behaviours observed in the local chickens which contributed to the reduction of the total egg production were broodiness, chicken diseases as well as cannibalism. However, with proper selection and management, it is

likely that the egg production potential of indigenous chickens could be increased significantly (Kumar & Achary, 1980).

In most of the chicken lines, the average egg production on hen-day basis rose gradually from 22 to 25 weeks of age and increased sharply to a peak at about 27 to 28 weeks of age. After that, it tended to decline gradually and then increased sharply at 39 to 40 weeks of age (Figure 6.2). This laying pattern resulted in low egg production in both indigenous and RIR chickens, since it took a relatively long time to reach the peak period and then remained at a peak for only a short time. However, Choprakarn *et al*. (1998) found that egg production of the Thai indigenous chickens had increased gradually from 21 to 45 weeks and increased sharply to a peak at 47 weeks of age.

Table 6.9 Age at first egg and egg production performance of indigenous and RIR chickens from 22 to 44 weeks of age

Variables	Indigenous chicken populations							RIR
	Tilili	Gelila	Debre-Elias	Melo-Hamusit	Gassay/Farta	Guangua	Mecha	
Age at point of lay (days)*	157.33[abc]	160.67[ab]	143.67[c]	168.33[a]	158.67[abc]	155.67[abc]	153.00[bc]	149.67[bc]
Number of egg/hen/day	0.40[ab]	0.39[ab]	0.25[b]	0.42[ab]	0.36[ab]	0.48[a]	0.42[ab]	0.54[a]
Number of eggs/hen/year	147.00[ab]	143.33[ab]	91.70[b]	154.20[ab]	132.40[ab]	175.50[a]	154.70[ab]	197.40[a]
Egg mass /hen/day (g)	17.40[ab]	14.90[ab]	9.40[b]	16.00[ab]	13.90[ab]	20.50[a]	17.70[ab]	27.30[a]
Hen-day (%)	39.99[ab]	39.22[ab]	25.06[c]	42.13[ab]	36.24[bc]	48.04[a]	42.28[ab]	54.04[a]
Hen-housed (%)	29.41[ab]	34.49[ab]	21.51[b]	34.95[ab]	30.72[b]	35.72[ab]	36.47[ab]	50.09[a]

[abc] Means with a different superscript in a row are significantly different (p< 0.05), * No of chickens used please see Table 6.5
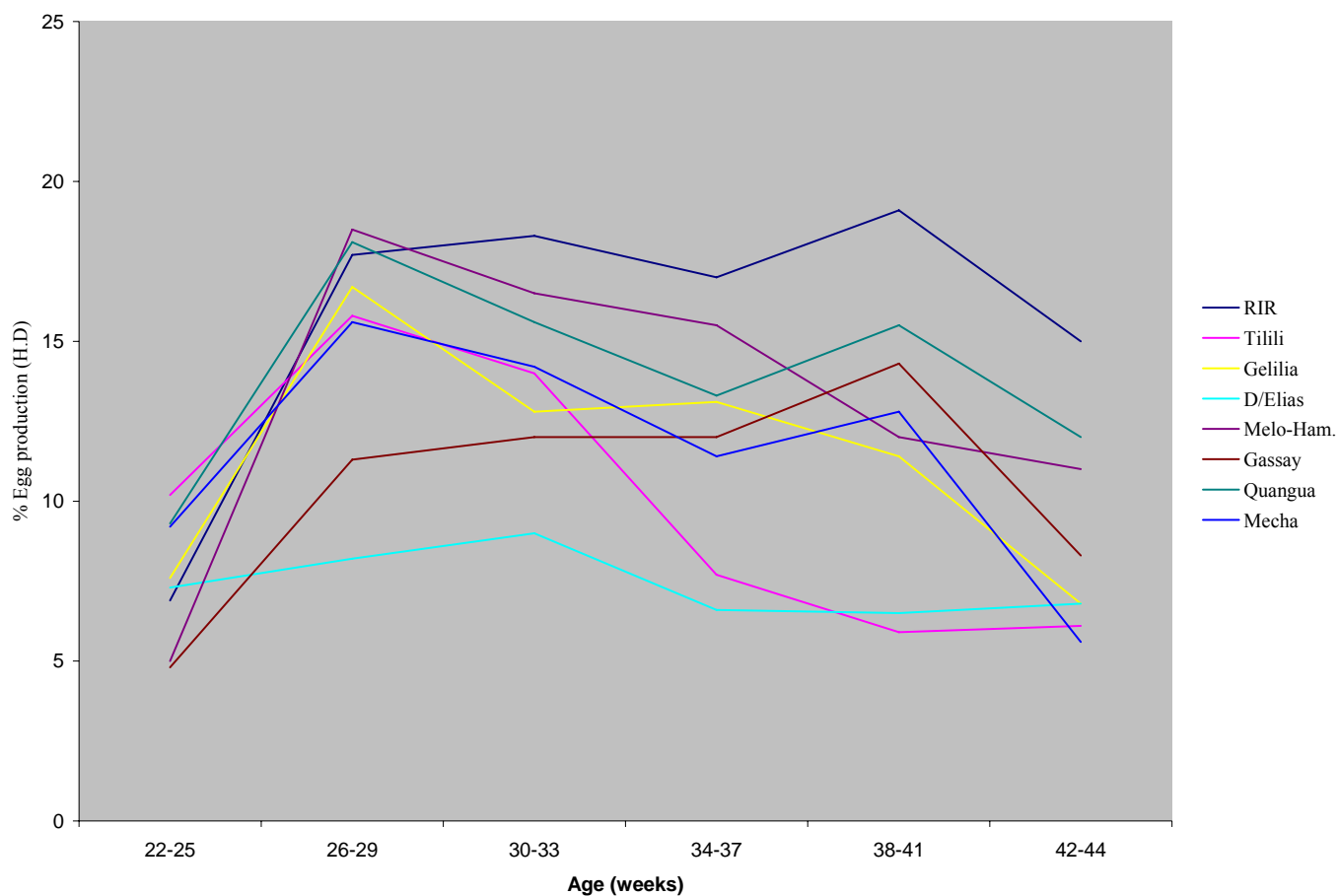
Figure 6.2 Egg production pattern (hen-day basis) of indigenous hens

6.4.2.1 Egg characteristics and composition

The mean values for the external and internal qualities of the eggs collected from indigenous and RIR hens kept under intensive and extensive production systems are presented in Tables 6.10, 6.11, Appendix 6.7 and 6.8, respectively. Under intensive systems, Tilili and RIR hens with average egg weights of 41.75 g and 47.56 g, respectively, laid significantly heavier eggs than the rest of the indigenous hens. The eggs collected from the scavenging hens (parent stock) had an average egg weight ranging from 31.73 g to 45.45 g (Table 6.11). This is an indication of contribution of non-genetic factors towards the variation of egg weight among the indigenous

chickens managed under favourable and conventional systems. The average egg weight of local hens in Eastern (Abebe, 1992) and Southern Ethiopia (Teketel, 1986) was found to be 40 g and 46 g, respectively. Similarly, Lawrence (1998) reported the average egg weight of the free range local Tanzanian chickens, to have ranged from 37.7g to 45g.

Shell thickness for hens managed under confined system ranged from 0.67 mm for Mecha chickens to 0.77 mm for Debre-Elias chickens. The shell thickness of indigenous and RIR chickens showed non-significant (p>0.05) variation. The local chickens under good management had thicker shells, which is an important bio-economic trait during egg storage since it encourages the best use of the nutrients in the egg by the embryo (Sergeyeva, 1986), reduces the chance of bacteria to penetrate inside the egg (Tsarenko, 1988; Fisinin *et al.*, 1990), prevents the egg from dehydration (Tsarenko, 1988; Roque & Soares, 1994) and provides protection from mechanical damage (Sergeyeva, 1986;Tsarenko, 1988). This is in line with the work done by Fayeye *et al.* (2005) on Fulani chickens who found a mean shell thickness of 0.58 mm. Zaman *et al.* (2004) reported an average shell thickness of 0.33 mm for RIR x Fayoumi breeds under semi-scavenging system in Bangladesh.

Chickens grown under intensive systems had a mean egg shell weight ranging from 4.02 to 5.73 g. Among the indigenous chickens, the shell weight of Tilili, Gelila, Guangua, Melo-Hamusit, Gassay and Mecha was slightly higher than that of the Debre-Elias indigenous chickens (Table 6.10). Similarly, the mean value for shell weight was 5.12 g for Fulani chickens (Fayeye *et al.*, 2005), 5.62 g for brown shelled layer, 5.28 g for white shelled layer and 3.66 g for indigenous hens (Ershad, 2005).

