Dissertation Ref. No. 052/01/2020

EVALUATION OF PRODUCTIVE AND REPRODUCTIVE PERFORMANCES OF DIFFERENT STRAINS OF CHICKENS UNDER VARIED MANAGEMENT SYSTEMS IN WESTERN ETHIOPIA

PhD DISSERTATION

By

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January 2020

Bishoftu, Ethiopia

EVALUATION OF PRODUCTIVE AND REPRODUCTIVE PERFORMANCES OF DIFFERENT STRAINS OF CHICKENS UNDER VARIED MANAGEMENT SYSTEMS IN WESTERN ETHIOPIA

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

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January 2020

Bishoftu, Ethiopia

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Evaluation of productive and reproductive performances of Horro chickens with emphasis on their crosses and exotic Koekoek, under varied management systems in western Ethiopia

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BIOGRAPHICAL SKETCH

Demissu Hundie Senbeta, the author of this PhD Dissertation, was born in November 1973 in Arsi Zone in the Oromia Region, in Ethiopia. He attended his Elementary school at Amigna Dinkity, Junior Secondary and High School Education at Amigna Gasgar and Didea Senior Secondary Schools in Arsi Zone. After a successful completion of his High School Education, he joined Addis Ababa University, Faculty of Veterinary Medicine the then College of Veterinary Medicine and Agriculture to attend a diploma program in animal Health and graduated with diploma in Animal Heath in 1995. Soon after graduation, he was employed by the Agricultural and Rural Development Bureau of Oromia to serve as Animal Health Assistant. After his employment, he had served being animal health assistant, team leader of animal health unit, and department head of livestock development and health division in different districts of East Wollega Zone. While on work, he joined Haramaya University in the year 2003 to attend a summer in service program and awarded his BSc in Animal Science with great distinction in the year 2007. He then was assigned to be an officer of Livestock Development and Health office at district level and served till he joined the school of graduate studies of Wollega University in 2010 to pursue Master of Science Degree in Animal Production and graduated on July 2012 with MSc Degree in Animal Production. His thesis that covered Reproductive and Productive Performance of Horro Cattle and their F1 Jersey crosses was awarded excellent grade. He was then employed by Wollega University as an instructor where he was working as student services Coordinator, Research and Extension Coordinator and Associate Dean for Administrative and Development Affairs at Shambu Campus till he joined Addis Ababa University for his PhD study.

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I first, declare that this dissertation is my *Bona fide* work and that all sources of materials used for this dissertation have been duly acknowledged. This dissertation has been submitted to the requirements for PhD degree at Addis Ababa University, College of Veterinary Medicine and Agriculture and is deposited at the University's Library to be made available to borrowers under rules of the Library. I solemnly declare that this dissertation is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

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ACKNOWLEDGEMENT

I begin by thanking the **Almighty God** for His indescribable gift, love and courage and the **Virgin St. Merry**, who have always been my guide and hope and have seen me through the completion of this work.

It is with a deep sense of gratitude that I express my utmost respect to my major supervisor Dr Gebeyehu Goshu, for his keen interest in the work, priceless guidance and constructive comments at each phase of the research and preparation of the thesis. He was always ready to help me even beyond my curricular issues. My Co-supervisors, Professor Berhan Tamir, Head Department of Animal Production, College of Veterinary Medicine and Agriculture (Addis Ababa University) deserves special thanks for his supports at all stages of this work. I had the privilege of working with Dr Gemeda Duguma, Associate professor of Animal Breeding and Genetics, School of Veterinary Medicine (Wollega University), my Co-supervisor, because of his comments on draft of the proposal of this research project that I have significantly improved the quality of the thesis. Thank you all for your heartfull support.

I should very much like to thank the Wollega University, Directorate of Research and Technology transfer especially the director Dr Diriba Diba and Miss Diribe Kumsa (Director of Research, Innovation and Community engagement at Shambu Campus) for their efforts they had exerted and I could get a budget grant for the research project and the research work could be undertaken successfully. The staff of the Wollega University at Shambu Campus; Geleta Gobena, Debela Itana, Mergersa, Amsalu File and Edosa and Gemechu Ararso all who were very cooperative and helpful, and deserves special acknowledgments.

I am very greatful for Debrezeyit Agricaltural Research Center (DZARC) and the staff mainly Mr Misbah Alewi, Dr Emebet Moreda and Mr Alemayehu for their cooperation in providing study animals.

Finally and boldly I have always believed that the support, love and prayer of my mother W/ro Mulunesh Jimayou Geletu, my brother Dejene Simie, whom I consider as my father since I lost my Father while I was only 16, and his beloved wife Desi Zeleke had brought me to this level.

Last but by no means the least, is the contribution of my beloved wife, Zertihun Negera Gemechu, and my kids Meron, Tolawak and my little daughter Do'i. Others and whole family in my home; Haregua, Addisu and Feben Tesfaye have paid much during my study is beyond words can express. I appreciate and acknowledge all your efforts in experimental house cleaning, feed preparation and a support you provided in chick managements. Thanks all.

DEDICATION

This dissertation is dedicated to my father ***Hundie Senbeta*** who passed when I was only sixteen and who was dreaming to see this day early, from my childhood. **Dad**, let your Soul rest in **Heaven**.

LIST OF ABBREVIATIONS & ACRONYMS

AFE	Age at First Egg
AEST	Average Egg Shell Thickness
AEW	Average Egg Weight
AFC	Average Feed Consumption
AH	Albumen Height
ANOVA	Analysis of Variance
BW	Body Weight
BWG	Body Weight Gain
Ca	Calcium
CCW	Chilled Carcass Weight
CGIAR	Consultative Group for International Agricultural Research Centers
CP	Crude protein
CSA	Central Statistics Agency
DZARC	Debre Zeit Agricultural Research Center
DZ1	DZ white feathered chickens
EL	Egg Length
EN	Egg Number
ESI	Egg Shape Index
FAO	Food and Agricultural Organization of the United Nation
FAS	Foreign Agriculture Service
FCE	Feed Conversion Efficiency
GDP	Gross Domestic Product
GLM	Generalized Linear Model
HCW	Hot Carcass Weight
HU	Haugh Unit
IFPRI	International Food Policy Research Institute
IH	Improved Horro
ILRI	International Livestock Research Institute
ME	Metabolizable Energy

MoARD	Ministry of Agriculture and Rural Development
NABC	Netherlands-Africa Business Council
NRC	National Research council
PK	Potchefstroom Koekoek
SAS	Statistical Analysis System
SPSS	Statistical Package for Social Sciences
UNPD	United Nations Population Division
USA	United States of America
USAID	United State of Agency for International Development

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EVALUATION OF PRODUCTIVE AND REPRODUCTIVE PERFORMANCES OF DIFFERENT STRAINS OF CHICKENS UNDER VARIED MANAGEMENT SYSTEMS IN WESTERN ETHIOPIA

Demissu Hundie Senbeta

PhD Thesis

Addis Ababa University (2019)

ABSATRACT

A cross sectional survey, follow-up and evaluation, and on-farm and on-station performance evaluation were employed to study the productive and reproductive performances of three improved and one unimproved chicken strains. Improved Horro chicken, a synthetic Debre-zeyit (DZ) White-feathered and the exotic Potchefstroom Koekoek chickens were used for the on-station and on-farm evaluation study where as an assessment on poultry production system of unimproved Horro chickens was undertaken on-farm. Statistical Package for Social Sciences (SPSS) and Statistical Analysis system (SAS) were used for statistical analysis based on the appropriatness of statistical softwares. The mean age at first egg of hens at the highland, mid-altitude and lowland were 28.44±0.43, 25.49±0.52 and 23.63±0.46 weeks, respectively that the variation was significant (P<0.05) among the agro-ecologies. The difference among egg per clutch and length of days in lay per clutch were also significant (P<0.05) where as variation in clutch per year was highly significant (P<0.001) among the three agro-ecologies. Concerning the mean chicks' age at weaning and male chicken at marketing, the overall mean age at weaning was (9.72±0.21) (in weeks) where as the mean age at marketing for male chicken (7.72±0.23) (in months). The on-station study revealed that breed of chicken, age in weeks and interaction of chicken breed with age in weeks had significant effect (P <0.001) on growth performances of chicks before their eight weeks age. The highest overall mean daily feed consumption (53.89±14.37) was recorded for the Potchefstroom Koekoek chicken breed and the lowest for DZ White-feathered chickens (50.28±10.50) though the variation among the chicken breeds was statistically non significant (P > 0.05). The mean feed conversion efficiency (17.47±2.79) of DZ White-feathered chickens was higher than the feed conversion efficiency (13.56±2.74) reported for Improved indigenous Horro chickens, though the difference was statistically non significant. In all the three breeds of chickens, males grew significantly (P <

0.001) faster than females. Significant effects of agro-ecology on the performance of chicken breeds also showed the presence of genetic-environment interactions among the three ecologic locations of the study areas. The internal and external egg quality characteristics of unimproved Horro chickens' egg collected from the three agro-ecologies was determined and the mean internal egg quality traits (albumen weight, yolk weight, yolk-albumen ratio and yolk diameter) was significantly (P<0.001) affected by agro-ecology. The external egg quality traits were also significantly (P<0.001) affected by agro-ecologic variation where the lowland chickens' egg scored higher value in egg quality. The low performance of Improved Horro chickens both in weight gain at their starter and growing phase and low younger (growing) age survival rate leads to a recommendation that these birds in addition to their productive performance need to be selected for their better adaptability.

Key Words: Agro-ecology, Improved Horro, Reproductive performance, Potchefstroom Koekoek, Selection

1. INTRODUCTION

Global human population in 2050 is estimated to be 9.15 billion, with a range of 7.96–10.46 billion (UNPD, 2008). To feed the world in 2050 therefore, it needs to increase total food production by 70% (FAO 2009). The high human population and demand for protein food will be increasingly challenging, being augmented with a changing climate that is considered with global warming as some of the major threats to agriculture and food production. By 2030, crop and pasture yields are likely to decline in many places, about 50 percent or more of population in Africa is expected to live in cities (Parrot *et al.*, 2010). The dynamism of the global poultry sector has been supported by a strong growth in demand of food ingeneral and protein food in particular. The market for poultry meat is growing faster than that for any other meat products, and is projected according to the report by the International Food Policy Research Institute (IFPRI) to maintain this position in the coming decades as cited by (Delgado *et al*., 2001).

According to Africas Agriculture Status Report (2017), climate change may have a modest positive effect on oilseed production in SSA, little effect on production of pulses, and small negative effects on production of meat, fruit and vegetables. Poultry production still remains the major contributor of meat on the table for many developing countries and continues to be an integral part of nearly all rural, peri-urban and urban households both directly and indirectly. Scanes (2007) stated that eggs and poultry meat provide an excellent source of critically important nutrient, protein, together with minerals and vitamins. Over 30% of the global meat production, recently estimated at 275 million metric tons, is sourced from poultry (Chemnitz, 2014).

Of all poultry, the most common sources of meat are chickens (87%), turkeys (6.7%), and other minor commercially available poultry meat including meat from duck (4%), and that from geese, pigeons, quails, pheasants, ostriches and emus (2.3%) (FAO, 2010). At a global level, total poultry meat production increased from 69 million tons in 2000 to 94 million tons in 2008, which corresponds to an increase of 35%. This growth was attained despite recurrent consumer scares and regional trade restrictions linked to the spread of various diseases (FAO, 2012). In developing countries, local chickens in particular provide an important food resources to the

rural poor and hence a hedge against food insecurity and poverty. This is because they are easier to rear and survive more favorably with minimal resource inputs at household level, high disease resistance and low initial investment costs compared to other types (Kperegbeyi *et al.*, 2009).

In recent years, an emerging middle-class urban society and urbanization with better income and more purchasing power has increased the demand for chicken and chicken products. Over the last decades, the consumption of poultry products in developing countries therefore grew by 5.8 percent per annum, faster than the human population growth (Sonaiya *et al*., 2004). Chicken accessibility and availability mainly in rural areas not only plays roles in poverty alleviation (Pica-Ciamarra and Dhawan, 2009) but also their consumption is associated with less health risk diseases (Wattanachant *et al*., 2004). This has led to the expansion of poultry production particularly within urban and peri-urban areas. Thus, production and productivity of village chicken should be improved through the type of chicken breed used, management and husbandry practices applied.

Smallholder farming systems are bio-economically complex involving several kinds of resources and input/output flows such that it would not be advisable to study poultry production only without considering other crop-livestock components of the farming system (Muchenje *et al*., 2001). The traditional chicken production system of Ethiopia is mostly an indigenous integral part of the farming system and chickens play a complementary role to agriculture in relation to other crop-livestock agriculture. The total poultry population at country level was estimated to be about 60 million of which 90.8%, 4.4% and 4.8% were reported to be indigenous, exotic and hybrid, respectively (CSA, 2017). The large percentage of indigenous chickens indicates the significance of the indigenous chicken ecotypes as principal potential farm animal genetic resources of the country. Indigenous chickens also provide major opportunities for increased protein production and income for smallholders though their productivity is still unreliable. The most dominant chicken types reared in Ethiopia are local ecotypes, which show a large variation in body conformation, plumage color, comb type and productivity (Halima, 2007). Some of the characterized and designated chicken ecotypes (native chickens) to Ethiopia include; Tilili, Horro, Jarso, Tepi, Gelila, Debre-Elias, Melo-Hamusit, Gassay/Farta, Guangua and Mecha (Halima, 2007). On the other hand, scholars also reported the names of indigenous chicken

designated based on their plumage colors like for instances: Tikur (black), Nech (white), Key (Red) and Gebsima (Roan) in the country (Nigussie *et al*., 2010).

According to CSA (2016), the estimate of total number of eggs produced during the year was about 93.13 million. The average number of egg-laying period per hen per year was about 4 and 5 months for the local, and hybrid chickens respectively. On the other hand, the average length of a single egg-laying period per hen was about 21, 32 and 93 days for local, hybrid and exotic breeds, respectively. The annual estimated production of eggs in Ethiopia was 41 thousand tons, which was by far below average and contributed only about 0.1% share of the global production and 9.7% of the East Africa (FAOSTAT, 2016). The per capita chicken meat and egg consumption in the country was reported 2.85 kg and 57 eggs per annum, respectively (Alemu and Tadelle, 1997) with the higher meat consumption in urban areas than in rural areas (Kena *et al*., 2002). However, according to (FAS, 2017), the per capita poultry consumption fall even in Sub Saharan Africa to 2.3 kilograms in 2015, which was more than four-times the consumption level (0.5kg) in Ethiopia.

The production performance of indigenous or local scavenging chickens of Ethiopia is low because of their low egg production potential, high chick mortality and longer reproductive cycle and due to their low genetic potential (slow growth rate, late sexual maturity and broodiness for an extended period). Local chicken flocks are self propagating, with broody hens laying only 30–80 eggs per year in 2–4 clutches, and spending longer time between clutches to rear chicks (Mapiye *et al*., 2008 and Fotsa *et al*., 2014). The carcass weight of local chickens at maturity varies from 1045 to 1292g for male and from 642 to 874g for female (Halima, 2007). Small eggs with thick shells and a deep yellow yolk color (Alemu and Tadelle, 1997; Emebet, 2015) are produced by local chickens. About 40-70% of the chicks hatched dies during the first eight weeks of life (Tadelle and Ogle, 2001) mainly due to disease and predation. Therefore, about half of the eggs produced have to be hatched to replace chickens that have died (Tadelle, 1996) and the brooding time of the laying bird is longer, with many brooding cycles required in order to compensate for unsuccessful brooding.

The past genetic improvement efforts of the Ethiopian village chicken via exotic chicken extension programs was constrained by lack of comprehensive poultry technology package and extension to the end users (Teklewold *et al*., 2006; Reta, 2009). Yami and Dessie (1997) also reported that the quality of mixed feed for commercial poultry production is generally poor in Ethiopia. Under the 'favourable' conditions of high-input production systems, no one questions the superiority of commercial stock however, the high cost of commercial poultry feed discourages farmers from supplementing local chickens. Consequently, the results from these interventions have not been encouraging under the smallholder production systems. Therefore, farm feed formulations using locally available feed resources and improving the productivity of local birds should be encouraged (Njue *et al*., 2004).

Under the harsh conditions of low-input village poultry production systems, the superiority of commercial exotic chicken productivity is less obvious, especially in terms of cost effectiveness, as shown by various studies (Rahman *et al*., 1997; Tadelle *et al*., 2000; Singh *et al*., 2004). Birds of different breeds/strains and of different age, sex, stage of production and reproduction are responding differently to climatic variations (Alade and Ademola, 2013). The Lohmann Brown, for example, produced 303 eggs in 12 months under the optimal conditions of the German Random Sample Test (Sørensen, 1997), but only 140 eggs under semi-scavenging conditions, while the Sonali produced 156 eggs under the latter conditions. In contrast to this, indigenous chickens are good scavengers as well as foragers and have high levels of disease tolerance, possess good maternal qualities and are well adapted to harsh conditions and poor quality feeds as compared to the exotic breeds, though they are also blamed for their low egg and meat production (Solomon, 2003). Indigenous chickens are also known to possess desirable characteristics such as thermo-tolerance, resistance to some diseases, good egg and meat flavour, presence of hard eggshells, high fertility and hatchability as well as high dressing percentage (Aberra, 2000).

Despite the introduction of exotic and crossbred types in different forms including as fertile eggs, pullets and cockerels to rural Ethiopia is too low which was only about 4.4% and 4.8% were reported to be exotic and hybrid, respectively (CSA, 2017). This is mainly because, farmers have not been able to afford the high input requirement of the introduced breeds and the program was

not designed with their participation and demand. Therefore, to exploit the genetic potential of improved chicken breeds and to amalgamate that potential with farmers' lifelong practices, evaluation of different breeds under controlled environment and comparing to on-farm participatory and semi-scavenging management shall be undertaken.

Improved productivity of native birds could also be attained by 'up-grading' their blood level through crossbreeding by introduction of cocks, pullets and /or fertile eggs of high egg producing local strains integrated with intensive selection (Ali *et al*., 2000). Developing appropriate animal breeding programs under semi-scavenging village conditions also requires defining the production environments and identifying the breeding practices, production objectives, and trait choices of rural farmers (Solkner *et al*., 1998). Therefore, objective of this study was to assess the production and feeding systems of indigenous Horro chicken and evaluate their reproductive and productive performances in comparison to the Koekoek (exotic) and DZ White-feathered (synthetic) chicken breeds under controlled environment (on-station), and on-farm (under three agro-ecologic conditions) of western Ethiopia.

Specific Objectives:

- To assess poultry production systems and feed resources under varied agro-ecologies
- To evaluate the reproductive and productive performances of unimproved Horro chickens produced under traditional management at different agro-ecologies
- To study genotype × environment interaction of the three chicken breeds within and across agro-ecologic conditions
- To determine the on-station and on-farm reproductive and productive performances of Improved Horro, Koekoek and DZ White-feathered chicken breeds
- To evaluate egg quality characteristics of unimproved Horro chickens produced under different agro-ecologies and carcass characteristics of the three chicken breeds produced under same management.

2. LITERATURE REVIEW

2.1. Poultry Production System in Ethiopia

The world poultry population has been estimated to be about 16.2 billion, out of which 71.6 % are found in developing countries, producing 67,718,544 metric tons of chicken meat and 57,861,747 metric tons of hen eggs (Gueye, 2005). In Africa, village poultry contributes over 70% of poultry products and 20% of animal protein intake (Kitalyi, 1998). The human settlement pattern, communal housing of chicken, exchange of live birds and chicken products affect chickens' production performances, breeding pattern and disease epidemiological status. In East Africa in particular, over 80% of human population live in rural areas and over 75% of these households keep indigenous chickens where in Ethiopia the number of urban dwellers and the rate of local chicken per househld is even more larger (Kitalyi, 1998).

There are four poultry production systems in developing countries named as the free-range system or traditional village system, the backyard or subsistence system, the semi intensive system and the small-scale intensive system (Sonaiya, 1990; Dessei, 1997; Kitalyi, 1998; Branckaert and Gueye, 2000). In many countries of the world, poultry are kept as scavengers in and around the residence areas of humans. The most common production systems found in Africa are the free-range and backyard production systems (Sonaiya, 1990; Gueye, 2003) and approximately 80% of chicken populations in Africa are reared under these systems (Gueye, 1998). Chicken produced in this production system are mainly indigenous and are a function of natural selection. The local chicken ecotypes remained predominant in African villages (Kitalyi, 1998). The most dominating poultry production system is extensive/village poultry production system that depends mainly on local/indigenous chicken ecotypes and a scavenging feeding system. The term village chicken describes scavenging-chicken as it reflects the effect of the village socio-economy, biophysical-environments, production and health status of chicken. These production systems are characterized mostly as an indigenous integral part of the farming system with short life cycle and quick turnover, low-input and low-output production systems

which are accessible at both inter household and intra household levels and a means of converting unusable protein to high quality proteins.

