PHENOTYPIC CHARACTERIZATION OF LOCAL CHICKEN ECOTYPES IN THE CENTRAL ZONE OF TIGRAY IN NORTHERN ETHIOPIA

M.Sc. THESIS

MEARG FITSUM

February, 2016

JIMMA UNIVERSITY

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BY

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APPROVAL SHEET OF THESIS
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As Thesis Research advisor, I hereby certify that I have read and evaluated this thesis prepared, under my guidance, by Mearg Fitsum, entitled **"phenotypic Characterization of Local Chicken Ecotypes in the Central Zone of Tigray in Northern Ethiopia**". I recommend that it can be submitted as fulfilling of the Thesis requirement.

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As member of the *Board* of Examiners of the MSc Thesis Open Defense Examination, we Certify that we have read, evaluated the thesis prepared by Mearg Fitsum and examined the candidate. We recommended that the thesis is accepted as fulfilling the Thesis requirement for the Degree of Master of Science in Agriculture (Animal Breeding and genetics).

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External Examiner	Signature	Date

DEDICATION

I dedicated this manuscript to my family especially to my wife Asefu Abraha and my sweet daughter Danait Mearg for their moral, encouragement and sacrifice, to finalize my study.

STATEMENT OF AUTHOR

I, the undersigned, declare that this thesis is my own original work and I have not previously in its entirety or part submitted to any institution for the award of any academic degree, diploma or certificate. I also believe that all sources of materials used for this thesis have been duly acknowledged.

Name: Mearg Fitsum

Signature: _____

Place: Jimma University, Jimma

Date of submission: _____

LIST OF ABBREVATIONS AND ACRONYMS

BoARD	Bureau of Agriculture and Rural Development
CSA	Central Statistical Authority
EARO	Ethiopian Agricultural Research Organization
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agricultural Organization Statistics
HH	Household
GLM	General Linear Model
ILRI	International Livestock Research Institute
LIVES	Livestock and Irrigated Value Chain for Ethiopian Smallholders
NCD	New Castle Disease
Ne	Effective population size
Nf	Number of breeding female
Nm	Number of breeding male
PA	Peasant Association
PCA	Principal Component Analysis
PC	Principal Component
PRA	Participatory Rural Appraisal
SAS	Statistical Analysis System
SFRB	Scavenging Feed Resources Base
SD	Standard Deviation
SE	Standard Error
SNNPRS	Southern Nations, Nationalities and Peoples Regional State
SPSS	Statistical Package Social Software
TARI	Tigray Agricultural Research Institute

BIOGRAPHICAL SKETCH

The author, Mearg Fitsum, was born town on September, 1986 in Dura kebele near Axum. He attended his elementary and junior education at Dura and Axum primary and junior schools, and Secondary and preparatory School in Axum Comprehensive High School. Then he joined Jimma University in 2004 and graduated with B.Sc. in Animal production and health in 2007.

After his graduation, he had worked for Tahitay Maichew district Office of Agriculture and Rural Development and served as an animal production expert for about three years. In November 2010, he joined Tigray Agricultural Research Institute (TARI) where he served as Assistant Researcher. In September 2013, he re-joined the School of Graduate Studies at Jimma University to pursue his graduate study in Master of Science in Animal breeding and genetics.

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ABSTRACT

Phenotypic Characterization of Local Chicken Ecotypes in the Central Zone of Tigray in Northern Ethiopia

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The study was conducted in three districts of central zone of Tigray, with the aim to assess the socioeconomic characteristics and production environments of local chicken ecotypes, along with farmers' breeding objectives, breeding practice, and traits of preference for local chickens and to assess the phenotypic characteristics of the local chicken. A total of 242 chicken owners were selected for the study. Nine qualitative and nineteen quantitative traits from 457chickens were considered. The research finding revealed that village chicken production seems to be an important activity with an average flock size 9.41 and 8.98 birds per household in midland and highland agro ecology. The most important chicken production system of the study area is traditional with small feed supplementation. A separate house to keep chicken was practiced in 36.8% and 28.9% of the respondents in highland and midland area, respectively. About 87.6% of the respondents select eggs for incubation and straw was commonly used as bedding material. About 96.7% of the respondent use broody hens for incubation and rearing chicks. About 81% of households participate in chicken and egg marketing as a source of income. Culling is practiced by 78.9% of households based on production level of chicken, age, plumage color, ill and bad temperament of hens and cocks. The main breeding objectives of the respondents were meant for household consumption, income generation and for replacement of the flock. The effective population size (Ne) and the rate of inbreeding (ΔF) calculated for the indigenous chicken flock of the study area were 3.99 and 0.13, respectively.The selection criteria used for selection of breeding hen were egg size, plumage color, broodiness, disease resistance and hatchability with an average index value of 0.067, 0.064, 0.062, 0.054, 0.042. The highest selection criteria used for selection of breeding cock were egg number of the dam, comb type, plumage color, and disease resistance, egg size growth rate with an index value of 0.053, 0.052, 0.045, 0.044, 0.041 and 0.041, respectively. Farmers preferred traits like comb type, plumage color, egg size, broodiness, disease resistance, meat quality, fertility growth, egg number and body size with indices of 0.169,0.156,0.137,0.117,0.114,0.113,0.108,0.096 and 0077, respectively. Reproductive performance study revealed that the overall mean age at first mating of male chickens and the age at first egg of female chickens were 5.29 and 5.96 months. Local chicken were mostly normally feathered (hens 97.8%, cocks 96%), red (33%), grayish (17.5%), brownish (17.3%) colors. Morph metric measurements indicated that significance differences ($P<0.05$) were observed between agro ecology with respect to breast width, spur length, chest circumferences and shank length. In all parameters, male shows higher significance ($P<0.001$) value than female except breast width and beak width. Multivariate analysis result showed that five PC were extracted that accounted for 58.45% of the total variation. The differentiation of highland and midland populations was apparent based on the weights of neck length, beak length, body length, wattle width, body weight, wattle length and height at back traits. The Mahalanobis' distances between populations shows the smallest and largest distances between highland and midland chicken ecotypes. In conclusion, there is diversity of indigenous chicken population and farmers' preference for specific traits that may invite to design community based genetic improvement.

***Key words**: Breeding Objective, Indigenous Chicken, Highland, Midland, Traits Preference*

1. INTRODUCTION

1.1. Back ground and justification

Poultry is the largest livestock group in the world estimated to be about 23.39 billion consisting mainly of chickens, ducks and turkeys (FAOSTATA, 2012). In Africa, village poultry contributes over 70% of poultry products and 20% of animal protein intake (Kitalyi, 1998). According to the author in East Africa over 80% of human population live in rural areas and over 75% of these households keep indigenous chickens.

According to CSA (2014), there are 53 million chickens in Ethiopia of which 96.6% are indigenous. These indigenous chickens produce 90% of total eggs and 95% of total meat in the country. According to CSA (2010/11), the total poultry population in Tigray region is estimated to be about 4,308,595, which are about 8.74% of the total national indigenous chicken population and contributes about 15% of the total annual national egg and poultry meat production. About 80.90% of the total regional chicken populations are found in rural areas while the urban areas constitute 19.10% (CSA, 2010). Central administration zone of Tigray accounts for more than 1.1 million chickens which account for about 34.68% of the total regional poultry population (CSA, 2010).

The traditional poultry production system is characterized by small flock sizes, low input, low output, and periodic devastation of the flock by disease (Tadelle *et al.,* 2003a). With a number of challenges, backyard poultry production is still important in low-income, food-deficit production systems to supply the fast-growing human population with high demand for quality protein (Tadelle *et al.,* 2003a). Backyard poultry is also a source of employment for underprivileged groups in many local communities (Mengesha *et al.,* 2008). According to Aklilu (2007), village poultry is the first step on the ladder for poor households to climb out of poverty and is a source of self-reliance for women, since poultry and egg sales are decided by women and provide women with an immediate income to meet household expenses. A traditional stew (Doro wot dish) is served in festivities and to honor guests and demonstrates respect to guests, that strengthens social relationship.

Despite the importance of indigenous breeds in rendering income, posses' cultural value and source of nutrition for household, they are under threat due to various factors such as changing production systems and indiscriminate crossbreeding (Besbes, 2009). Importation of exotic chicken breeds for commercial investments has gradually increased during the past years due to the high local demand for chicken products in the region. This has encouraged a continuous gene flow and genetic erosion of local chicken genetic resources. The replacement of local by exotic breeds and/or uncontrolled breeding with local populations has been posing a serious threat to the existence of few local chicken breeds on small-scale farms, putting these local animal genetic resources at risk of extinction (Kadim *et al.,* 2009).

Recently a genetic improvement program has been initiated for increasing productivity of indigenous chickens of Ethiopia through selective breeding, as a means both to improve the livelihood of poor people and conserve the existing genetic diversity through utilization (Nigussie *et al.,* 2010b). Developing appropriate animal breeding programs for village conditions requires characterizing local chickens, defining the production environments and identifying the breeding practices, production objectives, and trait choices of rural farmers (Soelkner *et al.,* 1998. Therefore, these existing chicken ecotypes have to be characterized for their overall merits and for subsequent improvement. Characterization is the initial step for long-term genetic improvement as it provides the basis for any other livestock development interventions and provides information for designing appropriate breeding programs. Breed characterization includes all activities related with the description of the origin, development, structure, population, quantitative and qualitative characteristics of the breeds in defined management and climatic conditions (FAO, 2012). Breeds can be characterized by morphological (phenotypic) and molecular tools. Phenotypic characterization is a comparatively easy and cheap tool of breed characterization (FAO, 2012)

A "people-cantered" breed characterization method has recently emerged with a more participatory approach to identify and understand the indigenous animal genetic resources. According to Haile *et al*. (2009), community is defined as a group of people having social,

cultural and economic relation based on common interest, goal, problems or practices shared interest and living in a well defined area.

Some attempts have been done on characterization of local chicken ecotypes in different parts of Ethiopia on a comprehensive standard by different researchers. Previous research works indicated that indigenous chickens are non-descriptive, with a variety of morphological appearances (Halima, 2007; Mokonnen, 2007). Research on phenotypic and genetic characterization of indigenous chicken ecotypes was done in some selected areas of Ethiopia (Tadelle, 2003; Halima, 2007; Aberra and Tegene, 2011). Nigussie (2011) also examined the morphological and genetic characterization of indigenous chickens in different parts of Ethiopia (Oromia, Amhara, Benshangulgumuze, South nation and nationality people and Gamabela) and identified that there were sufficient genetic variation between groups of indigenous chickens. Researches on phenotypic characterization of indigenous chickens of Ethiopia have been carried out at Debre Ziet agricultural research center (Duguma, 2006), at SNNPR (Aberra and Tegene, 2011), at South West and South Part of Ethiopia Emebet *et al. (*2014), at Fogera district (Bogale, 2008) and at North Wollo zone of Amhara regional state (Addisu, 2013) that has identified a large variations in morphological appearances, conformation and body weights of indigenous chickens.

Moreover, characterization of smallholder poultry production and market system had been also carried out in Alamata and Atsbi-wonberta woredas of Tigray region (Dawit, 2010), in three districts of SNNPRs (Mekonnen, 2007), in Halaba district of southern Ethiopia (Nebiyu, *et al.*, 2014), in Gomma wereda of Jimma zone (Meseret, 2010), in Gondar town (Wondu *et al.*, 2013) and in Bure wereda (Fisseha, 2009). Generally they reported that the productivity of local scavenging chicken is low with high mortality of chicks.

There was little attempt to study the chicken production and marketing system, flock composition and socio-economic importance in the central zone of Tigray region in northern Ethiopia. Moreover, there was little research carried out in central zone of Tigray to characterize and classify the existing local chickens through the participation of the community. Given the high potential of the central zone for poultry production and presence of diverse ecotypes, it is

imperative to conduct comprehensive studies that can cover the entire characteristics of morphological, functional, and adaptive traits of local chickens, identifying farmers' breeding objectives, breeding practices, and trait preference of local chickens producers with "people – centered" perspective. This will serve as a foundation for proper conservation, utilization and genetic improvement program. This research was, therefore designed with the following general and specific objectives.

1.1. General Objective

- To characterize phenotypes of local chicken ecotypes in the central zone of Tigray through participating the community that serve as a baseline information for further genetic improvement and utilizations.

1.2. Specific Objectives

- To assess the socioeconomic characteristics and production environments of local chicken ecotypes in the study area
- To asses farmers' breeding objectives, breeding practice, and traits of preference for local chickens in the study area.
- To assess the phenotypic characteristics of the local chicken ecotypes based on their phenotype in their environment.

2. LITERATURE REVIEW

2.1. Overview on Poultry Production and Distributions in Ethiopia

Poultry include all domestic birds kept for the purpose of human food production (meat and eggs) such as chickens, turkeys, ducks, geese, ostrich, guinea fowl, doves and pigeons. In Ethiopia ostrich, ducks, guinea fowls, doves and pigeons are found in their natural habitat (wild) whereas, geese and turkey are exceptionally not common in the country. Thus the word poultry is synonymous with chicken production under the present Ethiopian conditions (EARO, 1999).

According to the CSA (2010), the total poultry population at country level is estimated to be about 49,286,932 and with regard to breed, 47,954,978 (97.3 percent), 188,032 (0.38 percent) and 1,143,922 (2.32 percent) of the total poultry were reported to be indigenous, hybrid and exotic, respectively. Poultry includes cocks, cockerels, pullets, laying hens, non-laying hens and chicks. Most of the poultry are chicks (37%), followed by laying hens (32%). Pullets are estimated to be 4,878,184 (10%) in the country. Cocks and cockerels are also estimated separately, and are 5,614,700 (11%) and 2, 771, 22 (6%), respectively. The others are non-laying hens 1,834,686 that make up about 4% of the total poultry population in the country. Among these 5.45 million (11%) cocks, 2.69 million (6%) cockerels, 4.72 million (10%) pullets, 15.37 million (32%) laying hens, 17.8 million (4%) non-laying hens and 17.9 million (37%) chicks are indigenous poultry.

According to the CSA (2010), Oromia, Amhara, SNNP, and Tigray regional states account for 38.07%, 28.50%, 21.12% and 8.74% of the total national poultry population, respectively. Collectively poultry population of the four major regions account for about 96.43% of the total national poultry population. Chicken rearing is not common in the lowlands of Ethiopia i.e. Somali, Gambella, Afar and Benishangul-Gumze regional states, which collectively own about 3.3% of the total national chicken population.

2.2 Overview of poultry production and distributions in Tigray region

According to the CSA in 2010/11, the total poultry population in Tigray region is estimated to be about 4,308,595. In this report, rural areas constitute about 81.0 percent of the total poultry, while urban areas comprised of 19.0 percent. Flock structure of Tigray regional state and zones of Tigray are indicated in Table 1 below.

Table 1.Flock composition of poultry in Tigray by zone and national

Geographical Area	Total poultry	Cocks	Cockerel	Pullets	Non-laying hens	Chicks	Laying hen
Ethiopia	49,286,932	5,614,700	2,771,221	4,878,184	1,834,686	18,294,799	15,893,347
Tigray	4,308,595	434,837	295,208	465,162	234,683	1,666,593	1,212,112
N.west Tigray	994,147	85,649	85,611	109,388	38,218	458,647	216,633
Central Tigray	1,117,881	121,365	72,790	126,659	47,134	409,502	340,430
Eastern Tigray	690,006	82,832	34,410	75,415	45,930	184,327	267,092
S. Tigray	845,548	93,310	39,661	85,737	63,639	313,482	249,719

Source (CSA, 2010/11)

Table 1 shows pertaining to zonal distribution, 35.41 percent, 34.58 percent, 17.07 percent, and 11.49 percent of the total poultry population of Tigray regional state are found in West, Central, South, and East Tigray Zones, respectively. The remaining 1.45 percent of the total poultry population of the region was found in Mekele zone.

2.3. Flock size

The average flock size of chickens in Tigray regional state were 7.2 Solomon (2008) and the average flock size of chickens of North West Ethiopia reported by Halima *et al.* (2007) was 7.13. The average flock size of chickens per household in lowland agro-ecology of central zone of Tigray was 5. 6 and in midland was 8 (Alem, 2013). There was higher number of chickens reported in Burre district of which 13 chickens/household (Fisseha *et al.*, 2010). Melesse and Negesse (2011) reported average flock size of 7.0 chickens for northwest and southern parts of

Ethiopia. In southern Ethiopia, Mekonnen (2007) reported an average flock size of 9.2 chickens per household for scavenging local chickens. On the other hand, a relatively higher flock size of 12 chickens per household was reported by Hunduma *et al.* (2010) in the Oromia regional states of Ethiopia. However flock size of indigenous chicken is not known in two districts of the study areas with this regard this study solves the problem in central zone of Tigray.

2.4. Production and reproductive performance of indigenous chickens

Regarding the production potential of indigenous birds, studies carried out at in Wetsren zone of Tigray (Markos *et al.,* 2015) indicated that the average annual egg production of the indigenous chicken was 52.68. Authors reported about 48.98, 54.20 and 54.87 annual average egg production for lowland, highland and midland chicken ecotypes, respectively. A study carried out by Meseret (2010), Halima (2007), Ayalew & Adane (2013) and Addisu *et al.* (2013) at Gomma wereda of Jimma zone, North West Ethiopia, Chagni town in Awi administrative Zone Amhara and North Wollo zone of Amhara, respectively, revealed that the average egg production of local birds were 43.8 eggs, 18-57 eggs, 27-45 eggs and 49.51 eggs. Aberra and Tegene (2011); Nigussie *et al.* (2010a) has also reported that the production level of scavenging hens is generally low, with only 40-60 small sized eggs produced per bird per year under smallholder management conditions. Higher egg productions per year per hen were reported by Fisseha *et al. (*2010) in Bure district (60 eggs), Mekonnen (2007) in Wonsho district (62.95 eggs).

The overall number of eggs/hen per clutch of local hen reported by Meseret (2010), Addisu *et al.* (2013), Wondu *et al.* (2013) and CSA (2003) in Gomma wereda, North Wollo Zone North Gondar Amhara region and Ethiopia were 12.92, 12.64, 11.53 (8-15) and 12 (national average of egg yield/hen/clutch). But higher overall number of eggs/hen per clutch of local hen were reported by Tadelle (2003) 17.7 eggs in five agro-ecological zones of Ethiopia and Bogale (2008) 16.6 eggs in Fogera district.

Amsalu, (2003) reported that local hen lays about 36 eggs per year in 3 clutches of 12 to 13 eggs in about 16 days. Each reproductive cycle lasts for 17 weeks. Three cycles then make one

year. These are very efficient, productive and essential traits for survival. By using brooding coop or other means of controlling broody character of village chicken it is possible to shorten the period to switch the clutch to every 27 days and to increase the egg produce by bird in 81 days time to 30 eggs. However, there was little research carried out in central zone of Tigray to identify production and productivity performance of indigenous chickens but it is was not through the participation of the community.

2.5. Sexual maturity, clutch size and incubation practice

Sonaiya and Swan (2004) reported that indigenous village chicken, in Ethiopia attains sexual maturity at an average of 7 months. Halima (2007) also reported that pullets and cocks reached sexual maturity at an age ranging from 20 to 24 weeks; however, 31.92% of the pullets and 20.07% of the cocks reached maturity at 28 to 32 weeks, indicating late maturity in North West Ethiopia. Similarly Worku *et al. (*2012) and Markos *et al.* (2015) reported that age at first mating for cockerel in West Amhara region and western zone of Tigray was 6.49 month and 5.71 month, respectively. However, late (5.9-7.1 month) average age at first egg laying of indigenous chicken reported by Fisseha *et al.* (2010) in Bure districts and Habte *et al.* (2013) (7.02 months) in the Nole Kabba wereda of Western Wollega which is an expression of low productivity of local chickens . Mekonnen (2007) was also reported that the mean age at first egg laying of young indigenous pullets in three districts of SNNPR was 7.7 months and Addisu *et al. (*2013) also reported that the age at first egg laying of local chickens in North Wollo zone of Amhara region was 6.6 months.

According to Horst (1989) indigenous chickens are ideal mothers, good setters, hatching their own eggs, excellent foragers and vigor. They are aggressive, hardy and possess some degree of natural immunity against some diseases. These factors are important ideal requirements for replication and sustaining their generation in scavenging nature. The most important characteristic of indigenous chicken is their broodiness (maternal instinct), which is pronounced for indigenous chickens in Ethiopia. Broody hens were the sole means of egg incubation and brooding young chicks.

It is identified that, the average hatchability percentage of local hens in western zone of Tigray was 74.3% (Markos *et al.,* 2015).

Other authors Halima (2007), Habte *et al.* (2013) and Tadelle and Ogle (2001) were reported that the average hatchability of eggs of indigenous chickens under scavenging management condition was 60.7% - 82.1%, 82.74% and 81% in North Western of Ethiopia, Nole Kabba wereda of Western Wollega and Central highlands of Ethiopia, respectively. Similarly, higher hatchability percentage were reported by Solomon *et al.* (2013), Wondu *et al.* (2013), Nebiyu *et al.* (2014) and Worku *et al.* (2012) who reported that the average egg hatchability of local chickens in Metekel Zone of North West Ethiopia, North Gondar Amhara regional state, Halaba wereda of southern Ethiopia and West Amhara region of Ethiopia were 84.74%, 87.29%, 83.72% and 79.1%, respectively. On the other hand, lower hatchability (22%) was reported for indigenous chickens in Gomma districts of Oromia region (Meseret, 2010).

Markos *et al.* (2015) reported that in western zone of Tigray the survival rate of chicken to weaning age were 73.06 with chick mortality rates ranging from 27% to 29.2% under extensive system. The apparent high chick loss implied might have been caused by diseases, predators and other factors as it has been reported from other studies on local chicken under extensive system in North West Ethiopia (Halima, 2007).

Clay pots, bamboo baskets, cartons or even simply a shallow depression in the ground are common materials and locations used for egg setting (Tadelle *et al.,* 2003a; Fisseha, 2009). Crop residues, usually tef, wheat and barley straws were used as bedding materials (Tadelle *et al.,* 2003a). Similarly Markos *et al.* (2014) reported that clay pots with straw bedding (1%),ground with soil/sand/ash bedding (15.6%), bin with grasses/straw/cotton seed bedding (68.8%), plastic with grasses/soil/sand bedding (7.8%), bamboo cages with soil and straw breeding (0.3%),bin with straw bedding during rainy season and with sand bedding during dry season (3.9%), cartoon with grasses and clothes bedding (0.8%), dish with soil or clothes bedding (0.5%), ground / bin or dish with grasses bedding (0.3%) or plastic and bin with grasses bedding alternatively (1%) as egg setting materials were used in western zone of Tigray. According to farm households, the number of eggs set per bird depends, in their orders of importance, on season, experience and size of the bird (Tadelle *et al.,* 2003a). Related selection of broody hens, indigenous practice

were practice a culture of selecting broody hens used for breeding/ egg incubation purposes by looking hen's past egg incubation performance (73.9%), presence of big body size (7.9%), presence of thick feather (2.1%), size of eggs laid (2.5%), respectively (Tadelle *et al.,* 2003a).

2.6 Husbandry practices

2.6.1 Feed resources, feeding and watering practices

Feed supplementation has been reported in various countries as a common practice to promote chicken performance. In Ethiopia, more than 97%, feed supplementation by chicken owners were reported (Halima, 2007; Fisseha *et al.,* 2010); Mengesha *et al.,* 2011).

In Ethiopia, village chicken production systems is usually kept under free range system and the major proportion of the feed is obtained through scavenging. The major components of Scavenging Feed Resource Base (SFRB) are reported to be insects, worms, seeds and plant materials, with very small amounts of grain and table leftover supplements from the household.

Many studies showed that there is no purposeful feeding of rural household chickens in Ethiopia and the scavenging feed resource is almost the only source of feed. Messertet (2010) reported that almost all of the respondents (97.8%) reported to practice scavenging system with supplementary feeding in Gomma districts, and Asefa (2007) and Mekonnen (2007) who reported 95-98% of the small scale household poultry producers in Awassa Zuria and Dale offer supplementary feeding to their chickens.

On the other hand Halima (2007) reported that 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 practiced supplementary feeding systems (mostly once per day) used maize, barley, wheat, finger millet and household waste products to feed their chickens. After hatching, the chicks were allowed to forage and roam freely with their mothers in open areas near the home and surroundings. Halima (2007) was also reported that about 99.45% of the farmers in Amhara region provided water for their chickens in

plastic, wooden or clay bowls, and 31.52% of the respondents cleaned the bowl daily. In many cases the bowl was filled once per day.

2.6. 2 Housing

Housing systems in backyard system is rudimentary and mostly built with locally available materials. In traditional free range, there is no separate poultry house and the chickens live in family dwelling together with humans (Solomon, 2007). Lack of housing is one of the constraints of the smallholder poultry production systems. In some African countries, a large proportion of village poultry mortality accounted due to nocturnal predators because of lack of proper housing (Dwinger *et al.,* 2003). Some research works also indicated that the mortality of scavenging birds reduced by improved housing. Tadelle and Ogle (2001), reported that there was no special housing provided for birds. In most cases (88.8%) they roosted inside the family dwelling at night, the roost being made of two or three raised parallel planks of wood. A few households (11.5%) had constructed the house and this night shelter was occasionally cleaned by the housewife.

Meseret (2010) has also reported that in Gomma district about 94.4% of the rural household have no separate poultry house, Mekonnen (2007) was also reported that there is no specific separate poultry houses in Dale District. Halima (2007) reported that significant size of the rural households (51%) of Northern Ethiopia had separate sheds for their chickens, almost all farmers provided night shelter 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 (51%). These shelters were made of locally available materials such as Eucalyptus poles and branches. Fisseha *et al.* (2010) reported that in Bure district, North West Ethiopia, 77.9% of the village chicken owners provide only night shelter and only 22.1% provided separate poultry house. Another study by Mengesha *et al.* (2011) in Jamma district, South Wollo reported that 41.3% and 21.2% of chicken owners share the same room and provided separate poultry house, respectively.

2.6.3 Diseases and Predators

Scavenging system is characterized by high chick mortality in the first two weeks of life, caused mainly by predators and Newcastle disease (Aberra, 2011). Bushra Badhaso (2012) cited that the major causes of death for village poultry production were commonly disease (mainly New Castle Diseases locally known as "Sombe/Fengil"), followed by predation. High incidence of chicken diseases, mainly Newcastle Disease (NCD), is the major and economically important constraint for village chicken production system (Fisseha *et al.,* 2010*).*

Mortality of village chicken due to disease outbreak is higher during the short rainy season, mainly in April (66.8%) and May (31.4%). Serkalem *et al.* (2005) also reported that NCD is one of the major infectious diseases affecting productivity and survival of village chicken in the central highlands of Ethiopia.

Predators were listed alongside diseases as major cause of premature death. The predation is strongly associated with the rainy season. The predators include primarily birds of prey such as vultures, which prey only on chicken and wild mammals such as cats and foxes, which prey on mature birds as well as chicks (Tadelle and Ogle, 2001). Predators such as birds of prey (locally known as "Culullee") (34%), cats and dogs (16.3%) and wild animals (15%) were identified as the major causes of village poultry in rift valley of Oromia, Ethiopia (Hunduma *et al.,* 2010).

Aberra (2007) has also reported that about 46% of the respondents in Southern Ethiopia reported, that wild birds (eagle, hawk, etc.) are the most common predators during the dry season, while wild cat (locally known as Shelemetmat) is the most dangerous predator during the rainy season. Halima (2007) also reported that predation is one of the major constraints in village chicken production in northwest Ethiopia.

Generally different authors' reports different husbandry practice; with this regard, the final interest lies in answering the question of what poultry husbandry management practice exists in central of zones Tigray through the participation of the community.

2.6.4 Marketing

Markos *et al.* (2014) reported that 99.7% of the respondents had participated in selling of chicken products. Higher proportions of households sold chicken products to their neighbors in the same village (98.8%) in lowland than in midland (67.9%). Greatest proportions of respondents in western zone of Tigray sold their chicken products in either of wereda market (9.6%) or both same village and wereda market (90.4%) in highland as compared to both midland (3.1% and 28.2%) and lowland (3.3% and 1.2%) (Markos *et al.*, 2014). Similarly, Bogale (2008) was also reported that 41.7% and 33.3% of the respondents in Fogera districts sold their chicken products in the nearest market and wereda market during market days, respectively while 19.4% sold their products within their respective kebeles during non-market days. Meseret (2010) also reported that chicken products were sold either at the farm gate, primary market (small village market) or at secondary market (at large wereda town) in Gomma wereda of Jimma zone,

The marketing system is generally informal and poorly developed. Unlike eggs and meat from commercial hybrid birds (derived from imported stock), local consumers generally prefer those from indigenous stocks. The premium for local birds is attributed to better meat flavor and more deeply colored egg yolks (Dessie and Ogle, 2001). The influences of morphological appearances, particularly plumage color and comb types are significantly important for price variations of the marketable birds of various chicken-ecotypes beside other quantitative traits.