The mean albumen height, albumen weight, HU, yolk colour and yolk weight of chickens under intensive management system ranged between 4.23 to 6.96 mm, 17.71 to 28.7 g, 55 to 81 %, 3 to 4 and 10.81 to 13.34 g, respectively (Table 6. 10). Fayeye *et al.* (2005) reported the mean value of albumen height (4.92 mm), albumen weight (20.33 g), HU (73.43 %) and yolk weight (13.03 g) for Fulani chickens. Rashid *et al*. (2004) conducted an on-farm study on Sonali hens, and found an average albumen height ranging from 6.28 to 6.59 mm, albumen weight of 26.9 to 27.3 g, HU of 83.3 to 85.4 %, yolk colour of 8.51 to 8.67 and yolk weight of 13.1 to 13.6 g. In this study, the RIR breed with a mean albumen height of 6.96 mm, differ significantly ($p<0.05$) from the indigenous chickens (Table 6.10). The present result is in agreement with the report of Crawford (1990) who reported that genetic and non-genetic factors such as age of the hen, length of storage and season had played a large role in determining the albumen quality. Albumen quality, which is the most important trait by which to measure egg quality, is determined by its height. Hence, the larger the albumen height, the better the albumen quality would be, which varied between 1.5 mm for low quality eggs and 11.5 mm for extremely good and fresh eggs (TSS, 1980).

The albumen height, HU and yolk colour of scavenging hens ranged from 2.8 to 4.15 mm, 60.35 to 74.70 % and 8.00 to 11.25, respectively for eggs collected from the respective administrative village markets of Northwest Ethiopia (Table 6.11). This is in agreement with the result reported by Rashid *et al.* (2004) who found mean values of 6.37 mm albumen height, 84.1 % HU and 9.03 yolk colour for scavenging Sonali hens in Bangladesh.

The colour of the egg yolk is mainly dependent on the type of ration and the management systems of the chickens. The eggs collected from scavenging birds had a higher yolk colour

count (Table 6.11) because scavenging birds have free access to green plants and other feed sources rich in xanthophylls. However, under intensive management both the indigenous and RIR chickens had lower egg yolk colour count (Table 6.10) since the commercial chicken ration did not contain yellow maize as an ingredient. North (1984) showed that morbidity, fat content of the ration, ingredients of the ration, strain as well as individual variations played a significant role in determining yolk colour of the egg.

The percentage fertile eggs and hatchability percentage of the fertile eggs for chickens managed under intensive conditions ranged from 85.1 to 100 % and 50 to 80.3 %, respectively (Table 6.10). On the other hand, the eggs laid by the scavenging birds had fertility and hatchability percentage ranging from 53.1 to 69.3 and 60.7 to 82.1, respectively (Table 6.11). The variation in rate of fertility of eggs for the confined and scavenging hen can be explained by unbalanced male to female ratio, storage condition and duration of the eggs in addition to the age of the bird, nutrition, disease, management and environmental factors (North & Bell, 1990). Hoque *et al*. (1975) reported fertility of 83 % and hatchability of 52 % for eggs of Deshi/local chickens under scavenging systems.

Table 6. 10 Mean egg characteristics and hatchability of eggs laid by the indigenous and RIR hens under intensive management conditions

Parameters*	Indigenous chicken populations							RIR
	Tilili	Gelila	Debre-Elias	Melo-Hamusit	Gassay/Farta	Guangua	Mecha	
Eggs used to measure egg quality								
Mean egg weight (g)	41.75 ^{b}	35.93^{cd}	34.11^d	34.56^{cd}	36.81^{bc}	38.64^{bc}	39.87^{bc}	47.56^a
Shell weight (g)	4.88^b	4.86^b	4.02^c	4.52^{bc}	4.52^{bc}	4.82^{bc}	4.61^{bc}	5.73^a
Egg shell thickness (mm)	0.69^a	0.73^a	0.77^a	0.71^a	0.68^a	0.72^a	0.670^a	0.69^a
Albumen weight (g)	23.52^b	19.25^{bc}	19.28^{bc}	17.71^c	20.48^{bc}	20.95^{bc}	23.60^b	28.70^a
Albumen height (mm)	4.92^b	4.32^b	4.95^b	4.47^b	4.23^b	4.73^b	4.70^b	6.69^a
Haugh unit (%)	64.67^b	58.33^b	65.00^b	58.33^b	55.00^b	61.67^b	64.67^b	81.00^a
Yolk colour (Roche fan(1-15)	3.00^a	3.00^a	3.33^a	3.67^a	4.00^a	3.33^a	3.67^a	4.00^a
Yolk weight (g)	13.34^a	11.83^{ab}	10.81^b	12.32^{ab}	11.81^{ab}	12.87^a	11.66^{ab}	13.13^a
Eggs used for hatching of chicks								
No. of eggs set	51	67	39	21	31	61	67	67
Mean egg weight (g)	44.60	40.50	41.20	41.40	41.10	46.70	44.60	53.40
Fertile eggs (%)	90.20	95.50	92.30	85.70	100.00	85.10	91.00	94.00
Hatchability on TES (%)	49.00	56.70	46.20	61.90	71.00	62.30	73.10	62.70
Hatchability on FES (%)	54.30	59.40	50.00	72.20	71.00	65.50	80.30	66.70

^{abc} Means with a different superscript in a row are significantly different (p< 0.05), * See Appendix

Table 6.11 Production traits and hatchability of eggs laid by scavenging indigenous and confined RIR chickens in North West Ethiopia

Variables	Indigenous chicken populations							RIR
	Tilili	Gelila	Debre-Elias	Melo-Hamusit	Gassay/Farta	Guangua	Mecha	
Mean egg weight (g)	37.80[cd]	31.93[de]	35.60[ce]	41.88[bc]	31.73[de]	45.45[b]	31.90[de]	56.73[a]
Shell weight (g)	4.75[cd]	4.00[def]	4.25[cf]	5.25[bc]	4.25[cf]	6.00[ab]	4.50[ce]	7.00[a]
Albumen height (mm)	3.65[b]	4.13[b]	2.80[b]	3.80[b]	3.65[b]	4.15[b]	3.28[b]	6.13[a]
Haugh unit (%)	67.48[ab]	74.70[a]	60.35[b]	66.45[ab]	71.20[ab]	67.83[ab]	67.73[ab]	75.28[a]
Yolk colour (EMT-5200)	11.00[a]	9.25[bc]	8.00[cd]	10.00[ab]	11.25[a]	9.75[ab]	10.00[ab]	6.00[d]
Fertile eggs (%) *	56.10	53.10	57.90	57.80	57.10	64.80	69.30	85.90
Hatchability (TES) (%)	34.10	36.40	42.50	44.40	42.10	45.00	56.90	55.10
Hatchability (FES) (%)	60.70	68.50	73.50	76.90	73.70	69.40	82.10	64.20

[abc] Means with a different superscript in a row are significantly different (p< 0.05), * No. of eggs set please see 6.2.2.1

6.5 Conclusions

The performance of indigenous chicken populations in terms of growth, carcass yield, egg production and egg quality was evaluated under intensive management conditions compared with the RIR commercial breed. Significant differences were observed in performance among the indigenous chickens and between the indigenous and RIR commercial breed. This indicates that provision of better management, feed and health care helped the indigenous chickens to express their genetic make-up; hence due emphasis should be given for the improvement of indigenous chickens in the region.

CHAPTER 7

GENERAL CONCLUSIONS AND RECOMMENDATIONS

Indigenous chickens, which account for 99 % of the total poultry population in Ethiopia, according to available statistics (AACMC, 1984; ILCA, 1993) provide major opportunities for increased protein supply and income for smallholders because they require low capital investment, have a short generation interval and a high rate of productivity. They also play a complementary role in relation to other crop-livestock activities. Characterization, utilization and conservation of these poultry genetic resources are highly important for countries like Ethiopia whose economy depend heavily on the agricultural sector.

In Northwest Ethiopia, indigenous chickens are managed under village based traditional systems, and are exposed to both natural and artificial selection, leading to the existence of diverse domestic chickens. However, many of these indigenous chickens are currently affected by the random and extensive introduction of exotic chicken breeds such as RIR and WLH. In addition, the lack of information on the genetic characteristics, performance, utilization of feeds, seasonal outbreak of diseases, conservation and utilization strategies of indigenous chickens remain to be the major bottlenecks towards improving their productivity and reproductive ability.

Hence, the present study was carried out to generate information on village based indigenous chicken utilization, management practices, opportunities and challenges, to identify, characterize and describe the phenotypic variation of indigenous chicken populations. A further objective was the generation of preliminary data on the genetic variation of indigenous chickens' populations using microsatellite markers and to compare and evaluate the growth, egg production,

reproductive performances, as well as the rate of survival of indigenous chickens under intensive and extensive management levels.

Surveys on village-based chicken production systems were carried out to generate information on village based indigenous chicken management systems using both purposive and random sampling methods in four zones of Northwest Ethiopia. Results revealed that almost all indigenous chickens are managed under extensive systems with an average flock size of about seven chickens. Up to, 99 % of the chicken owners provided supplementary feed for chickens mostly once per day. However, the amount of the supplementary feed provided to these chickens is not known and very difficult to determine as they are left to scavenge and will be fed a variety of left over crops that may be available. Chicken diseases are considered the largest threat to traditional poultry production in Northwest Ethiopia with a peak during the rainy season along with predation. Veterinary services are limited and no regular vaccination takes place against the killer diseases such as NCD. Further studies to determine the type, amount and nutrient composition of the supplementary feeds and to quantify the economic importance and coverage of chicken diseases as well as veterinary services need to be carried out.

The survey has also identified the poultry management profile in the region indicating that women and children were more involved in rural chicken poultry management activities than men. Men on the other hand, are mostly involved in crop cultivation, meetings and other off-farm activities. As most of the poultry production is managed by women, focusing on training and education of women will aid not only the improvement of poultry production but also family management, family planning and the overall living standards of the family and the community.