The mean annual egg production of indigenous chickens is estimated at 40-60 small eggs with thick shells and a deep yellow yolk color (Alemu and Tadelle, 1997 and Emebet, 2015). The carcass weight of local chickens at maturity in Ethiopia varies from 1045 to 1292 gm for male and from 642 to 874 gm for female (Halima, 2007). About 40-70% of the chicks hatched die during the first 8 weeks of life (Tadelle and Ogle, 2001) mainly due to disease and predation. About half of the eggs produced have therefore, to be hatched to replace chickens that have died (Tadelle, 1996) and the brooding time of the laying bird is longer, with many brooding cycles required in order to compensate for unsuccessful brooding. It is estimated that under scavenging conditions, the reproductive cycle consists of 21-day incubation phase, 2 to 4 clutches and finally a 56-day brooding phase (Tadelle and Ogle, 2001; Halima, 2007; CSA, 2016). Similar to the indigenous chickens, the performance of high producing exotic lines could not reach their maximum potential due to failure to provide optimum production environment.

According to Moreki *et al*. (2001), family chicken are rarely the sole means of livelihood for the family, but is one of a number of integrated farming activities contributing to the overall well-being of the households. Chicken in Ethiopia are a priority animal for holy day and religious sacrifices. Besides its advantage as a source of food and income, village chicken production ensures employment opportunities for rural smallholder farmers and offers socio-cultural advantages (Sonaiya, 2000; Tadelle and Ogle, 2001; Gueye, 2003; Moges *et al*., 2010; FAO, 2014;). Village chicken also play a role of converting household leftovers, wastes, worms and insects into valuable and high quality protein (Doviet, 2005).

In Ethiopia, village chicken production accounts for more than 95% of poultry production (Tadelle, 1996, 2003; Mekonnen *et al*., 2010), which was much higher than the 78% average village chicken's contribution reported for sub-Saharan African countries (Tadelle, 1996; 2003). Chicken under this production system contributed about 90 and 92% of the national egg and poultry meat production, respectively (Tadelle, 1996; 2003). Moreover, land, which is a critical production resource like in Ethiopia, is not a limiting factor in village chicken production.

Consequently, disadvantaged groups of the community can be direct beneficiaries of village chicken improvement programs (Kitalyi, 1998). Therefore, landless and people with few initial capital can engage in poultry production with even more improved and profitable way of production.

2.2. Ethiopian Indigenous Chickens and their Productive Performances

Local chicken breeds of Ethiopia and their relative performances are presented in Table 1. Poultry have provided nutrition to human beings since their domestication over 8000 years ago (Ahlers *et al.,* 2009). Chickens were originated in Southeast Asia and were introduced to the rest of the world by sailors and traders (Crawford, 1990). Chicken populations can be categorized into; wild populations, indigenous and local breeds that are unselected but domesticated, selected breeds for morphological traits mostly by fanciers, selected lines for quantitative traits such as industrial layers and broilers, and experimental research lines (Weigend and Romanov, 2001). Nowadays, indigenous chickens are the result of centuries of cross-breeding with exotic breeds and random breeding within the flock. As a result, it is not possible to standardize the characteristics and productive performance of indigenous chickens. There is no comprehensive information on the categories of breeds identities and geographical distributions of many animal populations including chicken in the developing countries of the world, thus some of them are commonly referred to as non-descript breeds (FAO, 2011). There is also no list of breeds and varieties of chickens used by rural smallholders however; there is considerable information on some indigenous populations from various regions.

More than 95% of the total chicken populations of Ethiopia are comprised of the indigenous genotypes varying in feather and shank colour, comb type, and other morphologic and production characteristics (Dana *et al*., 2010). Recent advances in molecular genetics and genomics has given more insight into the diversity of indigenous chickens. The local birds in Ethiopia are entirely nondescript breeds closely related to the jungle fowl (Gallus gallus); show a great variation in their body size, conformation, plumage colour, comb type and feather cover (Alemu and Tadelle, 1997 and Halima, 2007). 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 were studied so far in two approaches as criteria for their differentiation and identification. Based on their ecological or main habitat, thus the chickens are named after their area of geographical origin, for example; Tilili, Horro, Jarso, Tepi, Gelila, Debre-Elias, Melo-Hamusit, Gassay/Farta, Guangua and Mecha (Halima, 2007). Based on morphological characteristics for identification specially feather type and color, for example as; Tikur (black), Nech (white), Key (Red) and extra in Ethiopia (Nigussie *et al.,* 2010). The Horro is therefore, an indigenous chicken ecotype named after the geographic region of origin located in the western part of Ethiopia near the Blue Nile gorge. There were about 30,000 chickens restricted to this original environment (Nigussie *et al*., 2009).

The production performance of indigenous or local scavenging chickens of Ethiopia is low because of their low egg production potential, high chick mortality and longer reproductive cycle or the low genetic potential (slow growth rate, late sexual maturity and broodiness for an extended period). About 40-60% of the chicks hatched die during the first eight weeks of age mainly due to disease and predators attack. About half of the eggs produced have to be hatched to replace chicken that have died, and the brooding time of the laying hens is longer, with many brooding cycles required to compensate for its unsuccessful brooding (Besbes, 2009). Studies showed that, under scavenging conditions, the reproductive cycle of indigenous hens consists of 20-days of lying phase, 21-days of incubation phase and 56-days of brooding phase (Alemu and Tadelle, 1997).

Table 1. Local chicken breeds of Ethiopia and relative performances

Chicken Breed	Traits						References
	24 wk body wt (g)	Age at 1st egg (d)	Eggs/bird/ year	Egg wt (g)	Fertility (%)	Hatchability (%)	
Tukur	960	173	64	44	56	42	Beker and Banerjee, 1990.
Melata	1000	204	82	49	60	42	Forssido, 1986.
Kei	940	166	54	45	57	44	Beker and Banerjee, 1990.
Gebsima	950	230	58	44	53	39	Beker and Banerjee, 1990.
Netch	1180	217	64	47	56	39	Beker and Banerjee, 1990.

2.3. Socio-Economic Characteristics of Poultry Production in Ethiopia

Poultry is by far the largest livestock group kept, consisting mainly of chickens, ducks and turkeys (FAO 1999; Copland and Alders, 2009). Rural poultry represents a significant part of the rural economy. In developing countries, many rural households keep poultry in their farmyard. Poultry production still remains the major contributor of meat on the table for many developing countries and continues to be an integral part of nearly all rural, peri-urban and urban households both directly and indirectly (Copland and Alders, 2009). Scanes (2007) stated that eggs and poultry meat provides an excellent source of critically important nutrient, protein, together with minerals and vitamins.

Chicken production is an important agricultural activity of almost all rural communities in Africa that makes the best use of locally available resources (Tadelle, 2003). This segment of production in Africa as a whole represented an asset value of US$ 5.75 billion (Sonaiya, 1990). If village poultry are significant for their nutritional or economic value, they could also play a significant role in human society through their contribution to the cultural and social life of rural people. The proportional contribution of poultry to the total animal protein production of the world by the year 2020 is believed to increase to 40%, the major increase being in the developing world (Delgado *et al*., 1999). However, most communities lack the required husbandry skills, training and opportunity to effectively improve their household chicken production (Mlozi *et al*., 2003).

In addition to their contribution to high quality animal protein and being used as a source of easily disposable income for farm households, rural poultry integrate very well and in a sustainable way into other farming activities, because they require little in the way of labour and initial investment compared to other farm activities (Tadelle and Ogle, 1996). A number of authors, including Veluw (1987), Sonaiya (1990), Gunaratne *et al*. (1992), have also reported that rural poultry play a significant role through their contribution to the cultural and social life of rural people. These animals also plays a significant role in cultural and social life of rural people being as gifts for relatives and for religious ceremonies, chicken sous (‘Doro wat’) for pride in Ethiopia, cock as alarm clock, to cure a sick person, staring capital for youth and for

special guests' invitation (Gueye, 2003). The gift of a chicken is often in many parts of Africa a way of welcoming high status visitors or honouring affine and kin. Birds are also frequently sacrificed, and in some cultures the entrails of dead birds are consulted as oracles. For this reason the anthropologist Michael Whyte notes "poultry are not simply birds, they are a human creation, a social and cultural practice" (Whyte, 2002).

There are fewer religious or social taboos associated with poultry production than there are with pigs and cattle. Poultry keeping rather has a symbolic importance within the context of social, cultural and religious functions. For most of these social and cultural functions or sacrifices, a specific sex and plumage color of poultry are prescribed (Gueye, 2003). For instance, Tadelle and Ogle (2003) reported white and red cock sacrificed for the purposes of good harvest wishes and red and black spotted cock sacrificed for the purpose of Ethiopian New Year. For instance, farmers in rural area invite special guests to partake of the popular dish "doro wat", which contains both chicken meat and eggs (Sonya, 1990; Sonaiya, 2000; Tadelle and Ogle, 2001).

Family poultry is rarely the sole means of livelihood for the family but is one of the most in integrated and complementary farming activities contributing to the overall well-being of the household. Village chicken could be particularly important in improving the diet of young children in sub-Saharan Africa (Alam, 1997). Chicken meat and eggs contributes 20–30 percent to the total animal protein supply in low-income and food-deficit countries. Poultry provide a major income-generating activity from the sale of birds and eggs. Occasional consumption provides a valuable source of protein in the diet. Scavenging chicken also serves in waste disposal system by converting leftover of grains and human foods and insects in to valuable protein foods (egg and meat) (Doviet, 2005). In general, poultry keeping uses less cost and family labour, and women (who often own as well as look after the family flock) are main beneficiaries.

Nearly all rural families keep a small flock of poultry and rearing of poultry has practiced for many generations for different social and cultural reasons (Gueye, 2003). However, the most common purpose for keeping chickens and eggs were primarily as source of income and for hatching, respectively. According to the study conducted and reported by Tadelle *et al*. (2003),

in the Central Highlands of Ethiopia, about 50, 27 and 23% of the egg produced are used for hatching, sale and home consumption, respectively. In another study conducted by Aberra (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. Mutizwa -Mangiza and Melmsing (1991) reported that economic evaluation of village chicken at household and national levels was complicated by multiple functions of livestock in the economy. Moreover, estimating the value of rural poultry is even more difficult than for other livestock because of the lack of reliable production data. However, rural poultry doesn't rate highly in the mainstream national economies because of the lack of measurable indicators of its contribution to macro-economic indices such as gross domestic product.

Though neglected in the development themes for a long time, various scholars and rural development agents nowadays are recognizing the importance of village poultry in the national economy of developing countries and its role in improving the nutritional status and incomes of many poor farmers and landless communities in the last two decades (Kitalyi, 1998). Accordingly, Sonyaiya (1990) reported that village chicken in Africa provides employment opportunity and disposable income for small scale farmers, particularly in the off seasons, rural poultry integrated very well into other farming activities as it requires very little time and investment. The smallholder poultry production in general is considered as an income-yielding activity that fits well with the concept of small-scale agricultural development.

2.4. Genetic Improvement of Indigenous Chickens of Ethiopia

In the past many decades, genetic improvement programs for increasing chicken productivity in Ethiopia mainly focused on use of imported temperate breeds. Many exotic breeds of chicken (White and brown Leghorns, Rhode Island Red, New Hampshire, Cornish, Australoup, Light Sussex etc.) were introduced over the years. The other approach to improve productivity of the village poultry production was based on use of crossbred animals (Nigussie, 2011). Improving the poultry productivity would improve protein nutrition and could increase the income levels of the rural population. In most rural areas, farmers favour a breed that combines both growth and egg production traits. Researchers described dual-purpose chickens as breeds that give

reasonable amount of meat and eggs (Iraqi *et al*., 2005; Mekki *et al*., 2005). Studies of these dual-purpose chickens have not clearly demonstrated reasonable egg numbers or changes in body weight, but a within breed selection of indigenous chickens has the potential to develop a well-adapted dual-purpose chickens. However, developing a dual-purpose chickens through selective breeding can be difficult because of the negative genetic relationship between the egg and growth traits. The specialization of chicken production either for egg or meat through genetic improvement also plays a significant role in meeting the high demand for poultry products. For example since the early 1960s, feed conversion in egg production in the USA and Canada has improved by almost 1g, from 2.96g feed per 1g egg to 2.01g feed per 1g egg. However, it is not possible to know exactly how much of this improvement was due to genetic and management. But it is safe to assume that a major part of the change is due to improved breeding stock (Arthur and Albers, 2003) as cited by (Fassil, 2010).

Successful selective breeding program requires sufficiently large population, pedigree recording, accurate measurement of individual performances and the capacity to minimize environmental variation (Besbes, 2009). These conditions can hardly met under smallholder farmer's conditions in tropics. Accurate record keeping by smallholder farmers in tropics have proven to be difficult due to involvement of smallholder farmers in many farm activities and hence less time for recording and complexity of recording process (Kiwuwa, 1992; Jainter *et al.*, 2001; Wollny *et al*., 2002; Lwelamira, 2007).

Despite their low productivity, indigenous chicken are known to possess desirable characteristics such as thermo-tolerance, resistance to some diseases, good egg and meat flavour, presence of hard egg shells, high fertility and hatchability as well as high dressing percentage (Aberra, 2000). However, selection for productivity may affect the adaptive capacity of indigenous chicken. In the past; White Leghorn, Brown Leghorn, New Hampshire, Light Sussex and Barred Rock exotic chicken breeds were evaluated for egg production (Wilson, 2010). The indigenous chickens have many conserved traits and advantages to thrive under scavenging system (Reta, 2006 and Reta, 2009). Yet they are blamed to be low producers of egg and meat compared to exotic chickens (Teketel, 1986; Solomon, 2003). Their comparative performance with the White Leghorn at on-station under full package management indicated that the indigenous chickens achieve less than

70% of the total egg production and 85% of the mature body size of the Leghorns (Teketel, 1986; Solomon, 2003). This suggests that even under improved management, the indigenous chickens do not compete successfully with improved exotic breeds, as far as productive performance is concerned (Wondimeneh, 2015).

The past genetic improvement efforts of the Ethiopian village chicken via exotic chicken extension was constrained by lack of comprehensive poultry technology package extension to the end users (Tekle-wold *et al.,* 2006; Reta, 2009). The public agricultural extension program in Ethiopia dates back to 1953 (Gebremedhin *et al*., 2006). Since then, poultry breeds (eg. Rhode Island Red and White Leghorn) were imported and disseminated to rural poultry producers through on-farm research and public extension programs to improve the egg and meat production in Ethiopia. In the 1980s the Ministry of Agriculture initiated a cockerel distribution scheme. This involved importation and distribution of cockerels to be used as breeding males in villages. This scheme again failed because farmers were unwilling to remove their local cocks and the exotic cocks failed to adapt in the village environments (Nigussie, 2011).There is no documented evidence how exotic breeds were chosen by the public extension body or whether the choice was supported by studies of the adaptability of the breeds under local conditions (Wondimeneh, 2015).

Limited empirical evidence available on the adoption of exotic chickens in Ethiopia shows that after 40 years of dissemination, exotic chicken breeds had contributed less than 2% to the national eggs and meat production (Tadelle *et al*., 2000). The Rhode Island Red poultry were reported for that they were not adopted by farmers in most parts of the country because of factors such as lack of extension follow-up, lack of complementary inputs, diseases, unavailability of credit services, and market problems (Teklewold *et al*., 2006). Exotic chickens are also prone to predators and theft because of their docile characteristics. However, available studies are not adequate to draw conclusions about the adoption of exotic chickens distributed into villages through the public extension system.

2.5. Reproductive and Productive Performances of village Chickens

The productivity of village chicken production systems in general and the free-range system in particular is low (Kondombo, 2005). This is due to low egg production and high mortality rate (Nigussie *et al*., 2003). Teketel (1986) and Aberra (2000) also characterized and reported the low productivity of local chicken was due to low egg production performance, production of small sized eggs, slow growth rate, late maturity, small clutch size, an instinctive inclination to broodiness and high mortality of chicks.

Village chickens reach point of lay at 26-30 weeks (Pedersen, 2002). This is fairly late compared to layer breeds that normally reach point of lay at 18-22 weeks old. The local average egg weight was 52 g (with a range of 35-60 g) (Muchenje and Sibanda, 1997; Mapiye and Sibanda, 2005), thus very low compared to commercial strains that have an average egg weight of 60-70g. Hatchability and survivability levels vary from 20-70% (Pedersen, 2002; Muchadeyi *et al*., 2005). Chick mortality represents a major loss in the studied village chicken production systems (Pedersen, 2002; Muchadeyi *et al*., 2004). Reports from other countries in Africa showed that 50- 70 percent of chicks die between hatching and at the end of brooding (Kitalyi, 1998; Tadelle and Ogle, 2003). Various studies recorded hatching weight values that range from 30-40g (Maphosa *et al*., 2004; Muchadeyi *et al*., 2004).

In Ethiopia, a local scavenging hen on average lays about 36–40 eggs/year (Tadelle *et al*., 2000; FAO, 2004). The average egg weight of local hens around Arsi, Ethiopia, was reported to be 38g (Brannang and Persson, 1990). The average number of eggs/clutch of local hens in Burkina Faso was estimated to be 12 eggs (Kondombo, 2005), which is comparable to the range of 12–18 eggs reported by Gueye (1998). This was a bit higher than that of 10eggs/clutch reported by Mourad *et al*. (1997) in Guinea and 9eggs/clutch by Kuit *et al*. (1986) in Mali. The average number of clutches/hen per year and the number of eggs/clutch of local chicken reported in Sudan were 3 and 12 eggs, respectively (Khalafalla *et al*., 2001). Halima (2007) reported an average productivity of 9–19 eggs/clutch with 2–3 clutch periods/hen per year and an average total egg production ranged from 18–57 eggs/year per hen for local hens in North-West Ethiopia.

Improving the poultry productivity would improve protein nutrition and could increase the income levels of the rural population. In addition, consumers prefer meat from indigenous chickens, because of its leanness. Evaluation of the egg production performance of crossbreeds, between local and exotic birds was conducted by different research and development organizations. Most results showed that the overall performance of the crosses was better than either the native or the exotic parents under the existing management condition (Haile-Mariam, 1998; Melesse *et al*., 2005).

Compared to performance reported on-station, village chicken productivity in the smallholder system is inefficient, characterized by high reproductive wastage and low productive performance (Tadelle and Ogle, 2001; Pedersen, 2002). When making comparisons of flock sizes, it is important to use the same base, that is, the location, type and timing of survey, as there are likely to be variations overtime (Chitate and Guta, 2001). Village poultry production is constrained by poor access to markets, goods and services, weak institutions, and lack of skills, knowledge and appropriate technologies (Guèye, 2002).

The reproductive performance is generally low, hens lay 30-80 small eggs/hen/year under smallholder conditions compared to commercial strains that produce up to 300 eggs. The number of eggs incubated per clutch varies from 8-14 and the average clutch size range from 2-3 clutches/hen/year (Kusina and Kusina, 1999; Pedersen, 2002). Smith (1990) estimates that under scavenging conditions the reproductive cycle consists of a 10-day laying phase, a 21- day incubation phase and finally a 56 day brooding period which is inline with the results of most studies in Zimbabwe. Pedersen (2002) also reported that at any given time only 40-50 percent of the hens were productive (laying, incubating or brooding).

Chick mortality rate in rural production systems in different African and Asian countries during their 6-8 weeks of age is presented in (Table 2). Reproductive wastage and mortality: Village chicken flock productivity is mainly determined by egg production, hatchability, chick survivability and growth rates (Tadelle and Ogle, 2001; Pedersen, 2002). Any management factors that would have a positive impact on egg production and chick survival can be used to increase the output from village chicken flocks. The flock size is a function of egg production

per hen and the proportion of mature laying hens in a flock (Kitalyi, 1998). Various studies conducted in the smallholder communal areas showed average flock sizes of between 15 and 20 chickens (Lombrou, 1993; Pedersen, 2002) within a range of 1-50 (Muchenje and Sibanda, 1997; Muchadeyi *et al*., 2004). The flocks are mainly composed of chicks (Maphosa *et al*., 2004; Muchadeyi *et al*., 2004).

Table 2. Chick mortality rate in rural production systems in different African and Asian countries during their 6-8 weeks of age.

Country	% Mortality	Reference
Sri Lanka	65	Gunaratne *et al*. (1992)
	46	Roberts (1994)
	79	Kingston and Cresswell (1982)
Indonesia	56	Hadiyanto *et al*. (1994)
Northern Ghana	80	Veluw (1987)
Ethiopia	61	Tadelle and Ogle (1996)
Cote d'Ivoire	50	Diambra (1990)

2.6. Indigenous Poultry Product Quality Charecteristics

Indigenous chicken production contributes immensely to the economy and food security of many smallholder farmers, particularly in the rural areas. Their meat and eggs are important food products that enhance the nutritional needs of malnourished children across rural Africa (Rosegrant and Cline, 2003), and they are affordable to most of the rural poor. Their accessibility and availability in rural areas not only play roles in poverty alleviation (Pica- Ciamarra and Dhawan, 2009) but also their consumption is associated with less health risk diseases (Wattanachant *et al*., 2004). Understanding factors that affect carcass characteristics and the quality of chicken meat is important in a poultry enterprise. Unfortunately, knowledge of such factors in indigenous chickens is limited. Weight and physical appearance of live birds, and egg size and shell color also determines the marketability of the product in Ethiopia.