2.6.4.1 Determinant factors that affect chicken marketing

Reta (2009) cited that chicken morphology is linked to the socio-cultural and religious sacrifices. Red and white cock is sacrificed for good rain and harvest, red and black spotted color (giracha) cock for New Year celebration, white and black spotted (gebsima) cock to prevent evil and calamities and red pullet for dead ancestors (animism) (Tadelle and Ogle , 2001). According to Fisseha *et al.* (2010) chicken type (sex, age, color and comb type) played an important role on market price of live birds. In addition, most village chicken owners considered plumage color and comb type as main determinant factors in selection of birds for production, consumption and marketing purposes. Red and white plumage colors were most preferred and demanded highly in

the chicken marketing system of Burea district (Fisseha, 2010). The selection of plumage colors was attributed to attractiveness by the public and high sale price in marketing. Regarding comb type, double (rose) comb was more privileged than single comb types in terms of preference, market price and demand.

Markos *et al.* (2014) reported that plumage color, body weight, comb type, shank color, smoothness of shank, sex, spur presence, length of legs, head shape and market site were the major factors that cause variation in the price of live chickens in western zone of Tigray. Similarly, Bogale (2008) reported that plumage color, comb type, plumage color and comb type, body weight, age, sex and seasons were relevant factors that brought variations on the price of live chickens at market level in Fogera district. Addisu *et al.* (2013) also reported that the prices of live chickens were determined by body weight (41.83%), combination of comb type and plumage color (32.4%) and plumage color (25.8%) in North Wollo zone of Ethiopia. Likewise, most of the respondents were the opinion that the eggs (90%) and meat (92%) obtained from modern breeds have poorer taste. This have confirmed by the lower market preference for eggs from exotic chickens. Plumage color, live weight, and comb type were important traits affecting market price of chickens (Nigussie *et al*., 2010b).

Although various socio-economic importance of qualitative traits of chickens and marketing system were identified in the country, economical, social and cultural merits of chickens like the mystical activity of the farmers and the extent of the practice are not yet well studied in the central zone of Tigray.

2.7 Trait Preference

Morphologic traits such as plumage color and comb type were also found to have significant economic values beside other quantitative traits related to growth and egg production (Nigussie *et al.*, 2010a). Fisseha *et al.* (2010) in North West Ethiopia reported that red was the most preferred (83.6%) plumage color and double comb cocks were the most preferred chickens (81.1%). According to Aklilu *et al.* (2007) double combed birds were preferred to single combed birds but black colour chickens were believed to bring bad fortune. Farmers also select double comb cocks for reproduction purpose in order to fulfil their ritual interest and to fetch higher

price at market. They have different reasons for the preference of plumage colour such as demand of consumers at market, camouflage to prevent chickens from attack of predators and other different spiritual reason**.** Nigussie *et al*. (2010b) reported that farmers in different part of Ethiopia mainly select adaptive traits, meat and egg test as their preferred traits. The most important traits of farmers in Jordan were growth rate, disease tolerance, egg yield, body size and fertility (Abdelqader *et al.,* 2007). Majority of the farmers in Kenya considered egg yield as the most important trait followed by mothering ability and body size (Okeno *et al.,* 2011). Plumage color of birds (low altitude) and comb type (high altitude) were identified as the traits farmers would like the least to be improved in both classes of sex (Nigussie *et al.*, 2010b). However, there was no research carried out in central zone of Tigray to identify trait preference of farmers through the participation of the community.

2.8 Adaptive Traits

In terms of adaptive traits and consumption the indigenous chickens were considered favorable. Nigussie *et al*. (2010b) reported that most of the respondents claimed that the modern breed is poor in disease and stress tolerance (86%) and ability to escape predators prevalent in their village conditions (96%). The modern breed generally required higher level of management (83%) often hard to afford and are poor scavengers (86%) compared to indigenous chickens. In addition, 77% of the farmers in Horro and 90% in Sheka claimed that hatchability of eggs obtained from the modern breed is inferior to eggs from indigenous chickens.

Adaptive traits (specifically disease and stress tolerance, flightiness, and scavenging vigor) in both males and females, growth in males and number of eggs in females, ranked first and equal in importance in low altitudes. In the highlands, adaptation is second in importance to growth (males) and egg production (females). With this regard, the final interest lies in answering the question of what adaptive traits of chicken exists in central of zones Tigray through the participation of the community.

2.9. Breeding Objectives

Like in any other village, poultry systems in developing countries, there is no specialized egg or meat chicken production in Ethiopia. Mengesha *et al*. (2008) reported that the purpose of keeping poultry in Jamma district was mainly for sale (38.1%), followed by home consumption (31.7%) and no defined (16.3%), at last for religious purposes (13.9%). In central highlands of Ethiopia the purpose of keeping poultry was 50%, 27% and 23% for hatching, sale and home consumption, respectively (Tadelle *et al.*, 2003a). In another study conducted by Aberra and Tegene (2007), in Southern parts of Ethiopia, about 71.4% of chickens raised by the rural community were used for egg production while the rest 28.6% were used for meat production purposes. Nigussie *et al.* (2010b) also reported that, chickens are raised importantly as source of income and egg production for home consumption. Meat production for home consumption is second in importance in Oromia (Horro) and Southern regions but the function of chickens as source of cash income was rated to be as important as (Horro) or more important than egg and meat production in Mandura district (Nigussie *et al.*, 2010b). It is second in importance to egg production in Farta. In Konso, the principal purpose of raising chickens is for home consumption and their value as income source is third in importance. Based on Nigussie *et al.* (2010b) reports, only 5% of the farmers in Farta and Konso included the cultural–religious role of chickens rating it fourth in importance.

Mengesha *et al*. (2011) reported in Jamma district that egg utilization for consumption in Woinadega (30.6) and in Dega, (33.9%) and egg utilization for gift in Woinadega (10.5%) and in Dega, (6.8%). In some parts of Africa (Gondwe *et al.*, 2004; Muchadeyi *et al.* 2007) indicated that the cultural/religious role of indigenous chicken types is important. Some efforts were done in one district of the study area but in the two districts still remain unexplored initiating investigation as a prior step for the endeavors of poultry production and productivity improvements and sustainable utilization of indigenous chickens.

2.10 Breeding and Selection Practices

Traditional chicken production system is characterized by lacks systematic breeding practice in Gomma district (Meseret, 2010). Furthermore, a study conducted in different parts of Ethiopia revealed that village chicken breeding is completely uncontrolled and replacement stock

produced through natural incubation using broody hens (Negussie, 2007; 2011). In another study conducted by Fisseha (2009) revealed that about 92.2% of chicken owner farmers in Bure district had the tradition of selecting cocks for breeding stock. Okeno *et al.* (2011) in Kenya reported that farmers who are confining their flocks do selection of chicken for breeding. According to Fisseha (2009), plumage color (45.4%) and comb type (8.6%) were some of selection criteria for breeding stock in Bure district. Another study conducted in mid Rift valley of Oromia revealed that 68% of the farmers select productive hen by its body size, 12% by finger accommodation between the pelvic bones and 20% by pedigree performance for replacement (Hunduma *et al.,* 2010).

2.11 Mating System and Culling Practices

According to the report of Nigussie *et al*. (2010b) there was no systematic mating in different regions of Ethiopia. Another study conducted in the three districts of SNNPRS disclosed that the free-range feeding practice attributed to indiscriminate mating of cocks and hens (Mekonnen, 2007). Bogale (2008), who reported that the home consumption, selling (46.5%), old age and poor productivity (25%) and sickness (5.65%) were the main culling ways of chicken from their flock. Another study in Northwest Ethiopia by Halima (2007) also revealed that farmers cull poor productivity and old age chickens via selling. The breeding practice, mating system and culling practice remain unexplored in the study areas that initiating to investigation these through participating the communities.

2.12 Effective Population Size and Inbreeding in Village Chickens

Effective population size is a measure of genetic variability within a population with large values of Ne indicating more variability and small values indicating less genetic variability (Maiwashe *et al.,* 2006; Cervantes *et al.,* 2008). Inbreeding is the probability that two alleles at any locus in an individual are identical by descent relative to a base population (Falconer and Mackay, 1996). The maximum acceptable level of inbreeding is 0.06 (Armstrong, 2006) with inbreeding higher than this value may decrease genetic diversity because the gene pool narrows.

Nigussie *et al.* (2010b) reported that from 31% to 55.6%, of the farmers of different regions of Ethiopia did not own breeding males. Most of them shared breeding males with neighbours. The largest effective population size was recorded in Konso with the subsequent lowest inbreeding coefficient. The effective population size ranged from 3.19 in Sheka to 5.22 in Konso and the number of breeding individuals is very small (Nugussie, 2010), in Jordan the average size of 15.4 was reported (Abdelqader *et al.*, 2007). According to Bogale (2008) report in Amhara region Fogera district the cock to hen ratio among the local chickens was found to be 1:3.21. Similarly the effective population size (Ne) per breeding population and rate of change in breeding coefficient (ΔF) of the area were 3.9 and 1.95, respectively. However, there was no research carried out in central zone of Tigray to identify the effective population size and inbreeding rate in village chickens.

2.13 Physical Traits

Horst (1989) has indicated that indigenous chicks have the most important traits (ranging from seven to nine important major genes) that are genetically conserved for their special utility in tropical environment. According to Nesheim *et al.* (1979) the size and color of the comb and wattles are associated with gonad development and secretion of sex hormones. Large combs, large wattles and long legs are important morphological traits that allow better heat dissipation in the tropical hot environment. The comb and wattles have a large role in sensible heat losses. This specialized structure makes up about 40% of the major heat losses, by radiation, convection and conduction of heat produced from body surfaces at environmental temperature below 80^0F (Nesheim *et al.*, 1979). According to Horst (1989) the gene coding for these traits, which are not major genes but the result of multiple genes and their interactions, could be considered for incorporation into the development of high performer local birds for the tropical hot environments. Yellow skin coloration is currently more preferred by consumers of developed nations and such color is associated with carotinoid pigments in the epidermis which obtained through the dietary origin (Nesheim *et al.*, 1979).

2.13.1 Phenotypic variation of indigenous chicken populations

Ethiopia is endowed with varied ecological zones, ethnic groups, and socioeconomic, religious and cultural considerations 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 makeup of domestic resources, including chickens (Workneh *et al.*, 2004). As a result, Ethiopia possesses a substantial amount of phenotypic diversity for various traits in the indigenous chicken genetic resources. Indigenous chickens in Ethiopia are found in huge numbers distributed across different agro ecology categories under a traditional family-based scavenging management system (Alemu and Tadelle, 1997).

Reta (2006) and Halima (2007) reported that the names of the indigenous chicken groups were being called as chicken-ecotypes and native-chickens, respectively. The indigenous chickens are studied so far in two approaches as criteria for their differentiation and identification. (1) Based on their ecological or main habitat, thus chickens are named after their area of geographical origin. (2) Based on morphological characteristics for identification specially feather type and color. Some of the characterized and designated chicken ecotypes (native chickens) of Ethiopia by the same authors were: Tilili, Horro, Jarso, Tepi, Gelila, Debre-Elias, Melo-Hamusit, Gassay/ Farta, Guangua and Mecha .The chickens are named after the names of the area of origin. For instance, Tilili, Horro, Tepi, Konso and Jarso are areas located in the northwest, west, southwest, south and east of the country, respectively. The chickens distributed in these areas are named after the names of the areas (Reta, 2009).On the other hand, other scholars reported also that the names of indigenous chicken designated based on their plumage colors like for instances: Tikur (black), Nech (white), Key (Red) and extra in the country (Aberra and Tegene, 2011;Fisseha, 2009)

There are large variations in morphological appearances, conformation and body weights (qualitative traits**)** of indigenous chicken in Ethiopia. Morphological variations of indigenous chicken ecotypes (between and within) are described in terms of comb types, shank types, earlobe types, plumage colors and other qualitative traits. Plumage color of Ethiopian indigenous chicken is very much diversified. Commonly observed plumage colors of indigenous chickens

are: red, white, black, multicolor, black with red strips, white with red strips and red-brownish (Nigussie *et al*, 2010b; Aberra and Tegene, 2011).

2.13.2 Variation in qualitative traits

Reta (2009) reported that there is morphological diversity within and between the indigenous chicken ecotypes. Their plumage color is quite variable even within ecotype (pure black, white, silver white, gray, red and various combinations of several colors). Halima (2007) reported that predominant color was white (25.49 %) followed by a grayish mixture (22.23 %) and red (16.44 %) and considerable numbers of chickens showed heterogeneity and have diverse plumage Colour in North West Gojam. The large variations in plumage colours may be the result of their geographical isolation as well as periods of natural and artificial selections. Duguma (2006) also found similar results for the Horro, Tepi and Jarso indigenous chickens with regard to plumage colour. Aberra and Tegene (2011) also indicated that 55.0 percent of chicken populations were single combed followed by rose (28.5 percent) and pea (15.2 percent) combs. According to the other authors, Yellow was the major shank colour (52.5 percent), followed by white (29.1 percent) and black (14.7 percent). The further reported that, about 46.4, 34.2 and 19.4 percent of chicken populations exhibited red, white and yellow earlobes, respectively. The predominant plumage colour was Kei (36.6 percent) followed by Tikur (20.7 percent), Gebsima (15.3 percent), Netch (12.3 percent), Kokima (8.4 percent), Wosera (3.7 percent), Zigrima (1.7 percent) and Zagolima (1.3 percent) (Aberra and Tegene, 2011).

The common comb types of indigenous chicken are rose, pea, walnut/strawberry, single and V-shape. Most of the indigenous chickens have no shank feather (Halima, 2007; Bogale, 2008); Nigussie *et al.*, 2010b). A variety of plumage colors such as red, white, greyish mixture, black, brown and other mixed colors were also discovered by different researchers in Ethiopia (Halima *et al.,* 2007; Mengesha *et al.,* 2008; Fisseha *et al.,* 2010). It was appeared that red plumage color was dominant followed by white plumage colour.

Alem *et al.* (2013) was also reported that red color was the most dominant and accounted for 52.3% followed by greyish (segemo), which was accounted for 20.9% and multicolour (Checheq) that accounted for 14.1%. Some of the multicoloured chickens were of brown color

with white spots, red with white spots, deep red with black strips, and white with black spots. This multi color plumage was observed more in male chickens (cocks and cockerels) than in female chickens (hens and pullets) in central zone of Tigray.

2.13.3 Variation in quantitative traits

Quantitative traits of chicken have high economic importance. These traits can be expressed by measuring production traits that can be affected by many genes and environment. Productivity figures of chicken in some parameters were reviewed by many authors in different part of the region. Some chickens are dwarf/small, medium or heavy in body size. Reta (2009) reported that dwarf chicks were mainly dominated in Jarso ecotypes (31.1%) that dwell in eastern part of Ethiopia and the heavy ones in Horro ecotypes (56.4%) originated from western Ethiopia. In Horro ecotypes, few chickens with naked neck and feathered shank were observed (Reta, 2009). Aberra and Tegene (2011) indicated that the highest adult body weight was found in Naked-neck chickens (1.7kg), followed by Kei (1.5 kg), Gebsima (1.45kg) and Wosera (1.46 kg). The Naked-neck and Wosera males had the longest shank of about 15 and 13 cm, respectively. Kei male chickens had large body weight shank length ratio compared to other indigenous chickens (Aberra and Tegene,2011).

Eskindir *et al.*, (2013) also reported that, the average body weight of local adult hens in Horro and Jarso were 1.29 kg and 1.12 kg, respectively. Halima (2007) reported that the Guangua cock lines were heavier than the other indigenous chicken groups, while the other indigenous hens were relatively similar in body size. 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. Among the local hens, chickens from Mecha (7.50 cm) had the shortest shank lengths (Halima, 2007). Therefore, various qualitative and quantitative traits of indigenous chickens were identified in the different part of the country. But in rural backyard poultry production system, the qualitative and quantitative traits of indigenous chickens across the different agro-ecological zones in the study area have not yet addressed.

3. MATERIALS AND METHODS

3.1 Description of Study Area

The study was conducted in three rural districts of the central zone of Tigray: Laelay Maichew, Ahferom and Adwa (Fig. 1). The Central Tigray zone is bordered by Eritrea in the north, East Tigray zone in the East and south east Tigray, West Tigray zone in the west and Amhara National Regional State in the south. The central zone of Tigray covers about 9741 km^2 with a total population of 1,132,229 of which (51% are female). The central zone is divided into nine districts and three major marketing towns, Axum, Adwa and Abyi Adi. The zone consists of about 859,066 cattle, 134,223 sheep, 711,624 goat, 98,910 honeybee colonies, 1,117,881chicken and about 26,709 ha of irrigated area largely used for vegetable and fruit (CSA, 2010).

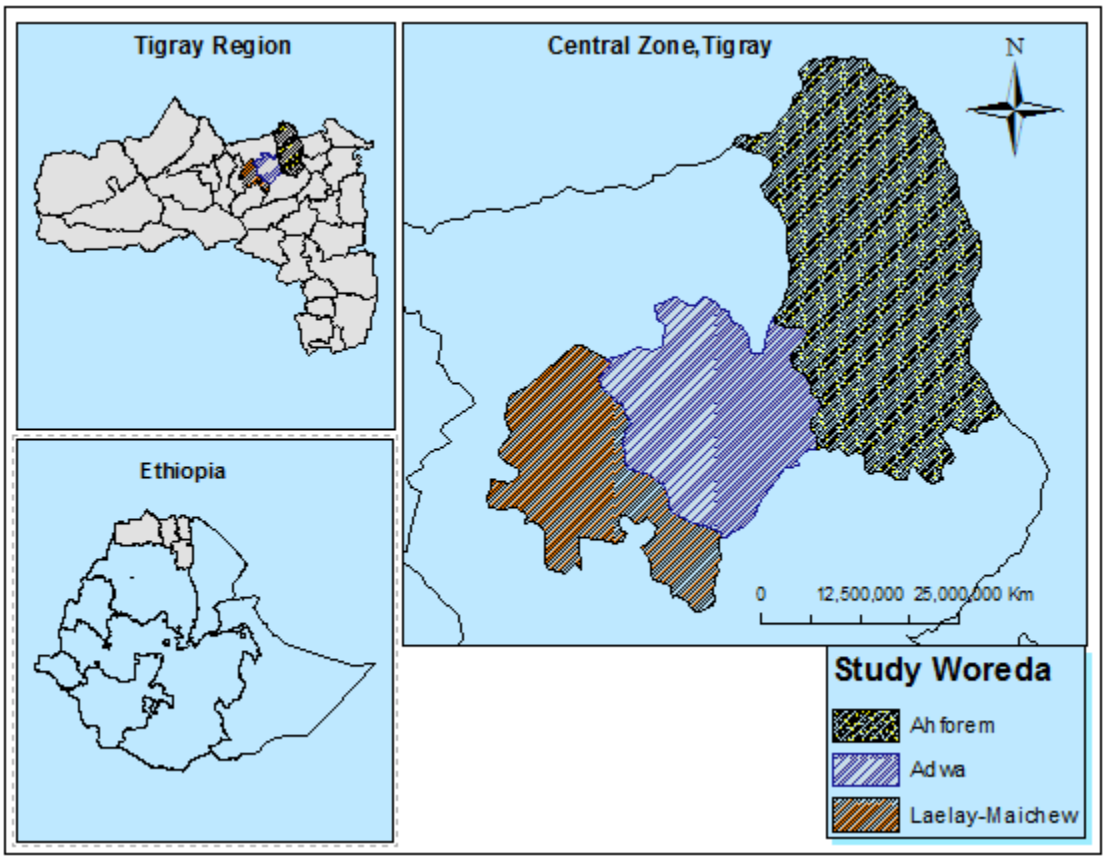

Figure 1. Map of the study area

3.1.1 Topography and Climate

The Central zone of Tigray extends between 13°15' and 14°39' North latitude, and 38° 34' and 39°25' East longitude. The larger part of the zone receives mean annual rainfall ranging from 400 to 800mm. The mean monthly maximum and minimum temperatures of the zone are 30°C and 10°C, respectively (National Meteorological Service Agency of Ethiopia, 1996).

The selected districts vary in biophysical conditions including agro-ecological zoning, elevation, rainfall pattern and amount, temperature, land use and soil types. The selected zone was categorized as Dry Weina Dega in Laelay-maichew and Adwa districts followed by Dega in the highlands of Ahferom. The elevation of the study districts ranges from 1920 to 2921 masl. Annual rainfall is variable within a range of 540-850mm. Temperature ranges from 14 to 22°C. Most of the lands are cultivated with some patchy grazing bottomlands and degraded hilly sites (Gebremedhin *et al.,* 2013).

3.2 Sampling Method and Sample Size

Stratified sampling technique was employed to stratify kebeles (smallest administrative unit in Ethiopia) of the three districts in to midland or waina dega (1500-2500 masl) and highland or dega (>2500masl) (EARO, 2000). Ahferom (Sefo and Mayqeyah kebeles) represented highland, Laelaymaichew (Dura and Medego kebeles) and Adwa (Mariam Shewito and Bete Yohannes kebles) represented as midlands.

Rapid field survey or mapping expenditure was done before the main survey, to validate the geographical distribution, concentration and populations of local chicken ecotypes, the kebeles of each sample districts and to gate sampling framework from which sampling of district was taken. Multi-stage sampling technique was employed to select both sample kebeles and respondents. Six sample kebeles were selected purposively to represent midland and highland (four kebele from midland and two kebele from highland agro ecology) based on the village poultry population density, chicken production potential, road accessibility and agro-ecological representation. A total of 242 (124 from midland and 118 from highland agro ecology) village chicken owners having three or more chickens were selected randomly for the interview and the numbers of respondents per midland and highland agro ecology were determined by proportionate sampling technique based

on the households' size and they were interviewed using a pre-tested well structured questionnaire. One focus group discussion that included 10 elderly members per agro ecology having similar sex, religion and literates was carried out to collect data other than the individual interviews. Members of the focus groups were selected from the community known to have a good understanding of poultry production.

3.2.1 Sample size determination

The total households included in the study were determined according to the formula given by Arsham (2002).

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

Thus, using the standard error of 0.0321 with 95% confidence level, 242 households were included in the study.

The numbers of respondents (farmers) per single agro ecology were determined by proportionate sampling technique based on their house hold population size as follows:

$$W = \left[\frac{A}{B}\right] \times N_0$$

Where:

W, Number of respondents required per single agro ecology

A, Total number of households (farmers) living per a single selected agro ecology

B, Total sum of households living in all selected sample ago ecology and

$\mathbf{N_0}$, the total required calculated sample size (http://www.raosoft.com/samplesize.html)

3.3 Data collection

Six villages, (four villages from midland and two villages from highland agro ecology), were selected for the study based on chicken production potential, village poultry population density, road accessibility and agro-ecology representation level. A total of 242 chicken keepers (124 from midland and 118 from highland agro ecology) were selected and interviewed. For the interviews structured and semi structured questionnaires were used that covered the following topics. Before the survey was conducted, enumerators were trained and the questionnaire was pretested. Data were collected through structured and semi-structured questionnaires, field observation, group discussions, from secondary sources and own flock ranking.

Secondary data on agro-ecology of all study districts, total livestock population by species, main crop, topography, and climate data (rainfall, temperature), animal disease prevalence and total human population size of each sample districts of the zone were gathered from each districts agricultural office.

Information on flock structure, flock size, husbandry practice, important diseases, chicken housing practices, land size, feed and feeding, reason for keeping chicken, sources of first foundation stock, water sources and watering, distance access to veterinary service, selection of practice of egg and chicken, breeding and culling practice, mating system, breeding objective, trait preference and egg incubation practice were collected using questioners.

Information on reproductive and productive performance(functional traits) such as age at first mating of cock, age at first egg laying, average length of inter clutch period, average length of single clutch, average number of eggs laid per clutch, frequency of egg laying , number of eggs incubated, clutch interval, annual egg production, average number of egg set to broody hen, average number of chicks hatched in dry and wet season, number of eggs wasted, number chicks surviving to adulthood in dry and wet season, number of total clutch/year, hatching time per year, total egg per year, frequency of egg collect and behavioral performance of indigenous chickens were collected using structured and semi structured questioners.

Information on market of chicken like place of chicken and egg market, means of transportation, quality specification of poultry and poultry product, price trend of chicken, factor that determine the price of chicken and egg, plumage and comb type were also collected using questioners.

Information on hatching, brooding and egg storage practice like place of storage egg with their reason, duration of storage in dry and wet season, selection practice of egg for incubation, material used during incubation method use for brooding and rearing chickens, interval between two consecutive brooding period, method used to eliminate un wanted broodiness behavior and temperament of the chicken were collected also collected using questioners.

Information on introduction of exotic chicken, cock ownership, breeds of cock, source of cock, types breeding and mating, cock sharing, concept on inbreeding issues, culling practice, factor that follow during culling, purpose of culling were collected using structured questioners.

By using focus group discussion information like: purpose of keeping chicken flock, traits preferred by chicken, selection criteria of farmers for breeding hen and cock, availability of distinct local chicken breeds and their distinguishing characteristics, concentration and distribution of the local chicken breeds, brooding and hatching methods and their procedures were collected.

3.3.1 Participatory rural appraisal (PRA) tools

PRA tools were applied to study the social and cultural contexts of chicken breeding in the community, local breeding and culling system and seasonal availability of feed, ranking of important diseases and predators, breeding objective and trait preference. The process involves listing of pre-identified traits which were normally done with knowledgeable local villagers. The producers were asked to rank for each of the traits or trait categories. The PRA tools employed include focus group discussions and own flock ranking. The PRA tools and procedure to capture the information were adopted from manual on PRA (Simon, 2000).

3.3.1.1 Participatory identification of breeding objectives, farmers' trait preferences

List of the different breeding objectives traits, farmers' preferences to traits for breeding stock, farmers' preferences for production traits, selection and culling criteria in male and female chicken identified in the interviews were prepared into separate flip charts and presented to each group for ranking them according to their order of importance. Similarly, overall objectives of keeping chickens (egg or meat production, income generation, cultural/religious roles), "traits" affecting consumer preferences in purchasing and/or selling chickens (live weight, plumage color, comb type), "traits" desired by farmers in improving village chickens adaptation (comprising disease and stress tolerance, flightiness/ability to escape predators, scavenging vigor), growth, egg production (annual egg number, persistency of egg laying), plumage color, comb type, reproduction" (broodiness, hatchability of eggs) were also be presented. Then participants were asked to rank their first, second, third, fourth, fifth, sixth, seventh and eighth major, breeding objective and farmers traits preference.

3.3.1.2. Own flock ranking methods

Participatory own flock ranking methods adapted from Tadelle Mairkena and Gemeda Duguma and ICARDA, ILRI and BOKU staff first implemented on Horro, Bonga, Menz and Afar sheep breeds were applied to collect data (Duguma *et al*, 2010). For own flock ranking experiment twenty and twenty one households from midland and highland agro ecology, respectively were selected and were asked to choose their first best, second best, third best and the most inferior hen and cock among the breeding hen and cock in their flocks. The reasons of ranking and life history of the ranked chickens (age at 1st egg laying and service for cockerel, number of clutches per year, number of eggs per clutch, number of chick hatched, number of chick grow) were inquired and recorded. Family members were involved in the ranking of activities to remind each other about reproduction history of their flock and other events as there are no written records kept by the households. They depended on recalled memory regarding the performance and pedigree of their flocks. The live body weight and some linear body measurement on each ranked chicken focusing only on attributes frequently mentioned were also taken. In case of hen additional information on reproductive performances were also collected as recalled by owners.

3.3.2 Estimation of net effective population and rate of inbreeding

Effective population size (Ne) and rate of inbreeding size(ΔF) were estimated based on the flocks of farmers who possess their own matured breeding males only for midland and highland agro ecology separately, using the following formula developed by Falconer and Mackay (1996).

$$\mathrm{Ne} = \frac{\mathbf{4NmNf}}{\mathrm{Nm+Nf}}$$

And the rate of inbreeding per generation was calculated as $\Delta \mathrm{F} = \frac{1}{2\mathrm{Ne}}$

Where Nm is the number of above six month age breeding cocks, **Nf** is the number of above six month age breeding hens and **Ne** is effective population size.

3.3.3 Observational and body measurements

3.3.3.1 Qualitative traits

From direct observation on sexually matured chicken and additional information of the owner, a total of 464 six-month or older chicken (279 from midland and 185 from highland agro ecology) were used to collect qualitative data such as plumage color, comb type, feather morphology, feather distribution, presence or absence of spurs, shank color, earlobe color, eye color and head shape based on standard format breed descriptor list (FAO, 2012). The data on morphological traits were collected by taking a picture of each surveyed bird.

3.3.3.2 Quantitative traits

A total of 457 adult chickens (357 female and 100 male) six month or older in age matured chicken were used based on the proportion of the poultry population of the selected districts to collect quantitative variables. Based on the methodology developed by FAO (2012), linear body measurement like body weight, breast width, thigh circumference, chest circumference, shank length (SL), neck length (NL), body length (BL), wing length, wingspan, wattles width, wattles length, ear lobes width, ear lobes length, beak length (BKL), beak width, comb length (CL), comb width, height at back were measured by using a textile measuring tape to the nearest unit centimeter.