There is an increasing shift towards the intensification of chicken production introducing exotic commercial chicken breeds by the MOA such as RIR and WLH. The emphasis is on the improvement of management systems for these new breeds rather than an understanding of the production potential of village chickens. However, there is a paucity of quantitative data to support the importance of the village indigenous chicken production systems in household and national economies in tropical and sub-tropical countries. Besides, the socio-economic status of the farmers, lack of farming infrastructure and access to farming support services are great hindrance to adopt and finance the cost of the new technology (improved breeds). Hence, an assessment of the indigenous genetic resources is of great importance and could be utilized for the purpose of their conservation, management and to plan breeding strategies so as to utilize these resources in a sustainable way.

Morphological (e.g. plumage colour, head type, etc), phenotypic (growth rate, egg yield, etc) and genetic (number of alleles, observed and expected heterozygosity) based information on the levels and patterns of genetic diversity is valuable for the efficient management of AnRGs and for effective utilization of the genetic resources in the breeding programs. Genetic diversity is also vital to meet the ever-increasing needs of consumers. Analyses of the morphological and phenotypic diversity were undertaken in seven indigenous chicken populations under village and intensive management conditions. The result revealed the presence of wide ranges of morphological and phenotypic variation within and among the indigenous chickens. The results also showed a rich diversity for quantitative and qualitative traits such as diverse plumage colour (Chapter 4), high carcass percentage and early maturing at point of egg lay (Chapter 6) as compared with the results reported in some other countries in the literature. Variations were also observed in traits such as egg size and body weight and other reproductive variables. This

suggests the availability of ample opportunities for genetic improvement through selection and cross breeding of the indigenous chicken genetic resources. In addition, it is important that research and development initiatives in the future should emphasize on the improvement of indigenous chickens through the adoption of improved feed, health care and management systems in order to improve rural livelihoods and to meet the increasing demand for poultry products.

In the present study, microsatellite markers were used in order to assess genetic diversity among indigenous chicken populations of Northwest Ethiopia. The result showed that there is a tendency for the chicken populations from Northwest Ethiopia to group into two major categories (Gojam and Gonder) with distributions running generally consistent with their geographical locations and marketing places. Exotic RIR chicken breed, introduced for the improvement and upgrading of the local chickens displayed higher genetic distance with the Ethiopian indigenous chicken populations. This indicates that these native chicken populations are probably not been severely diluted by the RIR chicken breed distributed through the agricultural extension program or through the regional poultry breeding and multiplication centers. As the present study was carried out only in selected zones of Northwest Ethiopia and the population size (sample size) was a severe limitation for conclusive results further cataloging and genetic characterization of Ethiopian indigenous chicken populations including the present chicken lines as well as in other provinces should be carried out to have a national picture of the genetic diversity of Ethiopian chickens.

ABSTRACT

This study was carried out to generate information on village based indigenous chicken utilization, management practices, opportunities and challenges, to identify, characterize and describe the phenotypic variation of indigenous chicken populations. The study was also aimed to provide preliminary data on the genetic variation of indigenous chicken populations using microsatellite markers and to compare and evaluate the growth, egg production, reproductive performances, as well as the rate of survival of indigenous chickens under intensive and extensive management levels.

Surveys using both purposive and random sampling methods were carried out in four zones of Northwest Ethiopia to describe the village-based poultry production systems and constraints in order to design future improvement and conservation strategies. The result of this study showed that the majority of the respondents were female (74.16 %). This indicated that most of the time the women, whether in male-headed or female-headed households are responsible for chicken rearing, while the men are responsible for crop cultivation and other off-farm activities. About 99% of the respondents gave supplementary feeds to their chickens. Night shelter was provided by almost all farmers in a part of the kitchen (1.36 %) or in the main house (39.07 %), in hand-woven baskets (7.29 %), in bamboo cages (1.51 %) or in a separate shed purpose-made for chickens (50.77 %). The major causes of death of chickens during the study were seasonal outbreaks of Newcastle disease (locally known as "fengele") and predation. It is important to collect and conserve local poultry breeds before they are fully replaced by the so-called improved exotic chicken breeds. As most of the poultry production is managed by women, focusing on training and education of women will aid not only the improvement of poultry production but also

family management, family planning and the overall living standards of the family and the community.

In the phenotypic characterization, a total of three hundred chickens were characterized under field conditions for qualitative and quantitative traits following standard chicken descriptors. Seven distinct indigenous chicken populations from four administrative zones were identified. Large phenotypic variability among chicken populations was observed for plumage colour. About 25.49 %, 22.30 %, and 16.40 % of the chickens have white, grayish and red plumage colours, respectively. The rest showed a considerable heterogeneity regarding plumage colours, like black, multicoloured, black with white tips, reddish brown and white with red stripes. The following characteristics were also displayed: plain heads (51.18 %), yellow shanks (64.42 %), and pea comb (50.72 %). About 97.52 % of the chickens did not have feathers on their legs. Variations were also observed in quantitative characteristics such as shank length, egg size and body weight and other reproductive traits exhibited in an intensive management system.

In the genetic analysis, indigenous chicken populations representing seven different areas of Northwest Ethiopia were studied using microsatellite markers to determine genetic diversity and relatedness. Three South African chicken lines and two commercial chicken (RIR and WLH) breeds were included for control. A high genetic diversity was observed overall loci and populations with a heterozygosity value of 0.76. The largest heterozygosity (0.93) across all markers was observed in the Mecha chicken population, while the smallest heterozygosity across all loci (0.66) was observed in the White Leghorn breed. A higher genetic distance (lower genetic similarity) between the RIR commercial chicken breed and the Ethiopian indigenous chicken populations were observed compared to RIR and South African fowls. This indicates that the Ethiopian indigenous chicken populations have still not been highly diluted by the RIR

commercial chicken breed either through the extension program or through the regional poultry breeding and multiplication institutes. The present result indicated that the clustering of the chicken populations is in accordance with their geographical origin and market places. Microsatellite markers used in this study were found suitable for the measurement of the genetic variation in Ethiopian chicken populations. These results can therefore serve as an initial step to plan the characterization and conservation of indigenous chickens in the Amhara region, Ethiopia.

A study on the performance of indigenous chicken populations in terms of growth, carcass yield, egg production and egg quality was evaluated under intensive management conditions compared with the RIR commercial breed. Significant differences were observed among the indigenous chicken genotypes of Northwest Ethiopia for body weight, feed intake, FCR, mortality percentage at different phases of growth, indicating the phenotypic variations of the different chicken ecotypes. The Mecha chickens had the highest growth rate, followed by Guangua and Melo-Hamusit chickens, indicating that these lines are good for meat production. Analysis of carcass characteristics has shown that most of the male and female finisher grower chickens have a higher dressing percentage than the commercial RIR chicken breed managed under intensive management. Furthermore, data on age at point of lay (days) indicated that indigenous chickens reached the first egg production stage from 144 to 168 days, while the RIR breed started producing eggs at 150 days. In general, the current result indicates that the performance of the indigenous chickens is comparable with the RIR breed under intensive management systems. This indicates that there is a chance for better performance if proper selection and breeding plan are designed for indigenous chickens.

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OPSOMMING

Hierdie studie is onderneem om inligting in te win oor bestuurspraktyke ten opsigte van inheemse hoenderboerdery op die platteland van Ethiopië, om groei, eierproduksie, reproduksieprestasies, sowel as oorlewingstempo van inheemse hoenders onder intensiewe sowel as ekstensiewe vlakke te evalueer, om die fenotipiese variasies van inheemse hoenderpopulasies te tipeer en te beskryf deur standaardprosedures te volg en om die omvang van die genetiese variasie binne en tussen inheemse hoenderpopulasies te beraam deur gebruik te maak van mikrosatellietmerkers.

Opnames wat van beide doelbewuste en toevallige monsteringsmetodes gebruik gemaak het is in vier sones van Noordwes-Ethiopië gedoen om die plattelandse hoenderproduksiestelsels en ‒beperkings te beskryf sodat toekomstige verbeterings‒ en bewaringstrategieë ontwikkel kan word. Die resultate van die studie het getoon dat die meerderheid van die respondente vroulik was (74.16 %). Dit het aangedui dat vrouens, ongeag of daar 'n man of vrou aan die hoof van die huishouding is, gewoonlik verantwoordelik is vir die hoenderboerdery, terwyl die man vir gewasverbouing en ander buite-boerdery-aktiwiteite verantwoordelik is. Ongeveer 99% van die respondente het aanvullende voeding aan hulle hoenders verskaf. Nagskuiling is verskaf in 'n afgeskorte deel van die kombuis (1.36 %) of woonhuis (39.07 %), in handgeweefde mandjies (7.29 %), bamboeshokke (1.50 %) of in 'n aparte konstruksie spesiaal vir hoenders opgerig (50.77 %). Die hoofoorsake van vrektes onder hoenders tydens die duur van die studie was seisoenale uitbreek van Newcastle-siekte (plaaslik bekend as ''fengele'') en roofdiere. Dit is belangrik om plaaslike hoenderlyne te bewaar voordat hulle heeltemal vervang word deur die sogenaamde "verbeterde" eksotiese rasse. Aangesien pluimveeproduksie hoofsaaklik deur vroue behartig word, sal opleiding en opvoeding van vroue nie alleenlik hoenderproduksie bevorder

nie, maar ook gesinsbestuur en ─beplanning en die algemene lewenstandaarde van die gesin en die gemeenskap.