2.6.1. Egg quality

Egg quality parameters used in different African countries are presented in Table 3. Chicken product quality determines the acceptability of a product to potential purchasers. The quality of eggs and the preservation of this quality during storage is a function of their physical structure and chemical composition. A basic outline of the most important factors of concern in egg quality are: Egg composition (egg shell, shell membranes, albumens and yolk), egg shell color, internal composition, egg weight (shell, albumen and yolk volume) and egg health. According to Islam *et al*. (2001) egg weight is also reported to be one of the important phenotypic traits that influence egg quality and reproductive fitness of the chicken parents. Egg weight influences the weight of components of eggs especially egg albumen and yolk (Aygun and Yetisir, 2010).

The egg-shell thickness is an important trait for hatchability. For best result of hatchability egg shell thickness should be between 0.33 and 0.35mm and few eggs with a shell thickness less than 0.27mm will hatch (Khan *et al*., 2004). The differences in egg-shell quality depend on the environmental conditions, season of production, rearing practices, relative humidity, feed quality and strain of layers (Washburn, 1990; Zita *et al*., 2009).

Table 3. Egg quality parameters for four breeds of chickens

Trait	Nigerian Local	Isa Brown	Trait	Ethiopian Local	White Leghorn	Nigerian Heavy and light breeds		
						Trait	LE	HE
(Asuquo *et al*., 1992)			(Forssido, 1986)			Momoh *et al*, 2010		
Egg wt., g	40.6	59.2	Egg wt., g	46.0	64.0	Egg length (mm)	53.6	52.9
Yolk, %	36.9	26.3	Yolk, %	36.8	34.0	Egg width (mm)	40.9	40.6
Albumen, %	52.6	62.8	Albumen, %	49.6	53.0	Shape index	0.76	0.77
Shell thickness, mm	0.30	0.35	Shell thickness, mm	0.35	NA	Shell weight(mm)	5.06	4.91
Yolk index	0.36	0.46	Fertility, %	56.4	46.0	Shell thickness(mm)	0.45	0.42
Albumen index	0.09	0.12	Hatchability %	42.1	24.1	Hough unit	79.1	78.3
Haugh unit	79.8	89.9	Haugh unit	NA	NA	Yolk weight(g)	18.3	17.9
						Yolk height(mm)	15.9	15.2
						Yolk width(mm)	38.5	37.4
						Yolk index	0.46	0.44
						Albumin weight(g)	31.1	30.2
						Albumin height(mm)	5.82	5.41

***** HE= heavy ecotype, LE= light ecotype

2.6.2. Carcass Characteristics

As is common in other animal species, the technological quality of poultry meat is now of major importance, since poultry meat is nowadays usually consumed as cuts or as processed products rather than as whole carcasses. The dramatic changes in the market forms for poultry in recent years, from a predominantly whole bird commodity to modern highly diversified industry focused on cut up, deboned meat and ready-to-eat further processed products, have resulted in a change of quality expectation. With increasing trends in further processing, meat functionality has increased in relative importance, especially because of its key role in determining the sensory quality of complex ready-to-eat products (Fletcher, 2002). It has been documented that genotype plays a major role in carcass fatness (De Smet *et al.*, 2004; Shahin and Elazeem, 2005). These genetic factors also influence the quality of meat produced.

Understanding factors that affect carcass characteristics and the quality of chicken meat is important in a poultry enterprise. Improving the poultry productivity would improve protein nutrition and could increase the income levels of the rural population. In addition, consumers prefer meat from indigenous chickens, because of its leanness. They also like the multi-colored plumage of these birds, particularly the Kei (local breed in Ethioipa) ecotype due to its reddish feather color. Evaluation of the egg production performance of crossbreeds between local and exotic birds was conducted by different research and development organizations (Haile-Mariam, 1998; Melesse *et al*., 2005).

Poultry meat consumption has changed from whole bird to cut-up or further processing modes. Earlier it was sufficient to measure performance using body weights. Experiments now often include commercial parts analyses or body chemical composition, or both. Commercial parts always include the portion of breast meat, often without skin. This is because of the usually greater value of breast for cut-up or in further processing. Other commonly reported parts include thighs, drumsticks, and wings. Body chemical composition is based either on the whole bird including feathers or sometimes on the whole processed (oven ready) bird. Sometimes just the feathers are removed.

Chen *et al.* (1987) examined the mass and slaughter yields of male and female carcass and reported genotype had no significant influence on the examined properties, as opposed to sex and age. Namely, males had significantly bigger carcasses than females at all ages. The increasing acidity of the maturing carcass varies in its speed, depending on a number of factors such as type of animal, breed, rearing characteristics, and treatment of the animal prior to slaughter. Elwinger (1981) in two experiments also examined the influence of the level of energy in the meals on the dressing percentage of different genotypes.

Nedeljka *et al*. (2009) defined that the carcass mass was in connection with a high correlation of chicken's body mass before the slaughtering, which caused chickens in different genotypes and different systems of nutrition not to approve statistically significant differences. The pH of muscle tissue is extremely important to meat science since the pH at specific times during the conversion of muscle to meat, as well as the ultimate pH of meat, affects many quality factors. The quality factors affected by pH include: color, grading characteristics and shrink of carcasses and wholesale cuts: texture, cooking loss and tenderness of steaks and roasts; and processing and binding characteristics of comminuted and restructured meats.

The pH-value or acidity of meat is important in relation to the meat's microbiological and keeping quality. In the live animal the pH-value of the muscular tissue is about 7.0 to 7.1. Very soon after slaughter a drop in the pH-value is observed and after several hours (24 hours or less) the pH-value reaches its lowest level of about 5.6 to 5.8. The increasing acidity is because of the post-mortem formation of lactic acid from glycogen, a sugar-like substance stored in the live animal's muscles for energy supply.

The pH value of the chicken meat is also regarded as paramount importance to meat quality as it influences the structure of myofibrils and in turn the colour of the meat (Dyubele *et al*., 2010). The rate and extent that muscle pH declines post slaughter are both variable and have a great impact on the color of meat and meat products. It is an indirect measure of meat color and has an effect on enzymatic activity and rate of oxygenation (Jane and Ronald, 2000). There is an increasing preference for indigenous chicken meat over commercial poultry due to their meat qualities (Sheng *et al*., 2013).

3. MATERIALS AND METHODS

Three research approaches were employed to conduct the current study. The research approaches were questionnaire survey (undertaken in three districts representing highland, mid-altitude and lowland agro-ecologies), a study conducted through follow up and evaluation (by preparing a checklist and collecting reproductive and productive data) of brooding hens, and on-station and on-farm experimental study. Under this chapter (materials and methods), subheadings like study areas, study animals, sampling and data collection and analysis methods were described.

3.1. Description of the Study Areas

Map of the study area is presented in Figure 1. The study was conducted in western Oromia where the Horro chicken ecotypes are mainly distributed. The study districts are sharing geographic boarders, social and cultural afiliations. The areas were selected for the study considering agro-ecology, socio-economic importance of poultry production and population of indigenous Horro chickens based on the Atlas published jointly by IFPRI and CSA (2016) and Dana, (2010). The study areas are situated within the geographical coordinates between 08º31´N and 38º49´E, and at altitude ranges approximately between 667-3602 m.a.sl., where mixed crop-livestock agriculture is the main stay. The area experiences an extended rainy season, which frequently begins in March and extends to mid-October ranging from 1000 – 2400 mm per annum (Olana, 2006) and the monthly mean temperature varies between 11.5°C to 27.5°C.

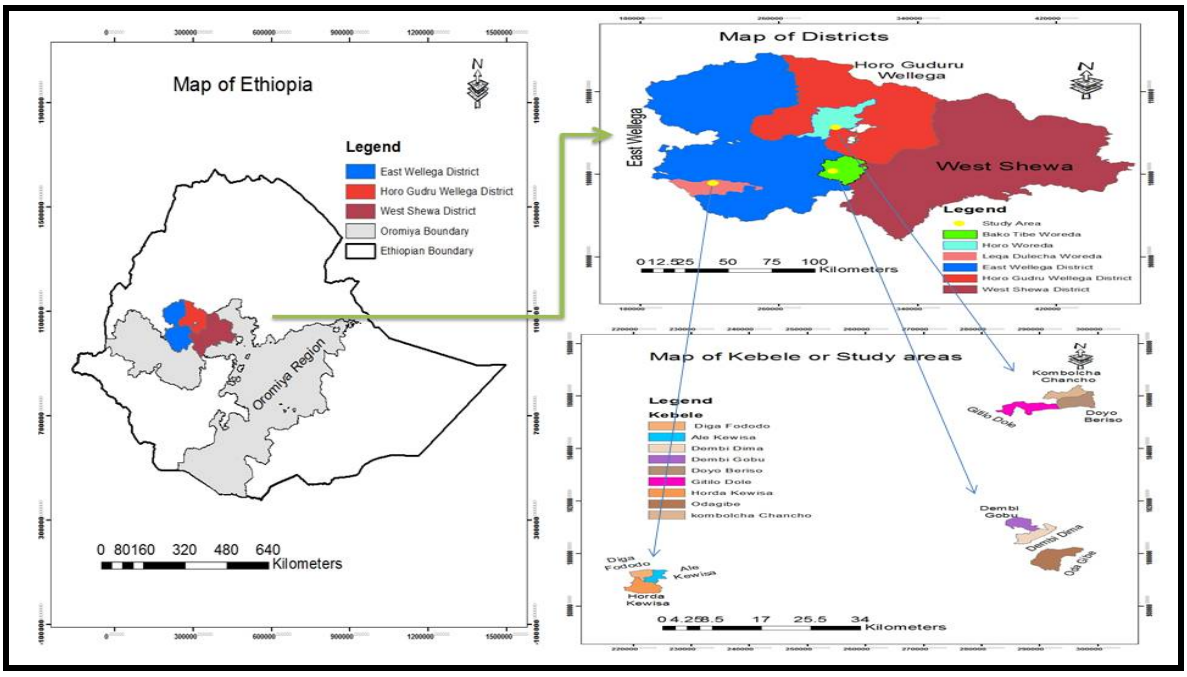


Figure 1. Map of the study area

Specific descriptions of the study districts

Horro District was a purposively selected district from the Horro Guduru Wollega Zone (located in the western Oromia in Ethiopia) that represented the Highland (Dega) agro-ecology. The district is the area from where the Horro chicken ecotypes got their name. The district is located in the Northeast central part of the then East Wellega zone and now Horro Guduru Wollega zone at 9°34'0" N 37°5'60" E. With an area of 998.7 km2, Horro district borders Abay Chomen and Guduru districts in the East, Bila Sayo and Abe Dongoro districts in the West, Amuru and Jarte districts in the North and Jimma Geneti district in the South. Shambu town is the administrative town of Horro Guduru Wollega zone and Horro district. Most of the district's landscape is characterized by undulating surface dominated by mountain ridge and hilly landforms.

Horro district experiences a temperate (Dega) type of climate. There are many mountains in the district such as; Belbela (3178m), Debisho (2980m) Jeldessa (2950m), Gudena (2740m) (2747m) and Korma (2820m). Most of these are the sources of many perennial rivers and streams. Some of perennial rivers originated from the areas are Geber, Gembo, Deneba and Abjar. The

dominant soil types are Rendzinas, Haplic and Luvic Phaeozems. There are natural and man-made forests. The wild animals found in Horro district include leopard, fox, buffalo, lion, ape and monkey. The district had no parks, game reserves or sanctuaries for wildlife conservation (Horro District annual report unpublished, 2015/16). Teff, wheat, barley, maize, millet and sorghum from cereals, horse beans, peas and haricot beans from pulses are important crops where, cattle, sheep, goats, equines, poultry and bee colony are among the major livestock resources of the district (CSA, 2016).

Leka Dullecha is another district which was purposively selected to represent the mid-altitude agro-ecology in East Wollega zone. The district is located in the Southwest of the Abbay basin at 9°5'21.5" N 36°33'19.4" E. Leka Dullecha district is situated at about 360 km West of Addis Ababa. The district share frontiers in the Northeast with Guto Gida district, in Southwest with the Dhidhessa River, in the North with Diga district and in the South and Southeast with Jimma Arjo and Nunu Kumba districts. The area is among the highest rainfall regions in Ethiopia. Despite fluctuations over the years, generally, the district has a mono modal rainfall pattern whereby it receives rain from mid-March through November. The rain is particularly heavy from June to September. January to mid-March is known to be the dry season in the district.

In some places in Leka Dullecha district, the mean annual rainfall exceeds 2,000mm.The altitude in the area varies from 1,200 to 2,342m.a.s.l. The midlands are steep, formerly forested terrain which is being rapidly cleared of trees. Leka Dullecha district comprises three agro-climates such as; lowland (35%) and midland (54%) and highland (11%). Didesa, Negesso, Kolati and Abonno rivers are among the perennial rivers found in the district and the great Nile basin which are tributeries to the Blue Nile and which flow all round the year. A mixed crop-livestock production system is the main stay for the agricultural and livelihood of the people in the district (Leka Dullecha Woreda, Livetock and Fishery Development Office's Report, 2015/16 unpublished report).

Bako Tibe district is the district found in West Shewa administrative zone, in the Oromia Regional State, in Ethiopia. The district is situated at about 250 km west of Addis Ababa on the main road to Nekemte. The geographical coordinates of Bako-Tibe district is at an latitude of

9.12^0 and a longitude of 37.05^0. The district was purposively selected to represent the lowland agro-climate. The topographic situation of the district is within an area of about 644.7 km^2 of which about 54.25% ha is under crop, about 23.98% ha is under pasture, about 5.12%ha was under forest and about 16.65% ha used was for infrastructure and construction (Bako Tibe District Livestock Resource Development and Health Office, 2015/16 unpublished report).

Bako-Tibe district borders east Wollega in the West, Horro-Guduru Wollega in North, Chaliya District in the East and Biloboshe distirict (East Wollega zone) in the south. Government and community owned forests are also available. Reserves, Vervet, Monkey, Baboon, Warthog, Hippopotamus, Leopard, Duiker, Colobus monkey, Bush buck, spotted hyena and Civet cats are some of wild animals found dispersedly in the District. Perinnial Rivers found in the district include Gibe, Robi, Abuko, Mara and other seven major rivers as well as several seasonal streams are flowing through the district. There is no lake in the district. Rendzinas, Haplic and Luvic phaeozems (4.0%), chromic and Orphic Luvisols (14.9%), Dystric Nitosols (60.2%), and Chromic and Pellic Vertisols (20.9%) are the major soil types found in the district. Climatically, the district is classified into high land (12%), midland (35%) and lowland (53%) zones.

3.2. Description of Study Animals

Three improved chicken breeds were used for on-farm and on-station which were Improved Horro (IH), Potchefstroom Koekoek (KK), DZ White-feathered chicken (DZ_1) and a local unimproved Horro chicken ecotype produced under village production system were used for survey and a follow uo and evaluation study.

3.2.1. Improved Horro chicken breed **(IH)**

The Horro chicken ecotype is one of Ethiopian indigenous chicken breed named after the geographic region of origin such as; Tilili, Jarso, Tepi, Gelila, Debre-Elias, Melo-Hamusit, Gassay/Farta, Guangua and Mecha (Halima, 2007). Horro chicken ecotype is named after the particular area Horro. Now adays, this chicken breed has been distributed to a wider area in

Ethiopia in particular through research institutions and Universities. There were about 30,000 chickens restricted to this original environment (Nigussie *et al*., 2009).

The Horro chicken breed used for the present study was of 11th generation for which the breeding program at National Agricultural Research Institute; Debre Zeit Agricultural Research Center (DZARC) was developed to achieve genetic improvement in the body weight (growth) and egg number through mass selection. The performance of individuals was used in making selection decisions. Selection criteria were body weight at 16 weeks of age on both males and females and egg number at 45 weeks of age on females. The target set by DZARC for Horro chicken breed improvement was to reach 1500g of body weight at 16weeks and 200 eggs per hen per year. These birds were reported for the potential of 171 egg per year during their 7th generation (Wondimeneh *et al*., 2015).

*3.2.2. Potchefstroom Koekoek Chicken Breed (***PK***)*

The Potchefstroom Koekoek chicken breed is a composite of the *White Leghorn*, *Black Australorp* and *Bared Plymouth Rock* bred at the Potchefstroom Agricultural College, in South Africa during the 1950s (Grobbelaar, 2010). The Potchefstroom Koekoek cocks and culled hens are used for meat production. The Koekoek's colour pattern is a sex-linked gene that is very useful for colour sexing in cross-breeding for egg producing types of hens used in medium input production systems. The breed is popular among rural farmers in South Africa and neighboring countries for egg and meat production as well as their ability to hatch their own offspring (Grobbelaar, 2010). Koekoek was used in Ethiopia for more than 10 years. The Koekoek was selected based on good advantages as seen in DZARC farm, with 200 eggs per hen per year, 55.5g egg weight, deep yellow skin, relatively high body weight (BW) of male (2.65kg) and female (1.87kg) at the end of production, and it carries sex-linked gene for color sexing of DOC (Grobbelaar *et al*., 2010; Wondmeneh *et al*., 2011).

*3.2.3. DZ White-feathered chicken (**DZ1**)*

DZ1 is a white colored chicken breed produced at the Debre Zeit National Agricultural Research Center (DZARC) through selective cross breeding. This breed of chicken was produced with a combination of *Lohnmann Silver*, *Potchefstroom Koekoek*, and local White colored chicken ecotype of Ethiopia. The synthetic DZ White-feathered chicken used for the on-farm and on-station comparison with the exotic Koekoek and Improved local Horro in the current study were at their 9th generation at DZARC. Figure 2 below depict study animals used for on-farm and on-station study.



Figure 2 Pictures illustrating study-animals (Horro, Koekoek and DZ White-feathered chicken breeds from left to right). Source: Nigussie *et al.* (2010) and Esatu *et al*. (2011).

3.3. On-farm Sampling Method and Sample Size Determination

Three districts namely Horro, Leka-Dulecha and Bako-Tibe were selected from (western Oromia National Regional State) in Ethiopia. The districts represented three agro-ecologies namely (Highland/temperate, Midaltitude and Lowland) for the characterization of poultry production and marketing system, and to evaluate chicken reproductive and productive performances. The study districts were classified into climatically hetrogenous strata to study the effects of spatial and agro-climatic variations on productivity of Horro chicken ecotypes.

The agro-ecologic condition of the study areas were determined based on the traditional classification that depends mainly on altitude and temperature; the lowland areas are those, which lies between 500 to 1,500m altitudinal ranges and a temperature range of 20 to 27.5°C, the midland areas were represented by altitudinal range between 1,500 to 2,300m with a temperature range between 17.5 and 20.0°C. The highlands were those areas featured by an altitude ranges between 2,300 to 3,200m, and a temperature range of 11.5 to 16.0°C (EMA, 1988).

Questionnaire survey and a follow-up and evaluation were employed side by side. For survey, and follow up and evaluation purposes, 360 households (HH), where 120HHs from each agro-ecology were selected by systematic random sampling method (Bellhouse, 2005) and the sample size of the study 'kebeles' within the district was determined using a proportionate sampling technique with the formula;

$W = [A/B] \times N_o$.

Where, A = Total no of chicken rearing households in the selected agro-ecology.

B = Total sum of households living in sample 'Kebele'.

N_o = The total required calculated sample size.

Figure 3 presents research participants on training. For the on-farm experimental research, participants were determined based on farmers' willingness to participate in the study, experience in poultry production and access to follow up and evaluation. Therefore, a total of 45 households and 15 HHs of each agro-ecology were randomly selected among volunteer survey respondents by lottery method of random sampling. During selection of chicken strains' reproductive and productive performance evaluation participants, ecologic homogenity was considered. After a one day training was provided for research participants, each household were offered ten chicks from any of the three breeds namely; Improved Horro, Potchefstroom Koekoek or DZ White-feathered (DZ1). Selected households were then given a continuous orientation on experimental chicken management and data recordings.



Figure 3. Research participant farmers' training before study animals distribution

3.4. Methods of Data Collection

3.4.1. Questionnaire Survey

Figure 4 and 5 present pictures taken during survey questionnaire interview, key informant interview and on training of data collectors. For the interview, semi-structured questionnaire was prepared in English and administered in ‘Afan-Oromo’ (local language of the study area and the Oromia National regional State in general), and 10% of the planned respondents, six enumerators from each district were selected and trained for pretesting questionnaire. Then the questionnaire was re-edited and prepared for interview and data was collected on a general household demography, livestock composition, poultry production and marketing systems used, and chicken management, and major chicken marketing and health constraints of the study areas.