Body and shank lengths were measured using a graduated tape while the bird was standing upright and body weight was measured in kilogram using sensitive balance.

3.4 Statistical model and data analyses

3.4.1 Statistical model

General linear model was used to evaluate the effect of sex and agro-ecology on the quantitative traits of each prevailing local chicken types at each district separately.

$Y_{ijk} = \mu + A_i + B_j + AB_{ij} + e_{ijk}$

Where Y_{ijk}: the corresponding quantitative trait of local chicken in i^{th} agro-ecology (i=2, midland & highland) of j^{th} sex (j= 2, male and female)

μ: overall population mean for the corresponding quantitative trait

$A_{i:}$ effect of i^{th} agro-ecology

$B_{j:}$ effect of j^{th} sex (j=2, male & female)

AB_{ij}: agro-ecology & sex interaction effect and e_{ijk}: residual error

3.4.2. Data analyses

3.4.2.1. Questionnaire data

Survey data were analyzed using descriptive statistics by Statistical Package for Social Sciences (SPSS 16.0 for windows, release 16.0, 2006).General linear model was employed to investigate the effects of agro-ecology in the study districts on household characteristics and various performance related parameters of chickens. Chi-square test was employed to variables describe in percentage across agro ecologies.

3.4.2.2. Ranking of breeding objective and farmers' trait preferences

Ranking analyses were used for computing data on breeding objective, farmers' traits preferences, and conformation traits as related to selection of chicken. Indexes were used to calculate data collected from rankings using weighed averages by the following formula employed by Musa *et al.* (2006).

$$Index = \frac{\sum(\mathrm{Rn} \times \mathrm{C1} + \mathrm{Rn}-1 \times \mathrm{C2} \ldots\ldots + \mathrm{R1} \times \mathrm{Cn}) \text{ for individal variable}}{\sum(\mathrm{Rn} \times \mathrm{C1} + \mathrm{Rn}-1 \times \mathrm{C2} \ldots\ldots + \mathrm{R1} \times \mathrm{Cn}) \text{ for } all\ variable}$$

Where, R_n = the last rank (example if the last rank is 8^{th}, then $R_n = 8$, $R_{n-1} = 7$, $R_1 = 1$).

C_n = the % of respondents in the last rank, C_1 = the % of respondents ranked first Index was ranked using auto ranking with MS-Excel 2007.

In own flock ranking experiment, the proportion of traits preferred by the farmers and occurred at field during study were analyzed by the frequency procedure. The body measurements and other traits from the life history obtained from own flock ranking were analyzed by GLM procedure.

3.4.2.3. Qualitative morphological data

Descriptive statistics were used to analyze qualitative traits (plumage colour, body shape, comb type, feather morphology, feather distribution, presence or absence of spurs, shank colour, earlobe colour, eye color and head shape) of the local chicken ecotypes for each district and agro-ecology.

3.4.2.3. Quantitative morphological data

Morphological traits that show quantitative characteristics were subjected to analysis of variance using the general linear model procedure (PROC GLM) of SAS 9.1 to determine the effects of agro-ecology, sex and their interaction.

Multivariate analyses were used to investigate the morphological structure and quantify differences among the sub-populations. From the correlation matrix, data were generated for the principal component factor analysis to transform the correlated quantitative traits to orthogonal quantitative traits (Everitt *et al.*, (2001). Cumulative proportions of variance criterion were employed in determining the number of principal components to extract.

Stepwise discriminate procedure was applied using PROCSTEPDISC to determine which morphological traits have more discriminate power than the others or to gain information about traits particularly important in the separation of sub-populations for eventual use in cluster analysis. Canonical discriminant analysis using CANDISC procedure was employed to calculate the Mahanobis distance between chickens of the agro-ecology and to obtain the function of all traits necessary for the separation of sub-populations. The degree of morphological similarity or divergence between the chicken were determined using wards option of PROC CUSTER procedures. Hierarchical cluster methods were used to group morphological similarity or divergence of the local chickens of the agro-ecology with the aid of dendrogram. The analyses were performed by taking individual birds as a unit. In order to avoid potential sampling bias due to low number of males in the study, only female birds were considered in discriminant analysis.

4. RESULTS AND DISCUSSIONS

4.1. Socioeconomic characteristics of respondents

Household size and age structure of the study households' is presented in Table 2. The overall mean family size of sample households was 6.29 and ranged from 1-10. This value was higher than the national average of 5.2 persons and that of SNNPRS 5.1 persons per household (CSA, 2003).

The age composition of households typically resembled population pyramid in most developing countries, with the majority of household members being children under 14 years of age (Speizer *et al.,* 2015). Similarly, in the study area children (<15 years old) accounted for 39% while that of youth male and female (age class of 16-30) accounted for 34% of the total household size, youth male and female (age class of 31-60) accounted for 25% of the total household size. Husband, wife and other members of the family above 60 years old covered the remaining proportions. In the study village, the households' age group <30years covers 73%,showing that the productive labor necessary for care, marketing and management of chicken production was dominant in the family.

General characteristics of the respondents presented in Table 2. About 38% of the interviewed farmers were female, while 62% were male. The overall mean age of respondents was 44.7years. Concerning the educational background of the interviewed farmers, about 36% were illiterate, 47.1% literate, 13.2% can read and write and 3.7% learn from religious school. Among the literate members, 28.9%, 15.7% , 1.7% and 0.8% had gone through primary first cycle (1-6), Junior & high school (6-12), diploma and degree, respectively.

The overall mean of land size per household in the study area was 0.58 hectare (range of 0–2.5 ha). The result was lower than the 1.0 ha reported from lowland and midland of central Tigray (Alem *et al.,* 2013) and 1.22 ha (Fisseha *et al.,* 2010) and 1.28 ha/household reported from North-west Amhara (Halima *et al.,* 2007) and the National land holding of 1.02 ha/household and the 0.86 ha/household reported from South Ethiopia by Mekonen (2007). There was

significant difference ($p<0.0001$) in farm land size/household between the agro-ecologies of the study areas.

Table 2. Household characteristics of respondents in the study area

Variable	Agro ecology Midland(124)	Highland(118)	Over all (242)
Sex Male	73 (58.9%)	77 (65.3%)	150 (62%)
Female	51 (41.1%)	41 (34.7%)	92 (38.0%)
Family size (mean ± SD)			
<15years	2.56±1.68	2.36±1.65	2.47±1.66
15-30 years	2.06±1.62	2.15±1.50	2.11±1.56
31-60 years	1.55±0.86	1.57±.80	1.56±0.83
> 60 years	0.22±0.49	0.11±0.31	0.17±.41
Total family size	6.35±2.22	6.23±2.36	6.29±2.29
Average Age	44.6±13.59	44.84±11.24	44.71±12.47
Average land holding	0.76±0.46	0.41±0.36	0.58±0.82
Educational status in n(%)			
Illiterate	55 (44.4%)	32 (27.1%)	87 (36.0%)
Religious school	4 (3.2%)	5 (4.2%)	9 (3.7%)
Writing & reading	16 (12.9%)	16 (13.6%)	32 (13.2%)
Primary (1-6)	32 (25.8%)	38 (32.2%)	70 (28.9%)
Junior&high school(8-12)	16 (12.9%)	22 (18.6%)	38 (15.7%)
Diploma	1 (0.8%)	3 (2.5%)	4 (1.7%)
Degree	0 (0.0%)	2 (1.7%)	2 (0.8%)

Number in bracket is referred to total number of respondents

4.2. Livestock ownership per households

4.2.1. Flock/herd Size and Species Composition

The mean values for livestock holding per household are presented in Table 3. The mean flock and herd size per household were 9.20 for chicken, 3.73 for goat, 0.07 for camel, 3 for cattle, 3.43 for sheep, 0.31 modern bee hives, 0.25 traditional bees and 0.89 for donkey. Among the large livestock species, cattle dominate in both midland and highland agro ecologies and the majority of the farmers used them as source of draught power and for milk. The average cattle holding/household is 2.41 and 3.61 in midland and highland agro ecologies, respectively. The average household of small ruminants holding is (sheep and goat) is 4.72 and 2.08 and 3.32, 4.16

animals for midland and highland agro ecology, respectively. Village chicken production seems to be an important activity in all study areas as indicated by the high average chicken holding per household of 9.41 and 8.98 for midland and highland agro ecologies, respectively.

Table 3. Ratio livestock holding in house hold in the study area (Mean ±SD)

Variable	Agro ecology		Over all (242)	F Value	P value
	Midland(124)	Highland(118)			
Goat	3.32±4.38	4.16±13.08	3.73±9.65	2.50	0.115
Donkey	0.94±0.72	0.84±1.01	0.89±0.88	0.86	0.354
Cattle	2.41±1.77	3.61±2.25	3.00±2.10	7.28	0.007
Chicken	9.41±5.84	8.98±5.55	9.20±5.69	10.41	0.0014
Sheep	4.72±5.53	2.08±2.76	3.43±4.59	21.64	<0.0001
Camel	0.13±0.34	0.02±0.13	0.07±0.26	11.46	0.0008
Modern bee hives	0.22±0.75	0.40±0.87	0.31±0.81	3.01	0.084
Traditional beehives	0.11±0.43	0.4±1.31	0.25±0.98	5.26	0.0227

Number in bracket is referred to total number of respondents

4.2.2. Flock structure and composition

4.2.2.1. Flock Size

The overall mean average chicken flock size per household was 9.2 birds with 9.41 in midland and 8.98 in highland agro ecology of the central zone of Tigray with a sex ratio of three hens for one cock. The result was higher than 5.6 and 8.00 chicken/ household reported for Tigray region (Alem *et al*., 2013; Solomon 2008), the 7.13 chicken/household reported in North West Ethiopia Halima *et al.* (2007) , The current result was, however, lower than12-13 chicken/household reported from other regions of Ethiopia (Fisseha *et al.,* 2010; Hunduma *et al.,* 2010), and those reported 23.1 chickens/household in Pakistan and 13.9 birds per household in Nigeria (Farooq *et al.,* 2004; Yakubu, 2010), but almost similar with report 9.22 chickens/household in South Ethiopia (Mekonen, 2007). Scavenging space is the criteria behind the decision of flock size. About 26.9% of the households reared less than 5 birds, 43.4% reared 5- 10 birds, 21.1% reared 11-15 birds and 8.7% reared more than 15 birds (Table 4).

The result of this study revealed that 78.9% of the households were bought chickens from market to obtain starter poultry flocks, 13.6% by inheritance and 5.3% obtained from extension office

(Table 4). There was significant difference ($p<0.05$) in household chicken ownership and source of starter flock among and between the agro-ecologies of the study areas.

Table 4. Flock size of the respondents from midland and highland agro ecology of the study area

Variable	Agro ecology			X^2 Value	P value
	Midland(124)	Highland (118)	Over all(242)		
Household chicken ownership in %				13.652	0.003
2-5	29 (23.4%)	36 (30.5%)	65 (26.9%)		
6-10	59 (47.6%)	46 (39%)	105 (43.4%)		
11-15	24 (19.4%)	27(22.9%)	51 (21%)		
>15	12 (9.7%)	9 (7.6%)	21 (8.7%)		
Source of starter flock in n(%)				9.581	0.022
Purchase	101(81.5%)	90(76.3%)	191(78.9%)		
Inherited	13(10.5%)	25(21.2%)	38(15.7%)		
Extension office	10(8.1%)	3(2.5%)	13(5.4%)		

-Number in bracket is referred to total number of respondents

Flock structure is described in terms of the number and proportion of the different age groups and sex in a flock. The mean values of chickens in different age category and proportion of the respondent owning different size of chickens are shown on Table 4. The numbers of chickens in the household in different age categories vary considerably. The overall mean flock size per household was 9.20 and ranged from 3-46. Highest mean number of hen per household (35.43%) was observed followed by chicks, (32.78%), pullet (15.56%), cockerel (8.69%) and cock (7.53%), respectively (Table5 and Figure2).

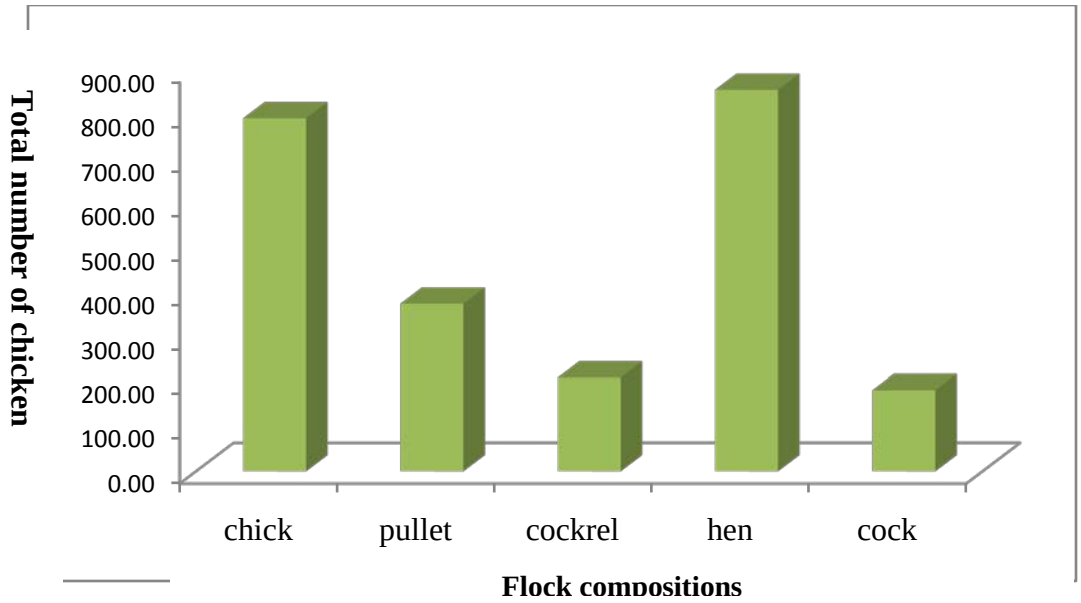

Figure 2. Overall flock structure by number in the study area

Table 5. Flock structure and characteristics of the study area (mean ±SD)

Variable	Agro ecology		Over all	F Value	P value
	Midland	Highland			
Chick	3.11±3.56	3.44±4.00	3.27±3.78	0.04	0.843
Pullet	1.67±1.84	1.43±1.91	1.55±1.88	0.28	0.600
Cockerel	0.98±1.51	0.75±1.71	0.87±1.61	6.07	0.014
Hen	3.68±2.69	3.39±2.20	3.54±2.47	13.46	0.0003
Cock	0.79±1.11	0.71±0.98	0.75±1.05	3.54	0.0613

4.3. Husbandry and marketing practice

4.3.1. Feed resources and feeding practice

The major feeds and feeding practices of chickens in the study area as indicated by the respondents are reported in (Table 6). Almost all of the respondents (90.1%) reported to practice scavenging system with supplementary feeding while the remaining 8.9% don't use supplementary feed due to different reasons. The result of this study was in agreement to that of Meseret (2010), Asefa (2007) and Mekonnen (2007) who reported 95-98% of the small scale household poultry producers in Awassa Zuria, Dale and in Gomma districts offer supplementary feeding to their chickens, 99.28% the farmers in Northwest Ethiopia provided supplementary feeding to their chickens Halima (2007).

About 93.2%, 5% and 1.8% of respondents offer supplement every day, every three day and every other day, respectively. This is in line with report of Alem *et al*. (2013) which stated that 48.7% of the respondents of midland and lowland of central Tigray provide supplement 2 times a day, 41.9% of the respondents provide feed once a day and 9.4% of the respondents provide three times a day to their chickens. According to feed resource 49.1%, 25.9%, 16.8% and 8.2% of the respondent's gate supplementary feed material from harvest and purchase, crop harvest, household and purchased market, respectively and were offered indiscriminately to all classes of chicken on bare ground. Almost all (93.4%) farmers in the study area did not use feed trough, they simply pour the grain on the ground. The remaining (6.6%) farmer's uses plastic made, earthen plot, wooden and stone made materials to feed their chickens. There was no significant difference ($p<0.05$) in supplementary feed providing of the households in highland and midland agro-ecological zones but there was significant difference ($p<0.05$) in source of feeding of in highland and midland agro-ecological zones.

Table 6. Feed resources and feeding practice

Variable	Agro ecology		Over all	X^2	P
	Midland(124)	Highland(118)	(242)	Value	value
Supplementary feed for chicken n (%)				0.537	0.523
Provide supplement	110 (88.7%)	108 (91.5%)	218 (90.1%)		
No provide supplement	14 (11.3%)	10 (8.5%)	24 (9.9%)		
Source of supplementary feed n (%)				51.038	0.000
Purchased from market	3 (2.7%)	15 (13.8%)	18 (8.2%)		
Household leftover	31(27.9%)	6 (5.5%)	37 (16.8%)		
Crop harvest	42 (37.8%)	15 (13.8%)	57 (25.9%)		
Harvest and purchased	35 (31.5%)	73 (67%)	108 (49.1%)		
Frequency of supplementary feed n (%)				1.117	0.572
Every days	104 (93.7%)	101(92.7%)	205 (93.2%)		
Every other days	1 (0.9%)	3 (2.8%)	4 (1.8%)		
Every 3 days	6 (5.4%)	5 (4.6%)	11 (5.0%)		
Form of feed provision n (%)					
By feeder	13 (11.3%)	2 (1.8%)	15 (6.6%)	8.231	0.004
Spreading on the floor	102 (88.7%)	109 (98.2%)	211(93.4%)		
Types of feeder in use n (%)				2.168	0.538
Plastic made	6 (46.2%)	1 (33.3%)	7 (43.8%)		
Earthen pot	3 (23.1%)	1 (33.3%)	4 (25.0%)		
Wooden trough	3 (23.1%)	0.0%	3 (18.7%)		
Stone made	1 (7.7%)	1 (33.3%)	2 (12.5%)		

-Number in bracket refers to total number of respondents

4.3.2. Poultry watering

Water plays an important part in the digestion and metabolism of the fowl in addition it serve as a media to administer some important vaccines. Source of water in wet and dry season was almost similar. The major sources of household water supply in dry season in midland agro ecology of central zone of Tigray are rivers(4.1%), pond(2.5%), springs(1.2%), water well (12.5%) and hand operated pipe water(26%), while in highland the water sources are rivers (6.6%), ponds (2.1%), spring(12.8%), water well(5.8%) and hand pump(9.9%).

About 17.7% of the respondents provided water for their chicken twice a day, 74.2% adlib item (free access) and 8.1% once a day at any time in midland agro ecology while 12.7% of the respondents give twice a day, 50% adlib item (free access) and 37.3% give once a day at any time in highland agro ecology.

Despite variations in source of water and frequency of watering, about 99.2% of respondents have regular watering troughs in midland and highland agro ecologies. In midland, plastic made troughs (29.8%), wooden trough (25%), earthen pot (24.2%), stone made(9.7%) and metal made(11.3%) are the most widely used watering troughs; while in the highland, plastic made troughs (35.6%), wooden trough (18.6%), earthen pot (20.3%), stone made(20.3%) and metal made(5.1%) are common. This is in line with the report of Alem *et al*. (2013) in central Tigray, Mekonen (2007) in Southern Ethiopia; Tesfu (2006) in villages of Diredawa town, Fisseha *et al.*, (2010) in Bure district.

Table 7. Provision of water, watering frequency, sources of water and watering trough

Variable	Agro ecology		Over all	X^2	P value
	Midland(124)	Highland(118)	(242)	Value	
Provision of water in n (%)					
Yes	124 (100%)	118 (100%)	242 (100%)		
Frequency of water provide to chicken n (%)					
Once a day	10 (8.1%)	44 (37.3%)	54 (22.3%)	29.813	0.000
Twice a days	22 (17.7%)	15 (12.7%)	37 (15.3%)		
Adlib item	92 (74.2%)	59 (50.0%	151(62.4%)		
Source of water in dry season n (%)				55.510	0.000
River	9 (7.3%)	16 (13.6%)	25 (10.8%)		
Dam/pond	6 (4.8%)	5 (4.2%)	11 (4.5%)		
Spring	7 (5.6%)	27 (22.9%)	34 (14%)		
Water well	12 (9.7%)	14 (11.9%)	26 (10.8%)		
Hand pump	63 (50.8%)	24 (20.3%)	87 (36%)		
Hand pump, river and rain	27 (21.8%)	32 (27.1%)	58 (23.9%)		
Source of water in wet season n (%)				48.744	0.000
River	9 (7.3%)	18 (15.3%)	27 (10.0%)		
Dam/pond	6 (4.8%)	6 (5.1%)	12 (5.0%)		
Spring	1 (0.8%)	26 (22.0%)	27 (11.2%)		
Rain	5 (4.0%)	3 (2.5%)	8 (3.3%)		
Water well	13 (10.5%)	15 (12.7%)	28 (11.7%)		
Hand pump	44 (35.5%)	21 (17.8%)	65 (27.1%)		
Hand pump, river and rain	46 (37.1%)	29 (24.6%)	75 (26.4%)		
Availability of watering trough n (%)				2.002	0.367
Yes	123 (99.2%)	117 (99.2%)	240 (99.2%)		
No	1 (0.8%)	1 (0.8%)	2 (0.8%)		
Types of watering trough n (%)				9.569	0.48
Plastic made	37 (29.8%)	42 (35.6%)	79 (32.6%)		
Earthen pot	30 (24.2%)	24 (20.3%)	54 (22.3%)		
Wooden made	31 (25.0%)	22 (18.6%)	53 (21.9%)		
Stone made	12 (9.7%)	24 (20.3%)	36 (14.9%)		
Metal made	14 (11.3%)	6 (5.1%)	20 (8.3%)		

-Number in bracket is referred to total number of respondents

4.3.3. Poultry housing systems

Housing is essential to chickens as it protects them against predators, theft, rough weather (rain, sun, cold wind, dropping night temperatures) and to provide shelter for egg laying and broody hen. However, only 56.5% and 75.4% of the respondents in highland and midland of the study area respectively had separate house for their chickens. Among the households who have no separate poultry houses, about 12%, 15.5% and 6.6% of the respondents indicated that their birds perch in the kitchen, veranda and on trees during night time, respectively (Table 8). This result is in line with report of Fisseha *et al.* (2010) in Bure district, North West Ethiopia, with reports of Mengesha *et al.* (2011) in Jamma district, South Wollo, but lower as compare to reports of Halima (2007) reported that 51% of farmers of Northern Ethiopia have separate house for their chickens, but better than Mekonnen (2007) report which reported that there is no specific separate poultry houses in Dale District.

Out of the total households who have night shelter for their chicken around 16.6% of the households made shelters with wooden made with corrugate iron sheet, 50.3% of the house hold made shelter with stone wall+ grass roof or soil and the rest 12.4% made wooden made with grass roof, 16.6% wooden made with corrugate iron sheet and, 4.1% gabion with gabion, respectively. The major reasons for not constructing separate poultry houses in the study areas were lack of knowledge, lack of construction material, risk of predators, because of hot, lack of time, lack of land and because of carelessness, respectively. About 25.7% of the respondents have no special disposal or storage of poultry manure and 74.3% use as fertilizers. None of the households were using poultry manure as animal feed source (Table 8).

Table 8. Poultry housing system of the study areas

Variable	Agro ecology		Over all	X^2	P
	Midland(124)	Highland(118)	(242)	Value	value
Place of chickens kept at night in n (%)				17.377	0.004
Separate shelter	70 (56.5%)	89 (75.4%)	159(65.7%)		
Perch in the kitchen	18 (14.5%)	11 (9.3%)	29 (12%)		
Perch on the veranda	22 (17.7%)	16 (13.6%)	38 (15.7%)		
Perch on trees	14 (11.3%)	2 (1.7%)	16 (6.6%)		
Types of poultry house in n (%)				18.377	0.003
Stone wall+ grass roof or soil	31 (41.3%)	54 (57.4%)	85 (50.3%)		
Stone made with corrugated iron	18 (24.0%)	10 (10.6%)	28 (16.6%)		
Wooden made with grass roof	7 (9.3%)	14 (14.9%)	21 (12.4%)		
Wooden made with corrugated iron	12 (16.0%)	16 (17.0%)	28 (16.6%)		
Gabion with gabion	7 (9.3%)	0.0%	7 (4.1%)		
Reason for not to have poultry house n(%)				16.572	0.020
Lack of knowledge	19 (38.8%)	5 (2.2%)	24 (32.0%)		
Lack of construction material	12 (24.5%)	6 (2.7%)	18 (24.0%)		
Risk of predators	5 (10.2%)	10 (4.5%)	15 (20.0%)		
Lack of time	2 (4.1%)	0.0%	2 (2.6%)		
Because of hot	10 (20.4%)	1 (0.4%)	11 (17.3%)		
Because of carelessness	1 (2.0%)	0.0%	1 (1.3%)		
Lack of land	0.0%	2 (0.9%)	2 (2.7%)		
Days of cleaning the house in n (%)				5.806	0.214
Daily	64 (51.6%)	54 (45.8%)	118(49.6%)		
In three day	17 (13.7%)	25 (21.2%)	42 (17.6%)		
Weekly	39 (31.5%)	33 (28.0%)	72 (30.3%)		
Monthly	1 (0.8%)	3 (2.5%)	4 (1.7%)		
No clean	3(2.4%)	3(2.5%)	6 (0.8%)		
Methods of dispose manure of chicken in n(%)				0.731	0.392
No special disposal	29 (23.4%)	34 (27.4%)	63 (25.7%)		
Use as fertilizer	95 (76.6%)	84 (67.6%)	179(74.3%)		

-Number in bracket is referred to total number of respondent

4.3.4. Egg Storage and incubation practice

Results on hatchability and brooding performance of indigenous hens are presented in Table 9.The study revealed that in midland and highland agro ecologies of the study area, 66.1% of the farmers collect the egg daily, 18.5% and 25.4% collect every two day, 12.1% and 8.5% collect

every three day and 3.2% do not collect until incubation. It seems that storing of eggs with grain and keeping eggs for sell and for incubation separately were a relatively more common practice in the study area. Thus, the study revealed that, 75.8% and 36.8% of them stored the egg in safe container mixed with grains, 13.7% and 8.5% stored mixed with flour, 9.7% and 9.3% stored in any available material that could be grass made or plastic made container in midland and highland agro ecology of the study area, respectively (Table 9).

Farmers in the study area also seem to have good practice of selecting eggs and hens for incubation based on different criteria. A very large proportion (87.6%) of the respondents selected eggs for incubation purposely looking on the size of the eggs, 58.4% looking on the size of the egg and cleanness of eggs, 12.7% looking on the shape of the eggs, 1.4% looking on crack of the eggs, 3.2% looking on age of the eggs, 9.5% looking on size of the egg, shape and cleanness of the eggs.

About 59.1% of the households mix eggs for incubation obtained from different hens. A variety of local materials were used for incubation in the study area which aimed at providing comfortable incubation environmental conditions for broody hens in the study area. Most of the farmers (77.7%) are used mud container, 8.7% used clay made container, 7.0% used carton made and 2.1% used plastic material (Meseben) while the rest set the eggs on the ground with sand by spraying water and on window (Meskot). There was significant difference ($P<0001$) in use of material and bedding materials for incubation between the households living in highland and midland agro-ecological of the study area.

Straw was commonly used as bedding material in highland and midland covered 48.4% and 70.2% of the households whereas cow and or goat dung 16.1% and 14.5% and the rest of the households used sand cloth soil and bran (nifay) as bedding materials in midland and highland agro-ecology, respectively. According to the key informants in the group discussion straw and sand was used almost by all farmers as bedding material to keep the environmental temperature low and to protect egg from damage. In the study area broody hens (96.7%) were the only means of incubation and rearing chicks at household level except 3.3% use hay box for rearing chickens (Table11).

Similarly Markos *et al.* (2014) reported that clay pots with grasses(straw) bedding (1%), ground with soil/sand/ash/cow dung/chopped grasses /straw/sand filled sack bedding(15.6%), bin with grasses/straw/cotton seed/sand & feather of brooding hen/sack sand /clothes/cow dung and

straw/ bedding (68.8%), plastic with grasses (straw)/soil(sand)/soil or sand/ bedding (7.8%), or plastic and bin with grasses /soil/ clothes bedding alternatively (1%) were used as egg setting materials in western zone of Tigray. This result is also in agreement with Tadelle *et al.* (2003a) who reported that clay pots, bamboo baskets cartons or even simply a shallow depression in the ground are common materials and locations used as egg setting sites, and crop residues of Tef, wheat and barley straws were used as bedding materials in five different agro-ecological zones of Ethiopia.