In die fenotipiese tipering is 'n totaal van driehonderd hoenders onder veldtoestande getipeer vir kwalitatiewe en kwantitatiewe eienskappe deur gebruik te maak van standaard hoenderprosedures. Sewe duidelik afgebakende hoenderpopulasies is uit vier administratiewe sones geïdentifiseer. Beduidende fenotipiese variansie t.o.v. kleur van vere is tussen die populasies waargeneem. Ongeveer 25.49 %, 22.30 % en 16.40 % van die hoenders het onderskeidelik wit, gryserige en rooi vere gehad. Die res het taamlike heterogeniteit t.o.v. verekleedkleur getoon, soos swart, veelkleurig, swart met wit aan die veerpunte, rooibruin en wit met rooi strepe. Die volgende kenmerke is ook waargeneem: nie-vlesige koppe (51.18 %), geel bene (54.42 %) en ertjiekamme (50.72 %). Ongeveer 97.52 % van die hoenders het geen vere aan hul bene gehad nie. Variasie ten opsigte van kwantitatiewe kenmerke soos beenlengte, eiergrootte en liggaamsgewig is ook waargeneem, asook ander reproduktiewe kenmerke wat in 'n intensiewe bestuurstelsel waargeneem kan word.

In die genetiese ontleding is inheemse populasies verteenwoordigend van sewe verskillende gebiede in Noordwes-Ethiopië bestudeer deur gebruik te maak van mikrosatellietmerkers om genetiese diversiteit en verwantskap te bepaal. Drie Suid-Afrikaanse hoenderlyne en twee kommersiële hoenderrasse (RIR en WLH) is ingesluit vir vergelykingsdoeleindes. Die Ethiopiese hoenderpopulasie Gassay/Farta het die hoogste getal allele per lokus (10) vir mikrosatellietmerker MCW 158 gehad. Hoë genetiese diversiteit is oor alle loci waargeneem vir alle populasies met heterosigositeitswaarde van 0.76. Die grootste heterosigositeit (0.93) oor alle merkers is in die Meccha-hoenderpopulasie waargeneem, terwyl die kleinste heterosigositeit oor

alle loci (0.66) in die wit Leghornras waargeneem is. Die RIR kommersiële hoenderras het hoër genetiese afstand (laer genetiese ooreenkoms) met die Ethiopiese inheemse hoenderpopulasies getoon as die Suid-Afrikaanse hoenders. Daaruit kan afgelei word dat die Ethiopiese inheemse hoenderpopulasies nog nie beduidend verwater is met die RIR kommersiële ras óf deur die voorligtingsprogram óf die streeksinstitute vir pluimveeteling nie. Van die filogenetiese stamboomresultaat kan afgelei word dat die groepering van die hoenderpopulasies in die huidige studie in ooreenstemming is met die oorsprong en bemarkingstelsels van hierdie inheemse hoenders ─ 'n aanduiding dat die mikrosatellietmerkers wat in hierdie studie gebruik is, geskik was vir die meting van die genetiese biodiversiteit en verwantskap van Ethiopiese hoenderpopulasies. Hierdie resultate kan gevolglik dien as 'n aanloop tot die tipering en bewaring van inheemse hoenders in die Amharastreek van Ethiopië.

Die prestasie van inheemse populasies met betrekking tot groei, karkasopbrengs, eierproduksie en eierkwaliteit is met dié van die RIR kommersiële ras vergelyk. Opvallende verskille tussen die inheemse hoendergenotipes van Noordwes-Ethiopië is waargeneem ten opsigte van liggaamsgewig, voerinname, VOV en mortaliteitspersentasie tydens verskillende groeifases, wat 'n aanduiding is van die genetiese variasies van die verskillende hoender-ekotipes. Die Mechahoenders het die hoogste groeitempo gehad, gevolg deur die Guyanga– en Melo– Hamusithoenders – 'n aanduiding dat hierdie lyne baie geskik is vir vleisproduksie. 'n Ontleding van karkaseienskappe het getoon dat die meeste van die manlike en vroulike afrondingshoenders 'n hoër uitslagpersentasie het as die kommersiële RIR-ras onder intensiewe bestuur. Data ten opsigte van ouderdom met aanvang van lê (dae) het aangetoon dat inheemse hoenders die eerste eierproduksiestadium vanaf 144 tot 168 dae bereik het, terwyl die RIR-ras op 150 dae begin het om eiers te produseer. Oor die algemeen toon die huidige uitslag dat

inheemse hoenders vergelykbaar met die RIR-ras presteer onder intensiewe bestuurstelsels. Dit impliseer die moontlikheid van beter prestasie met dien verstande dat behoorlike seleksie en teelprogramme op inheemse hoenders toegepas word.

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APPENDICES

Appendix 3.1. Checklist

1.General information of the study area

  a..General

- Region----------------------------------
- zone: ----------------------------------
- District: ---------------------------------
- PA/Village:-------------------------------
- Agricultural institutes involving on research-------
- Extension services--------------------------
- Human population density---------------------
- Estimated average family size-----------------
- Occupation------------------------------

Land use patterns

- Arable land _____ha
- Forest land_____ha
- Grazing land_____ha
- Un-utilized land_____ha
- Other types of land_____ha

Availability of infrastracture --------------------------
Mobility

- Transhumance
- Romadism
- Sedentary
- Others, specify

Ethinic groups --
Major religions---
Accessibility of the study areas with other districts ------
Population distribution of male and female --------------

  b.Physical environment----------------------------------

  c. Farm resources---
  d. Source of cash income-------------------------------

2.Flock characteristics ------------------------------------
3.Housing ---
4.Production & productivity potentials
5.Management and feeding------------------------------------
6.Disease occurrence & health management----------------------
8.Role of poultry farming------------------------------------
9.Role of extension system----------------------------------
10.Major constraints: --
11.Potential of poultry farming for development--------------------
12.Research & development interventions for Q.10----------------

Appendix 3.2 Questionnaire for the characterization, identification of poultry types and rural poultry production systems in ANRS, 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   1.1.Male -------------- 1. 2. Female------------- 1.3. Age----------------

2. Major occupation---

3. Educational level of the respondent

      1. Illiterate   2. Read & write   3.1^{st} –4th 4. 5th –8th 5. 9th-12th

5. Religion (%)

      1. Muslim ------------------   2.Orthodox Christian-------------------- 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)

		Purpose		
Type	No. per family	Owned	Consumed	Sold
Cattle				
Small ruminants				
Equines				
Poultry/Chickens				

**11. The extent of exotic chickens (RIR, WLH, Others) distribution in the area

B. Production system/Husbandry practices

12. State the number or members who care of Poultry? (Based on sex age group)

Age group	Male	Female
Under 14 years		
Age between 15 and 30 years		
Age between 31 and 60 years		
Age above 61 years		

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

14. What Chicken types do you raise? --

Chicken types	Age group of the owner		No. of poultry species		No. of chicks	Source of foundation stock	Source of replacement stock
	Male	*Female*	*Male*	*Female*			
Starter (0-4wks)							
Finisher(5-8wks)							
Grower							
Layer/hen							
Breeder							

Foundation of 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 <u>raising, consumption and sale</u> 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?

    1.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	State briefly *FORM* of consumption at different *AGE LEVEL*
Grains		
Vegetation		
Oil seeds		
Concentrated		
Minerals		
Vitamins		
Others by-products, specify		

4. 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

5. 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--

6. 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---------------

7. Do your birds scavenge?   1. Yes   2.No

8. Do you give water to your birds?   1. Yes   2.No (Why?)

9. 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--------------------------

10. If you give water for the chickens, what type of container do you use to supply water---------

11. 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

Chicken types	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
	Hen	Cock						
Starter								
Finisher								
Layer								

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.