Figure 4. Recall method of questionnaire interview used for survey data collection

Key Informants interview comprising of ‘Kebele’ administrators, men and women elders, district experts and local poultry market dealers were selected and used for interview to complement the questionnaire interview.



Figure 5. Key informant interview and group discussions

Family size, agricultural land holding, livestock holding, household head educational status, family members’ responsibility in poultry production and marketing, and poultry holding, and product income administeration and ownership were collected through questionnaire interview. Data on poultry housing system, flock size and structure (age, sex and breed), prevailed management systems such as (breeding and hatchery management, egg storage, health care, feeding and watering) and technological inputs employed in the area for poultry improvement were assessed.

Data on poultry health constraints, health facilities available in the areas, and marketing system and market constraints were assembled by questionnaire survey and key informant interview. Veterinary clinical case books at respective district's animal health clinics were used for retrospective study and veterinarians of each district were consulted to collect data on disease prevalence, veterinary service delivery and technological interventions available. Farmers' opinion on use of veterinary services for their chicken and status of their satisfaction on the service delivery was also assessed. Socio-economic contribution of poultry and data on roles of poultry production were also collected by consulting; district experts, elders, women and physical observation, and intermediary men's interview.

3.4.2. Data collection for follow up and evaluation

Follow up and evaluation was employed to study the productive and reproductive performances of unimproved indigenous Horro hens and during questionnaire interview of 360 households, broody hens were identified at the back-yard of each respondent and a total of 191 broody hens were found. Among these hens identified for follow up and evaluation, 52 were found in Horro, 69 hens in Bako-Tibe and 70 brooding hens in Leka-Dulecha districts. The whole broody hens available during the study were purposively selected based on their stage of broodiness (nursing chicks) and recorded for follow-up. Therefore, 191 brooding hens which were nursing their chicks during the survey were recorded and followed for a maximum of three months to study reproductive and productive traits such as number of chicks per hatch, age at weaning, weaned chick per hatch and chicks' survival rate to weaning. Individual hen's reproductive and productive performances traits such as number of egg/cluch, cluch/year, age at first egg of hens reared for the last 12 months back from the study time were also collected by recall method through questionnaire interview. Figure 6 presents broody hens' pictures taken during follow up and evaluation.



Figure 6. Broody hens attending their chicks; Picture taken from different sites of the study area

3.4.3. Experimental animal Housing and Feeding management

3.4.3.1. House preparation and housing management

For on-farm and on-station evaluation studies, 900 day-old chicks; 300 chicks of each breed (Improved Horro, Koekoek and DZ White-feathered) were taken from Debre Zeit Agricultural Research Center and grown for ten weeks on-station in Nekemte city (the capital of East Wollega Zone, in West Ethiopia). Twelve chick-pens ($1.5\times2m^2$) each with a holding capacity of 75 day-old chicks were prepared properly (clean and warm), filled with bedding materials (made of barley (*Hordeum vulgarae*) and teff (*Eragrostis teff*) straw and wood shavings) and made ready before the chicks arrived.

The brooding chick-pens were equipped in addition to bedding materials with; feeder, waterer, a 200-watt light bulb as a heat and light source, and after week eight of chicks' age a perch and a box with dry sand for dust bathing were added. Each breed were weighed and randomly assigned into four chick-pens each filled with bedding materials. All chicks were checked for deformity and 260 Koekoek, 290 Improved Horro and 290 DZ white feathered (a total of 840 chicks) were assigned into 12 pens. All chicks were vaccinated against Marek's at the hatchery, Newcastle at Day 3 (HB1) and 27 and every 60-90 days (La Sota), Gumboro at day 14 and 21 and Fowl

Typhoid on day 45 based on vaccination schedule set by the National Poultry Research Case team at Debre Zeit Agricultural Research Center (DZARC).

3.4.3.2. Chick feeds and feeding

Scince the study area is the major maize (*Zea mays*), Soyabean (*Glycine max*, L) and Noug (*Guizotia abysinica*) producing area in Ethiopia, therefore a home-made feed formulation was employed in order that more economical ration could be produced as high costing chicken rations were transported to the area from Addis Ababa and Bishoftu areas. To determine the proportion of feed ingredients, feed samples of maize, wheat, nuog cake, and soyabean were analysed at Holleta Agricultural Research Center's National Nutrition Labortory prior to formulation; for dry matter (DM), crude protein (N × 6.25), crude fibre (CF), ether extract and ash; by standard AOAC methods (AOAC, 1990). Metabolisable contents of the diets were calculated from the chemical analysis data using the equation: ME (kcal/kg) = 4.26X1 +9.5X2 + 4.23X3 + 4.23X4. The calculated digestible crude protein, fat, fibre and nitrogen free extracts (g/kg feed) are represented by X1 through X4.The feed was formulated to meet the nutritional requirements for poultry as recommended by the Agricultural Research Council (ARC) (1994) and according to (Magala *et al*., 2012) and then chicks were provided *ad lib* with a standard chick (0-8 weeks: 20% CP and 2950 kcal/kg of ME) starter ration, grower (8-20 weeks: 18% CP and 2850 kcal/kg of ME) growers' ration and layers (wk20 onwards: 16% Cp and 2750 kcal/kg of ME) layers' diet.

A Trisulpha Forte® (made of Sulphadimidine Sodium, Sulphadiazine Sodium and Sulphatiazole Sodium ingredients) was administered via water every three days as a prophylaxis against coccidia, diarhoea and other bacterial infections. Chopped and grinded green alfalfa (*Medicago sativa*) and hydroponic barley (*Hordeum vulgare*) malt was offered two days weekly as a supplement to boost the protein, vitamins, and macro and micro mineral requirements in green forage. Male and female chicks were separately penned on the 8th week of their age. Starter, growers and layer feed ingredients used and proportions of preparation are presented in Table 4.

Table 4. Feed ingredients and proportions used to feed starters, growers and layers

Feed Ingredients (kg)	Starters	Growers	Layers
Corn (cracked)	63.25	59.75	63.50
Wheat	-	10.00	14.00
Roasted soyabean meal	26.00	20.00	20.00
Noug *(Guizotia abysinica)* Cake	10.00	8.00	-
Salt	0.50	0.50	0.50
Vitamin, Mineral Pre-mix	0.25	0.25	0.50
Limestone	-	1.5	1.50
Chemical composition (DM basis)			
Crude protein (%)	20.05	18.02	16.61
Metabolizable energy (Kcal/kg)	2950	2850	2750

3.4.4. On-farm data collection

Based on the data obtained during the survey and by using triangulation technique, on-farm experimental research participants were identified according to (Davis, 2001; Cavestro, 2003 and Kalim, 2011). A total of 45 household from three agro-ecologies were mapped for participatory research where areas selected for on-farm trial were made to have a homogenous (uniform agro-climate) agro-ecology. Therefore, 15 volunteer men and women farmers each from the highland, mid-altitude and lowland agro-ecologies were randomly selected based on their experiences in poultry rearing and provided a one day brief orientation on the purpose of the study and on how they could manage the chickens and record data. These farmers were randomly divided into 3 groups. A group was given one type of breed of 10 weeks age and 10 chicks for each individual in the group (both pullet and cockerels equally). However, among the participant farmers in the current study; one farmer from the mid-altitude and one farmer from lowland agro-ecology were dropout of the study and the analysis of data as well. The dropout was because of their loss of the total stock they were provided.

3.4.5. On-station data collection

Data for growth performance was collected by weighing chicks per-pen every weekend till they were eight weeks old whereafter male and female chicks were separated and repenned. Feed consumption was recorded for each pen and average daily feed consumption (AFC) per bird was calculated after correcting for mortality at entry into the chicks'-pens. Feed conversion efficiency per pen per week and individual body weight gain of chicks was recorded starting from eight weeks of chick's age on a biweekly basis until they were 18 weeks old. Body weight gain (BWG) was calculated as the difference between body weights measured in consecutive measurements/records every two weeks.

Growth performance was determined using live weights and growth rate parameters. Weight gain was calculated as follows;

- $WG = (LWti - LWto)/t$
- $t = t_i - t_o$

Where, WG is weight gain (daily, weekly or overall) per time period in gm;

LWt_i is live weight at particular week = t_i

LWt_o is live weight for the previous period = t_o

Feed Conversion was also calculated as follows:

- Feed Conversion Ratio (FCR): Weight gain divided by feed intake (average feed consumption).

Morbidity and mortality rate was also recorded as happened, to calculate relative disease tolerance and survival rate before age at first egg. Beginning from week-20 onwards; 45 females and 9 males for each breed (at a ratio of 1:5) where a total of 162 breeding male and female chickens were separated to rebreed. A (2m×1.5m) pens each fitted with a trap nests to facilitate performance recording and equipped with perch, grit sand box, egg laying boxes, feeder and waterer were constructed. At the on-farm condition, all hens were stayed to rebreed with a selected male of the same breed grown with those pullets for growth performance, age at maturity, mature age weight and age at first egg study.

3.4.6. Egg Quality and Carcass Characteristics

3.4.6.1. External and internal egg quality characteristics

For external and internal egg quality determination, 50 eggs of local Horro chickens from each agro-ecology and a total of 150 chickens' eggs reared under traditional management were bought. Hundred eggs of DZ White-feathered, eighty eggs of each from Koekoek and Improved Horro chicken egg and a total of 260 eggs on station was collected for external egg quality characteristics study. External egg quality traits such as egg weight, length, width, shape index, surface area, shell weight, shell thickness and shell ratio were determined. The individual eggs were weighed with a digital sensitive balance to the nearest of 0.01gm accuracy. The eggs' length and breadth were measured with the help of digital calipers and shape index was calculated as the ratio of breadth to length times 100 and surface area (S) was calculated with a formula of $S=4\pi r^2$. Radius (r) was calculated as ¼ (length + breadth) of the egg according to (Pradepta *et al*., 2015).

For egg shell weight and shell to egg ratio determination, the inner shell membrane was removed from the shells and kept to dry in the open air for 24 h. All the dried shells were weighed with the help of a digital balance. The shell weight was divided by the egg weight to get the shell ratio. In each egg, shell thickness was recorded as the average of three readings taken from three different sites on the egg, that is, at the equator (middle), broad and narrow ends as it has been suggested in previous studies by (Khatkar *et al*., 1994 and Mohammed *et al*., 2005). Egg shape index was measured according to (Chen *et al*., 1993 and Smith, 2001) as the ratio of egg width to length (in %). A vernier calliper was used to measure egg width and length.

For internal egg quality determination, the width of the yolk was measured in mm with the help of a vernier calliper. Albumen height was measured using a micrometer at 3 or 4 locations and averaged. Haugh unit (H.U.) was calculated by using the formula $HU = 100 \log(H+7.57-1.7W^{0.37})$ Where, H is albumen height in millimeters, measured by micrometer and W is observed weight of the egg in grams (Haugh R.R., 1937, and Oluyemi and Roberts, 2000). Albumen weight was calculated as egg weight- (Yolk weight + shell weight). Albumen and yolk

ratios were calculated taking their individual weights as the percentage of total egg weight. The yolk diameter was estimated as the average of yolk length and breadth. Yolk to albumen ratio was calculated as weight of yolk/weight of albumen.

The Haugh Unit values was calculated using the formula $HU= 100 \log(H + 7.57-1.7W^{0.37})$ as;

- HU = Haugh Unit
- H = Observed height of the albumen (mm)
- W= Weight of the eggs in grams.

Some of the egg quality traits were estimated using the following mathematical formulas:

- Shape index (%) = (Width of egg / Length of egg) × 100
- Albumen (%) = (Albumen weight / Egg weight) × 100
- Yolk (%) = (Yolk weight / Egg weight) × 100
- Shell weight = Egg weight – (Albumen weight + Yolk weight)
- Shell (%) = (Shell weight / Egg weight) × 100

3.4.6.2. Carcass characteristics determination

For carcass characteristics determination and comparison among chicken breeds, 30 male chickens or 10 chickens of each breed (the Improved Horro, Koekoek and DZ White-feathered) were slaughtered for carcass characteristics determination. The chickens were randomly selected, weighed and fasted for 12hr with free access to drinking water. Thereafter, the chickens were slaughtered by cervical dislocation. Carcass weight, breast meat, thigh and drumstick and edible offals; gizzard, Heart and liver were measured using a digital weighing scale.

For calculation of chilled carcass weight (CCW), the carcasses from other replicates were stored at 4ºC for 24 and 48hrs. Dressing percentage was calculated as the proportion of carcass weight to live weight of each bird according to (Forssido, 1986 and Ramokone *et al*., 2015). The post-mortem pH was also determined on the breast, drumstick and thigh muscle of each bird using a digital pH meter at time intervals of 30 min, 24 and 48hrs post-slaughter. The slaughtering was

performed in the laboratory of Wollega University by one skilled person in order that technical biases would be avoided.

3.5. Statistical Data Analysis

Survey data was entered into Microsoft Excel sheet for clearance, which then was exported to *Statistical Package for Social Sciences (SPSS) for windows, version 20.0*. Analysis was then employed for descriptive statistics (means, standard deviations, minimum and maximum values), frequencies and percentages. For quantitative variables such as family size, land holding, livestock holding, chicken flock structure and local chickens reproductive performances were employed using Generalized Linear Model (GLM) in SAS version 9.3 (2014).

For variables such as chicken flock structure, breeding cock ownership, breeding practices employed and hatching egg management study, crosstabs among agro-ecologies in descriptive statistics in an SPSS Ver.20 was employed. For production and reproduction traits collected both from the on-satation and on-farm management conditions the General Linear Model (GLM) *procedures in the statistical analysis system* (SAS, 2014) version 9.3 and Statistical Package for Social Sciences (SPSS ver. 20) were employed based on their compatability. Values of $p < 0.05$ were considered significant.

Statistical Models Fitted:

Model 1. Follow up and evaluation of reproductive performances of 'Horro' chickens across the three agro-ecologies;

$$Y_{ik} = \mu + A_i + e_{ik,}$$

Where, $Y_{ik,}$ is the k^{th} observation under the i^{th} agro-ecology

μ= is the overall mean,

A_i = is the fixed effect of agro-ecology (i=3, highland, mid-altitude and lowland),

e_{ik} = is error term that is randomly and independently distributed

Model 2. On-station early growth performances of the Improved Horro, DZ White-feathered and Koekoek chicks;

$$Y_{ijkl} = \mu + A_i + B_j + (AB)_{ij} + e_{ijkl}$$

Where:

Y_{ijkl} output (growth performance and body weight gain)

μ= overall mean

A_i = fixed effect of chicken genotype. i = 3 (Koekoek, DZ White-feathered and Improved Horro chicks)

B_j = fixed effect of sex of chicken j = 2 (male and female)

$(AB)_{ij}$ = interaction of fixed effects of genotype and sex

e_{ijkl} = random error of chicken genotype and sex

Model 3. Effect of agro-ecologic differences on external and internal egg quality traits;

$$Y_{ik} = \mu + E_i + e_{ik}$$

Where, Y_{ik} = external and internal egg quality traits

μ = Overall mean

E_i = effect of i^{th} Agro-ecology, i=3 (highland, mid-altitude, lowland)

e_{ik}= random error normally and independently distributed with mean zero and variance ($\sigma^2 e$) i.e. (N (0, $\sigma^2 e$)).

Model 4. Effect of chicken genotype on carcass characteristics;

$$Y_{ik} = \mu + G_i + e_{ik}$$

Where, Y_{ik} = external and internal egg quality traits

μ = Overall mean

E_i = effect of i^{th} chicken genotype, i=3 (Koekoek, Dz white feathered, Improved Horro)

e_{ik}= random error normally and independently distributed

4. RESULTS

This chapter has four subsections. Under subtitle 4.1. results from questionnaire survey, under subtitle 4.2. results from follow up and evaluation and under subtitle 4.3. results from on-station and on-farm experimental studies are presented. Subtitle 4.4. presented results on egg quality and carcass characteristics of chickens produced on-station and under traditional management of different agro-ecologies.

4.1. Rural Poultry Production and Marketing Systems

4.1.1. Family demography, cropland and livestock holding, and chicken flock structure

Descriptive summaries of the continuous and discrete variables used to characterize household characteristics as well as data on family size and status of literacy are presented in Table 5. Family characteristics studied indicated that, households in the present study areas were mainly male headed, where male and female-headed households were 87.45 and 12.55%, respectively. Majority of the targeted households (56.46%) studied had attended elementary level of education followed by population of illiterates (28.06%) and 15.48% of household heads interviewed had attended high school and above. About 90.32% of rural household heads of the study areas were aged between 20 and 60 years, where the household heads whose age was under 20 years and above sixty years together accounted only for about 9.68%. Very small number of young household head (< 20yrs age) and elders (>60yrs age old ones) were participated in poultry production.

Table 5. Household head sex, level of education and age characteristics

Household head characteristics	Study districts			Overall household characteristics	
	Horro	Leka Dullecha	Bako-Tibe		
Sex				Frequency	Percent
Male	93	99	79	271	87.45
Female	7	19	13	39	12.55
Level of education					
Illiterate	18	45	24	87	28.06
Elementary	66	56	53	175	56.46
High school	16	17	15	48	15.48
Age					
< 20 yrs	0	3	0	3	0.97
21-30yrs	3	25	8	36	11.61
31-40yrs	31	51	36	118	38.06
41-50yrs	37	24	28	89	28.71
51-60yrs	12	8	17	37	11.94
> 60yrs	17	7	3	27	8.71

- The educational level classification was based on the current Ethiopian educational level classification where: Illiterates are those didn't join school, Elementary schools were grade 1-8 and high school and above was for grade 9 and above.

The mean household family size, agricultural landholding, livestock holding and chicken flock structures are presented in Table 6. The mean household family size in the current study areas were; 6.55±1.99, 6.34±2.33 and 5.77±2.1) for Horro, Bako-Tibe and Leka-Dulecha districts, respectively. Agricultural landholding studied was mainly rain fed where per family landholding ranges between 0 and 10 hectares of land and the mean per household landholding for Horro (highland) was the largest (2.36 ±1.59) among the three districts, followed by Bako-Tibe (lowland) (1.63 ±1.51) and Leka-Dulecha (mid-altitude) (1.25 ±1.06) consecutively. Cattle, sheep, goats, equines and chickens were the common domestic livestock reared in the study areas all in one or either groups of them or only single group of animals where cattle were the first in the rank of preference and level of importance.

The largest mean landholding was recorded at the highland agro-ecology as opposed to mean chicken flock size 10.46±4.76 and 13.26±7.14 at Horro and Bako-Tibe districts respectively, where as the mean perhousehold cattle population was dominant in Horro (highland). Overall mean chicken flock size per household was 11.15±6.16, where mean of chicks, hens, pullets, cockerels and cocks were 4.31±4.16, 1.46±1.00, 1.39±1.95, 3.60±2.12 and 1.17±0.84, respectively (Table 6). The dominant population of poultry group in the chicken flock structure was group of chicks (4.31±4.16) followed by hens' group (3.60 ±2.12) which if summed up that accounts for about 79.94% of overall mean population.

Respondents of the present study indicated that the population of chicken flock was fluctuating with seasons of the year that eggs were not set for hatching during summer (wet season) and on the other hand some years of disease occurrences may result in occasions where producers may loss the whole flock or most of their chickens due to disease outbreaks. The population of cockerels and pullets calculated from this study were only 8.9 and 12.47% respectively, which implied the low survival rate of chicks produced under traditional management, and the challenge in getting hold of replacement stock.

Table 6. Cropland, livestock holding and poultry flock structure and productivity

Study-zones	N	Family size	Cropland holding	Livestock holding					Poultry flock structure				
				Cattle	Sheep	Goats	Equine	Chicken	Chicks	Cockerels	Pullets	Hens	Roosters
		Means ± Sd	Means ±Sd	Mean ±Sd	Mean ±Sd	Mean ±Sd	Means ±Sd	Means ±Sd	Means ±Sd	Mean ±Sd	Means ±Sd	Mean ±Sd	Means ±Sd
Highland (Horro area)	100	6.55 (1.99)	2.36 (1.59)	10.64 (4.93)	6.73 (3.75)	2.86 (2.97)	3.19 (1.98)	10.46 (4.76)	4.63 (3.01)	0.58 (1.17)	0.88 (1.86)	3.40 (1.76)	1.36 (0.84)
Lowland (Bako area)	92	6.34 (2.33)	1.63 (1.51)	7.92 (7.44)	0.43 (1.32)	0.47 (1.99)	0.65 (0.80)	13.26 (7.14)	5.59 (5.17)	1.54 (1.63)	1.53 (2.02)	3.65 (2.91)	1.01 (0.74)
Midland (Leka Dulecha area)	118	5.77 (2.1)	1.25 (1.06)	6.58 (4.83)	4.30 (4.55)	0.24 (1.03)	0.78 (1.0)	10.09 (6.03)	3.06 (3.77)	0.92 (1.42)	1.70 (1.90)	3.72 (1.60)	1.13 (0.88)
Overall	310	6.19 (2.16)	1.68 (1.50)	8.29 (5.99)	3.94 (4.37)	1.15 (2.41)	1.52 (1.78)	11.15 (6.16)	4.31 (4.16)	1.00 (1.46)	1.39 (1.95)	3.60 (2.12)	1.17 (0.84)

* N= number of household interviewed; Sd= standard deviation

Household family members' chicken ownership, income collection and utilization practices are presented in Table 7. Traditionally, any member of the family in the production system with no restriction to age and sex of individuals were participating in rearing chickens. School boys and girls (children) obtain foundation stocks in the form of gift or for sharing the outputs and use the income collected from sale of egg and live-birds to cover their school expenditure. Among the households studied, for about 28.06, 25.16, 24.84, 11.29 and 10.65% of income collected from live bird and egg sale was utilized by whole family, children, spouses, household heads, and husband and wife, respectively. Some of these chicldren save the income for their future investment. Poultry keeping uses family labour in general and house wives (who often own as well as look after the family flock and were also major beneficiaries) in particular plays the major role in chicks and egg management.