Table 9. Frequency of egg collection and storage of the study area

Variable	Agro ecology		Over all (242)	X^2	P
	Midland(124)	Highland (118)		Value	value
Frequency of egg collection				5.879	0.118
Every day	82 (66.1%)	78 (66.1%)	160 (66.1%)		
Every 2 days	23 (18.5%)	30 (25.4%)	53 (21.9%)		
Every 3 days	15 (12.1%)	10 (8.5%)	25 (10.3%)		
Not collected until incubation	4 (3.2%)	0.0%	4 (1.7%)		
Storage of eggs used for incubation and hatching purpose				12.06	0.61
In grain	94(75.8%)	97(82.2%)	191(78.9%)		
In flour	17 (13.7%)	10 (8.5%)	27 (11.2%)		
Put in straw	9 (7.3%)	8 (6.8%)	17 (7.0%)		
In plastic container	3 (2.4%)	3 (2.5%)	6 (2.5%)		
Mix with dung	1 (0.8%)	0.0%	1 (0.4%)		
Reason for egg storage				4.346	0.361
Not to be infertile (Keygodil)	104 (83.9%)	101(85.6%)	205 (84.7%)		
To maintain normal size	9 (7.3%)	8 (6.8%)	17 (7.0%)		
To cool	6 (4.8%)	1 (0.8%)	7 (2.9%)		
Not to broken	5 (4.0%)	8 (6.8%)	13 (5.3%)		
Place of eggs storage used for home consumption				7.639	0.177
In grain	82 (66.1%)	77 (65.3%)	159 (65.7%)		
In flour	17 (13.7%)	13 (11.0%)	30 (12.4%)		
Put in straw	11 (8.9%)	7 (5.9%)	18 (7.4%)		
In plastic container	14 (11.3%)	16 (13.6%)	30 (12.4%)		
In any container	0.0%	5 (4.2%)	5 (2.1%)		
Duration of eggs storage before incubation in dry season				16.844	0.001
One week	23 (18.5%)	8 (6.8%)	31(12.8%)		
Two week	47 (37.9%)	33 (28.0%)	80 (33.1%)		
Three week	23 (18.5%)	21 (17.8%)	44 (18.2%)		
Until incubation	31 (25.0%)	56 (47.5%)	87 (36.0%)		

Number in bracket is referred to total number of respondents

Table 10. Duration of egg storage, criteria of egg collection and materials used during incubation of the study area

Variable	Agro ecology		Over all	X^2	P
	Midland (124)	Highland (118)	(242)	Value	value
Duration of eggs storage before incubation in wet season				20.636	0.000
One week	18 (14.5%)	0.0%	18 (7.4%)		
Two week	21 (16.9%)	22 (18.6%)	43 (17.8%)		
Three week	40 (32.3%)	35 (29.7%)	75 (31.0%)		
Until incubation	45 (36.3%)	61 (51.7%)	106(43.8%)		
Do you mix eggs obtained from different hens				1.902	0.168
Yes	68 (54.8%)	75 (63.6%)	143(59.1%)		
No	56 (45.2%)	43 (36.4%)	99(40.9%)		
Do you select eggs before incubation				14.118	0.000
Yes	99 (79.8%)	113 (95.8%)	212(87.6%)		
No	25 (20.2%)	5 (4.2%)	30(12.4%)		
Criteria of egg selection practice				12.104	0.097
Size of the egg	64 (61.5%)	66 (56.4%)	130(58.9%)		
Shape of the egg	1 (1.0%)	2 (1.7%)	3 (1.4%)		
Cleanness of the egg	9 (8.7%)	3 (2.6%)	12 (5.4%)		
Broken(cracks)	1 (1.0%)	6 (5.1%)	7 (3.2%)		
Age	12 (11.5%)	9 (7.7%)	21 (9.5%)		
Size and clean of the egg	11 (10.6%)	17 (14.5%)	28 (12.7%)		
Size, shape and clean of the egg	6 (5.8%)	14 (12.0%)	20 (9.0%)		
Material used during incubation				26.578	0.002
Mud container	102 (82.3%)	85 (72.0%)	187(77.2%)		
Clay	10 (8.1%)	11 (9.3%)	21 (8.7%)		
Wooden	4 (3.2%)	3 (2.5%)	7 (2.9%)		
Carton (bako)	1 (0.8%	16 (13.6%)	17 (7.0%)		
Plastic material (meseben)	4 (3.2%)	1 (0.8%)	5 (2.1%)		
Window (meskot)	2 (1.6%)	2 (1.7%)	4 (1.7%)		
Under hole with sand by spraying water	1 (0.8%)	00.0%	1 (0.4%)		

-Number in bracket is referred to total number of respondents

Table 11. Bedding materials, brooding method and brooding behaviors of chicken

Variable	Agro ecology		Over all (242)	X^2 Value	P value
	Midland(124)	Highland(118)			
Kind of bedding material used during the incubation of eggs				44.800	0.000
Straw, buqbuq	60 (48.4%)	87(70.2%)	147(60.7%)		
wood Ash(Hamekushti)	0.0%	4 (3.2%)	4 (1.7%)		
Cow and or goat dung	20 (16.1%)	18 (14.5%)	38 (15.7%)		
Soil	5 (4.0%)	0.0%	5 (2.1%)		
Sand	38 (30.6%)	4 (3.2%)	42 (17.4%)		
Cloth	1 (0.8%)	2 (1.6%)	3 (1.2%)		
Bran(Nifay)	0.0%	3 (2.4%)	3 (1.2%)		
Methods used for brooding and rearing chickens				4.794	0.091
By brooding hen	121(97.6%)	113(95.8%)	234(96.7%)		
Hay box brooder	3 (2.4%)	5 (4.2%)	8 (3.3%)		
Broodiness behavior in of the hens				23.755	0.000
Common	94 (75.8%)	55 (46.6%)	149(61.6%)		
Sometimes	24 (19.4%)	54 (45.8%)	78 (32.2%)		
Rare	6 (4.8%)	9 (7.6%)	15 (6.4%)		

-*Number in bracket is referred to total number of respondents*

4.3.5. Diseases and predation

In the study area about 93.8% of the respondents confirmed the presence of dangerous disease outbreak in the midland and highland agro ecologies of the study areas. They reported that access to veterinary services appeared to be quite limited. Out of the total participants, only 2.5% reported of getting advisory services; while 97.5% of the respondents have not gate services (Table 12). Similarly, Abdelqader *et al.* (2007) reported that only 5% of the farmers accessed veterinary extension service; 12% of respondents practiced annual vaccination against New Castle disease and infectious bronchitis in Jordan. (Aberra, 2010) and Bushra Badhaso (2012) also reported that diseases are the major limiting factor to rural household poultry production system and their results are in agreement with the current reported.

The availability of vaccines and veterinary drugs in the study area is generally low. Lack of awareness about vaccines and vaccination (20%), lack of access of vaccination (42.6%), lack of information about availability of vaccine (17.4%), and lack of attention (20%) are the major reasons for the wide prevalence of diseases (Table 12).

There is need for a serious intervention in disease control and advisory services in order to minimize losses and improve chicken production and productivity. Further studies are needed on the identification of diseases in order to formulate effective preventive and control programs. Such limited coverage of veterinary services could negatively impact the development of poultry production in the area and deserve requisite attention from all concerned bodies. Strengthening disease prevention measures and overcoming reducing other causes of chicken mortality will, not only help to improve production and reproduction performance, but also conserve superior germ plasm useful for genetic improvement through selection or other means of improvement.

Predation is also an economically important constraint in village chicken production system in midland and highland agro ecologies of the study areas. This result is in line with report of Halima (2007) that predation is one of the major constraints in village chicken production in northwest Ethiopia. In midland agro ecology about 32.4% of the respondents indicated that wild cat is a dangerous predator, eagle followed by snake, dog, domestic cat and honey burger (locally called Titig). While in highland agro ecology eagle (34.6%), wild cat (32.9%), wild Egyptian Vulture (locally called Gedigedey) (11.7%) are the main important predators (Table 13). keeping the chickens inside a house, especially when there is no family member who looks after them could reduce mortality due to predators. This result is in agreement with report of Tadelle and Ogle (2001) that the predators include primarily birds of prey such as vultures, which prey only on chicken and wild mammals such as cats and foxes, which prey on mature birds as well as chicks are an important predators in Ethiopia. Hunduma *et al.* (2010) also reported that predators such as birds of prey (locally known as “Culullee”) (34%), cats and dogs (16.3%) and wild animals (15%) were identified as the major causes of village poultry in rift valley of Oromia, Ethiopia.

Table 12. Disease, vaccination availability and action taken

Variable	Agro ecology				Over all (242)		X^2 Value	P value
	Midland(124)		highland(118)					
	N	%	N	%	N	%		
Availability of poultry disease in the area							0.28	0.867
Yes	116	93.5	111	94.1	227	93.8		
No	8	6.5	7	5.9	15	6.2		
Poultry vaccination availability							1.936	0.380
Yes	3	2.4	3	2.5	6	2.5		
No	121	97.6	115	97.5	236	97.5		
Reason for not vaccinated of chicken							54.758	0.000
Lack of attention	40	33.1	9	7.8	49	20.0		
No access	24	19.8	73	63.5	97	42.6		
Lack of awareness	26	21.5	24	20.9	50	20.0		
No information about availability of vaccine	31	25.6	9	7.8	40	17.4		
Measures taken for sick chickens							49.517	0.000
Take to vet	18	14.9	4	3.4	22	9.2		
Treat by them self	74	61.2	67	57.3	141	59.3		
Slaughter for home consumption	4	3.3	16	13.7	20	8.4		
Sell to market	4	3.3	0	0.0	4	1.7		
No action	8	6.6	30	25.6	38	16.0		
Throw	11	9.1	0	0.0	11	4.6		
Take to vet and treat them	2	1.7	0	0.0	2	0.8		

-Number in bracket is referred to total number of respondents

-N refers to number of respondents

Table 13. Types and frequency of poultry predators in the study areas

Predators	Agro ecology				Over all (242)		X^2 Value	P value
	Midland(124)		Highland(118)					
Availability of predator	N	%	N	%	N	%		
Yes	111	90.2	110	94.0	221	92.1	1.171	0.279
No	12	9.8	7	6.0	19	7.9		
Types of predator available								
Wild cat	101	32.4	98	32.9	199	82.2		
Eagle	101	32.4	103	34.6	204	84.3		
Snake	53	17.0	34	11.4	87	36.0		
Dog	22	7.1	8	2.7	30	12.4		
Domestic cat	21	6.7	18	6.0	39	16.1		
Honey burger(titig)	14	4.5	2	0.7	16	6.6		
Wild Egyptian Vulture (Gedigedey)	0	0.0	35	11.7	35	14.5		

-Number in bracket is referred to total number of respondents

4.3.6. Marketing of chicken and egg

Based on the study results, most of the interviewed village chicken owners (81%) participate in chicken and egg marketing. Sale of chicken and egg is an important source of income. Chicken and egg are sold in wereda market (76.5%) followed by nearest market (12.2%) and neighborhood (6.6%). Farmers on average travel 6.8 km (ranged 1–30 km) in midland and 8.8 km (ranged 2–30 km) in highland agro ecology to reach the wereda towns and sale their chicken. This results was in agreement with reports of Markos (2014) who reported that 99.7% of the respondents had participated in selling of chicken products in either of wereda market (9.6%) or both same village and wereda market (90.4%) in highland , midland (3.1% and 28.2%) and lowland (3.3% and 1.2%) in western zone of Tigray. Similarly, this result is in line with finding of Bogale (2008) reported that 41.7% and 33.3% of the respondents sold their chicken products in the nearest market and wereda market during market days while 19.4% sold their products within their respective kebeles during non-market days in Fogrea districts. This result is in line with finding of Meseret (2010) reported that chicken products were sold either at the farm gate, primary market (small village market) or at secondary market (at large wereda town) in Gomma wereda of Jimma zone. This result is in line with finding of Jordan, Abdulkadir (2007) reported that farmers sold chickens to their neighbors and in the main markets to other farmers and middle men.

Concerning means of transportation of chicken to markets, the majority (74.5% in midland, 56.7% in highland) of the farmers transported on foot carrying their chicken by embracing by hand, hanging by hand upside down on a piece of stick upside down and in chicken transportation coop, (22.6% in midland, 35.6% in highland) of the farmers uses car and the remaining uses both car and foot as means of transportation. Due to the risk of breakage of eggs, farmers use different methods for transporting eggs to markets. For example, in midland and highland about 32.5% and 42.1% of the farmers had carry eggs using different material filled with straws (63.4%), filled with grain (31.7%) and the other with plastic container. In addition to its use in storage of eggs until incubation and or marketing, the grain/straw also used to protect eggs from breakage during transportation (Table 14).

About 21% and 29.1% of respondents from midland and highland areas respectively attributed the demand for chicken as very high and the corresponding 58.9% and 53.8% attributed chicken demand as high and 20.2% and 17.9% as medium. Similarly respondents also reported price differences for chicken between midland and highland areas. Fore stance about 71% and 65% of respondents in midland and highland areas, respectively, reported that chicken price is very high about 28.2% of respondents in midland and 32.5% in highland reported chicken price as high. In addition about 93.2% of respondents in midland and highland agro ecologies reported that chicken price has been increasing. Details of mode of transportation demand for chicken and chicken products, price of chicken in midland and lowland and chicken price trend are shown in Tabele15.

Table 14. Marketing and methods of transportation of eggs of the study area

Variable	Agro ecology						X^2 Value	P value
	Midland (124)		Highland(118)		Overall(242)			
	N	%	N	%	N	%		
Sell egg							0.054	0.817
No	32	25.8	32	27.1	64	26.40		
Yes	92	74.2	86	72.9	178	73.60		
Place of sell							5.833	0.054
Wereda market	77	80.2	60	64.5	137	72.50		
Neighbor-hood	8	8.3	14	15.1	22	11.60		
Nearest market	11	11.5	19	20.4	30	15.90		
Methods of transportation chicken							47.640	0.000
Embracing by hand	68	54.8	19	16.4	87	36.20		
Hanging by hand upside down	40	32.3	78	67.2	118	49.20		
In basket	3	2.4	12	10.3	15	6.20		
By car	11	8.9	5	4.3	16	6.70		
Hanging by hand upside down and by car	2	1.6	2	1.7	4	1.70		
Methods of transportation egg							16.608	0.000
Egg with grain	39	31.7	14	12.0	53	22.00		
Egg with straw	78	63.4	101	86.3	179	74.60		
In plastic container	6	4.9	2	1.7	8	3.30		

-Number in bracket is referred to total number of respondent-N refers to number of respondents

Table 15. Marketing methods of transportation and quality specification of chickens of the study areas

Variable	Agro ecology				Over all (242)		X^2 Value	P value
	Midland(124)		Highland(118)					
	N	%	N	%	N	%		
Do you sell chicken							1.369	0.242
Yes	104	83.9	92	78.0	196	81.0		
No	20	16.1	26	22.0	46	19.0		
Place of selling chicken							24.543	0.000
Wereda market	91	87.5	59	64.1	150	76.5		
Neighborhood	5	4.8	8	8.7	13	6.60		
Nearest market	2	1.9	22	23.9	24	12.2		
Nearest market and neighborhood	6	5.8	3	3.3	9	4.60		
Means of transportation							7.518	0.023
On foot	79	74.5	51	56.7	130	66.3		
By car	24	22.6	32	35.6	56	28.6		
On foot and rarely by car	3	2.8	7	7.8	10	5.10		
Demand of poultry and poultry product							3.211	0.360
Very high	26	21.0	34	29.1	60	24.80		
High	73	58.9	63	53.8	136	56.20		
Medium	25	20.2	21	17.9	45	18.60		
Price of chicken							2.854	0.415
High	35	28.2	38	32.5	73	30.20		
Very high	88	71.0	76	65.0	164	67.80		
Medium	1	0.8	4	3.4	4	1.70		
Poultry price trend							5.352	0.069
Increasing	116	93.5	109	93.2	225	93.40		
Decreasing	4	3.2	8	6.8	12	5.00		
Stable	4	3.2	0	0.0	4	1.70		

-N refers to number of respondents

The result of the survey indicated that almost all the respondents' reported that the price of live chickens varies based on different determinant factors. According to the result of 'interview plumage color (20.30%), comb type (8.30%), sex of chicken (5.80%), shank color (4.10%), breed (5.0%), plumage color and comb type (14.50%) and smoothness of shank, comb type, plumage color and body size (14.10%) were the major factors that cause variation in the price of live chickens in the study area(Table 16).

This result is in line with finding of Markos (2014) who reported that plumage color, body weight, comb type, shank color, smoothness of shank, sex, spur presence, length of legs, head shape and market site were the major factors that cause variation in the price of live chickens in western zone of Tigray. Similarly, the current result is in line with reports of Bogale (2008). The author reported that plumage color, comb type, plumage color and comb type, body weight, age, sex and seasons were relevant factors that brought variations on the price of live chickens at market level in Fogera district and Addisu *et al.* (2013) also reported that the prices of live chickens were determined based on body weight (41.83%), combination of comb type and plumage color (32.35%) and plumage color (25.82%) in buying and selling marketing system in North Wollo zone of Ethiopia. The current finding was also in agreement with reports of Reta (2009); Tadelle and Ogle (2001); Fisseha *et al.* (2010).

Table 16. Price determinant factor of chicken of the study area

Variable	Agro ecology						X^2 Value	P value
	Midland(124)		Highland(118)		Overall(242)			
	N	%	N	%	N	%		
Determinant factor that affect chicken price							35.788	0.001
Plumage color	25	20.2	24	20.5	49	20.30		
Comb type	3	2.4	17	14.5	20	8.30		
Sex of chicken	3	2.4	11	9.4	14	5.80		
Shank color	5	4.0	5	4.3	10	4.10		
Breed	7	5.6	5	4.3	12	5.00		
Plumage color and comb type	18	14.5	17	14.5	35	14.50		
smoothness of shank, comb type, plumage color and body size	25	20.2	9	7.7	34	14.10		
Plumage color, comb type and shank color	22	17.7	10	8.5	32	13.30		
Plumage color and shank color	3	2.4	0	0.0	3	1.20		
Plumage color and sex	7	5.6	8	6.8	15	6.20		
Breed and plumage color	1	0.8	1	0.9	2	0.80		
Body size	0	0.0	2	1.7	2	0.80		
Sex and shank color	5	4.0	4	3.4	9	3.70		
Weight and plumage	0	0.0	2	1.7	2	0.80		
Comb and shank	0	0.0	2	1.7	2	0.80		

-Number in bracket is referred to total number of respondents

-N refers to number of respondents

4.4. Production and Reproduction traits of local chickens

Table 17 shows least square means for various production and reproduction performance variables of local chicken populations in the study area. The results of the present study show that the overall mean age at first mating of male chickens and the age at first egg of female chickens were 5.29 and 5.96 months. There was no significant difference between the two agro ecologies with respect to age at first mating and age at first egg in females.

The overall age at sexual maturity obtained in the present study is slightly similar with those reported from other studies in North West Ethiopia 5 month (Halima, 2007) and West Amhara region 6.49month (Worku *et al.,* 2012). The age at first mating for cockerel obtained in the study is in agreement with the 5.71month reported by Markos *et al.* (2015) for male in western zone of Tigray.

Similarly the average age at first egg laying of indigenous chicken was in agreement with findings Halima (2007) who reported that the average age at first egg laying of indigenous young pullets in North West Ethiopia was 5month. The current result e of 5.9-7.1 month reported by stated Habte *et al.* (2013) reported 7.02 months as means age of first egg laying of indigenous pullets in the Nole Kabba wereda of Western Wollega. Age at first egg laying obtained in the current study was lower than the 7.7 month and 6.6 months reported from Mekonnen (2007) in three districts of SNNPR and Addisu *et al.* (2013) in North Wollo zone of Amhara region, respectively. While it is to be recognized that the variation observed both between and within agro ecologies with respect to age at first egg is attributable to both genetic and non-genetic factors the relative contribution of these factors cannot be ascertained at present.

The overall mean of number of clutches per hen per year of local chicken ecotypes was 4.58 with 4.43 in midland and 4.75 in highlands. The relatively large clutch size coupled by the large number of cycles/hen/year contributed to the larger estimated number of eggs per year for midland than highland agro ecology. Differences observed between agro ecology with respect to number of clutches per year might be due to both genetic and environmental differences between the populations. This result was in line with the findings of Markos *et al.* (2015) reported that the

overall mean of number of clutches per hen per year of local chicken ecotypes in western zone of Tigray was 4.42 with 4.57 in midland ecotypes, 4.35 highland and 4.34 in lowland ecotypes. This result was also comparable with the findings of Solomon *et al.* (2013) in which the average number of clutches per hen per year of indigenous chickens in Metekel zone of North West Ethiopia was 4.29. However, it was higher as compare with reports of Meseret (2010), Mekonnen (2007), Worku *et al.* (2012) and Addisu *et al.* (2013) in which the mean clutch number of indigenous chickens in Gomma wereda, three districts of SNNPRs, West Amhara region and North Wollo zone of Amhara regional state of Ethiopia was 3.43/year, 3.8/year, 3.24/year and 3.62/year.

It was also observed that highland and midland agro ecologies differed with respect to both clutch length and inter-clutch period. The mean values obtained in the present study were 17.8 and 14.0 days for clutch length and inter-clutch period. These values were much lower than those reported by Fisseha *et al*. (2010) for clutch length and inter-clutch period reported in Ethiopia, which were 26.2 and 25.6 days.

The overall number of eggs/hen per clutch in the present study was 15.20. However, there were no significant differences observed between agro ecologies with respect to this variable. These results were higher than those reported by Meseret (2010), Addisu *et al.* (2013), Wondu *et al.* (2013) and CSA (2003) in which the mean egg number laid per clutch per hen of local chickens in Gomma wereda, North Wollo Zone North Gondar Amhara region and Ethiopia were 12.92, 12.64, 11.53, (8-15) and 12 (national average of egg yield/hen/clutch),respectively. But it was lower as compared with findings of Tadelle (2003) 17.7 eggs in five agro-ecological zones of Ethiopia and Bogale (2008) 16.6 eggs in Fogera district.

There was no difference observed between agro ecologies with respect to number of eggs incubated per clutch per hen. The number of eggs incubated in midland and highland agro ecologies were 11.4 and 11.4, respectively. The average number of eggs incubated in the study area was 11.4. It was also observed that there were no significant differences between agro ecologies with respect to number of chick hatched/clutch/hen.

Differences between agro ecologies were observed for hatchability where midland had the highest hatchability (80.49), while highland district had the lowest hatchability (70.91). Other authors (Markos *et al.,* 2015; Mengesha *et al.,* 2008) reported hatchability figures which were within the range observed in the present study. This result was also slightly agreed with the findings of Halima (2007), Habte *et al.* (2013) and Tadelle and Ogle (2001) which reported that the average hatchability of eggs of indigenous chickens under scavenging management condition was 60.7%-82.1%, 82.74% and 81% in North Western of Ethiopia, Nole Kabba wereda of Western Wollega and central highlands of Ethiopia. However, lower results of about 22% hatchability were reported from Gomma wereda by Meseret (2010).

Agro ecology differed with respect to surviving age. Chickens from midland agro ecology tended to survive relatively higher than highland. The average number of chicks weaned was 8.67. The average weaning age observed in this study was closer to those reported by Ssewannyana *et al.* (2008) that associated indigenous hens reared their chicks for quite some time with good mothering ability. No significant differences was observed between agro ecology with respect to number of chicks survived per hen in wet season while significant differences were observed in dry season.

Differences in survival rate for chicks in dry season were observed between midland and highland. The survival rates were 6.85 (73.84%) and 6.58 (70.10%) for midland and highland, with the overall mean survival rates being 6.72 (72.02%). These results reflect high chick mortality rates of 26.16% and 29.9% in midland and highland, respectively. Similarly Markos *et al.* (2015) reported that, in western zone of Tigray the survival rate of chicken to weaning age was 73.06% with chick mortality rates ranging from 26.94% to 29.2% under extensive system. The apparent high chick loss implied in the present study might have been caused by diseases, predators and other factors as it has been reported from other studies on local chicken under extensive system in North West Ethiopia (Halima, 2007).

There is no difference observed between agro ecologies with respect to number of eggs per year per hen. The number of eggs per year per hen in midland and highland agro ecologies was 64.46 and 75.43 eggs. The average number of eggs per year per hen in the study area was 69.6 eggs. This result was higher as compared to reports of Markos *et al.* (2015), Meseret (2010), Halima

(2007), Ayalew and Adane (2013) and Addisu *et al.* (2013) who reported the mean annual egg yield per hen of indigenous chickens in western zone of Tigray, Gomma wereda of Jimma zone, North West Ethiopia, Chagni town in Awi administrative Zone Amhara and North Wollo zone of Amhara were 52.68 eggs, 43.8 eggs, 18-57 eggs, 27-45 eggs and 49.51 eggs. While this result was comparable with reports of Fisseha *et al.* (2010) and Mekonnen (2007) which reports that the mean annual egg yield per hen of indigenous chickens in Bure district and Wonsho district were 60 eggs and 62.95 eggs.

Table 17. Average of some reproductive and productive performance of local hens recalled by respondents of the study areas (Mean ± SD)

Variable	Agro ecology		Over all (242)	P value
	Midland(124)	Highland(118)		
Age at 1st service for cockerel(month)	5.28±1.19	5.30±1.10	5.29±1.14	0.8332
Age at 1st egg laying of hen(month)	5.90±1.17	6.03±1.00	5.96±1.09	0.4540
Number of clutch per year of local chicken	4.43±1.28	4.75±2.22	4.58±1.80	0.0366
Number of egg per clutch of local chicken	14.55±3.39	15.88±3.22	15.20±3.37	0.3525
Length of clutch in days for local chicken	17.12±3.22	17.92±2.96	17.51±3.11	0.5794
Total eggs per year of local chicken	64.46±16.72	75.43±14.29	69.6±15.57	0.0951
Interval between two consecutive brooding period	2.80±0.83	3.07±0.69	2.93±0.77	0.1061
Times eggs incubate for hatching per year	3.48±1.41	3.24±2.44	3.36±1.98	0.5080
Average egg set to broody hen	11.44±1.83	11.44±1.82	11.44±1.82	0.982
Survival rate of chicks to 8 weeks in wet season	6.85±1.74	6.58±1.79	6.72±1.77	0.0405
Survival rate of chicks to 8 weeks in dry season	6.12±2.46	6.37±1.57	6.24±2.07	0.6108
Hatchability % in dry season	70.91±1.6	80.49±1.1	75.58±1.0	0.000
Hatchability % in wet season	81.95±1.1	74.54±1.2	78.34±0.8	0.000
Survival % in dry season	73.84±1.4	70.10±1.2	72.02±0.9	0.054
Survival % in wet season	73.67±1.2	77.72±1.3	75.64±0.9	0.028

Number in bracket is referred to total number of respondents

4.5. Breeding objectives and breeding practice

Clear definition of breeding objectives might be difficult under subsistence level of managements with a wide range of production objectives and marketing strategies (Kebede *et al.*, 2012). In general, the results of this study suggested that farmers have multiple breeding objectives of chicken. In this study, almost all selected sample households were engaged in poultry keeping but the purpose of production differs based on the interest of producer households. The main purpose of producing poultry include cash from sale, meat consumption, egg consumption, for replacement, for brooding, spiritual/religious, ceremony, cultural and manure with an Index values of 0.101, 0.092, 0.115, 0.120, 0.242, 0.093, 0.046, 0.018 and 0.003 (Table 18). Similar purposes have also been reported by Mengesha *et al*. (2008) who reported that, in Jamma district the purpose of keeping poultry was mainly for sale (38.1%), followed by for home consumption (31.7%) and no defined (16.3%), at last for religious purposes (13.9%).

The main production objectives of chicken in midland of agro ecology were for brooding, for replacement, meat consumption, cash from sale of chicken and egg, egg consumption, spiritual/religious, ceremony, cultural and manure with an index value of 0.174, 0.083, 0.080, 0.068, 0.066, 0.061, 0.027, 0.013, and 0.002. While the main production objectives of chicken in highland of agro ecology were for brooding, for replacement, meat consumption, cash from sale of chicken and egg, spiritual/religious, egg consumption, ceremony, cultural and manure with an index values of 0.136, 0.073, 0.069, 0.065, 0.064, 0.051, 0.037, 0.010 and 0.001.

The study reveals that village poultry kept for brooding purpose, home consumption and income generation; which in one way or other improve the nutrition status of the family. Similarly, Tadelle (2003) also reported that income generation followed by consumption was the main production objectives for keeping chicken. Halima (2007) also reported that income generation was the primary objectives of chicken rearing in Southern and North western Ethiopia.