Symptoms	Name of diseases	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

Type	Male bird			Female bird			Chicks/Growers	Egg
	Small size	Medium size	Large size	Small size	Medium size	Large size		
Highest price, (Birr/Item)								
1. Christian festivals								
2. Muslim festivals								
3. Traditional festival								
4. Year round								
5. Scarification								

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. Morphometery

1. Age (Months/weeks/days) ---

2. Sex (M/F) 1.Male-----------------------------2.Fimale------------------------

3. Feather characteristics

    a. Body colour

        1. Completly 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. Completly 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--------------

    d. Back colour

        1. Completly 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--------------

4. Shank colour

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

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

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

6. Spur presence (P/A)   1. Present---------------------------------------

                           2. Absent-----------------------------------

7. Spur length (cm) --

8. Shank length (cm) --

9. Shank circumference (cm) ------------------------------

10. Comb type

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

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

11. Comb length (cm) --

12. Wattle length (cm) --

13. Head shape

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

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

15. Ear lobe colour

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

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

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

18. 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 5.1 Allele frequencies estimated for twelve chicken populations using seven microsatellite markers

Allele	Marker	RIR	Tilili	Gelila	D/Elias	M/Hamusit	Gassay	Guangua	Mecha	Ovambo	Koekoek	L.Venda	WLH
150		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
160		0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.10
164		0.00	0.00	0.00	0.13	0.07	0.00	0.00	0.13	0.00	0.00	0.25	0.00
166		0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.13	0.00	0.00	0.00	0.00
170		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
172		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00
176		0.00	0.00	0.07	0.06	0.07	0.10	0.10	0.00	0.00	0.00	0.00	0.10
178		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00
180		0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00
182		0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.06	0.00	0.00
184	MCW 145	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00
186		0.17	0.00	0.00	0.06	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.10
188		0.25	0.00	0.29	0.31	0.21	0.20	0.20	0.25	0.25	0.00	0.50	0.00
190		0.00	0.00	0.00	0.13	0.00	0.00	0.10	0.25	0.06	0.00	0.00	0.00
192		0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
196		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00
198		0.08	0.25	0.07	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
200		0.08	0.50	0.14	0.19	0.07	0.30	0.30	0.25	0.19	0.00	0.00	0.10
202		0.17	0.00	0.21	0.00	0.21	0.00	0.10	0.00	0.00	0.06	0.00	0.00
204		0.25	0.25	0.21	0.00	0.00	0.20	0.20	0.00	0.13	0.38	0.08	0.10
206		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.06	0.00	0.00
208		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.06	0.00	0.00
210		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.06	0.00	0.10
228		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00

152		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
154		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00
156		0.13	0.08	0.00	0.06	0.00	0.00	0.08	0.00	0.25	0.00	0.29	0.00
158		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.07
160		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.07	0.07
162		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00
164		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.07	0.00	0.07
166		0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00
168		0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
170		0.00	0.00	0.21	0.06	0.17	0.00	0.17	0.25	0.00	0.00	0.00	0.00
172		0.25	0.42	0.00	0.11	0.17	0.30	0.08	0.00	0.00	0.00	0.00	0.21
174	MCW 154	0.00	0.08	0.00	0.06	0.25	0.20	0.00	0.00	0.00	0.00	0.00	0.00
176		0.25	0.17	0.36	0.22	0.08	0.00	0.17	0.13	0.13	0.00	0.07	0.00
178		0.13	0.08	0.00	0.11	0.00	0.10	0.17	0.38	0.31	0.00	0.29	0.07
180		0.00	0.00	0.14	0.00	0.00	0.00	0.08	0.00	0.13	0.07	0.07	0.07
182		0.00	0.00	0.14	0.28	0.17	0.00	0.17	0.00	0.00	0.29	0.14	0.29
184		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00
186		0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.06	0.07	0.00	0.07
190		0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
192		0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00
194		0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00
196		0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00
198		0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.07	0.00	0.00
202		0.13	0.00	0.00	0.06	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
210		0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
236		0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

156		0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.07	0.00
158		0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.06	0.20	0.00	0.00
160		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00
162		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
164		0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00
166		0.25	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
168		0.00	0.20	0.38	0.13	0.36	0.19	0.30	0.13	0.11	0.10	0.00	0.00
170		0.00	0.00	0.00	0.06	0.07	0.06	0.00	0.00	0.06	0.00	0.00	0.00
172		0.00	0.00	0.00	0.06	0.07	0.00	0.00	0.13	0.00	0.00	0.07	0.00
174		0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.20	0.00	0.00
176		0.00	0.00	0.13	0.00	0.29	0.06	0.00	0.00	0.17	0.20	0.00	0.25
178	MCW 158	0.00	0.40	0.38	0.38	0.07	0.19	0.30	0.50	0.17	0.10	0.21	0.42
180		0.00	0.00	0.00	0.00	0.07	0.13	0.00	0.00	0.00	0.00	0.21	0.00
182		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00
186		0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
194		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00
196		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00
200		0.00	0.10	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17
202		0.00	0.10	0.00	0.13	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.08
206		0.50	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.06	0.00	0.00	0.00
208		0.25	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.06	0.00	0.00	0.00
216		0.00	0.00	0.00	0.00	0.07	0.00	0.10	0.13	0.00	0.00	0.00	0.00
218		0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.13	0.00	0.00	0.07	0.00
222		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00
224		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00
226		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00

252		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00
260		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00
262		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00
268		0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.13
272		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00
276		0.00	0.08	0.17	0.00	0.08	0.00	0.00	0.13	0.00	0.00	0.00	0.00
286		0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
288	MCW 213	0.25	0.00	0.08	0.00	0.17	0.00	0.10	0.00	0.00	0.08	0.00	0.00
290		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00
294		0.25	0.08	0.08	0.13	0.00	0.00	0.00	0.13	0.11	0.00	0.00	0.00
296		0.00	0.08	0.00	0.06	0.00	0.00	0.00	0.00	0.06	0.00	0.13	0.00
300		0.00	0.08	0.00	0.00	0.00	0.20	0.10	0.13	0.22	0.00	0.13	0.06
302		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.17	0.25	0.06
304		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.13	0.00
306		0.25	0.25	0.17	0.31	0.00	0.20	0.20	0.25	0.06	0.25	0.13	0.31
308		0.00	0.25	0.42	0.38	0.42	0.20	0.40	0.38	0.17	0.08	0.25	0.31
310		0.00	0.00	0.08	0.13	0.17	0.20	0.00	0.00	0.00	0.08	0.00	0.00
312		0.00	0.17	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
314		0.00	0.00	0.00	0.00	0.08	0.20	0.10	0.00	0.00	0.00	0.00	0.13

234		0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
236		0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.07
248		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.19	0.00	0.00	0.00
258		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00
268		0.79	0.00	0.00	0.00	0.00	0.10	0.10	0.00	0.13	0.33	0.00	0.21
270		0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.06	0.08	0.17	0.21
272	**MCW 214**	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.14
274		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.08	0.00
276		0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.25	0.08	0.07
278		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00
282		0.07	0.25	0.20	0.06	0.00	0.00	0.10	0.00	0.00	0.00	0.33	0.00
284		0.00	0.25	0.30	0.67	0.83	0.90	0.60	0.63	0.19	0.17	0.17	0.00
286		0.00	0.00	0.20	0.17	0.00	0.00	0.20	0.00	0.06	0.08	0.17	0.00
288		0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.08	0.00	0.07
290		0.00	0.25	0.10	0.06	0.08	0.00	0.00	0.13	0.00	0.00	0.00	0.07
292		0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00
300		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14

196			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00
208			0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00
214			0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
216			0.31	0.20	0.00	0.22	0.00	0.20	0.17	0.00	0.00	0.08	0.00	0.00
218			0.06	0.10	0.00	0.22	0.00	0.10	0.00	0.13	0.06	0.42	0.38	0.00
220			0.19	0.00	0.00	0.00	0.00	0.00	0.17	0.13	0.06	0.00	0.00	0.00
222			0.19	0.00	0.00	0.06	0.25	0.30	0.17	0.13	0.00	0.08	0.00	0.00
224			0.06	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.17	0.00	0.00	0.00
226			0.13	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.08	0.00	0.00
228		MCW 228	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
230			0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.08	0.00	0.00
232			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.25	0.00	0.00
234			0.06	0.20	0.25	0.22	0.33	0.20	0.17	0.13	0.06	0.00	0.38	0.00
236			0.00	0.10	0.50	0.00	0.17	0.00	0.08	0.13	0.00	0.00	0.13	0.00
238			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00
240			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.17
242			0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42
244			0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.13	0.08
246			0.00	0.10	0.00	0.11	0.17	0.10	0.00	0.00	0.00	0.00	0.00	0.00
248			0.00	0.00	0.00	0.11	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.08
250			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
258			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
262			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00

162		0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.06	0.08	0.00	0.00
180		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00
182		0.00	0.00	0.00	0.00	0.08	0.00	0.08	0.00	0.00	0.00	0.00	0.07
184		0.75	0.36	0.42	0.42	0.08	0.17	0.08	0.50	0.33	0.33	0.75	0.14
186		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.42	0.00	0.21
190		0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
194		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
198	MCW 238	0.00	0.29	0.33	0.33	0.50	0.25	0.67	0.38	0.00	0.00	0.00	0.07
200		0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14
202		0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.07
204		0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00
206		0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00
208		0.00	0.14	0.08	0.00	0.08	0.00	0.00	0.00	0.28	0.08	0.25	0.00
210		0.00	0.00	0.08	0.00	0.25	0.25	0.08	0.00	0.06	0.08	0.00	0.00
212		0.00	0.00	0.00	0.17	0.00	0.25	0.08	0.13	0.00	0.00	0.00	0.14
214		0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
232		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07

Appendix 6.1 Growth performances of indigenous chickens under intensive management system from day-old to 22 weeks of age