Table 7. Chicken ownership and product utilization practices

Family member	Chicken owner		Who use income of egg sold		Who use income of chicken sold		Chickens' order of importance in livestock production	
	Frequency	%	Frequency	%	Frequency	%	Order	Rate (%)
Household head	35	11.29	22	7.10	39	12.58	1st	11.93
Spouse	77	24.84	113	36.45	73	23.55	2nd	31.29
Children	78	25.16	54	17.42	53	17.10	3rd	31.29
Whole family	87	28.06	91	29.34	104	33.55	4th	11.61
Husband and wife	33	10.65	30	9.68	41	13.22	5th	13.55

The objectives of chicken production, source of initial capital for investment on poultry, and chicken ownership in the family is presented in Table 8. The result revealed the objectives of chicken production in the area was that, chickens were reared mainly (90.85% producers) for sale for the immediate income generation and savings, where only 3.27% producers rear chickens for consumption and Holyday sacrifices, while only 1.96% of producers interviewed were producing chickens for breeding and reproduction. This study also revealed that 29.22%

and 26.95% chickens were owned by husband and wives together (as a common property) and by whole families respectively, where as the remaining 11.27, 13.31 and 17.86% chicken ownership in particular goes to family head, spouse and children, with a respective order.

Table 8. Objective of poultry production and ownership characteristics

Objective of production		Frequency	%	Rank
Production for consumption		10	3.27	3
Production for sale		278	90.85	1
Production for saving		12	3.92	2
Production for breeding		6	1.96	4
Chicken Ownership				
	Household's	39	11.27	5
	Spouse's	41	13.31	4
	Children (Boys and Girls)	55	17.86	3
	Whole families'	83	26.95	2
	Husband and wife's	90	29.22	1
Source of initial Capital				
	Agriculture	261	87.58	1
	Private loan	10	3.35	3
	Family & friends	26	8.73	2
	Cooperative-finance	1	0.34	4

Income generation from live-chicken and egg sale according to the present study was the primary goal of poultry production and was ranked first followed by production for savings. Eggs produced for some families was a regular source of income although small while the sale of live-birds provided a more flexible and immediate source of cash as required. The income collected from sale of chicken was used for children's (school boys and girls) school fee, purchase of home consumables and sometimes for purchase of agricultural inputs. The initial capital for poultry production in the study area was mainly (87.58%) agriculture, where as a gift from

family and friends, private loan and cooperative micro-finances (extension services) were also used to commence an investment on poultry (Table 8).

4.1.2. Poultry production and management characteristics

The major feed resources, feeding practices and frequency of feed offering and housing management assessed is presented in Table 9. Feeding management of chickens practiced in the current study area was predominantly scavenging type where producers offer feed supplements from home source and purchased grains, kitchen leftover and either or sum of these feed sources. This study also revealed that about 94.19% producers offer supplementary feeds mainly grains produced at farmers home.

Peoples' tradition on chicken sacrifices and criteria used to select sacrifice birds are presened in Table 9. According to this study, about 57.33% of producers had no special occasions for chicken sacrifices, except for most (84.27%) of respondents chicken slaughtering was conducted during holy days. The major criteria used to select chicken for slaughtering by about 69.3% of respondents was body size or weight of the bird, the market prices were also determined based on the weight of the bird. The observation during the survey identified that non-black colored cocks were preferred on market. The result therefore, implied that the tradition of scarifying chicken for cultural rituals and selection based on plumage color and comb type was getting minimal.

Table 9. Traditional chicken sacrificing practices in the study area

Attributes	Label	Frequency	%
Do you have special occasion for chicken slaughtering	Yes	131	42.67
	No	176	57.33
Purpose of sacrifice	Cultural sacrifice	4	2.25
	Holy days	150	84.27
	Ceremonial	2	1.12
	Guest invitation	22	12.36
Criteria used to select chicken for sacrifice	Plumage color	41	26.8
	Comb type	6	3.9
	Body size	106	69.3

Household family members labour division on poultry management mainly in feeding and house cleaning is presented in Figure 6. The result revealed that women among the family members take the major role in chicken management where the whole family and children mainly girls in the family play roles in a successive order. Chickens' house cleaning and feed and water supplement was acted mainly by spouses (mothers). According to the present study, they were spouses who mainly provide supplementary feed for chicken at the highland (in Horro) and mid altitude (Leka Dullecha district) agro-ecologic locations while the whole family were participating at the lowland (in Bako-Tibe district) (Figure 7). House wives (mothers) in particular take responsibility in looking after the chickens of their young boys and girls who go for school and they were helping their children by collecting eggs for either marketing or incubation.

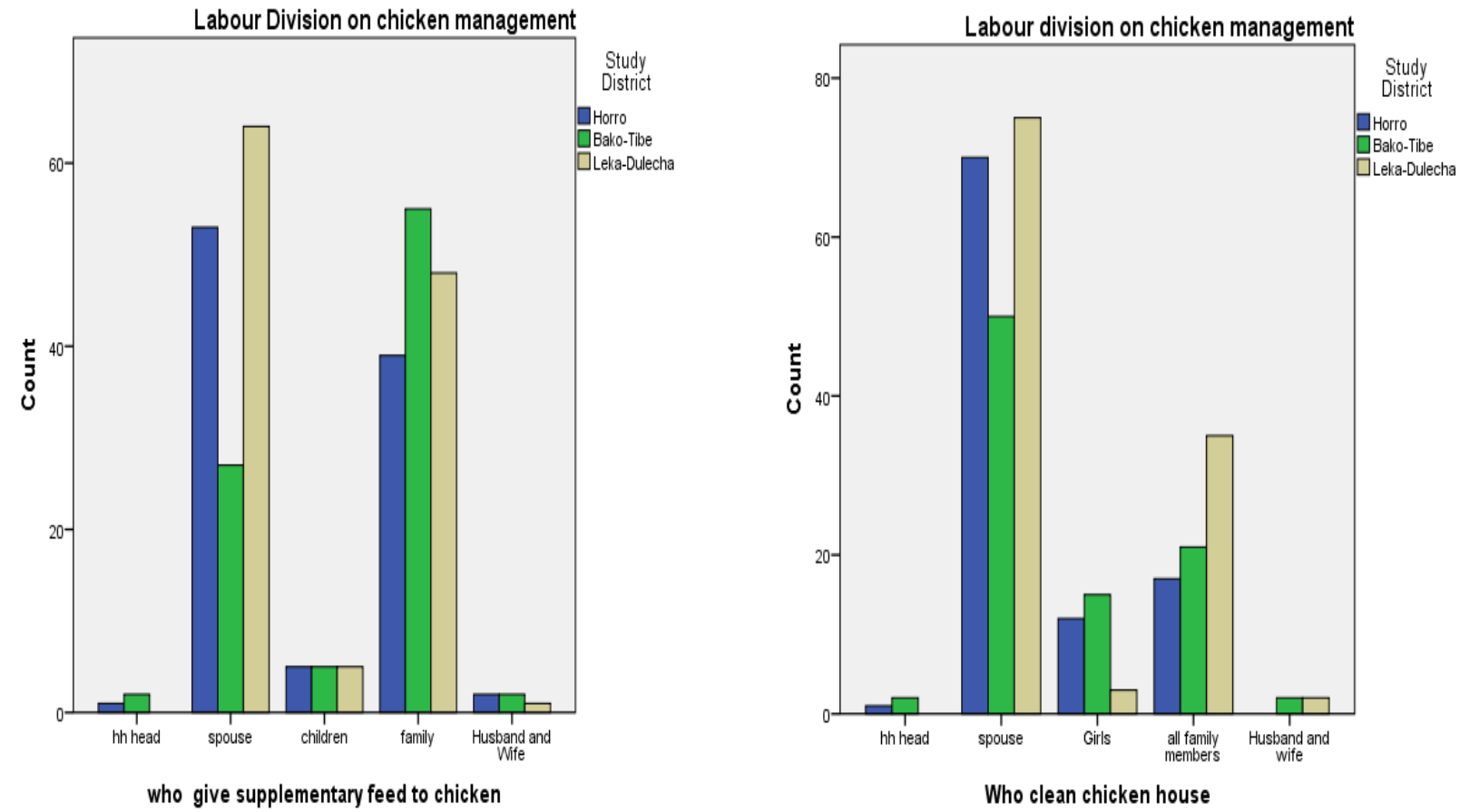


Figure 7. Labour division among household family members on chicken feeding and house cleaning

Chicken feeding, housing and hatchery management practices are presented in Table 10. Home made and grains bought from market, commercial concentrate and kitchen leftover were the major feed ingredients used in poultry production of the study areas (Table 10).

Table 10. Feeding, housing and hatchery management of chicken

Factors			
Feeding Management	Label of application	Frequency	Percent
▪ Offer feed supplement	Yes	292	94.19
	No	18	5.8
▪ Type and source of feed supplement	Grain from home	135	46.23
	Concentrate	12	4.11
	Kitchen leftover	5	1.71
	Grain from market	7	2.4
	Grain from home and Market	76	26.03
	Grain and kitchen leftover	57	19.52
Housing Management			
▪ Separate house for chicken	Yes	23	7.44
	No	286	92.56
▪ Alternative house for chicken	Kitchen	56	19.51
	In family house	211	73.52
	Under home ceiling	9	3.14
	In Basket or cartoon	11	3.83
Hatchery Management			
▪ Do you look for season of brooding	Yes	295	95.16
	No	15	4.84
▪ Storage of egg for incubation	one-week	3	0.97
	two-weeks	56	18.18
	10 days	25	8.12
	till hens sit to brood (not collected)	224	72.73

Chicken housing practices, chick management and common chicken houses used in the study areas are presented in Figure 8. The study revealed that majority (49.50%) of chickens perch for overnight housing at different sites in the living homes of family where as only 13.10%, 5%, 2.1% and 3.83% of chickens were kept in the kitchen, separate poultry houses, under the ceiling of living house and in baskets/cartons respectively, during the night. Chicks (mainly during their early age) were kept in pits (Fig. 8a) (under earth) covered with different materials, in woven baskets and under tree shades so that they are protected from preying birds. Rural houses mainly thatch covered houses had open walls (Fig. 8b) that could allow predators to enter and rob chickens. Accordingly, farmers do not use kitchens and other livestock's houses as poultry houses as these houses were riskful that these houses in all the study areas were open for preys may enter and rob chickens.

It was witnessed during group of researchers' and data collectors' observations that some of the producers in the study areas tie chickens (Fig. 8c) in house during the day time to protect the birds robbing cultivated crops, uprooting grain seedlings and destroying food and malt grains kept under sun's heat for flouring. All chickens, irrespective of their age and sex, move freely forming subgroups in and around the compound of households and neighbors' garden allowing hens to mate by chance with own flock and/or neighbor flock roosters where the breeding practices were uncontrolled (indiscriminate).



a b c

Fig 8. Some of the Chicks and Chickens Housing and management systems used in the area (*a= chick brooding in pits, b=bedding perchs in kitchen, c=chicken tied in homes during the day*)

Chicken breed composition, marketing system and stock replacement practices across the three studied agro-ecologic locations are presented in Table 11. Among chicken flocks in the current study; 82.94, 95.15 and 81.43% were indigenous chicken ecotypes at the Horro (highland), Bako-Tibe (lowland) and Leka-Dulecha (mid-altitude), respectively where as the remaining chicken breeds were either (commercial layers, broilers and exotic dual purpose chickens) or hybrid chickens. Commercial chickens in the current study areas were those types of birds of egg, meat and dual porpuse type in their character and bought from market or distributed for extension services and used for a commercial purpose. However, the hybride ones were those produced by crossing local chicken with exotic birds of any kind, or bought crossbred. Establishment of breeding chicken stock and/or replacement stock was obtained through hatching, purchasing pullets and cockerels, obtaining from relatives for share and sometimes gifts from family and friends (Table 11).

Table 11 Chicken breed composition, chicken marketing and flock replacement practices

Factors	Variables	Study agro-ecologies (districts)						Overall means and standard deviations	
		Horro (highland)		Bako-Tibe (Lowland)		Leka-Dulecha (mid-altitude)			
		N	Means± Std	N	Means± Std	N	Means± Std	N	Means± Std
Breed of Chicken	Local (Horro chicken)	100	9.31(4.97)	89	13.39(6.99)	117	9.34(6.11)	306	10.51(6.31)
	Commercial	99	1.915 (0.69)	87	0.47 (0.11)	117	1.43 (0.65)	303	1.45 (0.51)
	Crosses	97	0	87	0.21 (0.02)	115	0.78 (0.16)	299	0.50 (0.07)
Marketing and Utilization	Chicken sold in six months	100	3.65(1.82)	92	1.76(1.92)	118	2.43(2.42)	310	2.63(2.22)
	Chickens Consumed in 12 months	100	1.93(0.87)	92	1.62(1.21)	118	0.73(0.91)	310	1.38(1.13)
	Chickens bred for replacement	100	0.42(0.90)	92	0.55(1.07)	118	2.04(2.21)	310	1.08(1.74)
	Obtained by gift to produce	100	0	92	0.03(0.18)	118	0.05(0.26)	310	0.03(0.19)
	Obtained for share	100	0	92	0.17(0.88)	117	0.03(0.16)	309	0.06(0.5)
	Males bought for replacement	100	0.37(0.54)	92	0.29(0.58)	118	0.25(0.71)	310	0.03(0.62)
	Females bought for replacement	100	0.26(0.61)	92	0.62(0.61)	118	1.53(1.97)	310	0.85(1.84)

N = number of respondents interviewed, Std = standard deviations

Commercial = Exotic broilers, layers and/or egg and meat type birds, Hybrids are those crossbred chickens found in the flock.

4.1.3. Poultry health constraints

Some of prominent diseases observed among the major chicken disease symptoms in the study areas are presented in Figure 9. Most of chicken at rural back yards and sometimes the whole flock were reported to die because of Newcastle disease (fengil/most frequently used name). Newcastel disease, fowl pox, fowl typhoid, Marek's and other multi-symptomatic chicken diseases were the most predominant diseases affecting the productivity of chicken. The chicks on the pictures reveals pox lesion on the soft (featherless part of face), on the junction between cranium and beak (left) (Fig. 9a) and a sign with dropped feather, put head down, nasal discharge, coloured diarrhea, gasping for air and paralyzed with signs of Newcastle disease (right) (Fig. 9b).



a. b.

Figure 9. Common chicken diseases; Left chick affected by fowl pox and right Newcastle disease symptom: a photo taken during survey.

Poultry health and marketing constraints and veterinary service delivery practices of the study areas are presented in Table 12. Recurrent chicken disease outbreaks and lack of efficient veterinary services were among the major poultry health constraints in the study areas reported by about 88.6% producers interviewed that disease outbreaks had been happening in their flocks. Chicken vulnerability to different diseases (if it might existed) was studied by categorizing chickens into layers, adults, chicks and layers, and to a whole flock for the survey interview. Accordingly, the group catagorised under chicks and layers were found the most vulnerable ones

covering about (64.36%) of group of chickens affected followed by chicks alone which accounts for about 24.36%.

Production, marketing and poultry health constraints and veterinary services delivery practices are presented in Table 12. About 62.58% of chicken owners interviewed were getting veterinary services in the near distances and their surroundings. However, 83.82% of the respondents reported that they were not satisfied by the veterinary services efficiency because of lack of poultry drugs, high purchasing cost of poultry drugs, and lack of vaccination services in the area. Concerning animal groups affected out of chicken flocks, chicks and layers together were reported the most affected (64.36%) followed by death of only-chicks (24.36%), (Fig. 8 and Table 12) describe major chicken diseases and health constraints in the area.

Table 12. Production, marketing and poultry health constraints and veterinary services delivery

Attributes	Label	Agro-ecologies (Study Districts)							
		Highland(Horro)		Lowland(Bako)		Midland(Leka-Dulecha)		Overall	
		N	%	N	%	N	%	N	%
Was disease out-break occurred in your flock	Yes	97	97	88	96.7	87	74.34	272	88.6
	No	3	3	3	3.3	30	25.66	35	11.4
Chicken group affected more	Chicks	38	38.38	22	25.58	7	7.78	67	24.36
	Growers	0	0	4	4.56	1	1.11	5	1.82
	Layers	8	8.08	1	1.16	8	8.89	17	6.18
	Adults	2	2.02	0	0	3	3.33	5	1.82
	Chicks and layers	47	47.47	59	68.60	71	78.89	177	64.36
	Whole flock	4	4.04	0	0	0	0	4	1.45
Was vet service available in your area	Yes	58	58	52	56.52	84	71.19	194	62.58
	No	42	42	40	43.48	34	28.81	116	37.42
Was vet. service efficiency satisfied you	Yes	8	8	18	19.56	24	20.51	50	16.18
	No	92	92	74	80.43	93	79.49	259	83.82

Retail markets were the only marketing system employed in the current study areas mainly in bigger cities (mainly at Nekemte city and at Bako and Shambu towns) where chickens collected through a house to house marketing and those purchased from district markets were sold by retailers to individual consumers, hotels and breeders (producers). Marketing of live birds and eggs was conducted mainly at either village and/or nearby towns' (mainly district towns) market, which were the major practices in poultry marketing system of the study areas (Table 13).

Chicken and egg marketing practices and market types used in the current study areas is presented in Table 13. Chickens mainly about (54.89%) were sold at district (nearby) towns which was mainly because of a fair price and/or lack of chicken market at village/surroundings, however eggs were sold mainly (56.63%) at village markets.

Table 13. Chicken and egg marketing and market chain

Market opportunities used	Marketable products			
	Chicken sale/marketing		Egg sale/marketing	
	Frequency	%	Frequency	%
Sale at home	5	1.62	25	8.09
Village-market	110	35.60	175	56.63
Middle-men	25	8.09	12	3.88
Nearby-town	169	54.69	97	31.39

The mean production age of hens and frequency of major diseases' occurrence in the current study areas was presented in Table 14. The reports on occurrence of Newcastle disease, Fowl typhoid and Marek's diseases were 54.92%, 33.71% and 10.98% respectively, where about 0.38% disease occurrence was recorded for unknown and acutely killing poultry diseases in the areas. According to the questionnaire survey and retrospective data collected from three districts' veterinary clinics about 64.36% producers interviewed had responded that chicks and brooder hens were the most vulnerable classes of chickens. Class of chickens' vulnerability to disease and deaths encountered were 24.36% for chicks only, 6.18% for layer hens, 3.27% for whole flock and 1.82% for growers.

Table 14 The mean and SE production age of hens and frequency of major disease occurence.

Attributes	Horro area (Highland)		Bako area (Lowland)		Leka Dulecha area (Mid-altitude		Total	
	N	Means ± SE	N	Means ± SE	N	Means ± SE	N	Means ± SE
Old age at culling of hens	100	37.79(8.197)	89	38.92(6.274)	116	38.36(7.260)	305	38.34(7.309)
Common killer diseases of chickens	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Newcastle disease	99	100	27	30.68	19	24.67	145	54.92
Fowl typhoid	Na	0	38	43.18	51	66.23	89	33.71
Marek's Disease	Na	0	23	26.14	6	7.79	29	10.98
Unknown	Na	0	Na	0	1	1.3	1	0.38
Vulnerability of class of chicken								
Chicks	38	38.38	22	25.58	7	7.78	67	24.36
Growers	Na	0	4	4.65	1	1.11	5	1.82
Layers	8	8.08	1	1.16	8	8.89	17	6.18
Chicks and Brooders	47	47.47	59	68.6	71	78.89	177	64.36
Whole chicken	6	6.06	Na	0	3	3.33	9	3.27

* N= no of household, SE= standard error, Na= not availa

4.2. Reproductive and Productive Performances of Unipmroved Horro Chicken Ecotype under Traditional Backyard Production System

4.2.1. Breed of chicken and reproductive status of hens in flock

Sources of breeding chicken stock and egg selection practices, and materials used for eggs incubation with the use of broody hens is presented in Table 15. About 62% of producers interviewed had responded that they posses their own breeding cocks while the remaining 38% households had not. About 41% of households responded on the sources of breeding cocks they were using for breeding were obtained through hatch only, where as 24.56%, 20.35% and 0.70% households obtained breeding cocks through purchase, from neighboring flock and from unknown sources, respectively. It was evident from interview that about 95% producers got breeding hens through purchase and hatching where others had obtained through gift and through hens obtained from offers for share. It was a common practice that chickens, mainly reproducing hens could be provided to relatives, children and trusted poor people for share. In this system of chicken production, the egg and next produce would be shared where the hens provided for share remained the property of the share provider.