Table 18. Ranking of purpose for keeping chickens

Purpose of keeping chicken	In midland chicken owner								In highland chicken owner								average Index
	Rank								Rank								
	1	2	3	4	5	6	Sum	Index	1	2	3	4	5	6	Sum	Index	
Cash from sale	47	16	29	14	11	0	277	0.068	24	17	42	16	2	1	264	0.065	0.101
Egg consumption	25	54	24	9	2	3	269	0.066	57	42	12	2	3	1	206	0.051	0.092
Meat consumption	32	29	34	14	8	6	324	0.080	20	49	30	11	2	3	280	0.069	0.115
For replacement	4	7	17	29	22	7	337	0.083	2	3	9	36	19	4	298	0.073	0.120
For brooding	13	13	14	47	41	39	708	0.174	13	4	15	27	42	28	552	0.136	0.242
Spiritual/religious	3	4	3	4	11	26	247	0.061	2	3	8	15	11	19	261	0.064	0.093
Ceremony	0	1	1	1	9	9	108	0.027	0	0	1	5	12	11	149	0.037	0.046
Cultural	0	0	0	0	3	6	51	0.013	0	0	0	0	2	5	40	0.010	0.018
Manure	0	0	0	1	1	0	9	0.002	0	0	0	0	1	0	5	0.001	0.003

Percentages do not add up to 100% since respondents selected based on more than one trait category
Index=the sum of (6times first order +5times second order ..... + 1times six order) for individual variables divided by the sum of (6times first order +5times second order ….. +1times six order) for all variables.

Concerning breeding practice 80.1% of respondents have practice breeding in improving their chicken productivity through cross breeding (60.3%) and pure breeding (39.7%) methods (Table 19). This result shows an agreement with the report of Fisseha (2009) reported that about 92.2% of chicken owner farmers in Bure district had the tradition of selecting cocks for breeding stock but is not in line with the report of Meseret (2010) in which traditional chicken production system was characterized by lack of systematic breeding practice in Gomma district and finding of Nigussie (2011) who reported that breeding is completely uncontrolled and replacement stock produced through natural incubation using broody hens in different parts of Ethiopia.

The scavenging habit of village chickens does not allow farmers to directly influence the exact mates of the breeding stock. However, in the study area 66.5% of the respondents exercise controlled breeding system at the community level by retaining the best cock and hen (86.1%), culling unproductive chicken (6.7%), culling unwanted color of chicken at young age (6.1%) and preventing mate of unwanted cock (1.2%). Chickens that were not retained for breeding purposes were culled through sale (18.90%), consumption (25.20%), sales and consumption (49.50%) (Table20). This result agrees with the findings of Addisu *et al.* (2013) who reported that slaughtering (53.27%), selling (41.18%) and devour or sell eggs of unwanted hens (5.56%) were a major means of culling less productive chicken from the flock in North Gonder. Bogale

(2008) also reported that home consumption and selling were the main culling means of chicken from their flock and Halima (2007) also revealed that farmers cull poor productivity and old age chickens through selling.

Table 19. Mating system and culling practice of less productive chickens and traits preference of farmers in the study area

Variable	Agro ecology				Over all		X^2	P
	Midland(124)		Highland (118)		(242)		Value	value
Practice of breeding							0.30	0.584
	freq	%	freq	%	freq	%		
Yes	101	81.5	92	78.6	193	80.10		
No	23	18.5	25	21.4	48	19.90		
Was of improving local breeds							24.502	0.000
Cross breeding	56	45.2	88	76.5	144	60.30		
Pure breeding	68	54.8	27	23.5	95	39.70		
Mating system of the flock							11.516	0.001
Controlled	67	56.8	72	79.1	139	66.50		
Uncontrolled	51	43.2	19	20.9	70	33.50		
If controlled mating by what techniques							4.782	0.189
Culling unproductive chicken	5	6.5	6	6.8	11	6.70		
Culling unwanted color of chicken at young age	9	11.7	3	3.4	12	7.30		
Retaining the best cock and hen	63	81.8	79	89.8	142	86.10		
Have you know inbreeding concept							3.182	0.74
Yes	12	9.7	4	3.4	16	6.20		
No	112	90.3	114	96.6	226	93.80		

-Number in bracket is referred to total number of respondents

4.6. Selection and culling practices

The culling and selection criteria for breeding cock and hens are shown in Table 20. On average 78.9% of households of the study area cull chickens with an age 4.31 and 4.51month to male and female birds. There were no significant differences between agro ecology with respect to practice of selection and age of selection for male cock and hen but it was observed that highland and midland agro ecologies differed with respect to the practice of culling and purpose of culling chickens.

In both midland and highland agro ecologies low production of chicken, old age, unwanted plumage color, ill that was in poor health bad temperament of hens and cocks and low hatchability were highly ranked as culling criteria. As a result, farmers in different agro

ecological zones show almost similar trait preferences and use of the same breeding practices. Birds that were not retained for breeding purposes were culled through sales, consumption and gift. The culling criteria used give an indication of the implicit farmers' breeding goals (Muchadeyi *et al.,* 2004). The higher frequency of farmers culling chickens for productive than morphological traits implying that village chickens are kept mainly for economic and food security reasons.

Table 20. Reported culling and selection of breeding hen and cock

Variable	Agro ecology				Over all (242)		X^2 Value	P value
	Midland(124)		Highland(118)					
	N	%	N	%	N	%		
Practice of culling							8.293	0.004
No. of respondent who cull	107	86.3	84	71.2	191	78.90		
No. respondents who didn't cull	17	13.7	34	28.8	51	21.10		
Reasons for culling								
Old age	102	27.6	86	27.7	188	77.70	0.113	0.080
Low production	106	28.7	84	27.1	190	78.50	0.174	0.007
Unwanted plumage color	78	21.1	55	17.7	133	55.00	0.164	0.011
Illness	43	11.7	38	12.3	81	33.50	0.016	0.684
low hatchability	9	2.4	31	10.0	40	16.3	0.256	0.000
Bad temperament	31	8.4	16	5.2	47	19.40	0.145	0.025
Purpose of culling							0.290	0.002
For home consumption	24	21.1	33	35.9	57	29.70		
For sale	16	14.0	23	25.0	39	18.90		
Sale and consumption	66	57.9	36	39.1	102	49.50		
All	8	7.0	0	0.0	8	3.90		
Practice of selection breeding male and female							1.620	0.203
Yes	115	92.7	110	93.2	230	95.00		
No	9	7.3	8	6.8	12	5.00		
Selection Age for breeding Male (mean ±SD)	4.38±1.81		4.22±1.00		4.31±1.48		0.676	0.412
Selection Age for breeding Female (mean ±SD)	4.52±1.85		4.50±1.16		4.51±1.55		0.015	0.902

-Number in bracket is referred to total number of respondents
-N stands for number of respondents

4.7. Effective Population Size and Inbreeding in Village Chickens

The overall mean effective population size (Ne) and the rate of inbreeding (ΔF) calculated for the indigenous chicken flock of the study area were 3.99 and 0.13, respectively. The rate of inbreeding in the free-range chicken population of midland (0.14) was almost similar to highland (0.12) agro ecology, whereas net effective population size was higher in highland agro ecology (4.03) of the study areas. This result agrees with the findings of Nigussie *et al.* (2010b) who reported that the largest effective population size of 3.19 for Sheka and 5.22 for Konso was recorded with the subsequent lowest inbreeding coefficient and the number of breeding individuals is very small. But the current effective population size was lower as compared with the findings of Abdelqader *et al.* (2007) in Jordan who reported an average effective population size of 15.4.

Concerning ownership of cock 71.1% of the respondents reported that they rear their own local (54.9%), exotic (14.8%) and cross breed (27.5%) cocks. The remaining 28.9% respondents have not their own breeding cock. Most of them shared breeding cock with neighbors (71.4%) purchase from market (22.8%) and purchase from extension office (2.8%) (Table21). This result is in agreement with the report of Nigussie *et al.* (2010b) who reported that from 31% to 55.6% of the farmers of different regions of Ethiopia did not own breeding males. Most of them shared breeding males with neighbors. The result was also in line with reports of Bogale (2008) also reported that in Amhara region of Fogera district the effective population size (Ne) per breeding population and rate of change in breeding coefficient (ΔF) of the area were 3.9 and 1.95.

The current finding of the level of inbreeding (0.14 in midland and 0.12 in highland agro ecology) was higher than the maximum acceptable level of 0.06 (Armstrong, 2006). Utilization of breeding cock hatched within the flock and lack of awareness about inbreeding may lead to the accumulation of problems associated with inbreeding and may decrease genetic diversity.

Table 21. Possession of breeding males, effective population size and level of inbreeding of village chickens

Variable	Agro ecology		Over all	X^2	P
	Midland(124)	Highland(118)	(242)	Value	value
Farmers rearing their own cock n(%)	86 (69.4%)	86 (72.9%)	172(71.1%)	0.366	0.545
Farmers not possessing breeding cock n(%)	38 (30.6%)	32 (27.1%)	70 (28.9%)		
Breed of the cock n(%)				12.029	0.007
Local	60 (69.8%)	40(46.5%)	100(58.1%)		
Exotic	15 (17.4%)	12(14.0%)	27 (15.6%)		
Cross breed	11 (12.8%)	29(33.7%)	40 (23.4%)		
All	0.00	5(5.8%))	5 (2.9%)		
If no source of cock n(%)				4.248	0.374
Share with neighbors	26 (68.4%)	24 (75%)	31 (71.4%)		
Communal	1 (2.6%)	1 (3.1%)	2 (2.8%)		
Purchase from market	9 (23.7%)	7 (21.9%)	16 (22.8%)		
Purchase from Extension office	2 (5.3%)	0	2 (2.8%)		
Nm	1.48	1.76	1.62		
Nf	5.34	4.83	5.09		
Ne	3.96	4.03	3.99		
ΔF	0.14	0.12	0.13		

-Number in bracket is referred to total number of respondents

-Nm referred to number of breeding males, Nf number of breeding females, Ne effective population size, ΔF inbreeding coefficient.

4.8. Breeding hen and cock selection criteria of farmers in the study area

Farmers' decisions on choice of breeding stock are shown in Table 22. Chicken owners in the present study area also considered both morphological and production traits for selection criteria. The current study showed that the selection criteria used for selection of breeding hen were egg size, plumage color, broodiness, disease resistance and hatchability were the traits of highest importance for selection purpose with an average index value of 0.067, 0.064, 0.062, 0.054 and 0.042; while mothering ability, egg number, body size, growth rate, good scavenging, longevity, fighting ability were ranked low with an index values of 0.040, 0.036, 0.036, 0.033, 0.028, 0.027 and 0.022, respectively. The highest selection criteria used for selection of breeding cock were egg number, comb type, plumage color, disease resistance, egg size and growth rate with an index values of 0.053, 0.052, 0.045, 0.044, 0.041 and 0.041, respectively; while good scavenging, broodiness, fertility, hatchability, body size, mothering ability and fighting ability

were rank lowest with an average index values of 0.053, 0.052, 0.045, 0.044, 0.041, 0.041, 0.039, 0.033, 0.033, 0.032, 0.029, 0.025 and 0.022, respectively (Table 22, Appendix Table 46 and 47). In the study area for breeding hen and cock selection, farmers target was not only for breeding purpose but also they take into consideration the factors or traits that affected the market and cultural value.

The present findings are inconsistent with the report of Duguma *et al.* (2010) reported that conformation traits are important criteria of selection under traditional livestock breeding practices. This is because size/conformation heavily determines live birds prices in traditional poultry markets. Similarly the high rating of plumage colour in the present study is in line to the report of Nigussie *et al.* (2010) where this trait was used as a selection criterion. The present findings are also in agreement with reports of Okeno *et al.* (2011) who reported chickens traits of economic significance such egg number; body size and fertility were highly rated.

Development of a breeding goal for improvement of indigenous birds should focus on the traits perceived important by stakeholders (Okeno *et al.,* 2011). This is because breeding goals developed without considering the needs of all the stakeholders have high chances of rejection by end users. The discussions held with farmer's shows that morphological traits, particularly plumage colour and comb type for cock and hen, determined the market and cultural suitability of chickens and were very important in both midland and highland agro ecology of the study area.

Table 22. Selection criteria used for selecting breeding hen and cock in midland and highland agro ecology

Selection criteria	Agro ecology								
	Midland			Highland			Overall		
	Sum	Index	Rank	Sum	Index	Rank	Sum	Index	Rank
Breeding hen									
Egg number	391	0.041	6	263	0.031	8	654	0.036	6
Body size	388	0.041	6	265	0.031	8	653	0.036	6
Growth rate	310	0.032	9	283	0.033	8	593	0.033	7
Hatchability	382	0.04	7	375	0.044	6	757	0.042	4
Mothering ability	442	0.046	6	288	0.034	7	730	0.04	5
Broodiness	571	0.06	3	553	0.065	3	1124	0.062	3
Disease resistance	484	0.051	3	484	0.057	3	968	0.054	4
Egg size	641	0.067	1	571	0.067	1	1212	0.067	1
Plumage color	580	0.061	1	568	0.067	1	1148	0.064	2
Fighting ability	266	0.028	10	129	0.015	11	395	0.022	10
Good scavenging	290	0.03	9	224	0.026	9	514	0.028	8
Longevity	313	0.033	8	172	0.02	11	485	0.027	9
Breeding cock									
Egg number	466	0.049	2	480	0.057	1	946	0.053	1
Body size	289	0.03	10	239	0.028	11	528	0.029	9
Growth rate	332	0.035	6	397	0.047	2	729	0.041	5
Hatchability	294	0.031	8	279	0.033	6	573	0.032	8
Mothering ability	237	0.025	8	210	0.025	9	447	0.025	10
Broodiness	329	0.034	7	274	0.032	6	603	0.033	7
Disease resistance	386	0.04	4	402	0.047	2	788	0.044	4
Egg size	416	0.044	2	332	0.039	4	748	0.041	5
Good scavenging	358	0.037	3	340	0.04	3	698	0.039	6
Plumage color	411	0.043	2	401	0.047	2	812	0.045	3
Fighting ability	152	0.016	3	242	0.029	3	394	0.022	11
Fertility	339	0.035	2	259	0.031	2	598	0.033	7
Comb type	483	0.051	1	453	0.053	1	936	0.052	2

Index=the sum of (11 times first order + 10 times second order +…….…… + 1 times eleventh order) for individual variables divided by the sum of (11 times first order + 10 times second order +…….…….. + times eleventh order) for all variables.

4.9. Trait preference of farmers for genetic improvement of village chicken in the study area

Table 23 shows farmers' preferences for traits to be improved across both agro-ecological zones. It illustrates that given a choice; farmers in midland agro ecology of the study area would prefer traits comb type, plumage color, egg size, broodiness, disease resistance, meat quality, fertility

growth, egg number, body size, mothering ability and temperament with an Index value of 0.115, 0.101, 0.09, 0.077, 0.075, 0.074, 0.068, 0.063, 0.055, 0.050, 0.049 and 0.34, respectively. Qualitative traits have high preference to be improved. In highland agro ecology farmers prefer traits are plumage color, comb type, egg size, meat quality, fertility, disease resistance, broodiness, growth and mothering ability are the major prefer traits with an index values of 0.109, 0.108, 0.094, 0.085, 0.080, 0.076, 0.073, 0.065 and 0.053, respectively. There was no significant difference in the ranking of traits preference for genetic improvement with respect to the agro-ecological zones of the study areas. Comb type and plumage colour were the major preferred trait of farmers (Table 23, Appendix Table 48 and 49). This result is not in line with the report by Nigussie (2011) in which farmers in different parts of Ethiopia prefer qualitative traits. But during group discussions held with farmers' reported that production traits like body size, egg size, egg number, growth rate ranks first, second, third and fourth followed by adaptive and morphological traits like disease resistance, plumage color and comb type.

Table 23. Traits preference of farmers wanted to be improved in highland and midland agro ecological areas

Traits preferred	Agro ecology								
	Midland			Highland			Overall		
	Sum	Index	Rank	Sum	Index	Rank	Sum	Index	Rank
Comb type	751	0.115	1	662	0.108	2	1413	0.169	1
Plumage color	659	0.101	2	667	0.109	1	1326	0.156	2
Egg size	584	0.09	3	573	0.094	3	1157	0.137	3
Meat quality	484	0.074	6	518	0.085	4	1002	0.117	4
Broodiness	504	0.077	4	444	0.073	7	948	0.114	5
Disease resistance	487	0.075	5	464	0.076	6	951	0.113	6
Fertility	442	0.068	7	489	0.08	5	931	0.108	7
Growth rate	411	0.063	8	398	0.065	8	809	0.096	8
Egg number	356	0.055	9	267	0.044	10	623	0.077	9
Mothering ability	320	0.049	11	325	0.053	9	645	0.076	10
Body size	328	0.05	10	250	0.041	11	578	0.071	11
Prolificacy	214	0.033	14	247	0.04	12	461	0.053	12
Temperament	252	0.039	12	164	0.027	13	416	0.053	12
Heat resistance	246	0.038	13	124	0.02	15	370	0.048	13
Drought resistance	176	0.027	15	123	0.02	15	299	0.037	14
Good scavenging	130	0.02	16	111	0.018	18	241	0.029	15
Egg shell color	87	0.013	17	118	0.019	17	205	0.023	16
Chicken shape	39	0.006	18	165	0.027	13	204	0.02	17
Egg yolk color	38	0.006	18	14	0.002	19	52	0.007	18

Index=the sum of (12 time's first order + 11 time's second order +…… + 1 times twelfth order) for individual variables divided by the sum of (12 time's first order + 11 times second order +…… + times twelfth order) for all variables.

4.10. Participatory identification of breeding objectives

No literature report is found on ranking of chicken from own flock. But by using similar procedure adopted from Gemeda *et al*.(2010) chicken flock owners were asked to choose their first, second, third best and inferior breeding hen and cock chicken among their flocks then inquired to mention the reasons for their preferences. Subsequently, the most ranked reasons from the first, second, thirdly and inferior chosen animal were used.

4.10.1. Own flock ranking of breeding hen

The trait preference of households and their reason for each sex was presented in Tables 24, 25, 26 and 27. The traits of preference or reason for ranking for first, second, third and inferior by the farmers included both qualitative and quantitative characteristics of chickens were collected.

Plumage colors like red, red and white, grayish (sigem) and multicolor were the frequently occurred and liked traits while black and white color of chicken is disliked by farmers during own flock ranking in both midland and highland agro ecologies. Regarding comb type double followed pea type, smooth white and yellow shank color with absence of spur is the most preferred traits by midland and highland chicken owners (Table 24). Although there was similarity of the trait preference between the two agro ecologies and this result clearly associated with the breeding objectives and the agro ecology of the study area. The traits preference by the farmers reflects that chicken was not only used for breeding purpose but also they take into consideration the factors or traits that affected the market value and cultural values.

Table 24. Observed qualitative traits of ranked hen in own flock ranking of the study area

Traits		Midland (n=20) Chicken ranks				Highland(n=21) Chicken ranks			
		1st	2nd	3rd	Inferior	1st	2nd	3rd	Inferior
Plumage color	Red	19	7	6	-	12	7	6	-
	Red and white	1	7	8	-	9	7	8	-
	Grayish (Sigem)	-	4	4	-	4	3	3	-
	Multicolor	-	2	2	-	3	4	4	-
	White	-	-	-	9	-	-	-	9
	Black	-	-	-	11	-	-	-	12
Comb type	Single	-	-	-	14	-	-	-	18
	Double(rose)	20	17	4	-	19	19	4	-
	Pea	0	3	16	6	2	2	17	3
Shank color	Yellow	-	20	20	-	-	21	21	-
	White	20	-	-	-	21	-	-	-
	Black	-	-	-	20	-	-	-	21
Smoothness of shank	Smooth	20	20	20	-	21	21	21	-
	Sharked	-	-	-	20	-	-	-	21
Spur presence	Absent	20	20	20	20	21	21	21	21

-Number in bracket is referred to total number of respondents

Table 25 describes mean values for some reproduction and production traits and age of the ranked breeding hen. Age at first egg lying (month), number of clutch/year/hen, egg production/clutch/hen, number of egg/year, number of incubated/hen, number of hatched, hatchability percentage, number of chick survived to 8 weeks, body weight and breast width were influenced the ranking decision of the farmers in both agro ecologies of the study areas. This result revealed that the farmers' decisions for ranking of breeding hen were highly correlated with the reproduction and production traits of the given animals. In both agro ecologies there was a logical trend in the mean values of the production and reproduction traits between 1st best, 2nd best, 3rd best and inferior hen.

Table 25. Means ± SE of some qualitative traits from the life history and measured of the ranked hen

Attributes	Midland agro ecology(n=20) Chicken ranks				Highland agro ecology(n=21) Chicken ranks			
	1st	2nd	3rd	Inferior	1st	2nd	3rd	Inferior
Age at first egg lying(month)	5.5±0.15	6.7±0.18	8.2±0.18	9.7±0.34	5.8±0.19	6.6±0.24	8.0±0.24	9.5±0.23
No. of clutch/year/hen	8.6±0.43	6.8±0.34	5.2±0.23	3.1±0.11	6.8±0.48	5.4±0.38	4.0±0.3	6.8±1.43
Egg prod./clutch/hen	18.5±0.5	14.9±0.4	13.3±0.5	9.5±0.19	15.9±0.6	13.1±0.49	11±0.55	6.6±6.8
Number of egg/year	88±4.06	69.5±3.03	61.7±3.7	33.2±0.5	71±4.49	58.6±3.38	46.6±3.7	39.9±2.1
No. of incubated/hen	13.8±0.6	14.2±0.3	11±0.22	10.8±0.3	12.5±0.5	11.7±0.39	10.6±0.2	12.2±0.4
Number of hatched	12.8±0.6	12.3±0.17	8.1±0.49	4.4±0.21	10.14±0.57	9.4±0.45	8.9±0.21	7.5±0.5
Hatchability %	92.4±0.4	87.3±1.84	72.7±3.4	41.4±2.3	80.9±2.78	80.7±3.16	83.5±1.4	62.2±3.8
No. of chick survived to 8 wks	8.9±0.55	7.8±0.35	6.0±0.47	2.5±0.22	6.8±0.32	6.8±0.54	6.8±0.32	6.1±0.42
Body weight	1.7±12.7	1.4±9.12	1.4±2.7	1.3±1.99	2.0±33.9	1.6±5.3	1.4±2.8	1.3±6.1
Breast width	16±0.00	15.7±0.2	13±0.00	10.6±0.1	17.2±0.2	15.1±0.09	13.8±0.1	12.3±0.1

-Number in bracket is referred to total number of respondents

4.10.2. Own flock ranking of breeding Cock

Similarly plumage colors like red, red and white, grayish (sigem) and multicolor were the frequently occurred and liked traits while black and white color of chicken is dislike by farmers during own flock ranking in both midland and highland agro ecology for breeding cock. Regarding comb type double followed pea type, smooth white and yellow shank color with absence of spur was the most preferred traits by midland and highland chicken owners (Table 26). Although there was similarity of the trait preference between the two agro ecology for breeding cock and this result clearly associated with the breeding objectives and the agro ecologies of the study area. The traits preference by the farmers reflects that chicken was not only used for breeding purpose but also they take into consideration the factors or traits that affected the market value and cultural values.

Table 26. Observed qualitative traits of the ranked cock in own flock ranking experiment

Traits		Midland (n=20) Chicken ranks				Highland(n=21) Chicken ranks			
		1st	2nd	3rd	Inferior	1st	2nd	3rd	Inferior
Plumage color	Red	14	5	1	-	10	6	2	-
	Red and white	3	8	2	-	7	6	1	-
	Grayish (Sigem)	1	7	11	-	4	1	7	-
	Multicolor	1	0	6	-	0	8	11	-
	White	-	-	-	4	-	-	-	10
	Black	-	-	-	16	-	-	-	11
Comb type	Single	5	14	4	17	0	7	6	14
	Double	15	5	4	-	14	3	11	-
Shank color	Yellow	4	16	4	-	5	9	3	-
	White	16	4	2	-	16	12	1	-
	Black	-	-	2	12	-	-	6	10
	Gray	-	-	12	8	-	-	11	11
Smoothness of shank	Smooth	20	20	20	-	21	21	21	-
	Sharked	-	-	-	21	-	-	-	21
Spur presence	Present	-	-	-	20	-	-	-	21
	Absent	20	20	20	-	21	21	21	-
Mating behavior	Very active	20	20	-	-	21	21	-	-
	Active	-	-	20	-	-	-	21	-
	Inactive	-	-	-	20	-	-	-	21

-Number in bracket is referred to total number of respondents

Table 27 describes mean values for some reproduction and production traits and age of the ranked breeding cock. Age at first mating (month), body weight and height at back were influenced the ranking decision of the farmers in both study agro ecology. Similarly in both agro ecology there was a logical trend in the mean values of the production and reproduction traits between 1st best, 2nd best, 3rd best and inferior breeding cock.

Table 27. Means ± SE of some quantitative traits from the life history and measured of the ranked cock

Attributes	Midland agro ecology(n=20) Chicken ranks				Highland agro ecology(n=21) Chicken ranks			
	1st	2nd	3rd	Inferior	1st	2nd	3rd	Inferior
Body weight	1.74±0.20	1.42±0.18	1.41±0.34	1.01±26	2.18±0.9	1.7±23.1	1.5±0.59	1.2±0.2
Height at back	34.9±0.16	30.45±0.41	28.9±0.20	27.35±0.3	35.2±0.7	30.9±0.9	30.3±0.10	28±0.3
Age at first mating(month)	4.47±0.11	5.47±0.09	6.22±0.09	7.0±0.07	5±4.7	6±0.00	6.26±0.09	7.4±0.1

-Number in bracket is referred to total number of respondents

4.11. Phenotypic characteristics and morph metric measurements

4.11.1. Phenotypic characteristics of local chickens

Qualitative traits such as feather distribution, plumage color, earlobe color, spur presence, shank color, comb color, comb shape, eye color and head shape were evaluated in two agro ecology of central zone of Tigray (Table 28 and Figure 5). The results indicated that there are large variations in morphological appearances (Table 28, 29 and Figure 5). Local chicken were mostly normally feathered (hens 97.8%, cocks 96%) with a few showing necked neck (0.6%) and feathered shank and feet (2%).

This results are consistent with the observations of Halima, 2007; Bogale, 2008; Faruque *et al.* (2010) who reported that most of the indigenous chickens have no shank feathers and shanks are yellowish in color.

Very diverse plumage coloration of chicken was observed (Table 28 and Figure 5). The results indicated that red (32%), grayish/sigem (17.5%), brownish/bunama (17%), wheaten (7.8%), multi color (6.9%), black (6.5%), white (5.4%), gold (5.2%) and black and red white with red strips, respectively being the dominant color for these areas in hens. This result is in agreement with reports of Halima, (2007) which reports that, the plumage color in North West Ethiopia were 25.49% white, 7.79% black, 16.44% red, 22.23% gebisama and 13.64% black with white strips. The large variation in plumage color might be attributed to a lack of selection of breeders for this trait, which was also reported from Nigeria (Daikwo *et al.*, 2011), Jordan (Abdelqader *et al.*, 2007) and Botswana (Badubi *et al.*, 2006).

There was a high diversity in color and type of combs and earlobes observed between and within the agro ecology indigenous ecotypes. The commonest comb color observed was red (hens 95%, cocks 97%), while the remaining 5% of hens and 3% of cocks showed brown and black colors. Red comb color in females and males dominated in all our study area, which agrees with the findings of Halima, (2007) for local chicken in North West Ethiopia. The light color of comb and skin might contribute to the birds' tolerance of heat stress (Egahi *et al.*, 2010).

The highest proportion of eye color was orange (hens 96.1%, cocks 98%) followed by brown (hens 2.2%, cocks 2%) yellow and blue and red. Comb size is associated with gonadal development and intensity of light but comb type is the consequence of gene interaction (Bell, 2002). A significant domination ($P<0.05$) of the single comb in females (42.1%) and rose comb in males (67%) was observed. The majority of the chickens possessed comb shape with rose shape (44.3%) followed by single (39%) and pea (15.7%) (Table 29 and Figure 5). This finding was in line of the research work of Halima, (2007) who reported that in North West Ethiopia comp type 16.6% chickens have rose, 50.72% have pea and 13.34% single comb shape of chicken and Apuno *et al.* (2011) in Nigeria reported that (96.45%) single comb and 0.44% pea comb. Almost all chickens (91.6%) of the study area do not have spurred only 8.4% of the chickens have spurs. The predominant earlobe color was white and red (35.7%), black (33.7%) red (28.9%) white and black orange and white in lower proportion. The commonest shank color was white (47.1%), yellow (26.1%), black (9.1%), brown (5.6%), green (5.2%), gray blue (3.2%), red (1.7%), and orange (1.5%), respectively (Table 29). This finding was also slightly similar with findings of Halima (2007) reported that, chickens in North Western Ethiopia have yellow (64.42%), black (9.61%), white (13.99%), green (11.98%) shank color.