Traits	Chicken population	Mean	St. deviation	Minimum	Maximum
Day-old body wt (g)	RIR	35.24	0.36	34.88	35.59
	Tilili	27.17	0.45	26.81	27.68
	Gelilia	27.85	0.14	27.74	28.00
	Debre-Elias	27.14	0.25	26.90	27.40
	Melo-Hamusit	26.26	0.25	26.02	26.51
	Gassay/Farta	25.55	0.29	25.29	25.86
	Guangua	29.26	0.51	28.84	29.83
	Mecha	27.88	0.29	27.71	28.21
	Mean	28.29	2.90	25.29	35.59
Total feed Intake/bird (g)	RIR	12832.16	883.65	12175.38	13836.81
	Tilili	13799.45	1291.61	12986.39	15288.78
	Gelilia	15162.19	623.54	14670.11	15863.41
	Debre-Elias	13438.12	778.81	12691.90	14245.87
	Melo-Hamusit	13248.86	1587.39	11522.67	14645.83
	Gassay/Farta	13812.77	1243.54	12409.51	14778.11
	Guangua	13356.38	880.75	12659.34	14346.24
	Mecha	14111.89	1085.38	13028.27	15199.03
	Mean	13720.23	1129.44	11522.67	15863.41
Mean final body wt/bird (g)	RIR	1394.09	124.96	1285.67	1530.75
	Tilili	1191.25	142.17	1057.83	1340.80
	Gelilia	1186.29	74.46	1132.80	1271.33
	Debre-Elias	1054.38	32.74	1016.71	1076.00
	Melo-Hamusit	1222.43	74.27	1164.83	1306.25
	Gassay/Farta	1038.42	124.42	904.25	1150.00
	Guangua	1249.10	77.09	1175.00	1328.86
	Mecha	1256.80	80.07	1177.43	1337.56
	Mean	1199.09	136.05	904.25	1530.75
Mean daily feed intake/bird (g)	RIR	83.33	5.74	79.06	89.85
	Tilili	89.61	8.39	84.33	99.28
	Gelilia	98.46	4.05	95.26	103.01
	Debre-Elias	87.26	5.06	82.41	92.51
	Melo-Hamusit	86.03	10.31	74.82	95.10
	Gassay/Farta	89.69	8.08	80.58	95.96
	Guangua	86.73	5.72	82.20	93.16
	Mecha	91.64	7.05	84.60	98.70
	Mean	89.09	7.33	74.82	103.01

Mean body wt gain/bird (g)	RIR	1358.85	124.73	1250.41	1495.16
	Tilili	1163.98	141.95	1031.02	1313.47
	Gelilia	1158.45	74.48	1105.06	1243.53
	Debre-Elias	1027.24	32.53	989.81	1048.60
	Melo-Hamusit	1196.16	74.32	1138.32	1279.99
	Gassay/Farta	1012.87	124.28	878.96	1124.50
	Guangua	1219.84	77.25	1145.89	1300.02
	Mecha	1228.92	80.07	1149.72	1309.84
	Mean	1170.79	134.15	878.96	1495.16
Mean daily body wt. gain/ bird (g)	RIR	8.82	0.81	8.12	9.71
	Tilili	7.56	0.92	6.69	8.53
	Gelilia	7.52	0.48	7.18	8.07
	Debre-Elias	6.67	0.21	6.43	6.81
	Melo-Hamusit	7.77	0.48	7.39	8.31
	Gassay/Farta	6.58	0.80	5.71	7.30
	Guangua	7.92	0.50	7.44	8.44
	Mecha	7.98	0.52	7.47	8.51
	Mean	7.60	0.87	5.71	9.71
Feed Conversion ratio (FCR)	RIR	9.50	1.05	8.35	10.40
	Tilili	11.89	0.62	11.44	12.60
	Gelilia	13.14	1.19	11.80	14.08
	Debre-Elias	13.10	1.15	12.16	14.39
	Melo-Hamusit	11.08	1.27	10.12	12.52
	Gassay/Farta	13.87	2.89	11.04	16.81
	Guangua	10.97	0.89	10.05	11.82
	Mecha	11.56	1.64	9.95	13.22
	Mean	11.89	1.84	8.35	16.81

Appendix 6.2 Growth performances of indigenous chickens under intensive management system from 22 to 44 weeks of age

Traits	Chicken population	Mean	Std. deviation	Minimum	Maximum
Mean male mature body wt (g) at 22 weeks	RIR	1762.60	196.57	1556.00	1947.30
	Tilili	1380.43	170.63	1225.00	1563.00
	Gelilia	1416.73	201.37	1211.50	1614.00
	Debre-Elias	1284.33	1.89	1283.00	1286.50
	Melo-Hamusit	1519.63	96.96	1407.70	1577.50
	Gassay/Farta	1165.00	118.99	1087.50	1302.00
	Guangua	1538.00	115.99	1407.30	1628.70
	Mecha	1396.33	165.45	1215.30	1539.70
	Mean	1432.88	210.77	1087.50	1947.30
Mean female mature body wt (g) at 22 weeks	RIR	1259.53	125.09	1183.30	1403.90
	Tilili	971.13	193.23	762.30	1143.60
	Gelilia	1057.70	57.06	992.80	1100.00
	Debre-Elias	845.67	81.57	782.30	937.70
	Melo-Hamusit	900.00	128.27	756.00	1002.00
	Gassay/Farta	871.67	132.85	721.00	972.00
	Guangua	1032.40	62.14	992.50	1104.00
	Mecha	1124.33	126.32	987.50	1236.50
	Mean	1007.80	167.74	721.00	1403.90
Mean male mature body wt (g) at 44 weeks	RIR	2314.00	168.89	2156.00	2492.00
	Tilili	2029.00	287.20	1807.50	2353.50
	Gelilia	1943.10	229.79	1775.30	2205.00
	Debre-Elias	1801.67	126.21	1656.00	1878.50
	Melo-Hamusit	2430.33	218.83	2248.00	2673.00
	Gassay/Farta	1721.17	127.67	1643.00	1868.50
	Guangua	2246.07	232.61	1977.50	2384.00
	Mecha	2172.17	381.77	1758.00	2510.00
	Mean	2082.19	310.04	1643.00	2673.00
Mean female mature body wt (g) at 44 weeks	RIR	1588.87	52.35	1543.00	1645.90
	Tilili	1443.60	68.73	1395.00	1492.20
	Gelilia	1288.43	203.02	1123.00	1515.00
	Debre-Elias	1316.67	139.23	1173.00	1451.00
	Melo-Hamusit	1427.50	102.53	1355.00	1500.00
	Gassay/Farta	1266.33	150.36	1158.00	1438.00
	Guangua	1597.00	142.97	1432.00	1684.00
	Mecha	1349.90	254.68	1145.50	1635.20
	Mean	1407.45	183.17	1123.00	1684.00

Mean daily feed intake (g)	RIR	194.57	15.44	178.33	209.07
	Tilili	182.76	16.63	171.56	201.87
	Gelilia	157.50	16.72	143.24	175.91
	Debre-Elias	143.49	28.36	116.95	173.38
	Melo-Hamusit	243.37	25.31	221.55	271.12
	Gassay/Farta	224.50	10.85	213.89	235.58
	Guangua	245.22	27.35	217.57	272.25
	Mecha	263.81	69.88	202.24	339.76
	Mean	206.90	49.61	116.95	339.76
Mortality (%)	RIR	2.50	0.71	2.00	3.00
	Tilili	1.67	0.58	1.00	2.00
	Gelilia	2.50	0.71	2.00	3.00
	Debre-Elias	2.00	0.00	2.00	2.00
	Melo-Hamusit	3.00	0.00	3.00	3.00
	Gassay/Farta	1.00	0.00	1.00	1.00
	Guangua	2.33	0.58	2.00	3.00
	Mecha	4.50	0.71	4.00	5.00
	Mean	2.33	1.02	1.00	5.00

Appendix 6.3 Mean values for carcass characteristics of male finisher indigenous chickens at the age of 22 weeks

Traits	Chicken population	Mean	Std. deviation	Minimum	Maximum
Pre-slaughter body wt/bird (g)	RIR	1735.67	121.68	1602.00	1840.00
	Tilili	1131.33	221.15	876.00	1262.00
	Gelilia	1044.67	214.97	895.00	1291.00
	Debre-Elias	1141.33	169.22	1022.00	1335.00
	Melo-Hamusit	1292.00	77.16	1244.00	1381.00
	Gassay/Farta	1057.33	132.16	906.00	1150.00
	Guangua	1517.00	288.75	1336.00	1850.00
	Mecha	1157.33	284.44	974.00	1485.00
	Mean	1259.58	288.80	876.00	1850.00
Dressed wt (g)	RIR	1039.33	44.64	991.00	1079.00
	Tilili	625.33	272.78	311.00	800.00
	Gelilia	694.33	123.88	558.00	800.00
	Debre-Elias	700.33	124.44	626.00	844.00
	Melo-Hamusit	826.67	59.65	785.00	895.00
	Gassay/Farta	629.00	79.27	540.00	692.00
	Guangua	955.33	209.12	810.00	1195.00
	Mecha	743.67	132.91	601.00	864.00
	Mean	776.75	191.38	311.00	1195.00
Dressing (%)	RIR	60.00	0.03	57.00	62.00
	Tilili	53.33	0.15	36.00	63.00
	Gelilia	66.67	0.08	62.00	76.00
	Debre-Elias	61.00	0.02	59.00	63.00
	Melo-Hamusit	64.00	0.01	63.00	65.00
	Gassay/Farta	59.67	0.01	59.00	60.00
	Guangua	63.00	0.02	61.00	65.00
	Mecha	65.33	0.09	58.00	76.00
	Mean	61.63	0.07	36.00	76.00

Appendix 6.4 Mean values for carcass characteristics of female finisher indigenous chickens at the age of 22 weeks