Source of breeding stock, chicken breeding practices and incubation materials used are presented in Table 15. According to the result on survey, low proportion (36.13%) of producers practiced selecting eggs for hatching, where majority (63.87%) of them uses hatching eggs for incubation untouched before broody hen sit on.

Table 15. Source of breeding stock, breeding practices and incubation materials used

Attributes	Labels	Frequency	%
Do producers posses breeding	Yes	192	61.94
cock/s	No	118	38.06
	Hatch only	117	41.05
Source of breeding cock/s	Purchase only	70	24.56
	Neighbor	58	20.35
	Unknown	2	0.70
	Hatch & purchase	38	13.33
	Obtained by gift	6	3.23
Source of Existing hens	Hatch and purchase	177	95.16
	Taken for Share	2	1.07
	Hatch and obtained by gift	1	0.54
Do producers select eggs for	Yes	112	36.13
incubation	No	198	63.87
	Carton-box	156	50.65
	Wooden-box	27	8.77
Materials used for incubation	Woven-cage	82	26.62
	Any-corner of home	32	10.39
	Worn- tires	6	1.95
	Clay-pots	4	1.30
	Jerry-cans	1	0.33

The mean chicken breeds and per household hen production status, and age at chicks' weaning are presented in Table 16. In Horro (the highland district), the overall mean per flock chicken breed composition was 9.31±4.97, 1.92±0.69 and 0, for local breed, commercial layers and broilers, respectively. At mid-altitude (Leka Dulecha district) of East Wollega zone, the mean local, exotic layers and broiler chicken breeds were; 9.34±6.11, 1.43±0.65 and 0.78±0.16, respectively. The mean breed composition in chicken flock in the Bako-district (lowland) was 13.39±6.99), 0.47±0.110 and 0.214 ±0.02 local chicken, exotic layers and broilers, respectively.

In general, the overall per household flock size and chicken breed composition had significant (P<0.05) variation among the three agro-ecologies. The flock proportion of local chicken, exotic layers and broilers was 87.37%, 12.045% and 0.58%, respectively. The proportion of laying hens in flock was higher than the mean hens on incubation, brooding and idle (not laying or brooding) hens. The mean of laying hens, hens on incubation, brooding hens and idle hens had non-significant (P>0.05) variation among the three agro-ecologies.

Table 16. The mean and standard error per flock chicken breeds and per household hen production status

Study Districts /agro-ecologies	Number of Hhs	Mean Breeds of chicken in flock			Production status of Local hens in flock			
		Local	Exotic layers	Broilers	Laying hens	Hens on incubation	Brooding hens	Idle hens
		Mean±SE	Mean±SE	Mean±SE	Mean±SE	Mean±SE	Mean±SE	Mean±SE
Horro(highland)	100	9.31(4.972)	1.92 (0.69)	0	1.59(1.40)	0.66(0.54)	0.69(0.6)	0.66(0.82)
Bako(lowland)	89	13.39(6.99)	0.47(.11)	0. 21(0.02)	2.01(1.24)	0.69(0.84)	0.70(0.69)	0.71(0.75)
Leka-Dulecha (mid-altitude)	117	9.34(6.11)	1.43 (0.65)	0. 78 (0.16)	1.84(1.19)	0.66(0.80)	0.69(0.76)	1.04(0.93)
Total	306	10.51(6.31)** *	1.45(0.51) *	0.07(0.05) *	1.81(1.28) ns	0.67(0.74) ns	0.69(0.68)n s	0.82(0.86)* *

Note: ***= highly significant difference, *=significant difference, SE= standard error, ns= non-significant difference

4.2.2. Reproductive and productive performances of chicken

The mean reproductive performances and egg production of Horro hens are presented in Table 17. The overall mean indigenous Horro hens' age at first egg in weeks, the number of eggs per clutch and number of clutches per year were 25.33, 12.46 and 3.93, respectively. Average length of days for a single lay was 21.33. The differences in age at first egg, mean number of eggs per clutch, mean number of clutch per year and mean length of days for single lay had significant (P<0.05) variation across the three agro-ecologies. However, the variation in mean number of hatch per year (2.43) and inter-clutch length in days (17.99) among the agro-ecologies were non-significant (P>0.05).

The present study revealed that, indigenous (local) Horro chicken productivity traits such as; number of chick per hatch (10.39), weaned chick per hatch (6.69), age at weaning in weeks (8.84) and age at marketing in months (7.52) had significant (P<0.05) differences among the agro-ecologies. Weaning in the present study was used to express the age of chicks when brooding Horro hens are rejecting their chicks. Nevertheless, the variation in the mean age at slaughtering (in months) of male Horro chickens was 7.93±0.50, 7.67±0.45 and 8.61±0.43 for highland, lowland and mid-altitudes, respectively and non-significant (P>0.05) difference was observed among the agro-ecologies.

The mean age at first egg for the Horro chickens was longer in the highland (cooler sub-humid area) and was significantly (P<0.01) shorter for pullet-hens at Bako-Tibe (hot sub-humid lowland) where it was in between the two agro-eclogies at the mid-altitude. The mean age at first egg of hens at highland, lowland and mid-altitude was 28.44±0.43, 23.63±0.46 and 25.49±0.52, respectively where the variation was significant (P<0.05) among the agro-ecologies. Same to age at first egg of hens, egg per clutch and length of days per clutch were significantly (P<0.05) affected by agro-climate while the variation in clutch per year was highly significant (P<0.001) among the three agro-ecologies. However, the variation in number of hatch per year and inter clutch length in days was statistically non-significant (P>0.05) (Table 17).

Table 17. Mean reproductive performance and egg production potential of chicken

Attributes	Highland		Lowland		Mid-altitude		Overall mean & level of significance	
	N	mean±SE	N	mean±SE	N	mean±SE	N	Mean
Age at first egg (weeks)	52	28.44(0.43)	69	23.63(0.46)	70	25.49(0.52)	191	25.33*
Egg per clutch (number)	52	13.22(0.34)	69	12.39(0.35)	70	11.99(0.39)	191	12.46*
Clutch per year (number)	52	3.99(0.11)	69	3.39(0.12)	70	3.78(0.14)	191	3.93***
Length of single lay in days	52	20.63(0.67)	69	22.39(0.716)	70	20.79(0.81)	191	21.33*
No of hatch per year per hen	52	2.36(0.08)	69	2.34(0.09)	70	2.32(0.10)	191	2.43^{NS}
Inter clutch length in days	52	18.09(0.54)	69	18.27(0.58)	70	19.08(0.65)	191	17.99^{NS}

N= number of brooding hens monitored during the study, ** = stands for highly significant variation, NS= non significant

The mean hatchability, survival rate of chicks to weaning and age at marketing of chicken in the study area is presented in Table 18. Significant variation was obseved ($P< 0.001$) among the locations for the three attributes indicated. The mean number of weaned chick per hatch for the highland (Horro area), lowland (Bako area) and mid-altitude (Leka-Dulecha area) were 7.62 ± 0.24, 6.47 ± 0.25 and 6.78 ± 0.29, respectively. As indicated on Table 18 below, the mean chicks' age at weaning and male chicken age at marketing was also longer for the high land where it was lower for mid-altitude and it was the lowest for the lowland chickens.

The difference in mean age at slaughtering was longer for the mid-altitude (8.61 ± 0.43), and shorter for lowland (7.67±0.45). Average age of slauthering was moderate (i.e. in between the

lowland and mid-altitudes) at the highland (7.93 ± 0.50), even though the difference was statistically non-significant. Hatchability rate was also calculated and it was 83.36% for local chickens (which mainly were Horro chicken ecotypes), produced under traditional management while the chicks' survival rate computed to the age of weaning was about 64.34%.

Table 18. The mean hatchability, survival rate to weaning and age at marketing of chicken

Attributes	Highland		Lowland		Midland		Overall mean and level of significance	
	N	mean±SE	N	mean±SE	N	mean±SE	N	Mean
No of chick per hatch	52	11.32±0.27	69	10.37±0.29	70	9.94±0.32	191	10.39**
Age at weaning in weeks	52	9.72±0.21	69	7.28±0.22	70	8.49±0.25	191	8.84**
No of weaned chick per hatch	52	7.62±0.24	69	6.47±0.25	70	6.78±0.29	191	6.69**
Age at marketing (months)	80	7.72±0.23	100	6.76±0.21	120	8.06±0.20	300	7.52**
Age at slaughtering (months)	80	7.93±0.50	100	7.67±0.45	120	8.61±0.43	300	8.09^{NS}

N= number of brooding hens monitored during the study, ** = stands for highly significant variation, NS= non significant variation

4.3. On-station and On-farm Chicken Breeds' Growth, Reproductive and Productive Performances

4.3.1. Growth performance and survival rate of Improved Horro chicken in comparison with a synthetic and exotic chickens

4.3.1.1. On-station performances

Early growth performance till their eight weeks age of chicks is presented in Table 19. Three breeds namely Potchefstroom Koekoek (PK), DZ White-feathered (DZ1) and Improved Horro chicken were used for the current experimental study. There was no significant statistical difference in their mean weight in gram for the PK, DZ1 and Improved Horro chicken breeds at their day old age. Accordingly, the survival rate of DZ1 chicken until their eight weeks age was the highest (97.63%) followed by Improved Horro chicks (91.03%) where as the survival rate for the Koekoek was the lowest (88.26%).

There was significantly higher weight gain ($P < 0.05$) for DZ White-feathered chicken in comparison to Improved Horro at the end of their eight weeks age. However, the difference in their mean weight among DZ White-feathered chicks and the Koekoek, and among the Koekok and Improved Horro chicks was not significant during their starter age (Table 19). Accordingly, the DZ White-feathered chicks had the highest body weight (320.85g) followed by the Koekoek (309.59g) and the lowest mean body weight (281.87g) was recorded for Improved Horro chickens. During brooding period, therefore, genotype had a significant ($P< 0.05$) effect on the overall mean body weight and growth performance of chicken breeds. The study revealed that breed of chicken, age in weeks and interaction of chicken breed with age in weeks had showed significant effect ($P <0.001$) on growth performance of chicks before their eight weeks age.

The least square mean weight in gram, effect of breed, age in weeks, and interaction of breed with age in weeks is presented in Table 19. There were significant effects ($P<0.001$) of breed, age in week and interactions of breed × age in week for mean body weight gain of the chicks studied and repeated measurements taken during (1-8 weeks) age in weeks of chicks. The

difference in mean daily weight gain (1.12 ± 4.68) among Potchefstroom Koekoek and DZ White-feathered chicken had no statistical difference ($P > 0.05$) where a large gap was observed on the mean difference among Koekoek and Improved Horro (15.71± 4.68) and between DZ White-feathered and Improved Horro (16.83± 4.68) at ($P<0.01$) chicken breeds (Table 19).

Table 19. Least square means for early growth performance and survival rate of Improved Horro, Koekoek and DZ White-feathered chicks

Chicken Breed and sources of variation	Mean body wt at hatch (in gm)	Survival rate in (%) day old to eight weeks	Mean body wt (in gm) week eight	Least sq mean(SE) of weight gain for chicks from weeks (1-8)	On-farm survival rate (%) (week 10-20)	On-station survival rate (%) (week 10-20)
DZ White-feathered	28.74	97.63	320.85[a]	173.70±3.31	83.33	88.64
Koekoek	30.43	88.26	309.59[ab]	172.57±3.31	88.67	88.98
Improved Horro	28.83	91.03	281.87[b]	156.87 ±3.31	76.83	73.33
Source of variation						
Breed	-	-	-	***	-	-
Age in weeks	-	-	-	***	-	-
Breed× age in weeks	-	-	-	***	-	-

- Wt = weight, gm= gram and *** = highly significant difference at (P <0.01).

The difference in the rate and growth pattern among the three chicken breeds is presented on Figure 11 below. All the three chicken breeds had non significant statistical difference at their day old weight though the mean initial weight was slightly different. As indicated on the same figure, while the DZ White-feathered and Koekoek chicken breeds had side by side growth pattern, Improved Horro chicks showed a lagging growth pattern as the chicks' age was getting advanced.

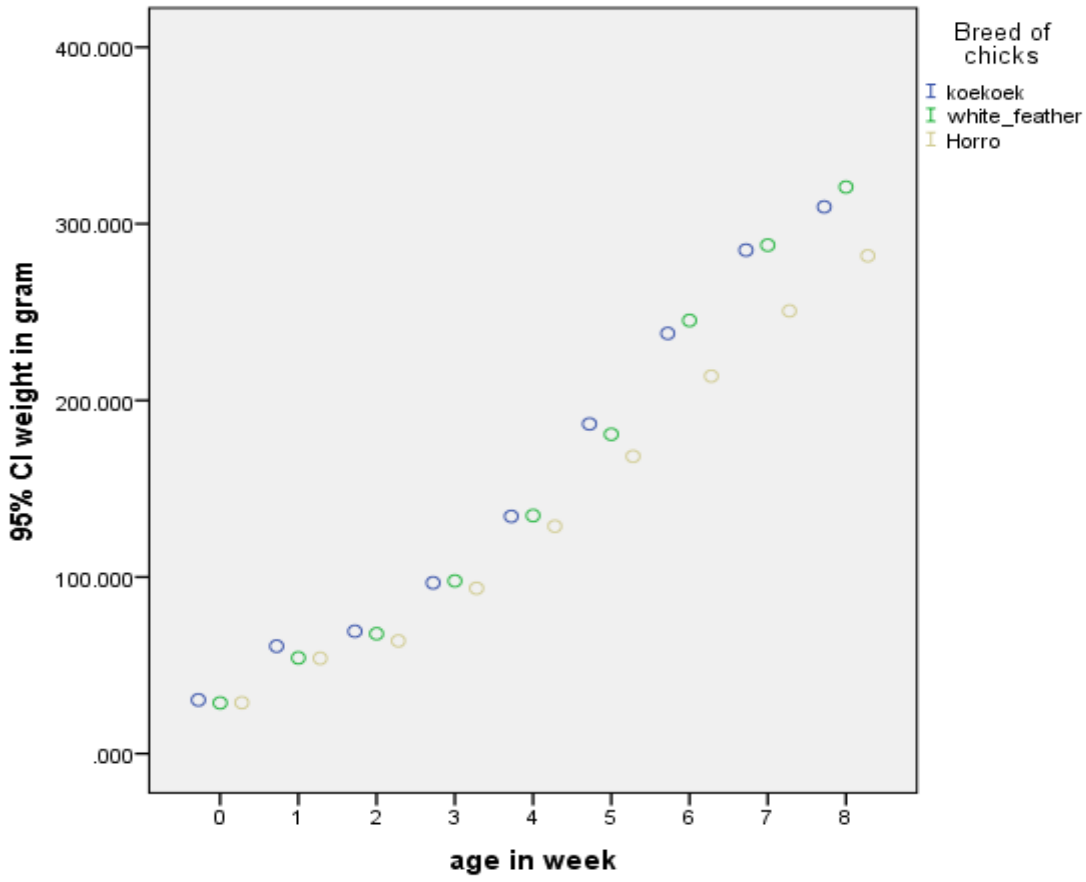


Figure 10. Growth performances of the three breeds of chicks until their eight weeks of age

The on-station growth performance of the three breeds of chickens during their early growing period during 10-18 weeks of chicks' age is presented in Table 20. In all the three breeds (koekoek, DZ White-feathered and Improved Horro) of chickens, sex of chicken significantly affected growth performance ($P< 0.001$). Males grew faster than females. The mean change in

weight of Koekok chicken breed was the highest followed by the mean DZ White-feathered chicken breeds where the change in weight for Improved Horro chicken breed was the lowest. Breed and age in weeks of chicken at all and every two weeks of their age had significant effects ($P < 0.0001$) on growth performance of chickens, however; the interactions of breed of chicken x age in week for growth performance had non significant difference($P > 0.05$). The maximum weight (1735gm) at the end of week 18 was recorded for male Potchefstroom Koekoek chicken where the least weight (383gm) was recorded for female Improved Horro chicken.

The mean chickens' daily feed consumption, and the per day feed conversion efficiency and weight gain till their 18 weeks age is presented in Table 21 and Figure 11. The highest overall mean daily feed consumption value of 53.89±14.37 was recorded for the Potchefstroom Koekoek chicken breed and the lowest value of 50.28±10.50 for DZ White-feathered chicken indicating that the variation among chicken breeds was highly significant ($P < 0.001$). The mean feed conversion efficiency (17.47±2.79) of DZ White-feathered chicken was numerically higher than the feed conversion efficiency (13.56±2.74) of Improved Horro chicken breed, though the difference was statistically non significant.

Overall mean daily feed intake, feed conversion efficieny and daily weight gain curve during the chicks' 10-18 week of age is indicated in Figure 11a, 11b and 11c respectively. The result revealed that, highly growing daily feed consumption and feed conversion efficiency was recorded while the daily weight gain was evenly distributed around the estimated growth curve.

Table 20. Mean and standard deviation weight of chicken until their 18 weeks age

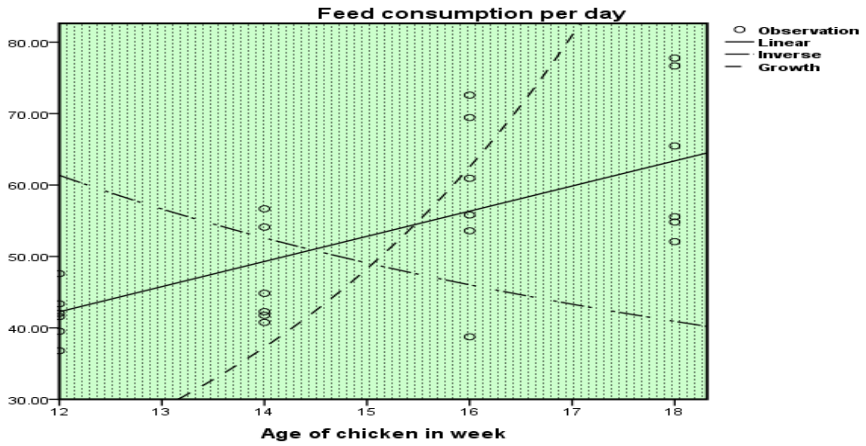
Breed of chicken	Sex of chicken	Mean weight in gram					Range at week 18	
		Week 10	Week 12	Week 14	Week 16	Week 18	Min	Max
Koekoek	Male	492.40±38.68	555.50±54.40	717.55±52.98	837.95±73.20	1079.30±80.73	453	1735
	Female	403.75±36.28	488.40±45.25	644.50±54.21	804.50±67.75	962.40±66.11	498	1554
DZ WF	Male	459.70±23.59	548.50±33.68	665.10±28.56	847.35±36.49	966.95±45.93	609	1248
	Female	423.35±24.74	520.75±32.81	629.55±38.77	816.85±39.56	901.80±48.10	442	1177
IH	Male	392.70±18.9	452.65±24.48	558.15±37.3	714.35±43.31	865.50±44.92	600	1405
	Female	306.50±22.87	370.60±27.56	449.15±26.39	540.05±27.14	659.75±28.60	383	819
Tests of B/n-Subjects Effects		***	***	***	***	***		
Breed								
Age in weeks		***	***	***	***	***		
Sex of chickens		***	***	***	***	***		
Breed×Weeks		NS	NS	NS	NS	NS		

- DZWF = Debrezeyite White-feathered, IH = Improved Horro chicken
- B/n= Test of between subjects effects

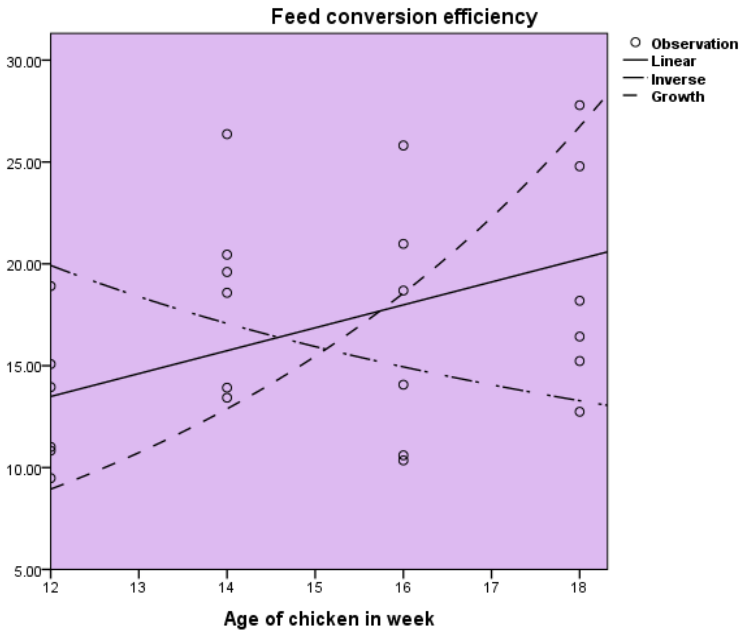
Table 21. On-station, Daily feed intake, weight gain and feed conversion efficiency