Table 28. Qualitative traits of chickens in different agro ecology of the study area

Qualitative traits	Agro ecology								Over all n=457						X^2 value	P-value
	Midland				Highland											
	Female n=214		Male n=65		Female n=149		Male n=36		Female n=363		Male n=101		Sum n=464			
	freq	%	freq	%	freq	%	freq	%	freq	%	freq	%	freq	%		
Feather distribution															4.975	0.083
Normal	207	96.7	61	93.8	148	99.3	36	100	355	97.8	97	96.0	452.0	97.4		
Necked neck	2	0.9	1	1.5	0	0	0	0	2	0.6	1	1.0	3.0	0.6		
Feathered shank & feet	5	2.3	3	4.6	1	0.7	0	0	6	1.7	3	3.0	9.0	1.9		
Plumage color															37.998	0.000
White	12	5.6	6	9.2	6	4.0	1	2.8	18	5.0	7	6.9	25.0	5.4		
Black	9	4.2	1	1.5	20	13.4	0	0	29	8.0	1	1.0	30.0	6.5		
Red	45	21.0	42	64.6	41	27.5	24	66.7	86	23.7	66	65.3	152.0	32.8		
Grayish/sigem	51	23.8	5	7.7	24	16.1	1	2.8	75	20.7	6	5.9	81.0	17.5		
Multi color	7	3.3	7	10.8	11	7.4	7	19.4	18	5.0	14	13.9	32.0	6.9		
Brownish/bunama	58	27.1	0	0.0	21	14.1	0	0	79	21.8	0	0.0	79.0	17.0		
Gold	15	7.0	4	6.2	2	1.3	3	8.3	17	4.7	7	6.9	24.0	5.2		
Wheaten	14	6.5	0	0.0	22	14.8	0	0	36	9.9	0	0.0	36.0	7.8		
White with red strips	2	0.9	0	0.0	0	0.0	0	0	2	0.6	0	0.0	2.0	0.4		
Black and red	1	0.5	0	0.0	2	1.3	0	0	3	0.8	0	0.0	3.0	0.6		
Earlobe color															4.963	0.420
White	69	32.2	12	18.5	47	31.5	5	13.9	116	32.0	17	16.8	133.0	28.7		
Red	54	25.2	39	60.0	46	30.9	26	72.2	100	27.5	65	64.4	165.0	35.6		
White and red	86	40.2	14	21.5	51	34.2	5	13.9	137	37.7	19	18.8	156.0	33.6		
Black	3	1.4	0	0.0	1	0.7	0	0	4	1.1	0	0.0	4.0	0.9		
White and black	0	0.0	0	0.0	4	2.7	0	0	4	1.1	0	0.0	4.0	0.9		
Orange	2	0.9	0	0.0	0	0.0	0	0	2	0.6	0	0.0	2.0	0.4		
Spur presence															0.902	0.342
Present	6	2.8	21	32.3	0	0	12	33.3	6	1.7	33	32.7	39.0	8.4		
Absent	208	97.2	44	67.7	149	100	24	66.7	357	98.3	68	67.3	425.0	91.6		

***n** = is referred to total number of chicken taken*

Table 29. Qualitative traits of chicken in different agro ecology of the study area

Qualitative traits	Agro ecology								Over all n=457						X^2 value	P-value
	Midland				Highland											
	Female n=214		Male n=65		Female n=149		Male n=36		Female n=363		Male n=101		464			
	freq	%	freq	%	freq	%	freq	%	freq	%	freq	%	freq	%		
Shank color															96.049	0.000
white	94	43.9	18	27.7	92	61.7	10	27.8	186	51.2	28	27.7	214	46.1		
Red	4	1.9	4	6.2	0	0.0	0	0.0	4	1.1	4	4.0	8	1.7		
Brown	10	4.7	0	0.0	5	3.4	11	30.6	15	4.1	11	10.9	26	5.6		
Yellow	71	33.2	39	60.0	9	6.0	9	25.0	80	22.0	48	47.5	128	27.6		
Black	18	8.4	3	4.6	20	13.4	1	2.8	38	10.5	4	4.0	42	9.1		
Gray blue	14	6.5	1	1.5	0	0.0	0	0.0	14	3.9	1	1.0	15	3.2		
Green	3	1.4	0	0.0	18	12.1	3	8.3	21	5.8	3	3.0	24	5.2		
Orange	0	0.0	0	0.0	5	3.4	2	5.6	5	1.4	2	2.0	7	1.5		
Comb color															4.778	0.189
Red	202	94.4	62	95.4	143	96.0	36	100	345	95.0	98	97.0	443	95.5		
Brown	7	3.3	3	4.6	1	0.7	0	0	8	2.2	3	3.0	11	2.4		
Black	5	2.3	0	0.0	5	3.4	0	0	10	2.8	0	0.0	10	2.2		
Comb shape															2.653	0.265
Single	87	40.7	14	21.5	66	44.3	14	38.9	153	42.1	28	27.7	181	39.0		
Pea	42	19.6	5	7.7	26	17.4	0	0.0	68	18.7	5	5.0	73	15.7		
Rose	85	39.7	46	70.8	57	38.3	22	61.1	142	39.1	68	67.3	210	45.3		
Eye color															9.296	0.054
Orange	201	93.9	63	96.9	148	99.3	36	100	349	96.1	99	98.0	448	96.6		
Yellow	1	0.5	0	0.0	0	0	0	0	1	0.3	0	0.0	1	0.2		
Brown	8	3.7	2	3.1	0	0	0	0	8	2.2	2	2.0	10	2.2		
Blue	1	0.5	0	0.0	1	0.7	0	0	2	0.6	0	0.0	2	0.4		
Red	3	1.4	0	0.0	0	0	0	0	3	0.8	0	0.0	3	0.6		
Head shape															37.069	0.00
Crest	86	40.2	22	33.8	20	13.4	3	8.3	106	0.3	25	24.8	131	28.2		
Flat plain	128	59.8	43	66.2	129	86.6	33	91.7	257	0.7	76	75.2	333	71.8		

***n** = is referred to total number of chicken taken*

According to Nesheim, Austic and Card (1979), the size and colors of combs and wattles are associated with gonad development and secretion of sex hormones. Large wattle and long legs are important morphological traits that allow better heat dissipation in the hot tropical environment.

4.11.2. Quantitative traits

Body weight and other body measurements are useful parameters that are used to describe a breed or type jointly with the breed's morphological characteristics and the environment it inhabited. The body weight and other linear measurements of sample population were summarized in (Tables 30, 31 and 32).

Table 30 show least square means for body weights (Bwt), breast width (Brwth), spur length (SPl), thigh circumference (TC), chest circumference (Cc) and shank length (SL) measurements of local chicken populations in the study area. The overall average values of body weights (Bwt), breast width (Brwth), spur length (SPl), thigh circumference (TC), chest circumference (Cc) and shank length (SL) measurements of local chicken in midland and high land agro ecologies were1.36kg, 13.61cm, 2.46cm, 9.08cm, 28.90cm and 9.7cm, respectively.

The results of the present study show that the overall mean body weight of local chicken across agro ecologies were 1.36kg (1.54kg male and 1.34kg female). The result was almost similar to values (1.46kg) from North Gonder (Addisu, 2013) and 1.27kg (1,035 gram female and1.5 kg male) from Central Highlands of Ethiopia Alemu and Tadelle (1997), while higher weights (1.7kg) were reported from Northwest Ethiopia (1,316 gm hen and 2049.07gm cock) by Halima (2007). Adult cocks (1.54kg) was significantly ($p<0.05$) heavier than that of hens (1.31kg). The differences in body weight and body measures between male and female birds are in agreement with reports from Central Highlands of Ethiopia Alemu and Tadelle (1997); North Gonder Addisu, (2013) and Northwest Ethiopia Halima (2007) such difference are due to the differential effects of androgens and estrogen on growth (Yakubu *et al.,* 2010). Results also revealed that both agro ecology and sexes differed also with respect to other body measurements.

Table 30. Least square means for body weight and other body measurements of local chickens summarized by agro ecology and sexes

Effect	Traits					
	Bwt	Brwth	SPl	TC	Cc	SL
Agro ecology						
Midland	1.36±0.02	13.69±0.10	2.61±0.3	9.20±0.11	29.16±0.19	9.95±0.07
Highland	1.36±0.03	13.48±0.13	2.13±0.36	8.88±0.13	28.49±0.25	9.51±0.09
Overall	1.36±0.02	13.61±0.08	2.46±0.23	9.08±0.09	28.90±0.15	9.78±0.06
P-value	0.553	0.038	0.0006	0.126	0.005	0.0003
Sex						
Male	1.54±0.04	13.52±0.17	2.62±0.8	10.31±0.21	29.67±0.38	11.01±0.12
Female	1.31±0.02	13.63±0.09	2.44±0.25	8.74±0.08	28.69±0.16	9.43±0.05
P-value	<.0001	0.267	<.0001	<0.0001	0.0507	<0.0001
Sex*agroecology	0.2097	0.081	0.0017	0.6922	0.061	0.5442

Bwt, body weights, Brwth, breast width, SPl, spur length, TC, thigh circumference, Cc, chest circumference SL, shank length.

Significance differences (P<0.05) were observed between agro ecologies with respect to breast width, spur length, chest circumferences and shank length. The length of spur, thigh circumference, and chest circumference and shank length in midland was relatively higher than those of highland agro ecology (Table 30). The average length of breast width, length of spur, thigh circumference, chest circumference and shank length in the study area was 13.61cm, 2.46cm, 9.08cm, 28.90cm and 9.78cm, respectively. It was also observed that there were no significant differences between agro ecologies with respect to body weight and thigh circumference because gene flow might have taken place between the two subpopulations.

The observed large variation in breast width, spur length, chest circumferences and shank length between agro ecology indicates the existence of divergent subpopulations within the local chicken population. Such variation gives room for genetic improvement between and within subpopulations.

The average shank lengths observed (9.78cm) in the present study were almost similar to values from Horro 9.99 cm (Eskindir *et al.,* 2013), from Fogera district 9.8 cm reported by Bogale (2008), from Northwest Ethiopia (10.31 cm) reported by Halima (2007) but higher than reports of Addisu (2013) 7.79cm in North Gonder. The average super length observed (2.46) in the present study were higher as compare to findings of Addisu, (2013) from North Gonder (0.18 cm).

Results also revealed that agro ecologies differed with respect to other body measurements. Significance differences (P<0.05) were observed between agro ecologies with respect to neck length and highly significant difference (P<0.01) were observed in wing span wattle width and wattle length (Table 31). The average length of neck, body length, wing length, wing span, wattle width, wattle length in the study area were 11.18cm, 26.39cm, 12.23cm, 33.07cm, 2.41cm, and1.92cm, respectively. It was also observed that there were no significant differences between agro ecology with respect to body length and wing length.

The average body lengths observed in the present study were much higher than those reported by Badubi *et al.* (2006) in Botswana which were 20.2 and 18.1cm for male and female chickens but lower than reports of Addisu (2013) in North Gonder (35.79cm). The average wing span observed in the present study were much higher than those reported by Halima (2007) in North West Ethiopia which were found (15.83cm) in Gelila and melo Hamisit male and (14.00cm) found in Tilili and Melo Hamusit female chickens but lower than reports of Addisu (2013) in North Gonder (but lower than reports of Addisu (2013) in North Gonder (35.79cm).

Table 31. Least square means for neck length and other body measurements of local chickens summarized by agro ecology and sexes

Effect	Traits					
	NL	BL	WL	WS	WAW	WAL
Agro ecology						
Midland	11.54±0.15	26.27 ±0.17	12.20±0.12	33.44±0.23	2.53±0.07	2.05±0.08
Highland	10.62±0.15	26.57±0.19	12.27±0.12	32.48±0.25	2.24±0.07	1.71±0.08
Overall	11.18±0.11	26.39±0.13	12.23±0.08	33.07±0.17	2.41±0.05	1.92±0.06
P-value	0.006	0.3098	0.8747	0.0015	<0.0001	<0.0001
Sex						
Male	12.08±0.24	27.26±0.28	13.30±0.18	36.27±0.34	3.79±0.12	3.61±0.13
Female	10.93±0.12	26.14±0.14	11.93±0.09	32.17±0.17	2.03±0.03	1.44±0.03
P-value	<0.0001	0.0004	<.0001	<0.0001	<0.0001	<0.0001
Sex*agroecology	0.0162	0..9479	0.4851	0.0762	0.0160	0.0141

NL, neck length, BL, body length, WL, wing length, WS, wing span, WAW, wattle width, WAL, wattle length

Data presented in Table 32 showed that earlobe width and height at back were affected by agro ecologies. There was highly significant difference between agro ecologies for earlobe width and height. It was also observed that there were no significant differences between agro ecology with respect to beak length, beak width, earlobe length, comb length and comb width. The average width of earlobe, beak length, beak width, earlobe length, comb length, comb width and height at back in the study area were 1.78cm, 2.80cm, 3.24cm, 1.50cm, 1.50cm, 3.85cm and 29.12cm, respectively.

Table 32. Least square means for earlobe width and other body measurements of local chickens summarized by agroecology and sexes

Effect	Traits						
	EAW	BKL	BKW	EAL	CL	CW	HB
Agro ecology							
Midland	1.82±0.05	2.82±0.03	3.27±0.03	1.53±0.04	1.59±0.08	3.91±0.12	29.49±0.20
Highland	1.71±0.05	2.77±0.03	3.20±0.03	1.46±0.05	1.35±0.09	3.77±0.14	28.53±0.22
Overall	1.78±0.04	2.80±0.02	3.24±0.02	1.50±0.03	1.50±0.06	3.85±0.09	29.12±0.15
P-value	0.0095	0.2776	0.1030	0.2951	0.059	0.928	0.0048
Sex							
Male	2.60±0.09	3.02±0.04	3.31±0.05	2.11±0.08	2.68±0.17	6.03±0.24	31.96±0.35
Female	1.55±0.03	2.74±0.02	3.22±0.03	1.33±0.03	1.17±0.05	3.25±0.06	28.32±0.14
P-value	<0.0001	<0.001	0.1792	<0.0001	<0.0001	<0.0001	<0.0048
Sex*agroecology	0.0039	0.579	0.4198	0.5572	0.432	0.636	0.573

EAW, earlobe width, BKL, beak length, BKW, beak width, EAL, earlobe length, CL, comb length CW, comb width, HB, height at back

The result was similar to values from North Gonder (Addisu *et al.,* 2013) reported that the overall length of local chicken ecotype 35.79cm, 2.76cm, 1.68cm and 2.03cm for body length, comb length, comb width and beak length. Comb size is associated with gonadal development and intensity of light but comb type is the consequence of gene interaction (Bell, 2002). Nesheim, Austic and Card (1979), also reported that the size and colours of combs and wattles are associated with gonad development and secretion of sex hormones.

4.11.2.1. Sex effect

In the current study wide variation were observed in body weight and other traits between male and female. In all parameters, male shows higher values than female except breast width and beak width. The average measurements of male and female of local chicken were 1.54 and 1.31kg for body weight 13.5 and 3.63cm for breast width, 10.31 and 8.74cm for thigh circumference, 29.67 and 28.69 for chest circumference and 11.01 and 9.43cm for shank length.

Concerning sex effect the average measurements were 12.08 and 10.93 cm for neck length, 27.26 and 26.14cm for body length, 13.30 and 11.93cm for wing length, 36.27and 32.17for wingspan, 3.79 and 2.03cm for wattle width and 3.61 and 1.44cm for wattle length, for male and female chickens in the study area. The average measurements were 2.60 and 1.55cm for earlobe width, 3.02 and 2.74cm for beak length, 3.31and 3.22cm for beak width, 2.11 and 1.33cm for earlobe length, 2.68 and 1.17cm for comb length and 6.03 and 3.25cm for comb width, 31.96 and 28.32cm for height at back for male and female chickens in the study area.

The differences in body weight and body measures between male and female birds are in agreement with reports from Jarso district and Horro (Eskindir *et al.,* 2013), from Fogera district (Bogale, 2008), from Northwest Ethiopia (Halima, 2007) and from North Gonder (Addisu, 2013); such differences are due to the differential effects of androgens and estrogens on growth (Yakubu *et al.,* 2010). The lower body measurement values observed for females than for male chickens in this study are also consistent with the findings from other studies (Msoffe *et al.,* 2004; Alabi *et al.,* 2012; Semakula *et al.,* 2011; Olawunmi *et al.,* 2008), suggesting that sexual dimorphism in chickens is manifested with respect to a large number of body attributes and in most breeds. This may be attributed to sex hormones which may promote larger muscle development in males than in females.

The effect of sex in favor of males can be attributed to the anatomical and physiological difference. Physiologically, the sex related differences might be partly a function of the sex differential hormonal effect on growth (Semakula *et al.,* 2011).

Therefore, the lower body measurement values observed for females than for male chickens in this study, suggesting that sexual dimorphism in chickens is manifested with respect to a large number of body attributes and in most breeds. This may be attributed to sex hormones which may promote larger muscle development in males than in females.

There was no significant($P<0.05$) interaction observed between agro ecology and sexes with respect to morph metric traits except for breast width, spur length, neck length, wattle width, wattle length and earlobe. In those traits higher measurements were observed in midland as compare to highland. The phenomenon observed significant interaction between agro ecology and sexes with respect to those morph metric traits was could be due to the differences between the two subpopulations with respect to the degree of expression of sex dimorphism for the traits.

4.12.3. Multivariate analysis

Multivariate analysis techniques are usually used to explore the factors of dissimilarity within a population, and eventually reorganize a heterogeneous set of observation units into relatively more homogenous groups from the total population ((Minitab, 1998). For this study the unit of analysis was the population of mature female chicken at each site characterized by the mean of the continuous variables. Mature females were selected because it is customary to describe a breed by a description of the females because they usually exist in larger numbers. The variables selected to describe the mature female chicken included continuous variables like body weights, breast width, spur length, thigh circumference, chest circumference, shank length, neck length, body length, wing length, wing span, wattle width, wattle length, earlobe width, beak length, beak width, earlobe length, comb length, comb width and height at back.

4.12.3.1. Principal component analysis (PCA) of different quantitative traits of local chicken

In this study to perform PCA a total of 19 variables from 375 female individuals' chickens were used with the weighting method of standardization. Five principal components' (PC) were extracted that accounted for 58.45% of the total variation (Table 33, Figure3 and Appendix 50). The first 5 of these PC accounted for 27.204% of the variance in the 19 variables (PC1 = 27.204%, PC2 = 12.132%, PC3 = 7.91%, PC4 = 5.665%, PC5 = 5.54%).

Table 33. Eigen values, proportion of variability and cumulative variability explained by the first five principal components

	Initial Eigen values		
Components	Total	% of Variance	Cumulative %
1	5.169	27.204	27.204
2	2.305	12.132	39.336
3	1.504	7.913	47.249
4	1.076	5.665	52.914
5	1.052	5.539	58.454

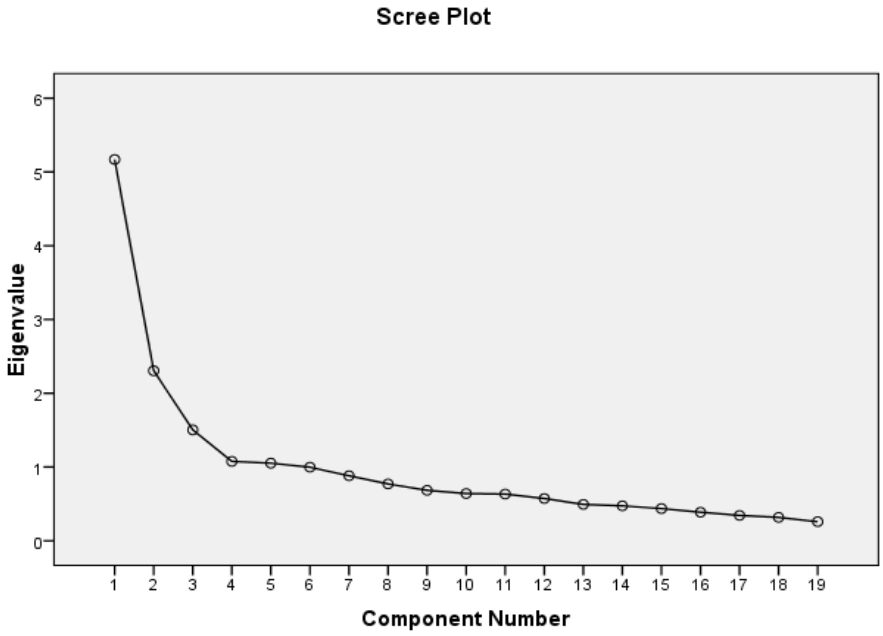

Figure 3. Scree plot of eigenvalue to component number

The correlation between the original traits and the first principal component were all positive (Table 34). Principal component one was most strongly influenced by wattle length, wattle width comb width, body weight comb length, wing span, chest circumference, earlobe length and height at back. Principal component 2 was most strongly associated with neck length, thigh circumference and height at back. Principal component 3 was closely related to chest circumference, wing length wing span beak width and beak length. Principal component 4 was highly related with shank length, neck length, wattle width, wing span and beak length and principal component 5 was highly related with spur length, thigh circumference and wattle length.

Table 34.Correlation between principal component analysis and qualitative traits of chicken

Traits	Principal component				
	1	2	3	4	5
BWTkg	0.809	-0.079	0.177	-0.142	-0.053
Brwth	0.461	-0.013	0.152	-0.572	0.076
SpL	0.251	0.072	-0.481	0.241	0.370
TC	0.303	0.608	-0.200	-0.288	0.262
Cc	0.589	-0.092	0.331	-0.043	-0.306
SL	0.562	0.445	0.165	0.280	-0.118
NL	0.156	0.761	-0.099	0.201	-0.073
BL	0.499	0.286	0.202	-0.358	0.140
WL	0.163	-0.138	0.360	0.020	0.634
WS	0.488	0.000	0.442	0.226	-0.082
WW	0.660	-0.041	-0.175	0.268	-0.217
WAL	0.739	-0.139	-0.254	0.183	-0.043
EAW	0.603	-0.384	-0.151	-0.092	-0.123
BKL	0.209	0.188	0.308	0.361	0.412
BKW	0.146	-0.586	0.436	0.192	0.092
EAL	0.532	-0.407	-0.264	-0.071	0.083
CL	0.653	-0.099	-0.300	0.007	0.121
CW	0.742	-0.204	-0.247	0.000	0.095
HB	0.525	0.522	0.204	-0.038	-0.158

Note: BWT was in Kg and the others in cm

Based on their associated eigenvalue seven variables from PC1, PC2, PC3, PC4 and PC5 were selected (Table 34). This reduces the variables from 19 to 7 and these were quite satisfactory for the analysis (Sneath and Sokal, 1973; Pimental, 1979). The first five PCs (Table 34) that display weight on the Scree plot profile (Fig.3) and explained 58.45% of the total variation were selected for classification.

4.12.3.2. Discriminant analysis

Discriminate analysis model was used to prove variations among the sampled populations. Discriminate functions have relatively higher trait coefficients which functions are termed as discriminate trait functions. The results on discriminate analysis of the study chicken ecotypes using nineteen linear traits are presented in Table 35.

Table 35. Linear discriminate function coefficients for each chicken eco type population

Variable	Midland chicken	Highland chicken
Sample size	172	185
Constant	-215.92	-223.54
Body weight	-49.19	-51.07
Breast width	3.16	3.23
Spur length	2.54	2.70
Thigh circumference	2.49	2.53
Chest circumference	2.86	2.93
Shank length	6.27	6.47
Neck length	1.17	1.43
Body length	2.75	2.65
Wing length	1.96	1.88
Wing span	2.02	2.05
Wattle width	-1.22	-0.97
Wattle length	-3.78	-3.32
Earlobe width	0.93	0.61
Beak length	7.73	7.59
Beak width	17.11	18.01
Earlobe length	10.85	11.19
Comb length	-3.31	-3.18
Comb width	-0.85	-0.96
Height at back	1.49	1.55

Discriminate function was classified by using all the data and functions in the form of classification matrix of all chicken populations. In this result the following discriminant function models were extracted (Table35).

$$Midland\ chicken = -49.19 * Bwt + 3.16 * Brwth + 2.54 * SPl + 2.49 * TC + 2.86 * Cc + 6.27 * SL + 1.17 * NL + 2.75 * BL + 1.96 * WL + 2.02 * WS + -1.22 * WAW + -3.78 * WAL + 0.93 * EAW + 7.73 * BKL + 17.11 * BKW + 10.85 * EAL + -3.31 * CL + -0.85 * CW + 1.49 * HB + -215.92$$

$$Highland\ chicken = -51.07 * Bwt + 3.23 * Brwth + 2.70 * SPl + 2.53 * TC + 2.93Cc + 6.47 * SL + 1.43 * NL + 2.65 * BL + 1.88 * WL + 2.05 * WS + -0.97 * WAW + -3.32 * WAL + 0.61 * EAW + 7.59 * BKL + 18.01 * BKW + 11.19 * EAL + -0.96 * CL + -3.18 * CW + 1.55 * HB + -223.54$$

Where:-
Bwt=body weights, Brwth=breast width, SPl=spur length, TC= thigh circumference, Cc=chest circumference SL=shank length, NL=neck length, BL= body length, WL= wing length, WS= wing span, WAW = wattle width, WAL= wattle length, EAW= earlobe width, BKL= beak length, BKW=beak width, EAL= earlobe length, CL= comb length, CW =comb width, HB =height at back

4.12.3.3. Canonical discriminate analysis

Canonical discriminate analysis measures the strength of the overall relationship between the linear composite of the predictor set of variables (Minitab, 1998). In this analysis the predictor is the canonical variants and the criterion is the ecotype. Canonical discriminant functions evaluated group means to discriminant distributions and graphic representations of the homogeneity of the two chicken ecotypes and were normally distributed from centroids of their multivariate means (group centroids).

Table 36 presents the total-sample standardized canonical coefficients and total variation explained by each canonical variable. The total sample standardized canonical coefficients indicate the partial contribution of each variable to the discriminant function, controlling for other attributes entered in the equation. Accordingly, the total sample standardized canonical coefficients given in the table indicate that the explanatory variables, beak length, wattle length, earlobe length, neck length, wattle width, shank length, spur length and comb length contributed significantly in that order to the first canonical variable (CAN1). The correlation between CAN1

and the chicken populations sampled from midland and highland agro ecology was moderate -0.518 and 0.346, respectively.

Table 36. Total sample standardized canonical coefficients and canonical correlation

Variable	Can1
Body weight	-2.180
Breast width	0.083
Spur length	0.191
Thigh circumference	0.050
Chest circumference	0.080
Shank length	0.236
Neck length	0.297
Body length	-0.114
Wing length	-0.098
Wing span	0.039
Wattle width	0.289
Wattle length	0.524
Earlobe width	-0.368
Beak length	-0.159
Beak width	1.037
Earlobe length	0.397
Comb length	0.155
Comb width	-0.123
Height at back	0.062
High land	-0.518
Midland	0.346

The significant ($p>0.001$) differences between means of neck length, beak width , body length wattle width, body weight ,wattle length, height at back producing high F values (Table 37) indicated that these variants have high discriminating power and better ability to differentiate the groups. The result was in agreements with finding of Deeve *et al.* (2013) reported that similar observation. These variables can be used to characterize and differentiate between isolated populations of local chickens.

Stepwise discriminate analysis was the most important techniques for discriminating the investigated ecotypes (Minitab, 1998). The result of the stepwise discriminant analysis is presented in Table 37. Seven standard canonical discriminant traits were extracted in the study.

Table 37. Summary of discriminate stepwise selection among midland and highland ecotypes

Step	Traits	Partial R^2	F-statistics	Significant	Wilki λ	Pr< λ
1	Neck length	0.06	22.72	<.0001	0.93	<.0001
2	Beak width	0.02	8.05	0.0048	0.91	<.0001
3	Body length	0.01	4.81	0.0290	0.90	<.0001
4	Wattle width	0.01	6.29	0.0126	0.89	<.0001
5	Body weight	0.007	2.48	0.1163	0.88	<.0001
6	Wattle length	0.011	4.04	0.0452	0.87	<.0001
7	Height at back	0.011	4.04	0.0452	0.87	<.0001

The significance of the discriminant function as indicated by wilks lambda is present in Table 37. Wilks lambda text indicated that traits like neck length, beak width, body length wattle width, body weight, wattle length and height at back was highly significant ($p< 0.0001$) to provide the validity for the canonical discriminant analysis.

The significant of the discriminant traits tested with the minimization of wilks' lambda (lambda= 0.93, 0.91, 0.90, 0.89, 0.88, 0.87 and 0.87 for discriminant neck length, beak width, body length wattle width, body weight, wattle length and height at back) provided the validity for the canonical discriminant analysis. By comparing the F-value and the P-value statistics for each significant explanatory variable, we can conclude that 'neck length' has the highest amount of significant discriminative potential, while 'height at back has the least significant discriminative power in differentiating the chicken populations sampled from the two agro ecology.

Therefore, the differentiation of those two populations, highland and midland was based on the weights of neck length, beak length, body length, wattle width, body weight, wattle length and height at back traits. These traits were very important both to discriminate and to classify populations. This result was almost similar with reports of Reddish and Lilburn (2004) and Rosario *et al.* (2008) who reported that average live weight was the most important trait to cluster many chicken populations and strains.

The result is also in agreements with finding of Abdelqader *et al.* (2007) who indicated that body weight, body length, heart girth and height at back showed the largest discriminatory power between three Jordanian chicken genotypes.