Traits	Chicken population	Mean	Std. deviation	Minimum	Maximum
Pre-slaughter body wt/bird (g)	RIR	1263.33	183.23	1075.00	1441.00
	Tilili	873.50	499.92	520.00	1227.00
	Gelilia	848.67	188.41	680.00	1052.00
	Debre-Elias	642.00	229.68	430.00	886.00
	Melo-Hamusit	745.50	178.90	619.00	872.00
	Gassay/Farta	749.00	243.67	596.00	1030.00
	Guangua	840.33	238.72	613.00	1089.00
	Mecha	794.33	93.50	701.00	888.00
	Mean	847.77	265.58	430.00	1441.00
Dressed wt (g)	RIR	767.00	111.10	648.00	868.00
	Tilili	513.50	293.45	306.00	721.00
	Gelilia	570.33	131.93	418.00	648.00
	Debre-Elias	387.00	142.45	255.00	538.00
	Melo-Hamusit	448.00	84.85	388.00	508.00
	Gassay/Farta	407.67	65.03	357.00	481.00
	Guangua	518.00	180.20	351.00	709.00
	Mecha	570.33	72.57	508.00	650.00
	Mean	526.55	165.62	255.00	868.00
Dressing (%)	RIR	60.67	0.01	60.00	62.00
	Tilili	59.00	0.00	59.00	59.00
	Gelilia	67.33	0.10	61.00	79.00
	Debre-Elias	60.00	0.01	59.00	61.00
	Melo-Hamusit	60.50	0.04	58.00	63.00
	Gassay/Farta	56.33	0.08	47.00	62.00
	Guangua	60.67	0.04	57.00	65.00
	Mecha	73.33	0.18	57.00	93.00
	Mean	62.45	0.09	47.00	93.00

Appendix 6.5 Growth performance of indigenous chickens under village based management system during 6 weeks to 16 weeks of age

Traits	Chicken population	Mean	Std. deviation	Minimum	Maximum
Mean body wt (6 wks) / bird (g)	RIR	198.68	10.50	186.93	207.14
	Tilili	199.03	19.27	176.79	210.75
	Gelilia	170.00	25.41	151.63	199.00
	Debre-Elias	193.11	23.74	174.67	219.90
	Melo-Hamusit	211.44	19.97	192.09	231.97
	Gassay/Farta	178.68	7.70	170.08	184.93
	Guangua	201.43	9.88	190.21	208.83
	Mecha	211.06	7.91	206.00	220.18
	Mean	195.43	19.89	151.63	231.97
Mean body wt (8 wks) / bird (g)	RIR	231.33	42.97	188.27	274.21
	Tilili	216.59	15.24	199.31	228.13
	Gelilia	184.24	22.07	158.75	197.13
	Debre-Elias	204.70	38.20	165.53	241.85
	Melo-Hamusit	245.04	33.88	222.42	284.00
	Gassay/Farta	197.11	34.87	162.42	232.15
	Guangua	237.61	48.18	182.51	271.85
	Mecha	229.49	32.43	197.66	262.48
	Mean	218.26	35.55	158.75	284.00
Mean body wt (10 wks) / bird (g)	RIR	247.98	86.99	187.78	347.71
	Tilili	229.19	34.17	208.20	268.62
	Gelilia	194.52	7.00	186.57	199.75
	Debre-Elias	227.75	64.90	170.50	298.25
	Melo-Hamusit	271.33	71.64	213.84	351.58
	Gassay/Farta	208.74	37.46	165.50	231.19
	Guangua	256.33	79.25	187.57	343.00
	Mecha	242.26	38.90	199.96	276.51
	Mean	234.76	54.32	165.50	351.58
Mean body wt (12 wks) / bird (g)	RIR	286.74	89.12	204.20	381.23
	Tilili	280.16	53.42	222.75	328.41
	Gelilia	220.22	15.35	202.50	229.40
	Debre-Elias	297.75	97.28	188.50	375.00
	Melo-Hamusit	308.01	54.13	268.35	369.67
	Gassay/Farta	255.46	67.93	181.60	315.25
	Guangua	303.67	78.85	213.06	356.68
	Mecha	300.39	67.61	222.62	345.16
	Mean	281.55	64.77	181.60	381.23

Mean body wt (14 wks) / bird (g)	RIR	334.39	92.18	246.08	430.00
	Tilili	321.63	60.50	252.55	365.20
	Gelilia	250.90	19.27	233.00	271.29
	Debre-Elias	355.70	160.08	183.50	500.00
	Melo-Hamusit	346.44	32.97	315.32	381.00
	Gassay/Farta	306.34	100.56	208.40	409.33
	Guangua	358.60	77.01	271.55	417.88
	Mecha	349.25	85.67	250.50	403.59
	Mean	327.91	81.35	183.50	500.00
Mean body wt (16 wks)/bird (g)	RIR	389.05	91.74	317.75	492.55
	Tilili	338.36	64.45	270.75	399.11
	Gelilia	235.93	50.45	200.25	271.60
	Debre-Elias	349.25	168.63	177.00	514.00
	Melo-Hamusit	356.52	11.31	345.07	367.69
	Gassay/Farta	307.32	90.32	218.00	398.60
	Guangua	342.54	37.79	299.00	366.90
	Mecha	369.26	78.67	284.59	440.10
	Mean	340.38	83.15	177.00	514.00
Mortality (%)	RIR	70.33	11.86	58.70	82.40
	Tilili	67.77	16.38	53.60	85.70
	Gelilia	70.77	31.56	37.30	100.00
	Debre-Elias	86.93	9.38	76.40	94.40
	Melo-Hamusit	64.67	18.25	53.10	85.70
	Gassay/Farta	74.10	10.10	63.30	83.30
	Guangua	79.53	4.55	75.00	84.10
	Mecha	58.43	21.08	34.10	71.20
	Mean	71.57	16.70	34.10	100.00

Appendix 6.6 Egg production performance of indigenous chickens during the layer phase
(22 to 44 weeks of age)

Traits	Chicken population	Mean	Std. deviation	Minimum	Maximum
Hen-day (%)	RIR	54.04	8.74	47.82	64.03
	Tilili	39.99	12.51	25.61	48.39
	Gelilia	39.22	6.85	32.92	46.51
	Debre-Elias	25.06	4.77	20.82	30.23
	Melo-Hamusit	42.13	6.22	36.55	48.84
	Gassay/Farta	36.24	17.81	19.90	55.23
	Guangua	48.04	9.27	40.00	58.18
	Mecha	42.28	3.40	38.80	45.59
	Mean	40.88	11.46	19.90	64.03
Hen-housed (%)	RIR	50.09	12.09	42.57	64.03
	Tilili	29.41	12.33	21.37	43.60
	Gelilia	34.49	14.27	18.72	46.51
	Debre-Elias	21.51	8.72	12.79	30.23
	Melo-Hamusit	34.95	12.36	25.19	48.84
	Gassay/Farta	30.72	22.30	11.63	55.23
	Guangua	35.72	7.99	26.74	42.05
	Mecha	36.47	10.94	23.84	43.12
	Mean	34.17	13.50	11.63	64.03
Age at point of lay (days)	RIR	149.67	4.62	147.00	155.00
	Tilili	157.33	7.64	149.00	164.00
	Gelilia	160.67	8.02	153.00	169.00
	Debre-Elias	143.67	1.15	143.00	145.00
	Melo-Hamusit	168.33	12.10	159.00	182.00
	Gassay/Farta	158.67	11.02	146.00	166.00
	Guangua	155.67	7.37	150.00	164.00
	Mecha	153.00	5.00	148.00	158.00
	Mean	155.88	9.64	143.00	182.00
Mean number of eggs/hen/day	RIR	0.54	0.09	0.48	0.64
	Tilili	0.40	0.12	0.26	0.48
	Gelilia	0.39	0.07	0.33	0.47
	Debre-Elias	0.25	0.05	0.21	0.30
	Melo-Hamusit	0.42	0.06	0.37	0.49
	Gassay/Farta	0.36	0.18	0.20	0.55
	Guangua	0.48	0.09	0.40	0.58
	Mecha	0.42	0.04	0.39	0.46
	Mean	0.41	0.11	0.20	0.64

Appendix 6.7 Egg qualities of eggs laid by the indigenous hens under intensive management conditions

Traits	Chicken population	Mean	Std. deviation	Minimum	Maximum
Mean egg wt. (g)	RIR	47.56	2.68	44.47	49.20
	Tilili	41.75	2.20	40.27	44.27
	Gelilia	35.93	1.66	34.10	37.35
	Debre-Elias	34.11	0.81	33.47	35.02
	Melo-Hamusit	34.56	3.64	31.17	38.40
	Gassay/Farta	36.81	2.84	34.25	39.87
	Guangua	38.64	4.08	34.37	42.50
	Mecha	39.87	3.89	36.68	44.20
	Mean	38.65	4.90	31.17	49.20
Mean shell wt (g)	RIR	5.73	0.22	5.52	5.95
	Tilili	4.88	0.28	4.60	5.15
	Gelilia	4.86	0.23	4.70	5.12
	Debre-Elias	4.02	0.13	3.90	4.15
	Melo-Hamusit	4.52	0.53	3.95	5.00
	Gassay/Farta	4.52	0.76	3.68	5.17
	Guangua	4.82	0.40	4.37	5.13
	Mecha	4.61	0.52	4.15	5.17
	Mean	4.75	0.59	3.68	5.95
Albumen height (mm)	RIR	6.96	1.28	5.62	8.17
	Tilili	4.92	0.84	4.00	5.65
	Gelilia	4.32	0.39	4.00	4.75
	Debre-Elias	4.95	0.48	4.62	5.50
	Melo-Hamusit	4.47	0.39	4.15	4.90
	Gassay/Farta	4.23	0.37	3.80	4.50
	Guangua	4.73	0.79	3.83	5.27
	Mecha	4.70	0.88	3.77	5.52
	Mean	4.91	1.04	3.77	8.17
Haugh Unit (%)	RIR	81.00	7.00	74.00	88.00
	Tilili	64.67	9.50	55.00	74.00
	Gelilia	58.33	5.77	55.00	65.00
	Debre-Elias	65.00	0.00	65.00	65.00
	Melo-Hamusit	58.33	5.77	55.00	65.00
	Gassay/Farta	55.00	0.00	55.00	55.00
	Guangua	61.67	5.77	55.00	65.00
	Mecha	64.67	9.50	55.00	74.00
	Mean	63.58	9.28	55.00	88.00