Variables	Breed of chicken	Chick age in weeks, daily feed intake, Daily weight gain and feed conversion efficiency					P value
		Week 12	Week 14	Week 16	Week 18	Overall mean ± sd	
Feed per day in gm	Koekoek	45.48 ± 2.98	49.47 ±10.18	55.67 ± 23.93	64.93 ±18.17	53.89±14.37	0.810
	DZ WF	39.41 ± 3.69	42.81 ± 2.88	58.37 ± 3.63	60.52 ± 7.01	50.28±10.50	
	IH	40.55 ± 1.46	47.93 ± 8.73	61.52 ± 11.21	65.74 ± 15.45	52.70±12.43	
Daily weight gain in gm	Koekoek	5.28 ±1.09	11.37 ± 0.31	8.75 ± 1.76	17.27 ± 6.16	10.67±5.29	0.292
	DZWF	6.65 ± 0.44	8.05 ± 0.39	11.55 ± 0.23	11.28 ± 1.86	8.69±2.07	
	IH	4.43 ± 0.21	7.57 ± 0.06	7.73 ± 2.89	8.52 ± 2.04	7.75±2.90	
Feed conversion Efficiency	Koekoek	11.72 ± 3.16	23.41 ± 4.18	18.08 ± 10.93	26.29 ± 2.12	19.87±7.54	0.054
	DZ WF	16.99 ± 2.71	19.09 ± 0.72	19.83 ± 1.62	17.31 ± 1.24	17.47±2.79	
	IH	10.92 ± 0.13	13.67 ± 0.35	12.33 ± 2.45	13.98 ± 1.76	13.56±2.74	

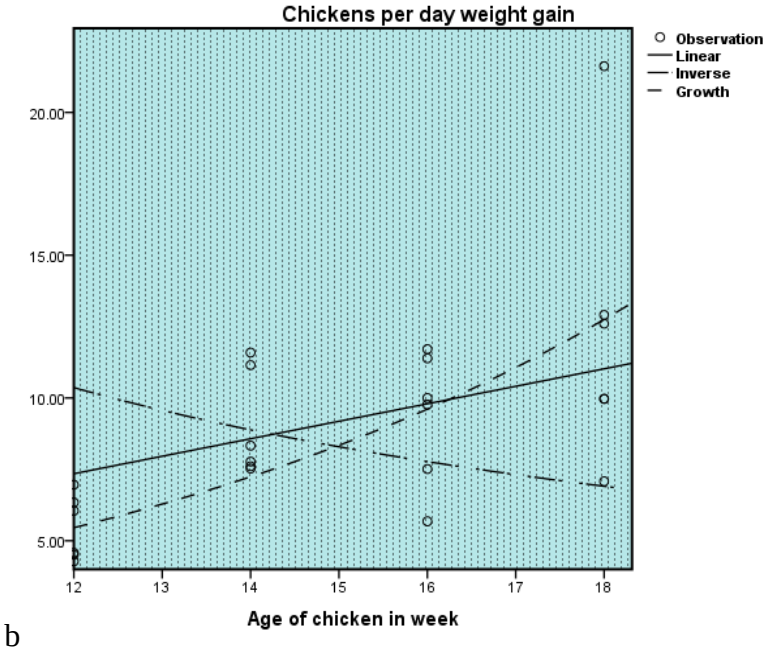
- DZWF= Debre zeit White-feathered, IH= Improved Horro,



a.



b



c

Figure 11 Groweres' daily feed intake, feed conversion efficiency and daily weight gain curve

4.3.1.2. On-Farm performances

On-farm survival rate of chicken breeds across the three agro-ecologies is presented in Table-22. The highest overall survival rate was recorded at the mid-altitude where the climatic condition is relatively moderate compared with the highland cool and lowland hot temperature. Specific to the breeds of chickens; the Koekoek and Improved Horro survived more at the mid-altitude while 100% of the DZ White-feathered chickens had survived at the lowland agro-ecology. Though Horro chickens were originated in the Horro area, (the area known by its high altitude and cool environment), the Improved Horro chickens in the current study survived best (90%) at the mid-altitude where in the contrary, the lowest (58%) survival rate was recorded for the Improved Horro chicken at the highland agro-ecology. The overall mean best survival rate (87.33%) of the three breeds of chickens was recoreded at the mid altitude compred to the 85% and 76% survival rates recorded at lowland and highland agro-ecologies respectively, even if there was variation in survival rate among breeds of chickens at different agro-ecologic locations.

Table 22 Survival rate of chicken breeds from week 10-20 across the three agro-ecologies

Breeds of chicken	Agro-ecologic Locations			Per Breed survival rate
	Highland	Mid-altitude	Lowland	
Potchefstroom Koekoek	82%	94%	74%	83.33%
DZ White-feathered	88%	78%	100%	88.67%
Improved Horro	58%	90%	82.5%	76.83%
Total Across agro-ecology	76%	87.33%	85%	

On-farm and on-station growth performances, and mean body weight at the age of maturity of chickens in different agro-ecologies are presented in Table 23. The highest mean weight (1512.83±72.16) recorded for male Koekoek chicken was the highest mean weight at mid-altitude where the variation in mean weight of chicken breeds among the three agro-ecologies

was highly significant ($P<0.001$). Among the three breeds of chickens under the study, it was the DZ White-feathered chicken breed that performs best at the lowland agro-ecology, where the mean male and female chickens' body weight was (1532.93±64.54) and (1265.61±69.33), respectively. However, the lowest mean body weight (1323.80±79.05) and (992.40±79.05) were recorded for male and female Improved Horro chickens, respectively at the mid-altitude agro-ecology.

The mean weight of chicken both under the three agro-ecologies and the two management systems was significantly ($P<0.001$) higher for male than their female contemporaries. Under on-station management, chickens were kept under intensive management where as on-farm the management system employed was semi-scavenging. Therefore, a higher mean body weight recorded by the three strains of chickens (PK, DZ1 and IH) on-station in comparison to the same strains of chickens on-farm was unquestionable. However, in contrast to other groups in the current study, the mean weight (974.33±42.84) of female Improved Horro chickens under on-farm condition was slightly higher than the mean weight (952.21±58.66) recorded for female Improved Horro chickens kept under on-station condition (Table 23).

Table 23. Mean and standard error mature age (six month) body weight of chicken breeds under different agro-ecologies and management systems

Breed	Sex of Chicken	Agro-ecology of study area			Management system	
		Highland	Mid-altitude	Lowland	On station	On farm
KK	Male	1206.33(64.54)	1555(55.89)	1512.83(72.16)	1592.48(59.93)	1432.96(41.92)
	Female	1051.21(66.81)	1213.71(51.02)	1256.33(83.32)	1368.35(56.36)	1173.47(41.92)
DZ1	Male	1159.08(69.33)	1152.05(55.89)	1532.93(64.54)	1522.83(58.66)	1272.98(41.48)
	Female	1113.67(72.16)	1174.83(58.92)	1265.61(69.33)	1398.83(53.37)	1185.21(43.83)
IH	Male	1113 (79.05)	1141.37(62.49)	1323.80(79.05)	1362.69(59.93)	1211.22(42.84)
	Female	995.08(72.16)	947.95(53.29)	992.40(79.05)	952.21(58.66)	974.33(42.84)
Sources of variation						
Breed			***			
Sex of chicken			***			
Agro-ecology			***			
Management system						***

- KK= Potchefstroom Koekoek IH= Improved Horro chicken
- DZ1 = DZ White-feathered

4.3.2. Reproductive age and production potential of Improved Horro, DZ White- feathered and the Koekoek chickens

Reproductive and productive traits such as; mean age at mating and age at first egg of three breeds of chickens under different management system and agro-ecologies are presented in Table 24. The result revealed that the DZ White-feathered chicken had the shortest age at first egg among the three chicken breeds under on-station experimental study where the Potchefstroom Koekoek breed followed in about fourteen days period later. However, the Improved Horro chicken's age at first egg was more extended (195 days). The relative shortest day at first egg (188 days) was recorded at the mid-altitude agro-ecology for the Potchefstroom Koekoek breed of chicken among the three agro-climates. The overall mean on-farm age at first egg among the three agro-ecologies was shorter at the lowland where among the three chicken breeds the Potchefstroom Koekoek breed's age at first egg was shorter, and the DZ White-feathered and Improved Horro chicken breeds followed in few days' difference by order (Table 24).

Table 24. On station and on farm mean age at mating and age at first egg of the three chicken breeds

Attributes			Breed of Chickens		
			KK	DZ1	IH
On station					
	Age at mating (days)	Male	110	117	105
		Female	125	125	147
	Age at first egg (days)		168	154	195
On Farm		**Agro-ecology**			
	Age at first egg (days)	Highland	210	198	230
		Mid-altitude	188	221	210
		Lowland	195	201	209

*KK: Potchefstroom Koekoek, DZ1: DZ White-feathered, IH: Improved Horro

The mean egg yield, external egg quality characteristics of the Koekoek, DZ White-feathered and Improved Horro chickens on-station and Local Horro chickens egg produced under village management is presented in Table 25. During the first three months of egg laying period of chickens, the DZ White-feathered and Potchefstroom Koekoek chickens respectively, produced (66.5) and (67.68) mean egg yield with a slight mathematical differences where the Improved Horro layed fewer (56.25) mean egg.

The mean egg weight, egg length and egg breadth of the three chicken breeds were significantly (P<0.001) affected by breed of chicken. In general, the highest mean egg weight, egg length, egg width and egg surface area 49.67±0.47, 54.32±0.27, 39.93±0.14 and 555.07mm^2, respectively were recorded for the DZ White-feathered chicken breeds while the lowest values of 40.66±0.47, 51.58±0.27, 36.51±0.14 and 484.88mm^2 were recorded for egg weight, egg length, egg width and egg surface area for local Horro chicken. With regard to rate of egg shape index the highest rate was recorded for Improved Horro and lowest for the local Horro chicken.

Table 25 Egg Productive performances and external egg quality characteristics of three improved and one unimproved chicken breeds

	90 days' per hen egg yield	Mean and standard error External egg quality charecteristics				
Breed of chicken		Egg wt	Length	Breadth	Egg shape Index	Egg surface area
Koekoek	66.5	48.67±0.52	53.87±0.29	39.17±0.16	72.7%	541.03
DZ White-feathered	67.68	49.67±0.47	54.32±0.27	39.93±0.14	73.5%	555.07
Improved Horro	56.25	44.45±0.52	52.29±0.29	38.56±0.16	73.9%	515.74
Local Horro	NA	41.18±0.41	51.58±0.27	36.51±0.14	70.9%	484.88
Source Variation						
Breed		***	***	***		

*NA= not available, wt= weight

The association among external egg quality characteristics such as egg weight, egg length, egg width and egg shape indices are presented in Table 26. The study revealed that, the egg weight

had highly significant correlation with the egg length and egg width where very minimal correlation was recorded among the egg weight and egg shape index. The egg shape index had negatively correlated with the egg length and positively correlated with the egg width. Generally the association among egg weight, egg length and egg width was significantly high ($P<0.001$) where egg shape index had lower and non significant ($P>0.05$) association with egg weight (Table 26).

Table 26 Pearson Correlation test among external egg quality characteristics

	EWt	EL	EW	SI
Egg weight in gm	1			
Egg length	0.676**	1		
Egg Width	0.747**	0.463**	1	
Egg shape index	0.027	-0.512**	0.495**	1

*EWt= egg weight; EL= Egg length; EW= Egg width; SI= Egg Shape Index

4.4. Egg Quality and Carcass Characteristics

4.4.1. Egg quality characteristics of unimproved Horro chicken Produced under traditional management in three agro-climates

Table 27, below presents the result of the external egg quality traits. The study revealed that there were highly significant ($P<0.001$) variation among the external egg quality traits studied across the three agro-ecologies. The egg weight, egg length, egg width, shell weight and shell thicknesses had significant differences except the shape index, which showed non significant ($P>0.05$) variation. Agro-ecology significantly ($P<0.01$) affected all external egg quality traits studied except egg shape index. Shape index which is the ratio of width to length of egg ranged from 70.37% at the mid-altitude to 71.61% at the highland agro-ecology.

The mean egg weight, egg length, egg width and egg surface area (504mm^2) of the mid-altitude Horro chickens' eggs produced under traditional management was the highest followed by the

lowland Horro chickens' surface area (487.08mm^2) where a relatively lowest surface area (473.93mm^2) was recorded for highland chickens' eggs. The highest mean shell weight, shell thickness and shell ratio 4.91±0.16g, 0.37±0.07mm and 11.73 respectively, were recorded for the lowland Horro chickens' egg compared to the chickens' egg shell weight, thickness and a shell to egg ratio of the highland and those of the mid-altitude. The egg of the lowland Horro chicken had much thicker shell than the egg shell of the egg at the other two agro-ecologies.

Table 27. Mean and standard error external egg quality traits of unimproved Horro chicken ecotypes under different agro-ecologies

Variables studied	Agro-Ecology				F Value	P Value
	Highland	Mid Altitude	Lowland	Grand mean		
Egg weight(gm)	37.38±0.64	43.55±0.66	42.60±0.79	41.18±0.41	25.347	0.000
Shell weight (gm)	3.61±0.13	4.49±0.14	4.91±0.16	4.34±0.08	21.810	0.000
Egg length (mm)	50.76±0.34	52.73±0.34	51.8±0.38	51.76±0.21	2.811	0.000
Egg width(mm)	36.31±0.23	37.06±0.23	36.84±0.25	36.74±0.14	8.123	0.000
Shape Index (%)	71.61	70.37	71.20	71.06	1.773	0.174
Shell thickness (mm)	0.35±0.06	0.36±0.06	0.37±0.07	0.36±0.04	13.911	0.000
Surface area(mm^2)	473.93	504.00	487.08	488.34		
Shell ratio (%)	9.63	10.3	11.73	10.55		

Internal egg quality characteristics of unimproved Horro chicken ecotypes produced under traditional managements are presented in Table 28. The mean internal egg quality traits (albumen weight, yolk weight, yolk-albumen ratio and yolk diameter) were significantly (P<0.001) affected by agro-ecology. However, albumen height did not show significant difference among the three agro-ecologies.

Higher yolk weight, a yolk to albumen ratio and yolk diameters were recorded at the mid-altitude among the eggs of the three agro-ecologies and the lowest measures were reported at the

highland. As opposed to other parameters studied, the Hough Unit (HU) and mean albumen height was the highest at the highland where the mid-altitude and lowland chickens' egg HU follows in that order; however, the numerical variation among the records for mid-altitude and lowland eggs' HU was small.

Table 28. Mean and standard error internal egg quality traits of unimproved Horro chicken ecotypes under different agro-ecologies

Variables studied	Agro-Ecology				F Value	P Value
	Highland	Mid Altitude	Lowland	Grand mean		
Albumen weight(gm)	20.99±0.40	22.62±0.41	23.30±0.49	22.30±0.25	7.536	0.001
Yolk weight(gm)	12.56±0.34	16.02±0.35	14.36±0.41	14.32±0.21	25.750	0.000
Yolk-Albumen ratio (%)	61.15±1.83	71.14±1.89	61.96±2.25	64.75±1.15	8.439	0.000
Albumen height(mm)	4.65±0.11	4.43±0.11	4.35±0.12	4.48±0.07	1.830	0.164
Yolk diameter(mm)	36.6±0.5	41.1±0.5	39.7±0.5	39.1±0.28	23.536	0.000
Albumen ratio (%)	56.15	51.9	56.08	54.71		
Yolk ratio (%)	33.6	36.76	36.66	34.99		
Hough Unit (HU)	0.76	0.71	0.71	0.73		

4.4.2. Carcass charecteristics of Improved Horro chicken in comparison to the Koekoek and DZ White-feathered chickens

Carcass characteristics of the Potchefstroom Koekoek, DZ White-feathered and Improved Horro chicken breeds are presented in Table 29. The live weight of chicken breeds had significant (P<0.01) differences where carcass weight and the cuts such as; HCW, CCW, breast yield, and

drumstick weight had no significant difference. However, the thigh weight among the cuts evaluated had a slight significant ($P<0.05$) difference. Higher dressing percentage and breast meat (*Pectoralis major plus minor*) were recorded for Improved Horro when compared with the Potchefstroom Koekoek and DZ White-feathered chickens as opposed to the lower thigh and drumstick weight though the difference was non significant.

Among the edible offals; the gizzard, liver and heart of chickens were evaluated and the gizzard weight was significantly ($P<0.01$) higher for the Koekoek and DZ White-feathered chicken breeds than gizzard of Improved Horro where the heart and liver had non significant differences in mean weight. Higher dressing percentage (62.63) was recorded for Improved Horro chicken which was higher than the dressing percentage 57.38 and 56.47 identified for the Potchefstroom Koekoek and DZ White-feathered chicken breeds, respectively.

Table 29. Genotype related differences on carcass characteristics of three chicken breeds of same age and management system

	Breed of chicken				
Carcass traits	PK	DZ1	IH	SE	P value
Live weight	1867.80	1922.80	1514.80	69.74	0.003
Hot carcass weight	1076.20	1085.40	951.20	58.63	0.236
Dressing %	57.38	56.47	62.63		
Chilled carcass weight	1072.98	1065.09	940.66	61.48	0.271
Breast yield	192.40	194.0	206.0	12.35	0.704
Thigh weight	236.00	231.20	200.0	13.15	0.044
Drumstic weight	201.60	189.60	159.60	10.71	0.152
Gizzard weight	52.20	58.80	29.40	5.16	0.004
Heart weight	8.60	8.40	6.80	0.92	0.237
Liver weight	34.60	34.00	28.20	2.77	0.352

SE: Standard error; PK: Potchefstroom koekoek, DZ1: DZ White-feathered and IH: Improved Horro chicken breeds

Table 30, presented the correlation among the liveweight, carcass yield, major chicken cuts and the edible offals of the Potchefstroom Koekoek, DZ White-feathered and Improved Horro chickens. The live weight of chickens had a highly significant (P<0.01) association with the HCW, CCW, Thigh muscle, Drumstick and Gizzard of chicken where Gizzard had negative association with the Breast yield, heart and liver weight of chicken. The highest association observed in the present study was recordeded among the hot carcass weight and chilled carcass weight of the chickens under the study. Improved Horro chickens whose thighs and drumsticks were lower in weight when compared with the thighs and drumsticks of the Koekoek and DZ White-feathered chickens had a more developed breast muscle and less weighing gizzard (Table 30).

Table 30. Association among the liveweight, carcass yield and edible offals of chicken breeds

	LW	HCW	CCW	Thigh wt	Drumstick	Breast yield	Gizzard	Liver	Heart
Live weight in gm	1	.							
Hot carcass weight	0.875**	1							
Chilled carcass wt	0.854**	0.996**	1						
Thigh weight	0.815**	0.919**	0.925**	1					
Drumstick weight	0.894**	0.890**	0.892**	0.823**	1				
Breast yield in gm	0.326	0.701**	0.707**	0.608*	0.457	1			
Gizzard weight	0.719**	0.377	0.352	0.345	0.500	-0.150	1		
Liver weight	0.530*	0.360	0.327	0.217	0.332	0.107	0.686**	1	
Heart weight	0.597*	0.706**	0.709**	0.788**	0.650**	0.402	-0.006	-0.226	1

- LW= live weight; HCW= hot carcass weight; CCW= chilled carcass weight

The mean effects of breed of chicken and meat aging for the 0.5hrs, 24hrs and 48hrs after slaughter on pH of meat is presented in Table 31. The differences among the three breeds of chicken had not significant (P>0.05) on pH of thigh, drumstick and breast muscles of chicken, though slight figuerative difference was observed in pH among both meat cuts and time of meat aging. For the figurative differences observed, more variation in meat pH was recorded for animal genotype where less variation was documented for the pH in interaction of breed to time

of meat aging. Slightly higher mean pH (5.64±0.052) and (5.62±0.063) was recorded for the thigh and breast meat of Improved Horro chickens respectively, where the the thigh, drumstick and breast meats of the Koekoek and DZ White-feathered chickens had a more or less similar pH measures.