4.12.3.4. Cluster analysis

The first 5 principal components, accounting for 58.45% of the total variance, were considered to develop the classification by cluster analysis. The set of three observations against those principal components was clustered by hierarchical technique. The Mahalanobis distance was the similarity coefficient used to develop the classification tree from which the desired number of clusters was obtained. The dendogram shows three distinct groups (cluster) of chicken populations (Figure 4). In general, a cluster with a high similarity percentage is more compact than one with a small similarity percentage (Minitab, 1998).

In the present study, the pair wise squared Mahalanobis' distances between populations' shows smallest and largest distances between midland and highland chicken ecotypes, respectively (Fig.4). Based on their pair wise squared Mahalanobis' distances the three clusters, cluster1 and cluster2 formed by the midland agro ecologies of the two district populations and cluster3 were formed by highland agro ecologies chicken population (Table 38).

The closeness of cluster1 and cluster2 was explained by the fact that both clusters have been fund with in the same midland agro ecologies with a short distance between the districts, as a result farmers of these two districts often exchange cock/hen through different means with the fact that there existed genetic migration from one district to the next district chicken populations and gene flow is unregulated.

Table 38. Squared distance between clusters centroids (Mahalanobis distance)

Cluster	Cluster1	Cluster2	Cluster3
Cluster1	-	6.31	7.69
Cluster2	6.31	-	5.87
Cluste3	7.69	5.87	-
Midland	2.00	1.00	3.00
Highland	29.01	10.95	1.96
Similarity	99.99	98.94	97.89

Result of the study shows that, the greatest distance were observed between cluster1 and 3 (7.69) followed by cluster1 and 2 (6.31) (Table 38). The distance between agro ecologies and cluster

shows that greatest distance were observed between cluster1 and highland (29.01) followed by cluster2 (10.95), whereas midland agro ecologies shows greatest distance with cluster3 (3.00)

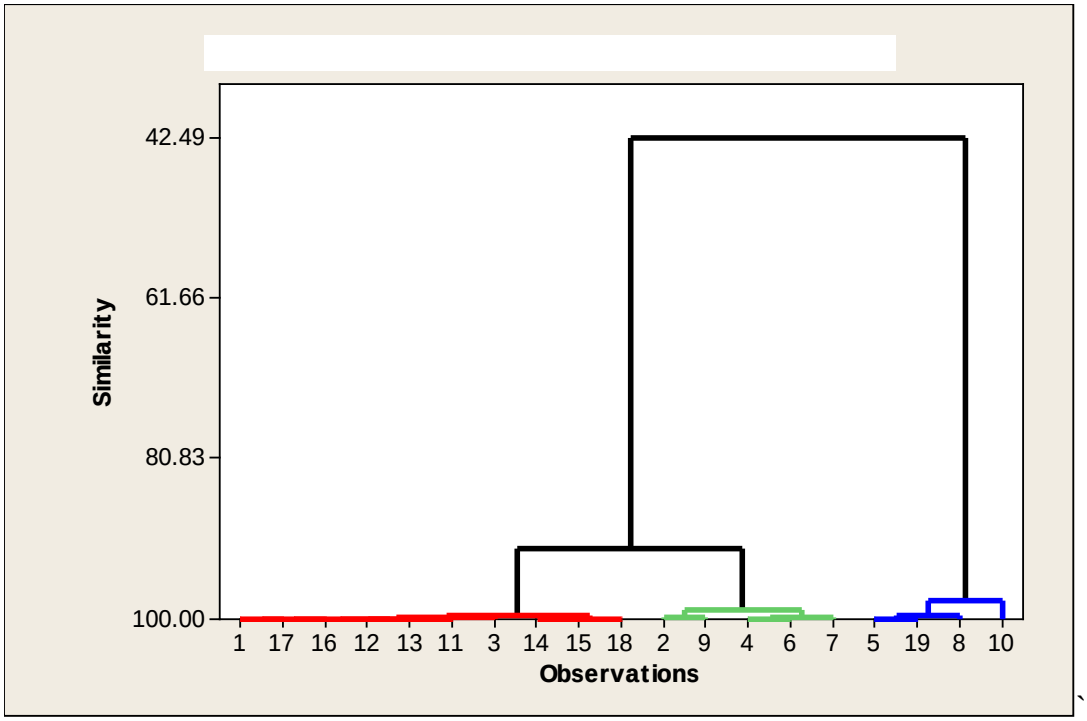

Figure 4. Clustering of chicken in midland and highland agro ecologies by using dendrogram

Number 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18 and 19 represents Bwt , Brwth, SPl ,TC ,Cc, SL, NL, BL ,WL,WS ,WAW, WAL, EAW, BKL, BKW, EAL, CL, CW and HB.

The formation of two large groups seen in Fig.4 showed that the distribution of the populations influence by agro ecology. Therefore, the current result of the study was in agreement with findings of Tunon *et al.* (1989) who reported that classification of populations should take into account not only the genetic aspect, but also the ecological, morphological and productive aspects.

Cluster1 have highest (99.9%) similarity level and was considered as highly compact and closet followed by cluster2 (98.94%). While cluster 3 has lowest similarity level as comparatively 97.89% (Fig.4) exhibited the slackness of the cluster. The relatively large size of similarity level (91.56%) of the midland chicken indicated that midland chicken share some phenotypic characters with other chicken types. Similarly, the intra-cluster similarity level of highland

chicken type with other clusters, as indicated by the similarity 42.49% indicated higher heterogeneity within the breed type (Fig.4).

The study reviles that traits like body weight, comb length, earlobe length, wattle length, earlobe width, wattle width, spur length beak length and comb width measurements are similar with similarity level 99.82% in both agro ecologies formed cluster1. Similarly traits like breast width, wing length, thigh circumference, shank length and neck length are similar with similarity level of 99.90% combine into one and formed cluster2. While chest circumference, height at back, body length and wing span are similar in both agro ecologies formed custer3.

5. SUMMERY AND CONCLUSION

The result of the current study revealed that, village chicken production appeared to be an important activity in all study areas as indicated by the high average chicken holding per household of 9.41, and 8.98 for midland and highland agro ecologies with a sex ratio of three hens for one cock.

Almost all of the respondents (90.1%) reported to practice scavenging system with supplementary feeding while the remaining 8.9% don't use supplementary feed due to different reasons. The main source of water in wet and dry season was rivers (4.1%), pond (2.5%), springs(1.2%), water well (12.5%) and hand operated pipe water (26%). only 36.8% and 28.9% of the respondents in highland and midland of the study area chickens sleep at night in separate poultry house.

Farmers in the study area also seem to have good practice of selecting eggs and hens for incubation based on size. There was significant difference ($P<0001$) in use of material and bedding materials for incubation between the households living in lowland and midland agro-ecological zones.

In the study area about 93.8% of the respondents confirmed the presence of dangerous disease outbreak in the midland and highland agro ecologies of the study areas. Out of the total participants, only 2.5% reported of getting veterinary advisory services. There is a need for a serious intervention in disease control and advisory services in order to minimize losses and improve chicken production and productivity. Predation is also an important problem in the midland and highland agro ecologies of the study areas. Almost all the interviewed village chicken owners (81%) participate in chicken and egg marketing as source of income.

The results of the present study show that the overall mean age at first mating of male chickens and the age at first egg of female chickens were 5.29 and 5.96 months. The overall number of eggs/hen per clutch, clutch length and inter-clutch period in the present study was 13.7, 17.8, 14.0 days. The mean values obtained in the present study were and for. The average number of eggs incubated in the study area was 11.44. It was also observed that there were no significant differences between agro ecologies with respect to number of chick hatched/clutch/hen. The

survival rates were 73.84% and 70.10% for midland and highland, with the overall mean survival rates being 72.02%. These results reflect high chick mortality rates of 26.16% and 29.9% midland and highland, under the free range management system. The mean number of egg laying cycles and the estimated number of eggs per hen per year were 4.58 and 69.6.

The main production objectives of chicken in midland and highland agro ecologies were for brooding, for replacement, meat consumption, cash from sale of chicken and egg, egg consumption, spiritual/religious, and ceremony, cultural and manure. Concerning breeding practice 80.1% of respondents have breeding practice in improving their chicken productivity through cross breeding (60.3%) and by pure breeding (39.7%).

On average 78.9% of households of the study area cull low production of chicken, old age, unwanted plumage color, ill that were in poor health and bad temperament of hens and cocks. The effective population size (Ne) and the rate of inbreeding (ΔF) calculated for the indigenous chicken flock of the study area were 3.99 and 0.13, respectively. The rate of inbreeding was higher than the maximum acceptable level of 0.06 which suggests that action is needed to minimize the risk of inbreeding depression. The current study showed that the selection criteria used for selection of breeding hen were egg size; plumage color, broodiness, disease resistance and hatchability were the traits of highest importance for selection purpose; while mothering ability, egg number, body size, growth rate, good scavenging, longevity, fighting ability were ranked low. The highest selection criteria used for selection of breeding cock were egg number, comb type plumage color, disease resistance, and egg size and growth rate, respectively.

Local chicken were mostly normally feathered (hens 97.8%, cocks 96%) with a few showing necked neck (0.6%) and feathered shank and feet (2%). Red (33%), grayish/sigem (17.5%), brownish/bunama(17.3%),wheaten(7.9%), multi color(6.8%) black(6.3%), white(5.2%), gold (4.8%) and black and red white with red strips, respectively being the dominant color for these areas in hens. The commonest comb color observed was red (hens 94.7%, cocks 97%). The highest proportion of eye color was orange (hens 96.1%, cocks 98%) followed by brown (hens 2.2%, cocks 2%) yellow and blue and red.

Morph metric measurements indicated that significance differences ($P<0.05$) were observed between agro ecologies with respect to breast width, spur length, chest circumferences and shank length. In all parameters, male birds shows higher significance ($P<0.001$) value than female except breast width and beak width.

Multivariate analysis result showed that five PC were extracted that accounted for 58.45% of the total variation. Most important variable for discriminating between the ecotypes was the neck length, beak length and body length with partial R^2 0.060, 0.22 and 0.013.

Greatest distance were observed between cluster1 and 3 (7.69) followed by cluster1 and 2 (6.31). The distance between agro ecologies and cluster shows that greatest distance were observed between cluster1 and highland (29.01) followed by cluster2 (10.95),

In the present study, the pair wise squared Mahalanobis' distances between populations shows the smallest and largest distances between highland and midland chicken ecotypes. The three clusters, cluster1 and cluster2 formed by the midland agro ecologies of the two district populations and cluster3 were formed by highland agro ecologies chicken population.

The closeness of cluster1 and cluster2 was explained by the fact that both clusters have been fund with in the same midland agro ecologies with a short distance between the districts, as a result farmers of these two districts often exchange cock/hen through different means with the fact that there existed genetic migration from one district to the next district chicken populations and gene flow is unregulated.

6. RECOMMENDATIONS

- The productivity of scavenging village chicken could be enhanced by relatively simple changes in management techniques (feeding, housing and health care) that promote improvement in productivity and reduction in mortality. A little technical support to farmers' experience or knowledge of supplementary feeding and watering would substantially improve productivity of local chicken; therefore higher institutions, research centers and other stockholders should play their role to develop knowledge and capacity of producers.
- Past attempts to improve poultry production in Tigray region are focused on introduction of highly productive exotic breeds that require high level of management and inputs, with very little or no attention to the indigenous breeds. Therefore, there is a need to design proper breed improvement programs in order to enhance the utilization and conservation of the huge diversity of the indigenous chicken populations. Thus, designing and implementing community-based breed improvement program for local chicken ecotypes is timely and essential.
- There is a strong need for appropriate intervention in disease and predator control activities so as to reduce chicken mortality and improve productivity through improvement in veterinary and advisory services; more detailed studies should be carried out to investigate the disease problems prevailing in the study area that would help develop a sustainable strategy of disease prevention and control.
- The findings of this study demonstrate that there are diverse indigenous chicken ecotypes in phenotype but there is a need to study but there is a need to study carcass and egg quality of the chickens and other variability at molecular levels that will further clarify the genetic similarity and diversity among the ecotypes in order to record and registered these breeds internationally.

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8. APPENDIXS

8.1. Appendix I.

Appendix Table 1. Goat population per household

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	42.614810	42.614810	2.50	0.1152
Error	240	4092.562876	17.052345		
Total	241	4135.177686			
Effect tests					
Agro-ecology	1	42.61481006	42.61481006	2.50	0.1152

Appendix Table 2 .Sheep population per household

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	419.168639	419.168639	21.64	<.0001
Error	240	4648.273510	19.367806		
Total	241	5067.442149			
Effect tests					
Agro-ecology	1	419.1686386	419.1686386	21.64	<.0001

Appendix Table 3. Donkey population per household

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	0.6610949	0.6610949	0.86	0.3547
Error	240	184.5455167	0.7689397		
Total	241	185.2066116			
Effect tests					
Agro-ecology	1	0.66109489	0.66109489	0.86	0.3547

Appendix Table 4. Cattle population per household

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	31.313938	31.313938	7.28	0.0074
Error	240	1031.681930	4.298675		
Total	241	1062.995868			
Effect tests					
Agro-ecology	1	31.31393775	31.31393775	7.28	0.0074

Appendix Table 5. Chicken population per household

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	324.663942	324.663942	10.41	0.0014
Error	240	7486.414571	31.193394		
Total	241	7811.078512			
Effect tests					
Agro-ecology	1	324.6639416	324.6639416	10.41	0.0014

Appendix Table 6.Camel population per household

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	0.75957146	0.75957146	11.46	0.0008
Error	240	15.90158557	0.06625661		
Total	241	16.66115702			
Effect tests					
Agro-ecology	1	0.75957146	0.75957146	11.46	0.0008

Appendix Table 7. Modern bee population per household

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	1.9712721	1.9712721	3.01	0.0843
Error	240	157.4006288	0.6558360		
Total	241	159.3719008			
Effect tests					
Agro-ecology	1	1.97127207	1.97127207	3.01	0.0843

Appendix Table 8. Traditional bee population per household

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	4.9249511	4.9249511	5.26	0.0227
Error	240	224.6990159	0.9362459		
Total	241	229.6239669			
Effect tests					
Agro-ecology	1	4.92495109	4.92495109	5.26	0.0227

Appendix Table 9. Number of chick per household

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	0.559869	0.559869	0.04	0.8435
Error	240	3441.440131	14.339334		
Total	241	3442.000000			
Effect tests					
Agro-ecology	1	0.55986878	0.55986878	0.04	0.8435

Appendix Table 10. Number of pullet per household

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	0.9707344	0.9707344	0.28	0.6004
Error	240	846.8309185	3.5284622		
Total	241	847.8016529			
Effect tests					
Agro-ecology	1	0.97073436	0.97073436	0.28	0.6004

Appendix Table 11. Number of cockerel per household

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	15.4898908	15.4898908	6.07	0.0144
Error	240	612.2787042	2.5511613		
Total	241	627.7685950			
Effect tests					
Agro-ecology	1	15.48989083	15.48989083	6.07	0.0144

Appendix Table 12. Number of hen per household

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	77.858564	77.858564	13.46	0.0003
Error	240	1388.306725	5.784611		
Total					
Effect tests					
Agro-ecology	1	77.85856427	77.85856427	13.46	0.0003

Appendix Table 13. Number of cock per household

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	3.8495000	3.8495000	3.54	0.0613
Error	240	261.2744669	1.0886436		
Total	241	265.1239669			
Effect tests					
Agro-ecology	1	3.84950002	3.84950002	3.54	0.0613

Appendix Table 14. Hatching rate in wet season

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	2.9099867	2.9099867	0.81	0.3697
Error	240	864.5982777	3.6024928		
Total	241	867.5082645			
Effect tests					
Agro-ecology	1	2.90998672	2.90998672	0.81	0.3697

Appendix Table 15. Survival rate in wet season

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	13.1124909	13.1124909	4.24	0.0405
Error	240	741.7800711	3.0907503		
Total	241	754.8925620			
Effect tests					
Agro-ecology	1	13.11249091	13.11249091	4.24	0.0405

Appendix Table 16. Survival rate in dry season

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	1.120623	1.120623	0.26	0.6108
Error	240	1035.495079	4.314563		
Total	241	1036.615702			
Effect tests					
Agro-ecology	1	1.12062320	1.12062320	0.26	0.6108

Appendix Table 17. Trend of clutch period

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	0.0215129	0.0215129	0.03	0.8662
Error	240	181.5032805	0.7562637		
Total	241	181.5247934			
Effect tests					
Agro-ecology	1	0.02151291	0.02151291	0.03	0.8662

Appendix Table 18. Age at first service of cockerel

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	0.0582093	0.0582093	0.04	0.8332
Error	240	314.1535675	1.3089732		
Total	241	314.2117769			
Effect tests					
Agro-ecology	1	0.05820934	0.05820934	0.04	0.8332

Appendix Table 19. Age at first egg lay hen

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	0.6723769	0.6723769	0.56	0.4540
Error	240	286.9143999	1.1954767		
Total	241	287.5867769			
Effect tests					
Agro-ecology	1	0.67237691	0.67237691	0.56	0.4540

Appendix Table 20. Number of clutch per year

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	14.1482283	14.1482283	4.42	0.0366
Error	240	768.6988792	3.2029120		
Total	241	782.8471074			
Effect tests					
Agro-ecology	1	14.14822827	14.14822827	4.42	0.0366

Appendix Table 21. Number of egg lay per clutch

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	9.850717	9.850717	0.87	0.3525
Error	240	2724.628622	11.352619		
Total	241	2734.479339			
Effect tests					
Agro-ecology	1	9.85071665	9.85071665	0.87	0.3525

Appendix Table 22. Length of clutch in day

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	2.997665	2.997665	0.31	0.5794
Error	240	2335.465145	9.731105		
Total	241	2338.462810			
Effect tests					
Agro-ecology	1	2.99766503	2.99766503	0.31	0.5794

Appendix Table 23. Total egg per year

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	675.74496	675.74496	2.81	0.0951
Error	240	57766.50711	240.69378		
Total	241	58442.25207			
Effect tests					
Agro-ecology	1	675.7449584	675.7449584	2.81	0.0951

Appendix Table 24. Clutch period to set egg

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	1.8464706	1.8464706	0.55	0.4571
Error	240	798.7165459	3.3279856		
Total	241	800.5630165			
Effect tests					
Agro-ecology	1	1.84647060	1.84647060	0.55	0.4571

Appendix Table 25. Interval between consecutive brooding

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	1.5596124	1.5596124	2.63	0.1061
Error	240	142.2461728	0.5926924		
Total	241	143.8057851			
Effect tests					
Agro-ecology	1	1.55961235	1.55961235	2.63	0.1061

Appendix Table 26. Age of culling of local chicken

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	527.8270	527.8270	0.44	0.5080
Error	240	288195.4995	1200.8146		
Total	241	288723.3264			
Effect tests					
Agro-ecology	1	527.8269930	527.8269930	0.44	0.5080

Appendix Table 27. Age of selecting for breeding male

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	192.0420	192.0420	0.45	0.5033
Error	240	102575.2070	427.3967		
Total	241	102767.2490			
Effect tests					
Agro-ecology	1	192.0419891	192.0419891	0.45	0.5033

Appendix Table 28. Age of selecting for breeding female

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	1	162.3704	162.3704	0.38	0.5375
Error	240	102221.5015	425.9229		
Total	241	102383.8719			
Effect tests					
Agro-ecology	1	162.3703973	162.3703973	0.38	0.5375

Appendix Table 29. Average body weight of local chicken

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	3	3.2212300	1.0737433	2.19	0.0888
Error	453	222.3544923	0.4908488		
Total	456	225.5757223			
Effect tests					
sex	1	2.54178141	2.54178141	5.18	0.0233
Agro-ecology	1	0.21069816	0.21069816	0.43	0.5127
sex* Agro-ecology	1	0.03085488	0.03085488	0.06	0.8021

Appendix Table 30. Breast width of local chicken

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	3	14.358703	4.786234	1.70	0.1671
Error	453	1278.529699	2.822361		
Total	456	1292.888403			
Effect tests					
sex	1	3.48217974	3.48217974	1.23	0.2673
Agro-ecology	1	12.10399762	12.10399762	4.29	0.0389
sex* Agro-ecology	1	8.59859331	8.59859331	0.05	0.0816

Appendix Table 31. Thigh circumference of local chicken

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	33	201.655365	67.218455	22.98	<.0001
Error	453	1325.179427	2.925341		
Total	456	1526.834792			
Effect tests					
sex	1	170.3622532	170.3622532	58.24	<.0001
Agro-ecology	1	6.8711311	6.8711311	2.35	0.1261
sex* Agro-ecology	1	0.4591592	0.4591592	0.16	0.6922

Appendix Table 32. Chest circumference of local chicken

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	3	157.421287	52.473762	4.97	0.0021
Error	453	4783.147641	10.558825		
Total	456	4940.568928			
Effect tests					
sex	3	40.54048514	40.54048514	3.84	0.0507
Agro-ecology	1	80.64525391	80.64525391	7.64	0.0059
sex* Agro-ecology	1	37.18242813	37.18242813	3.52	0.0612

Appendix Table 33. Neck length of local chicken

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	3	217.652221	72.550740	13.75	<.0001
Error	453	2390.341215	5.276691		
Total	456	2607.993435			
Effect tests					
sex	1	117.7822971	117.7822971	22.32	<.0001
Agro-ecology	1	18.3792119	18.3792119	3.48	0.0626
sex* Agro-ecology	1	30.7487138	30.7487138	5.83	0.0162

Appendix Table 34. Beak length of local chicken

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	3	109.786327	36.595442	5.01	0.0020
Error	453	3310.660062	7.308300		
Total	456	3420.44638			
Effect tests					
sex	1	91.55631079	91.55631079	12.53	0.0004
Agro-ecology	1	7.55563937	7.55563937	1.03	0.3098
sex* Agro-ecology	1	0.03123380	0.03123380	0.00	0.9479

Appendix Table 35. Wing length of local chicken

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	3	150.095900	50.031967	16.85	<.0001
Error	453	1344.736704	2.968514		
Total	456	1494.832604			
Effect tests					
sex	1	128.9446793	128.9446793	43.44	<.0001
Agro-ecology	1	0.0738744	0.0738744	0.02	0.8747
sex* Agro-ecology	1	1.4488704	1.4488704	0.49	0.4851

Appendix Table 36. Wing span of local chicken

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	3	1415.900533	471.966844	46.47	<.0001
Error	453	4600.996622	10.156725		
Total	456	6016.897155			
Effect tests					
sex	1	1078.134033	1078.134033	106.15	<.0001
Agro-ecology	1	103.208310	103.208310	10.16	0.0015
sex* Agro-ecology	1	32.085136	32.085136	3.16	0.0762

Appendix Table 37. Wattle width of local chicken

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	3	250.5416370	83.5138790	163.22	<.0001
Error	453	231.7771814	0.5116494		
Total	456	482.3188184			
Effect tests					
sex	1	205.8991876	205.8991876	402.42	<.0001
Agro-ecology	1	8.4757424	8.4757424	16.57	<.0001
sex* Agro-ecology	1	2.9911997	2.9911997	5.85	0.0160

Appendix Table 38. Wattle length of local chicken

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	3	378.8818331	126.2939444	180.81	<.0001
Error	453	316.4144251	0.6984866		
Total	456	695.2962582			
Effect tests					
sex	1	313.1805374	313.1805374	448.37	<.0001
Agro-ecology	1	11.7411678	11.7411678	16.81	<.0001
sex* Agro-ecology	1	4.2454145	4.2454145	6.08	0.0141

Appendix Table 39. Earlobe width of local chicken

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	3	90.5529257	30.1843086	75.55	<.0001
Error	453	180.9882559	0.3995326		
Total	456	271.5411816			
Effect tests					
sex	1	70.43149590	70.43149590	176.28	<.0001
Agro-ecology	1	2.71040322	2.71040322	6.78	0.0095
sex* Agro-ecology	1	3.36118643	3.36118643	8.41	0.0039

Appendix Table 40. Beak length of local chicken

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	3	6.07955447	2.02651816	11.81	<.0001
Error	453	77.76267747	0.17166154		
Total	456	83.84223195			
Effect tests					
sex	1	5.04237363	5.04237363	29.37	<.0001
Agro-ecology	1	0.20281993	0.20281993	1.18	0.2776
sex* Agro-ecology	1	0.05286583	0.05286583	0.31	0.5792

Appendix Table 41. Beak width of local chicken

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	3	1.2955967	0.4318656	1.86	0.1353
Error	453	105.1073793	0.2320251		
Total	456	106.4029759			
Effect tests					
sex	1	0.41995496	0.41995496	1.81	0.1792
Agro-ecology	1	0.61948564	0.61948564	2.67	0.1030
sex* Agro-ecology	1	0.15130030	0.15130030	0.65	0.4198

Appendix Table 42. Earlobe length of local chicken

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	3	47.6290754	15.8763585	47.01	<.0001
Error	453	152.9782769	0.3377004		
Total	456	200.6073523			
Effect tests					
sex	1	41.98842628	41.98842628	124.34	<.0001
Agro-ecology	1	0.37104933	0.37104933	1.10	0.2951
sex* Agro-ecology	1	0.11654815	0.11654815	0.35	0.5572

Appendix Table 43. Comb length of local chicken

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	3	182.2864934	60.7621645	49.05	<.0001
Error	453	561.1429596	1.2387262		
Total	456	743.4294530			
Effect tests					
sex	1	155.3621370	155.3621370	125.42	<.0001
Agro-ecology	1	4.4357309	4.4357309	3.58	0.0591
sex* Agro-ecology	1	0.7640029	0.7640029	0.62	0.4327

Appendix Table 44. Comb width of local chicken

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	3	606.052965	202.017655	86.73	<.0001
Error	453	1055.101215	2.329142		
Total	456	1661.154179			
Effect tests					
sex	1	566.1254667	566.1254667	243.06	<.0001
Agro-ecology	1	0.0186472	0.0186472	0.01	0.9287
sex* Agro-ecology	1	0.5115032	0.5115032	0.22	0.6396

Appendix Table 45. Height at back of local chicken

Source of Variation	df	Sum of Squares	Mean Square	F ratio	p value
Model	3	1109.520053	369.840018	46.84	<.0001
Error	453	3576.860691	7.895940		
Total	456	4686.380744			
Effect tests					
sex	1	901.7388767	901.7388767	114.20	<.0001
Agro-ecology	1	63.3620274	63.3620274	8.02	0.0048
sex* Agro-ecology	1	2.5044503	2.5044503	0.32	0.5736

Appendix Table 46. Selection criteria used for selecting breeding hen and cock in midland agro ecology

Selection criteria	In midland chicken owner Rank												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**sum**	**Index**
Breeding hen													
Egg number	23	23	33	16	5	8	7	1	1	2	0	391	0.041
Body size	31	21	23	14	11	8	7	1	1	1	1	388	0.041
Growth rate	14	16	18	14	10	7	4	3	0	1	0	310	0.032
Hatchability	29	24	13	23	8	6	3	5	3	1	0	382	0.040
Mothering ability	1	7	12	7	21	12	12	7	4	1	0	442	0.046
Broodiness	7	9	4	7	14	18	10	16	11	2	1	571	0.060
Disease resistance	8	6	6	7	13	19	19	4	6	2	0	484	0.051
Egg size	2	6	6	10	19	14	13	22	8	4	1	641	0.067
Plumage color	8	9	7	20	13	11	10	12	14	3	0	580	0.061
Fighting ability	1	2	0	0	1	0	3	3	4	12	5	266	0.028
Good scavenging	0	0	0	1	2	0	5	2	5	7	10	290	0.030
Longevity	0	1	2	4	0	4	5	11	3	6	5	313	0.033
Breeding cock													
Egg number	3	7	21	18	10	6	5	23	1	0	0	466	0.049
Body size	46	41	19	6	2	6	1	0	3	0	0	289	0.030
Growth rate	7	24	27	24	15	0	2	0	0	0	1	332	0.035
Hatchability	4	5	7	12	14	10	4	3	1	2	0	294	0.031
Mothering ability	0	0	0	2	7	5	4	4	7	3	1	237	0.025
Broodiness	0	1	2	2	5	6	4	6	9	4	5	329	0.034
Disease resistance	5	14	12	13	9	9	6	2	3	7	1	386	0.040
Egg size	1	3	1	2	15	10	17	6	5	4	1	416	0.044
Good scavenging	0	0	4	8	2	6	4	13	2	3	8	358	0.037
Plumage color	28	17	14	7	4	11	10	3	4	3	3	411	0.043
Fighting ability	2	3	2	7	6	2	1	4	1	2	0	152	0.016
Fertility	26	4	4	7	8	10	4	2	4	3	5	339	0.035
Comb type	2	5	10	10	17	20	5	7	6	4	1	483	0.051

Percentages do not add up to 100% since respondents selected based on more than one trait category

Index=the sum of (11 times first order + 10 times second order +…… + 1 times eleventh order) for individual variables divided by the sum of (11 times first order + 10 times second order +…… + times eleventh order) for all variables.