Yolk colour (Roche fan ,1-15)	RIR	4.00	0.00	4.00	4.00
	Tilili	3.00	1.00	2.00	4.00
	Gelilia	3.00	0.00	3.00	3.00
	Debre-Elias	3.33	0.58	3.00	4.00
	Melo-Hamusit	3.67	0.58	3.00	4.00
	Gassay/Farta	4.00	0.00	4.00	4.00
	Guangua	3.33	0.58	3.00	4.00
	Mecha	3.67	0.58	3.00	4.00
	Mean	3.50	0.59	2.00	4.00
Yolk wt. (g)	RIR	13.13	0.80	12.57	14.05
	Tilili	13.34	0.70	12.60	14.00
	Gelilia	11.83	0.43	11.50	12.32
	Debre-Elias	10.81	0.74	10.05	11.52
	Melo-Hamusit	12.32	1.43	10.85	13.70
	Gassay/Farta	11.81	1.22	10.57	13.00
	Guangua	12.87	0.83	12.05	13.70
	Mecha	11.66	0.97	10.60	12.52
	Mean	12.22	1.13	10.05	14.05
Albumen wt. (g)	RIR	28.70	3.30	24.90	30.73
	Tilili	23.52	2.16	21.37	25.69
	Gelilia	19.25	1.36	17.68	20.15
	Debre-Elias	19.28	0.40	18.83	19.60
	Melo-Hamusit	17.71	1.76	16.37	19.70
	Gassay/Farta	20.48	1.07	19.73	21.70
	Guangua	20.95	3.41	17.13	23.67
	Mecha	23.60	3.65	20.31	27.53
	Mean	21.69	3.91	16.37	30.73

Appendix 6.8 Egg qualities of eggs laid by scavenging indigenous hens in Northwest Ethiopia

Traits	Chicken population	Mean	Std.deviation	Minimum	Maximum
Mean egg wt. (g)	RIR	56.73	8.46	46.20	66.50
	Tilili	37.80	2.27	35.30	40.80
	Gelilia	31.93	0.61	31.30	32.70
	Debre-Elias	35.60	2.64	32.90	39.00
	Melo-Hamusit	41.88	7.88	34.20	52.90
	Gassay/Farta	31.73	0.94	30.80	33.00
	Guangua	45.45	5.17	39.30	51.20
	Mecha	31.90	0.42	31.50	32.40
	Mean	39.13	9.23	30.80	66.50
Shell wt. (g)	RIR	7.00	0.00	7.00	7.00
	Tilili	4.75	0.50	4.00	5.00
	Gelilia	4.00	0.82	3.00	5.00
	Debre-Elias	4.25	0.50	4.00	5.00
	Melo-Hamusit	5.25	1.26	4.00	7.00
	Gassay/Farta	4.25	0.50	4.00	5.00
	Guangua	6.00	0.82	5.00	7.00
	Mecha	4.50	1.00	4.00	6.00
	Mean	5.00	1.19	3.00	7.00
Albumen height (mm)	RIR	6.13	2.74	2.60	9.30
	Tilili	3.65	0.73	2.90	4.60
	Gelilia	4.13	0.75	3.50	5.20
	Debre-Elias	2.80	0.43	2.20	3.20
	Melo-Hamusit	3.80	0.37	3.40	4.20
	Gassay/Farta	3.65	0.48	3.10	4.10
	Guangua	4.15	0.66	3.30	4.80
	Mecha	3.28	0.52	2.50	3.60
	Mean	3.95	1.35	2.20	9.30
Yolk colour (EMT-5200)	RIR	6.00	1.15	5.00	7.00
	Tilili	11.00	0.82	10.00	12.00
	Gelilia	9.25	1.50	8.00	11.00
	Debre-Elias	8.00	0.82	7.00	9.00
	Melo-Hamusit	10.00	1.63	8.00	12.00
	Gassay/Farta	11.25	0.96	10.00	12.00
	Guangua	9.75	0.50	9.00	10.00
	Mecha	10.00	1.41	8.00	11.00
	Mean	9.41	1.92	5.00	12.00

Haugh Unit (%)	RIR	75.28	22.35	43.30	94.80
	Tilili	67.48	6.02	61.90	75.80
	Gelilia	74.70	5.73	69.60	82.80
	Debre-Elias	60.35	6.59	50.50	64.30
	Melo-Hamusit	66.45	7.33	56.40	72.60
	Gassay/Farta	71.20	3.93	66.60	74.90
	Guangua	67.83	8.25	55.80	74.50
	Mecha	67.73	4.80	60.60	71.10
	Mean	68.88	9.79	43.30	94.80

LIST OF PUBLICATIONS

1. Halima Hassen, F W C Neser & Tadelle Dessie. 2006 (a). Growth performance of indigenous & RIR chickens in Northwest Ethiopia. *Proceedings* of the 41st South African Society of Animal Science congress, April 3-6 2006, Bloemfontein, South Africa.

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4. Halima Hassen, F W C Neser, E Van Marle-Köster & A. De Kock. 2007 (b). Phenotypic variation of native chicken populations in Northwest Ethiopia. (Tropical Animal Health and Production Journal, In press).

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6. Halima Hassen, F W C Neser, A De Kock & E van Marle-Köster. Growth rate, feed utilization and rate of survival of indigenous and RIR chickens in Northwest Ethiopia. (South African Journal of Animal Science, Submitted).

7. Halima Hassen, F W C Neser, A De Kock & E van Marle-Köster. Phenotypic and genetic variation of native chicken populations in Northwest Ethiopia. (World Poultry Science Congress 2008, Submitted).

8. Halima Hassen, F W C Neser, A De Kock & E van Marle-Köster. Characterization of village chicken production systems and their marketing in Northwest Ethiopia. (World Animal Production Congress 2008, Submitted).

LIST OF ABBREVIATIONS

%	Percent
/	Per
µl	Microliter
AACMC	Australian Agricultural Consulting and Management Company
ABI	Applied Biosystem Institute
AFLP	Amplified Fragment Length Polymorphism
ALRC	Andassa Livestock Research Center
AnGRs	Animal Genetic Resources
ANRS	Amhara National Regional State
ARARI	Amhara Regional Agricultural Research Institute
EARO	Ethiopian Agricultural Research Organization
cm	Centimeter
CRD	Complete Randomized Design
CSA	Central Statistical Authority
D/Elias	Debre- Elias
Da	Chord distance
DNA	Deoxyribonucleic acid
dNTP	2'-deoxynucleoside 5'-triphosphate
Ds	Standard genetic distance
EDTA	Ethylene-diaminetetra acetate
EMT	Egg Multi Tester
ETH	Ethiopia
FCR	Feed Conversion Ratio
RIR	Rhode Island Red
FAO	Food and Agriculture Organization
FES	Number of chicks hatched per number of fertile eggs X 100
G	*Gallus*
g	Gram
H_e	Expected heterozygosity
H_O	Observed heterozygosity
HU	Haugh Unit
IBC	Institute of Biodiversity Conservation
IBD	Infectious Bursal Disease
IFPRI	International Food Policy Research Institute
ILCA	International Livestock Research Center for Africa
MOA	Ministry of Agriculture
WADU	Wolita Agricultural Development Unit
K	Potassium
Kg	Kiliogram
km	Kilometer
km^2	Square kilometer
L.Venda	Lebowa-Venda
MD	Marek's Disease
Mg	Milligram

min	Minute
ml	Milliliter
mm	Millimeter
mM	Millimolar
ND	Newcastle Disease
ng	Nanogram
nm	Nanometer
NRF	National Research Foundation
^{o}C	Degree Celsius
P	Probability
PCR	Polymerase Chain Reaction
PIC	Polymorphic Information Content
pmol	Picomole
RAPD	Random Amplified Polymorphic DNA
RFLP	Restriction Fragment Length Polymorphism
rpm	Revolution per minute
SAS	Statistical Analysis Software
sec	Second
SPSS	Statistical Package for Social Sciences
Taq	*Thermus aquaticus*
TE	Tris-EDTA
TES	Number of chicks hatched per number of eggs set X 100
TWOWS	Third World Organization for Women in Science
U/µl	Unit per micro liter
U$	United States Dollar
WLH	White Leg Horn