Appendix Table 47. Selection criteria used for selecting breeding hen and cock in highland agro ecology

Selection criteria	In highland chicken owner Rank														
	1	2	3	4	5	6	7	8	9	10	11	Sum	Index	Average Index	traits rank
Breeding hen															
Egg number	45	24	26	15	5	0	1	0	0		0	263	0.031	0.036	6
Body size	35	20	35	12	1	3	2	0	0	0	0	265	0.031	0.036	6
Growth rate	8	19	21	14	16	5	0	1	0	0	0	283	0.033	0.033	7
Hatchability	13	16	5	35	19	11	2	0	0	0	0	375	0.044	0.042	4
Mothering ability	4	10	4	2	19	8	7	3	2	1	0	288	0.034	0.040	5
Broodiness	4	4	6	4	14	19	5	15	7	5	5	553	0.065	0.062	3
Disease resistance	3	4	2	13	13	19	26	1	4	1	0	484	0.057	0.054	4
Egg size	2	21	15	11	15	11	16	14	7	1	0	571	0.067	0.067	1
Plumage color	4	0	2	9	5	19	20	18	11	0	0	568	0.067	0.064	2
Fighting ability	0	0	2	2	0	2	1	7	2	0	2	129	0.015	0.022	10
Good scavenging	0	0	0	0	0	2	9	1	4	5	5	224	0.026	0.028	8
Longevity	0	0	0	0	0	0	0	6	7	5	1	172	0.020	0.027	9
Breeding cock															
Egg number	9	11	15	19	17	1	3	9	16	0	0	480	0.057	0.053	1
Body size	50	32	25	7	0	1	0	2	0	0	0	239	0.028	0.029	9
Growth rate	7	22	28	23	13	7	1	0	4	2	0	397	0.047	0.041	5
Hatchability	1	1	3	20	12	13	7	0	0	0	0	279	0.033	0.032	8
Mothering ability	0	1	1	2	8	7	3	2	2	6	0	210	0.025	0.025	10
Broodiness	0	0	2	2	6	6	11	4	1	1	6	274	0.032	0.033	7
Disease resistance	4	9	6	11	17	11	18	4	1	0	0	402	0.047	0.044	4
Egg size	1	7	3	2	16	6	10	13	0	1	0	332	0.039	0.041	5
Good scavenging	0	2	1	4	1	9	2	20	6	3	0	340	0.040	0.039	6
Plumage color	12	10	22	5	3	15	9	1	5	4	2	401	0.047	0.045	3
Fighting ability	2	0	0	0	0	0	8	11	7	0	3	242	0.029	0.022	11
Fertility	30	17	9	12	8	7	1	0	0	2	1	259	0.031	0.033	7
Comb type	2	6	3	10	6	16	3	2	8	10	5	453	0.053	0.052	2

Appendix Table 48. Summary of reported traits preference of farmers wanted to be improved in midland areas

Traits want to be improved in midland chicken owner	Rank													
	1	2	3	4	5	6	7	8	9	10	11	12	Sum	Index
Growth rate	9	7	25	23	9	5	4	3	7	2	1	0	411	0.063
Body size	39	36	20	12	8	4	0	2	2	0	1	0	328	0.050
Egg number	34	33	14	15	10	8	0	3	1	0	1	1	356	0.055
Fertility	6	16	20	20	17	10	6	0	3	5	0	0	442	0.068
Prolificacy	10	0	0	2	3	5	3	4	3	6	1	0	214	0.033
Disease resistance	11	7	5	16	26	16	3	6	4	3	2	0	487	0.075
Heat resistance	0	0	0	0	1	1	10	2	2	5	3	4	246	0.038
Drought resistance	0	2	5	3	2	2	3	2	3	0	1	4	176	0.027
Broodiness	7	4	4	2	10	16	6	6	7	8	6	2	504	0.077
Mothering ability	0	4	1	3	3	7	5	3	2	4	9	2	320	0.049
Temperament	0	0	0	1	0	4	3	5	8	1	3	4	252	0.039
Plumage color	2	7	13	12	17	11	20	11	8	1	1	7	659	0.101
Chicken shape	0	0	0	0	0	0	1	0	0	2	0	1	39	0.006
Meat quality	1	3	3	3	5	11	16	15	8	5	1	0	484	0.074
Egg size	5	5	12	8	10	15	20	15	10	0	1	0	584	0.090
Egg shell color	0	0	0	0	1	0	2	2	2	1	0	2	87	0.013
Egg yolk color	0	0	0	0	0	0	0	1	1	1	1	0	38	0.006
Good scavenging	0	0	0	0	0	1	2	4	5	1	1	1	130	0.020
Comb type	0	0	2	3	1	7	14	18	7	21	9	6	751	0.115

Percentages do not add up to 100% since respondents selected based on more than one trait category

Index=the sum of (12 times first order + 11 times second order +…… + 1 times twelfth order) for individual variables divided by the sum of (12 times first order + 11 times second order +…… + times twelfth order) for all variables.

Appendix Table 49. Summary of reported traits preference of farmers wanted to be improved in highland areas

Traits want to be improved	in highland chicken owner Rank														
	1	2	3	4	5	6	7	8	9	10	11	12	Su m	Index	Average index
Growth rate	9	27	30	19	7	9	3	4	3	0	0	0	398	0.065	0.096
Body size	42	35	22	4	6	2	2	0	0	0	0	0	250	0.041	0.071
Egg number	35	38	21	13	3	3	0	1	0	0	0	0	267	0.044	0.077
Fertility	2	5	17	24	19	16	5	7	2	3	0	0	489	0.080	0.108
Prolificacy	2	0	1	1	4	7	4	9	4	4	0	0	247	0.040	0.053
Disease resistance	22	6	4	20	27	4	6	5	6	2	1	1	464	0.076	0.113
Heat resistance	0	0	0	0	0	0	1	0	7	2	2	1	124	0.020	0.048
Drought resistance	0	0	1	0	0	2	1	0	3	5	0	2	123	0.020	0.037
Broodiness	0	0	1	6	11	15	8	6	6	7	4	0	444	0.073	0.114
Mothering ability	2	1	3	1	5	8	13	5	2	2	6	0	325	0.053	0.076
Temperament	0	0	0	0	0	2	0	1	1	1	7	4	164	0.027	0.053
Plumage color	1	0	2	7	5	21	22	17	1	6	1	1			
									2				667	0.109	0.156
Chicken shape	0	0	0	0	1	1	0	2	1	0	3	8	165	0.027	0.020
Meat quality	1	0	4	11	5	16	9	17	9	6	0	0	518	0.085	0.117
Egg size	2	6	12	9	14	9	24	13	4	1	3	1	573	0.094	0.137
Egg shell color	0	0	0	0	1	1	1	2	3	1	1	3	118	0.019	0.023
Egg yolk color	0	0	0	0	0	0	2	0	0	0	0	0	14	0.002	0.007
Good scavenging	0	0	0	2	0	0	2	3	6	0	1	0	111	0.018	0.029
Comb type	0	0	0	1	10	0	13	9	1	19	6	3			
									7				662	0.108	0.169

Appendix Table 50. Eigen values, proportion of variability and cumulative variability

Total Variance Explained

	Initial Eigen values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Components	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.169	27.204	27.204	5.169	27.204	27.204	3.645	19.182	19.182
2	2.305	12.132	39.336	2.305	12.132	39.336	2.403	12.648	31.829
3	1.504	7.913	47.249	1.504	7.913	47.249	2.202	11.588	43.417
4	1.076	5.665	52.914	1.076	5.665	52.914	1.656	8.714	52.131
5	1.052	5.539	58.454	1.052	5.539	58.454	1.201	6.322	58.454
6	0.998	5.250	63.704						
7	0.882	4.640	68.344						
8	0.771	4.057	72.401						
9	0.684	3.600	76.000						
10	0.641	3.373	79.373						
11	0.633	3.332	82.706						
12	0.574	3.020	85.726						
13	0.494	2.599	88.325						
14	0.474	2.494	90.819						
15	0.437	2.298	93.116						
16	0.388	2.042	95.158						
17	0.344	1.813	96.971						
18	0.317	1.667	98.639						
19	0.259	1.361	100.000						

Extraction Method: Principal Components Analysis.

8.2. Appendix II

General information of HH

Name of Enumerator _____ Signature _____Date_____

Name_____ Sex_____Age_____ District_____ Tabia_____village (kushet)_____Agro-ecology _____

1.3 Educational level (tick one)

0.Illiterate	
1. Religious school	
2. Writing & reading	
3. Primary (1-6)	
4. Junior & high school (8 -12)	
5. other	

1.4 Family size living in the house by age and sex

Age classification	Number	
	Male	Female
Under 15years		
Between 15-30 years		
31-60 years		
Above 60 years		

1.5 HH head sex 1. Male 2. Female

1.6. What is your main farming activity? 1. Livestock production 2. Crop production 3. Mixed 4. Trade 5.employed 6. Other

1.7. What is the average land holding (in ha)?

1.8. What are the major crops grown in your area? 1st 2nd 3rd 4th

2. Production and management systems

A. herd size, livestock combosition flock structure and HH responsibilities

2.1 Total numbers of livestock species owned by the HH & rank based on their relative importance

No.	Types of livestock	Total number	Number in breed type			What types of animal do you prefer to produce Rank
			exotic	local	cross	
1	Goat		-		-	
2	Donkey		-		-	
3	Cattle					
4	Sheep		-		-	
5	Chicken					
6	Camel		-		-	
7	M.Bee hives					
8	T.Bee hives					

2.2 Classify your chicken flock according to age, sex and breeding category (number)

chicken	Total No.	No. of local	No. of improved	No. of cross
Chick(0-8wks)				
Pullet(8-20wks)				
Cockerel(8-20w				
Hen(>20wks)				
Cock(>20wks)				

2.3 Member of households who own chicks? 1. Head 2.spouse 3. Head and spouse together 4.sons 5.dauther 6.other

2.4. Labor division, ownership and decision making for poultry production in HH members

S/n	Activities	Adult		<15 year		Hired labor
		Male	Female	Boy	Girl	
I	Chicken management and marketing					
1	Shelter construction					
2	Cleaning chicken house					
3	Supplementary feeding					
4	Providing water					
5	Selling chicken					
6	Selling eggs					
7	Treatment of sick birds, if any					
II	Decision making					
1	Selling eggs					
2	Selling chicken					
3	Home consumption of eggs					
4	Home consumption of chicken					
5	Purchase of drugs, vaccines					
6	Purchase of foundation/replacement					
	Other specify					

3. Production system

3.1 What type of poultry production system do you practice? 1. Traditional (Scavenging only) 2. Scavenging +Seasonal/conditional supplementation 3. Intensive system 4. Semi scavenging (Scavenging +Regular supplementation) 5. Backyard (free ranging)

4. Housing

4.1. Where do chickens sleep at night? 1. Separate shelter 2. Perches in the house 3. Perches in the kitchen 4. Perches on the veranda 5. Other (specify)

4.2. If separate house, what type of poultry house? 1. Stone wall + grass roof or soil roof 2. Stone made with corrugated iron sheet 3. Wooden made with grass roof 4. Wooden made with corrugated iron sheet 5. Other (specify)

4.3 If you don't have a separate house for your chickens, why not? 1. Lack of knowledge (Awareness) 2. Lack of importance of poultry 3. Lack of construction materials (Availability and Cost) 4. Risk of predators 5. Risk of theft 6.Other (specify)

4.4. How many days do you clean the house?

4.5. How do you dispose of manure? 1. No special disposal or storage 2. Feed to other animals 3. Use as fertilizer 4.Sell 5. other describe----------

5. Feed and feeding

Do you provide supplementary feed for your chicken 1.Yes 2.No

If no what is the reason? 1.Lack of awareness 2.Unavailable 3.Expensive 4. time shortage

5.3 If yes, what type(s) of supplementary feed do you provide write based on their rank?

5.4 Source of supplementary feed? 1. Purchased from market 2. From household 3.crop Harvest 4. Harvested and purchased 5. Other specify……

5.5. Which breed of chicken gets supplementary feeding most frequently? 1. Local breed 2.cross breeds 3. Exotic breed 4.all breeds

5.6 What is the frequency of providing supplemental feed? 1. Every day 2. Every other day 3. Every3 day

5.6 Mark tick the months you provide additional feed?

Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug

5.7 Which age group of chicken given priority for feeding?

Age group	Rank	Feed type/status	Reason
Young chicken			
Pullet and cockerels			
Laying hen			
Cocks			

5.8 How do you provide the feed? 1. By feeder 2.spreading on the floor 3.other (specify)

5.9 If you use feeder, what types of feeder do use? 1. Plastic made 2.earthen plot 3.wooden trough 4. Stone made 5.other (specify)

5.10. Indicate availability of supplementary feed resources (Tick accordingly)

Status	Sep.	Oct.	Nov	Dec	Jan.	Feb	Mar	Apr	May	June	July	Aug.
Shortage												
Sufficient												
Surplus												

6. Watering

6.1. Do you provide water to your chicken? 1. Yes 2. No.

If yes how frequent do you provide water to your chicken? 1.once a day 2.Twice a day 3.adlibitem

6.3. Sources of water, distance to the nearest source and its quality during dry and wet season

No	Source of water	Dry season			Wet season		
		Yes	Rank	Distance[1]	Yes	Rank	Distance
1	River						
2	Dam/pond						
3	Spring						
4	Rain						
5	Water well						
6	Others						

[1]Distance to the nearest water source (1. at home, 2. < 1km, 3. 1-5km, 4.6-10km, 5. >10km)

6.4. Do you have waterer ? 1. Yes 2.No

6.5. If yes what types of watering trough do you have? 1. Plastic made 2. Earthen pot 3. Wooden trough 4.stone made 5.other

7. Chicken population trend

Did your chicken flock size change during the last 10 years? (Circled for the selected) 1=no, remained same 2=yes, increased 3=yes, decreased

Reason _____

Did your chicken flock size change during with season? 1= yes 2= No.

Which month are chicken numbers highest?

Which months are chicken numbers lowest?

8. Health

8.1. Is there any poultry disease in your area? 1. Yes 2. No

8.2. If yes define three periods for estimating mortality. 1. Age Period 1: 0-8 week 2.Age Period 2: 8-20week 3.Age Period 3: >20week

Most important reason for mortality	Age period 1	Age period 2	Age period 3
Disease			
accident			
Predator (incl. Theft)			
unknown reason			
write season of major losses			

8.3. Discuss the major economically important disease?

No	Disease name(local)	Common symptoms of the disease	Age of birds mostly affected	Occurrence (month/season)	Local treatment	prognosis

8.4. what are the measures that you are taken? 1. Take the chiken to vet 2.Treat them by my self 3.Sloughter them for house consumption 4. Sell to market 5. Throw 6.No action 7.Other (specify)

8.5. Access to veterinary services and distance to the nearest service?

Access	Yes	Distance to the nearest service *(km/walk hr)*			
		< 1 km	1 – 5 km	6 – 10km	> 10 km
Government veterinarian					
Private veterinarian					
Shop or market					
None					
Others (specify)					

8.6. What type of traditional control measures (Indigenous knowledge) you used to prevent the risk of economically important diseases?

8.7. Have you observed any variation in disease resistance among your chickens? 1. Yes 2.No

8.8. If yes what the unique characteristics of these birds?

8.9. Do you have access to advisory (technical) support from extension workers on poultry production? 1. Yes 2. No

8.10. Is there poultry vaccination campaign held in your area in the past 12months? 1. Yes 2.No

8.11. If yes what types of vaccination

8.12. To which breed do you vaccinate? 1. to local 2. To exotic 3. To cross 4. To all

8.13. If not what is the reason

9. Production constraints and opportunities

9.1. What pressures does the breed face that threatens its survival or sustainable use? *(tick as many reason as possible and rank the top 4)*

No.	Pressure/constraints	Yes	Rank	Possible action
1	Diseases or lack of health care			
2	Lack of market demand			
3	Lack of labor			
4	Lack of capital			
5	Thieves			
6	Water shortage			
7	Predators			
8	Feed shortage			
9	Shortage of land			
10	Others			

9.2. Is there any predator in your area? 1. Yes 2. No

9.3. If yes fill the following table

No	Type of predator	yes Tick	Rank	In which Season of the year	**targeted Age groups	More attacked Breed*	Control Methods
1	Wild cat						
2	Eagle(chilifit)						
3	Snake						
4	Dog						
5	Domestic cat						
6	Other						

*Breed; 1=local 2= exotic 3 =cross ** age group; 1=adult 2=growers 3=chicks

10. Marketing

10.1 Do you sale chicken? a. Yes b. No

10.2 If yes, Where do you sale your chicken (Circle accordingly)?

A. in local market B. to the neighbor-hood C. in nearby areas D. other specify____

10.3. Distance in KM----------

10.4. Means of transportation /specify/_____

10.5. Do buyers have quality specification in poultry products a. Yes b. No

10.6. If yes, what are these? ----------

10.7. What is the demand of poultry and poultry products in the market?

a. Very high b. High c. Medium d. Low e. Very low

10.9. How do you evaluate the local market price for your product? a. High b. Medium c. Low

10.10. How is the price trend of poultry in your locality? 1. Increasing 2. Decreasing 3. Stable Reasons

10.11. Do you sale eggs? a. Yes b. No

10.12. If yes, Where do you sale your Eggs (Circle accordingly)

A. in local market B. to the neighbor-hood C. in nearby areas D. other specify____

10.13 How do you transport chicken to local market? 1. Embracing by hand 2. Hanging by hand upside down 3. In baskets 4. By car 5.Others

10.14. How do you transport eggs to local and urban markets? 1. Eggs with grain 2. Eggs with straw 3. In plastic container 4. Others_____

10.15. What are the major determinant factors that affect (control) the price of chicken? 1. Plumage colour 2. Comb type 3. Sex of chicken 4. Shank color 5. Other

10.16. What are the major problems relating to marketing of poultry and poultry products?

S/n	Marketing constraints	Tick yes	Rank	Possible solutions
1	Low prices			
2	Seasonality of market prices			
3	Low marketable output (egg & chicken)			
4	Reliable markets found very far			
5	Limited market outlets			
6	Lack of buyers			
7	Lack of marketing information			
8	Disease outbreaks			
9	Lack of capital			
10	Price depend on plumage color			
11	No problem			
12	Others (specify			

11. Functional traits (Reproductive and productive performances)

Reproductive traits	Hen
Average length of inter-clutch period (wk)	
How many times a year do you incubate eggs for hatching	
Average number of eggs set to a broody hen	
Average hatch rate in the dry season(N)	
Average hatch rate in the wet season(N)	
Survival rate of chicks to 8 weeks(N) in wet season	
Survival rate of chicks to 8 weeks(N) in dry season	

11.1 How frequent hens lay eggs until the end of the clutch period?1. daily 2. every other day3. every 3 day 4. no egg(stop laying)

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

a. Increase b. Decrease c.No change d. No observation

Breed	Age at 1st service for cockerel	Age at 1st egg laying	No. clutches per year	No. eggs per clutch	Length of clutch in days	Total egg per year
local						
exotic						
cross						

11.2 How frequent do you collect your eggs? 1. Every day 2. Every 2 days. 3. Every 3 days 4. Weekly 5. Not collected until incubation/sale

11.3 After which clutch period the hen is supposed to set eggs for hatching chicks? ----------

12. Hatching, brooding and egg storage practice

12.1. Where do you store eggs used for incubation and hatching purpose? -

1. Mixed with grain. 2. Mixed with flour. 3. Put in straw. 4. Plastic container

12.2. Why? _____

12.3 Where do you store eggs used for sale or house consumption?

1. Mixed with grain. 2. Mixed with flour. 3. Put in straw 4. Plastic container

12.4. Why?_____

12.5. How long do you store your eggs before incubation in dry season?

1. One week 2. Two weeks 3. Three weeks 4. until incubation

12.6. How long do you store your eggs before incubation in wet season?

1. One week 2. Two weeks 3. Three weeks 4. until incubation

12.7. Do you mix eggs obtained from different hens? 1. Yes 2. No

12.8. Do you select eggs before incubation? 1. Yes 2. No

12.9. If yes which criteria's you practice?

1. Large size 2. Small size 3. Shape of the egg 4. Cleanness of the eggs (dirtiness) 5. Shell condition (crackness) 6. Other specify

12.10. Tick the months when you prefer to set eggs for hatching

Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug

12.11. Why you prefer to set in this month?.....

12.12. Why do you not set in these other months ?.....

12.13. What material do you use during incubation? 1. Mud containers 2.Clay 3.Wooden containers----- 4.Others, specify----------

12.14. What kind of bedding materials are used during the incubation of eggs? .....

2.15. What method do you use for brooding and rearing chickens? 1. broody hen(natural methods) 2. Hay box brooder 3. electricity 4.All methods

12.16.How would you describe broodiness in your hens ?1. Common 2. Sometimes 3..Rare

12.17.Interval between two consecutive brooding period (months) .....

12.18.How do you deal with unwanted broodiness behaviour? (Multiple answers are possible)

Dealing with unwanted brooding	Tick	Rank
Hanging hen upside-down		
Disturbing		
Inserting feathers through nostrils		
Taking to another place		
Taking away brooding nest		
Immersing in cold water		
Other (specify)		

12.19. How would you describe the temperament of your chickens?1. Docile Moderately 2.Tractable 3.Wild/Aggressive

13. Breeding (mating) and culling practice of chickens

13.1. What are your sources of foundation stock?

a) Purchase b) Inherited c) BOARD d) NGOs e) Research f) Gift

13.1. Do you have your own cock? 1. Yes 2. No.

13.2. If yes which breed? 1. Local 2. Exotic 3. Cross breed

13.3. if No. where do you get a cock for your hen? 1. Homebred 2. Neighbors/relatives 3. Communal 4. Bought 5. Borrowed

17. What is your source of replacement stock? a) Purchase b)Inherited c) gift d)Hatched e) Other, specify

13.4. Do you buy birds for your flock? 1. Yes 2.No

13.5. If YES, where do you buy chicken? 1.Market 2.Neighbor 3. Commercial chicken farm 4.extension5. other: .....……

13.6. If YES, what kind of chicken do you buy? 1. Local breed 2. Improved breed

13.7. Do you practice breeding? 1. Yes 2. No.

13.8. What types of breeding method do you practice? 1. Importing exotic 2. Improving Indigenous

13.9. By What ways do you improve the local breeds? 1. Cross breeding 2. Line breeding

13.10. Do you practice mating system for your chicken? 1. Yes 2. N

13.11. If yes how is mating/breeding system in the flock? 1. Controlled 2. Uncontrolled

13.12. If controlled mating, what are the techniques? 1. Culling underproductive chicken 2. Cull at young stage unwanted color 3. Retaining the best cock and hen 4. Preventing mate of unwanted cock

13.13. Have you know inbreeding concept? 1. Yes 2. No

13.14. Do you purposely cull your chicken at any time?1. Yes 2. No.

13.15. If yes, what factors determine which chicken you will cull (multiple answers are possible)

	Factor	Tick	Rank
	Old age		
	Low production		
	Unwanted plumage colour/pattern		
	Illness		
	Bad temperament		
	Other (specify)		

13.16. If you culled old age birds, at what age of the bird do you decide to cull it?

13.17. For what purpose do you cull the poultry? 1. for consumption 2. For sale 3.For sacrifice 4. Other specify

14. Breeding objective trait preference and selection criteria’s

Purpose of keeping chicken

14.1. What type of poultry breed do you prefer? Circle the reason

Breed type	Rank	Reason
local		1. Egg production 2.market 3.resistance 4.body size 5. flavor
exotic		1. Egg production 2.market 3.resistance 4.body size 5. flavor
cross		1. Egg production 2.market 3.resistance 4.body size 5. flavor

14.2. Where do you get your chicken first? 1.Market 2.Family 3.gift 4.neighbor 5.other

14.3. Why do you keep (rear) birds? the purpose?

Purpose		Purpose of keeping chicken (tick)	Rank	Purpose of using egg	Rank
1	For cash from sale				
2	For egg consumption				
3	For meat consumption				
4	For replacement				
5	For hatching				
6	Spiritual (religious)				
7	Ceremonies				
8	Cultural				
9	Manure				

14. 4. Do you practice selection for? Breeding male (1. Yes 2. No) If yes, at what age?.....
Breeding female (1. Yes 2. No) If yes, at what age? ___

14.5. What are the selection criteria used in deciding which males and females to become the parents of the next generation? *(Tick as many reason as possible for selection in 'yes then rank).*

Breeding hens		Yes	Rank	Breeding cocks	Yes	Rank
1	Egg number			Egg number		
2	Body size			Body size		
3	Growth rate			Growth rate		
4	Hatchability			Hatchability		
5	Mothering ability			Mothering ability		
6	Broodiness			Broodiness		
7	Disease resistance			Disease resistance		
8	Egg size			Egg size		
9	Plumage colour			Good scavenging		
10	Fighting ability			Plumage colour		
11	Good scavenging			Fighting ability		
12	longevity			fertility		
13	other specify			Other specify		

14.6. What traits do you want to improve (Tick as many reason as possible in 'yes' then rank).

s/n	Traits	Farmers preference	
		Yes	Rank
1	Growth rate		
2	Body size		
3	Egg number		
4	Fertility		
5	Prolificacy		
6	Disease resistance		
7	Heat tolerance		
8	Drought tolerance		
9	Broodiness		
10	Mothering ability		
11	Temperament		
12	Plumage colour		
13	Chicken shape		
14	Meat quality		
15	Egg size		
16	Egg shell colour		
17	Egg yolk colour		
18	good scavenging		
19	other specify		

14.7. Which plumage colour do you prefer? (Rank, 1=most important

Hen

1 .. ..

2 . .....

3 . .....

Cock

1.....

2.....

3.....

14.8. Which plumage colours do you dislike?

1 .....

2. .....

3.....

14.9. Reason for plumage colour preference? 1. Aesthetic value

2. High market value 3. Cultural and religious value 4. Other (Specify).....

14.10. Which comb type do you prefer? 1. Single 2. Double 3.Others (Specify).....

14.11. What is the reason for comb type preference? 1. Aesthetic value 2.High market value 3.Cultural and religious value 4. Other (Specify).....

14.12. Which shank colour do you prefer? 1. Yellow 2.White 3.Black/grey

8.3. Appendix III

Phenotypic description of chicken (morph metric)

Name District kebele Agro-ecology

Characteristics description	Animal number									
	1	2	3	4	5	6	7	8	9	10
Sex: Female= 1, Male=2										
Age										
Feather distribution: a. Normal b. Naked neck c. Feathered shanks and feet d. Muffs and beard e. Crest f. Vulture hocks										
Plumage color a. white b. black c. red d. Grayish/sigeme. Multicolor/ f. Black with white tips/checheway g. Red brownish/bunama h. White with red stripes i. Wheaten j. Others/specify										
Earlobe colors A.white B.red C.white and red D. Yellow										
Spur presence a. Present b. Absent										
Shank colors A.white B.red C.brown D.pale										
Comb colors A.red B.brownc. Paled. Other										
Comb shape A.single B.pea C.rose D.plain E.other										
Eyes colour a.Yellow b.Brown c.Grey-brown d.Blue e.Black										
Head shape A. Crest/Gutya B. Flat Plain/Ebab-ras										
Quantitative measurement of chicken										
Body weight										
Breast width										
Spur length										
Thigh circumference										
Chest circumference										
Shank length (SL)										
Neck length (NL)										
Body length (BL)										
Wing length										
Wingspan										
Wattles width										
Wattles length										
Beak length (BKL)										
Beak width										
Ear lobes width										
Ear lobes length										
Comb length (CL)										
Comb width										
height at back										

8.4. Appendix IV

Own flock ranking and life history of the ranked chickens

Own flock ranking of breeding hen

s/n	Traits	Rank			
		1	2	3	inferior
1	Plumage color (1.				
2	Comb type (1.single 2. Double)				
3	Shank color				
4	Smoothness of shank(1. Smooth 2. Sharked)				
5	Spur presence (1. Present 2.abesent)				
6	Plumage color (1.				
7	Mothering ability				
	Recall and measured data				
1	Age at 1st egg lying (months)				
2	Number of clutch/year/hen				
3	Egg production/clutch/hen				
4	Number of egg/year				
5	Number of eggs incubated/hen				
6	Number of eggs hatched				
7	Hatchability (%)				
8	Number of chicks survived in at 8 week				
9	Breaking of broodiness (1.one wks 2. 2wks 3.3wks 4.1month				
10	Body weight				
11	Breast width				

Cock traits

	Traits	Rank			
		1	2	3	inferior
1	Plumage color (1.				
2	Comb type (1.single 2. Double)				
3	Shank color				
4	Smoothness of shank(1. Smooth 2. Sharked)				
5	Spur presence (1. Present 2.abesent)				
6	Height at back				
7	Body weight				
8	Mating behavior(1. Very active 2. Active 3.inactive)				
9	Fertility (1. High2 medium3. Low)				
10	Spur length				
11	Age at first mating (months				

8.5. Appendix V

Figure 5. Some identified morphological traits of chickens in the study area

Feather distribution and morphology of chicken in the study area

Some plumage colors of local chicken identified in the study area

Some identified earlobe color of local chicken

Some identified eye color of local chicken

Some identified shank color of local chicken

Some identified head shape of local chicken

Figure 6. Photon taken during the study