Table 31. Effects of chicken breed and time of meat aging on post slaughter chicken meat pH

Variables		pH measure of cuts of carcass tested		
		Thigh	Drumstick	Breast
Breed of chicken	PK	5.59	5.61	5.51
	DZ1	5.57	5.60	5.50
	IH	5.64	5.54	5.62
	SE	0.052	0.065	0.063
Time of meat aging (hrs)	0.5	5.64	5.58	5.59
	24	5.55	5.61	5.61
	48	5.61	5.56	5.45
	SE	0.052	0.065	0.063
Probability				
Breed of chicken		0.443	0.842	0.160
Time of meat aging		0.591	0.699	0.369
Breed * time of aging		0.879	0.877	0.344

* SE: Standard error
*PK: Potchefstroom koekoek, DZ1: DZ White-feathered, IH: Improved Horro

5. DISCUSSION

This section comprises of three subsections. The subtitle 5.1 presented the survey, follow-up on production system, marketing and health constraints, subtitle 5.2 presente evaluation and follow up on reproductive performances of unimproved Horro chickens produced under traditional management.Section 5.3 presented the reproductive and productive performances of Improved Horro, Koekoek and DZ White-feathered chicken under on-station and on-farm management system where as the carcass and egg quality characteristics are presented on the subtitle 5.4.

5.1. Poultry Production System, and Market and Health Constraints

5.1.1. Family demography, land and livestock holdings characteristics in the study areas

Among the three districts studied representing three agro-ecologies, the highest number of female headed households were recorded in Leka-Dullecha district (mid-altitude) followed by larger number in Bako-Tibe (lowland). Concerning household heads' level of education, larger proportion (66%) of household heads in Horro district had attended elementary school level of education where as among the illiterates examined, larger proportion (39.8%) of illiterate (who do not read and write) household heads were recorded in Leka Dullecha district (mid-altitude). Regariding the age group, larger proportion (45.1%) of household heads in Leka Dullecha district were also in the age group between 31-40 years where as majority (37%) of household heads in Horro district were in the age range between 41-50years. The age group of household heads after retirement was also higher in Horro.

Households in between 21 and 60 years age ingeneral were those age groups which accounts for more than 90% of household heads. This age group among the households studied was the age range where family size was relatively larger which may implied because of large family size, the demand for higher income and larger labor size was demanded that impose farmers to engage in poultry production in integration with other livestock and crop production. In agreement with the present report where highland producers had larger agricultural cropland than the lowland farmers crop production is the main income generating activity for the farming community and

majority of producers keep poultry as an additional source of income. The variation in cattle population, agricultural landholding and perhousehold chicken flock size was recorded among the three agro-ecologies. The study revealed that higher per household cattle and cropland holding was recorded at the highland, larger per household chicken flock size was recorded at lowland agro-ecology.

With respect to age of producers, very small proportion of young households (< 20yrs age) and elders (>60yrs age old ones) were participating in poultry production. The small number of teenagers and older participant in poultry production might be because, these age groups are generally the ages before marriage for young males and after retirement from major rural cropland cultivation and livestock rearing activities for elders. Though small in number of producers were building poultry houses, majority of producers who improve the poultry management were younger householders who attended high school and above level of education.

In Ethiopia, the agricultural sector is a corner stone known to accommodate desirable characteristics such as of the economic and social life of the people, and is the major employing sector. In agreement with the above statement, poultry production systems in the study area was also a mix of family businesses and commercial operations, from the small to large-scale with varying degrees of modern technology mainly with respect to existence of exotic chicken in the flock, commercial feed utilization, modern housing system and population of chicken per flock.

The focus of governments in developing counties is more oriented to crop production though crop cultivation and livestock production complement each other. The highlands of Ethiopia in general and of the study area in particular are mainly known for its mixed crop-livestock production system. The livestock support crop production with input supply, draft power, manure and conversion of by products to meat, milk and egg where crop cultivation also hold up livestock production through feed supply, being an initial capital for investment and absorbs livestock wastes and un employed citizens.

The mean livestock holding (8.29 ±5.99, 3.94 ±4.37, 1.15 ±2.41, 1.52 ±1.78 and 11.15±6.16 for cattle, sheep, goats, equines and chickens, respectively) documented in the current study were

lower than the livestock holding 12.17, 13.5, 3.22, 2.79 and 0.96 for cattle, sheep, goats, Horse and Donkey, respectively, reported by Hundie (2015) in the Horro district of western Ethiopia. The overall mean per household chicken flock size of the present study (11.15±6.16) is in the range of the report by Guèye (1998); Tadelle and Ogle (2001) and Tadelle (2003) who documented almost every village household keeps domestic fowl (on average between 5 and 20 birds), and it is estimated that village fowl make up more than 80% of the total fowl population in Africa. However, the mean population holding documented in the present study is higher than the average holding 7.3/hhs reported in Ethiopia by Matiwos, (2013).

The overall mean per household chicken holding reported (11.15±6.16) in the present study is in agreement with the reports on chicken holding in rural Ethiopia by Addis and Malede (2014). However, the large mean family size (6.19 ±2.16) recorded in the present study is higher than the 5.20 ± 0.90 mean per household family size reported in Quara district in Northern Ethiopia. In contrast to family size, the overall mean per household agricultural landholding (1.68±1.50) documented in the present study agrees with the 1.7± 0.25ha per household landholding at Alefa district reported by Addis and Malede (2014) from same part of Ethiopia.

Chickens in the present study areas were not considerd as the first important animal at the farmers' back yard which could be used as a means of life, but were used to complement the agricultural sector in agreement with the report by Moreki *et al*. (2001) who documented that family chickens were rarely the sole means of livelihood for the family, but was one of a number of integrated farming activities contributing to the overall well-being of the households. In these study areas, producers' agricultural landholding and cattle holding potential was higher at the highland agro-ecology, however, higher population of chicken per stock, larger population of exotic and crossbred chickens, shorter age at production and higher productivity with respect to (egg per clutch, clutch per year and number of chick per incubation) was recorded at the lowland agro-ecology in comparison to the remaining two agro-ecologies. Chickens according to the present study were integrated into other livestock (cattle, sheep, goats and equines), and crop production in agreement with the report by Sonaiya (1990); Dessei, (1997); Kitalyi (1998) and Branckaert and Gueye (2000).

According to the respondents' openion of the current study areas, the main purpose of chicken production was for sale contrasting with the report by Andrews (1990) in Gambia and Cairns and Lea (1990) in the Kwazulu in South Africa where the main function of village chickens and purpose of production was reported for provision of meat and eggs for home consumption. Poultry producers also reported that they were making use of income generated from chicken sale for purchase of agricultural inputs (fertilizer and seeds), for farm-land renting, children's school fee and purchase of food items, and use as a starting capital for investment which could be used to purchase other livestock mainly small ruminants. Chickens in the current study areas also have social heritages that families and relatives offer a breeding hens for share, as a gift and to childrens to encourage into business affilation. The offer of breeding pullets for gift as a foundation stock for their poor relatives and children, and the distribution of hens for share could also strengthen the social relations among the share givers and share takers.

The most common chicken production system practiced in the current study areas was a smallholder back yard and extensive production system where chickens rely mainly on a scavenging type of feeding. There was no purposeful feeding of chicken under these conditions and scavenging type of feeding was the major source of chickens' diet in agreement with the report by Alemu, (1995) and Mekonnen, (1998) who documented the production system under village conditions is traditionally low-input with resulting poor performance for major production traits.

Although lack of fortified feeds and micronutrients in Ethiopia was mandatory to keep poultry under free ranging conditions, a full day scavenging chickens are vulnerable to predators (mainly during wet season when crops and different vegitations favour predators and disease agents) and diseases in accordance with the report by Fesseha *et al*. (2010) who documented that majority (99%) of these chicken are maintained under a traditional system with little or no inputs for housing, feeding or health care. Chicken housing in the present study areas were not constructed purposely where chickens were staying in family houses, in the kitchen, under the ceiling of living homes and at some corner of other livestock barns, mainly during the night. Only few, about 7.44% of households own larger number of chicken population in a stock and were trying to improve management system by constructing separate houses for chicken.

Poultry even though were the highest in mean population among the per household livestock composition, they were ranked the least with respect to their level of importance in the livelihood of the farming society. Nevertheless, for some households who do not have cropping lands, who are disabled and poor, chickens may take better position and level of importance among other domestic animals. Researcher's observation revealed that 100% of chickens in this production system were free ranging where chicken flocks were freely moving to the neighboring compounds in agreement with the report by Fisseha *et al*. (2010) who documented that the majority (99%) of chicken in Ethiopia are maintained under a traditional system with little or no inputs for housing, feeding or health care. This free ranging system therefore, gives a chance for uncontrolled mating of hens of any flock with the dominant cocks of own and/or other flock of chickens from the surrounding and neighboring flocks.

Concerning the distribution of exotic and improved breeds of chickens assessed in the current study areas, the per household exotic chicken holding calculated for either commercial layers, hybrids or dual purpose chickens was higher than the report by Dana (2010), who documented that more than 95% of the total chicken populations of Ethiopia are comprised of the indigenous genotypes. The proportion of local chicken ecotypes in the current study also is higher than the report by FAO, (2011) where in Ethiopia chicken populations were 97.3%, 2.32 % and 0.38% were indigenous, exotic and hybrid breeds, respectively. The result presented in the current study concerning the mean exotic and local breed composition in the flock of chicken also disagrees with the report by Tadelle *et al*. (2013) who documented chicken production is predominantly a local breed based in Horro woreda, with only 2.8% and 7.2% of the chickens reared in Homi and Dembel Gobeya villages, respectively. The higher percentage of exotic chicken ecotypes reported in the current study might be because of the intervention by a project run in the area by private commercial chicken suppliers such as "Ethio-chicken" who supplied a day old chicks to farmers and chick brooding organizations that might temporarily lift up the number of exotic chicken in the area.

5.1.2. Poultry production and management systems

Poultry in the current study areas were rarely the sole means of livelihood for the family, but they were among the most reliable animals in an integrated and complementary farming activities contributing to the overall well-being of the household in agreement with the report by FAO, (2004) and the Nzietcheung, (2008); citing Halderman (2004) where the livestock sector in Ethiopia was described to contributes an estimated 18.8% to the national GDP and 40% to the agricultural GDP. The households depending heavily on agriculture and livestock can depend on poultry as a low cost option to diversify and mitigate risks. However, for some families and mainly for children (school 'boys' and 'girls'), chickens were found more important than equine and small ruminants, and the most important of all for few households. Chickens in the present study area were also not the priority animals among the livestock reared except for very few and only about 11.93% poor and landless households in agreement with the report by Robert *et al*. (1992) and Sonaiya (2004), who documented smallholder farming families, landless labourers and people with incomes below the poverty line are able to raise chicken with low inputs and harvest the benefits of eggs and meat via scavenging feed resources.

Purposeful feeding was not practiced and chickens in the current study areas were searching for feed to satisfy their nutrient requirements by scavenging, though crop grain of different sources, kitchen leftover and concentrates were supplemeneted in rare cases. Different scholars Alemu (1995); Solomon (2008); Reta (2009) reported that traditional village poultry production is charcterised by minimum input, average flock size per household of 4.1 chickens that are scavenging for most of their food, and no investment beyond the birds. There was a variation in feed type and method of supplying feed among the agro-ecologies in the present study. The difference in methods of crop grain storage and management practices among the three agro-ecologies and crop type available in majority might had brought the differences in a feed supply practices.

At the lowland, it was maize and other stover grains which were the major crop-products produced and their storage was in semi-opened and well airated stores or sometimes kept on fields in the compound. Therefore, chicken could access feed grains freely and an offer might not

be planned. Every family member in the lowland therefore, had a chance to supplement at any time and most of family members were participating on feed supplement (offer) in contrast to producers at highland and mid-altitude. Concerning chicken house cleaning, as house cleaning in Ethiopia in general is the duty of females, they were spouses and girls in the family in these study areas who mainly engage in poultry house cleaning.

As opposed to the report by Tadelle (1996) who indicated that, in rural central Ethiopian highlands, the major uses of eggs are for hatching for replacement (51.8%), sale for cash income (22.6%) and for household consumption (20.2%), while the major purposes of keeping village chicken are for sale for income (26.6%), sacrifice or healing ceremonies (25%), replacement (20.3%) and home consumption (19.5%), about (90.85%) producers interviewed in the present study areas were rearing chickens for sale and the income collected from sale of chicken and eggs was used to satisfy home expenditure and children's school fee for family heads. In addition to the statements depicted above, income collected from sale of chicken and chicken product was also used as a source of initial capital of investment for young boys and girls.

Agriculture was the main source of livelihood for more than eight out of ten Ethiopians as more than 80% of Ethiopians are rural dwellers. Yet agricultural production is extremely vulnerable to risk owing to its dependence on weather/rain. Recurring droughts may leave poor farmers without food crops, causing periodic famines. Integration of chicken into agriculture is therefore, need to be a remedy. Though income collected from sale of egg was mainly used for home expenditure by house wives, income collected from sale of live birds were utilized mainly for the requirements of whole family by the consult of husband and wife as the money obtained from sale of this part of the animal is higher and could cover the expenses needed for the purchase of agricultural inputs.

Chicken owning children were mainly school 'boys and girls' who had been supported by their family, particularly by their mothers and use the property colleted from sale of egg and live bird for the fulfillment of school materials, clothing and sometimes savings. Children (boys and girls), who own chicken oversee income and chickens by themselves and use that to fulfill their school materials and begun to exercises independence of their family for school expenditure.

Children also begins practicing in chicken management and administering their income. However, chicken and product management and marketing falls mainly on mothers since males and children stay outside for agricultural works and at school respectively, during the day. According to the current study, majority of income collected from sale of egg and live birds 36.45 and 23.55% respectively, were used by spouses for the family home expenditure.

The source of initial capital for chicken production for about 87.58% respondents was agriculture where both poultry production and agriculture complement each other. According to the result, the mean chicken sold and slaughtered for consumption exceeds those replaced by hatching and purchased per annum which might have because of producers may cull chicken whenever disease outbreaks might happen. The result also revealed that some of rural farmers did not keep chickens for production only, but also purchase and sale for profit as the number of chicken sold was higher than those bought for replacement.

The household is the primary unit within the rural smallholder farming system, with age and gender determining the division of labour. But there is also capacity for cooperative management of resources where all family members take part on takecare of chicken. Chicken ownership among family members identified in the current study was a property to the whole family, to husband and wife in common, to spouses, to children and sometimes exclusively to the husband in a declining order of participation. The present study also revealed that, even though women took the main part in chicken control, and chicken and product management in agreement with the report by Bradley (1992); Bishop (1995) and Riise *et al*. (2004), who reported women though play the major role in poultry management, they did not take the main part of wnership. However, the report disagrees with the report by Gueye, (1998); Mcainsh *et al*. (2004); Bagnol, (2000); Sonaiya *et al*. (2004) and Abubakar *et al*. (2007), where in a number of African countries, approximately 80% of the chicken flocks are owned and largely controlled and managed by rural women.

It was examined that, in male headed households, whole family in general and house wife and husband in common in particular owns large flock population of chickens, and decisions on egg consumption and chicken slaughtering, poultry product sale and utilization, and breeding stock

selection were undertaken by the consult of husband and wife. Children sometimes were also allowed to sell their chicken and eggs to use income collected to cover school expenses, to purchase clothes and save for further investment.

For the study area, commercial chicken feeds were purchased with a high cost as this feeds were obtained from Addis Ababa and its surrounding. However, most of the feed ingredients used as raw materials by poultry ration formulating factories, for example; maize, Noug and soyabean were bought from Wollega area. The major constraints in poultry production identified in the study areas were poor management, high disease prevalence mainly New Castle Disease and fowl typhoid, low access to inputs mainly; (improved breeding chicken breeds, commercial concentrates, veterinary services and poultry drugs), and lack of sustainable market and marketing structure. This report therefore, is in accordance with the report by Wilson *et al*. (1987); Nigussie *et al*. (2003) and Kondombo (2005) who documented that poultry market price was fluctuating with festivals, season of the year and disease occurrences that the price gets higher during holy days, dry season of the year and when there is no disease outbreaks while it stands in contrary during regular market days.

The most prominent challenges in poultry production of the study areas were low productivity of local chicken because of poor genetic potential and poor management in agreement with the report by Lumpkins *et al.* (2005) who documented body weight and feed efficiency (gain/feed) in chicken were affected primarily by environmental temperature. The environmental challenges include poor housing and feeding management, high disease prevalence, and attacks by predators. Due to disastrous chicken disease outbreaks and epidemics, producers may loss the whole flock at a time where about 88.6% of chicken producers interviewed responded that they recurrently faced severe poultry disease outbreaks during their production practices.

Poultry marketing in the current study areas was performed mainly by intermediaries who lead their life by buying and saling chickens and eggs. Intermediaries are people who collect egg and chicken by a house to house and/or purchasing products standing on roads (ways) to towns to collect goods (eggs and chicken) before producers arrive at the main market. This people either collect chicken and egg through a house to house or by purchasing from village markets and

transporting goods (chicken and egg) to secondary markets where they could obtain better price and profits.

Low productive performance of local chickens in the area such as an extended mean age at first egg (25.33), egg per clutch (12.46), clutch per year (3.93) and length of single lay in days (21.33) is also in agreement with the report by Tadelle and Ogle (2001); Halima (2007) and CSA (2016) where under scavenging conditions, the reproductive cycle consisting of 21-days of incubation, a 2 to 4 clutches cycle per year and finally a 56-day brooding time which resulted in low productivity of indigenous chickens in rural Ethiopia.

Disease epidemics and predators of chicken were among the major constraints in poultry production reported in the area. Producers in the present study areas were reporting a loss of part of or whole flock of their chicken in occasions when diseases such as New Castle Disease (NCD) and Fowl typhoid breaks in agreement with reports by Aini (1990); Bishop (1995); Nigussie *et al*. (2003); Serkalem *et al*. (2005) and Nwanta *et al*. (2008) who documented NCD disease spreads rapidly through the flock and mortality could reach up to 100%. The result also is inline with the report by Alemayehu *et al*. (2015), who documented that Newcastle diseases were the most prevalent and economically important disease affecting chicken in Benishangul-Gumuz Region, Western Ethiopia.

Chicken marketing in the study areas was predominantly traditional and the chickens exchange method was a retail method in agreement with the report by Fisseha *et al*. (2010) who documented village chicken and eggs are sold in local and urban markets to traders (collectors) or directly to consumers depending on the location of the farm dwelling to the nearest local market and farm gate in order of importance, to the preferred outlets for egg and chicken marketing by producers. This marketing system was therefore, a discouraging type in its character that farmers do not produce large number of chicken and egg in fear of lack of market in addition to health problem because of which farmers may loss the whole capital at a time. Lack of sustainable market price and improved market structures identified in the present study is inline with the report by Kyvsgaard (2007) in Latin America who documented the lack of a

proper infrastructure for the sale of rural poultry is a constraint to generating revenue from poultry production.

5.1.3. Traditional chicken breeding practices and production performances

About 61.94% poultry producers in these study areas possess their own roosters majority of which (41.05%) were hatched from the flock at home. Though large population of farmers interviewed possess cocks in their chicken flock, these cocks in the flock were not kept for breeding purpose, rather they were reared mainly for sale and/or sold before mature age of successful mating. Chicken flocks in the study areas were characterized by free ranging system that the flock could move freely for scavenging in the surrounding neighbors' compounds where hens could mate with any of the cock/s in the area. This could therefore, bring about an opportunity that, through uncontrolled and indiscriminate mating, hens could get a chance to breed with own and/or neighbor flocks' dominant cock/s.

The chicken breeding system employed in the current study area and the result of the current finding agrees with the report by Meseret (2010) who documented on the study conducted in Gomma district of southwest Ethiopia that breeding of village chickens were completely uncontrolled. The result also agrees with the report by Nigussie (2011) for the research conducted in the western Ethiopia, who documented freely scavenging poultry production was allowing cocks and hens to mate indiscriminately without systematic mating where the dominant cocks in the neighborhood were used as a sire line.

Poultry producers in the current study areas established their foundation stocks through purchase, purchase and hatching, supply from agricultural extension services, a gift from family and friends, and keeping for share (where producers take share of the products while the foundation stock remains being the property of the share giver). In contrast to the report by Whyte (2002) where the gift of a chicken often in many parts of Africa is a way of welcoming high status visitors or honouring affines and kin. The study also revealed that a gift of chicken for production as an intial capital investment was to encourage the poor could have a working capital and their children could develope chicken management skills. Offer of foundation stock

for gift or as a share to a non- relative people of the area could consolidate social solidarity between the presenter and the offered. However, majority of producers in this study areas had mainly obtained their existing foundation flock through purchase and hatch.

Incubation systems used, incubation materials and chick brooding system in the study areas were exclusively natural and traditional inline with other backyard and a scavenging chicken production systems practiced in Ethiopia. Broody characteristics of local hens were used for natural incubation and chick brooding purposes. Cartoon-boxes, woven-materials, wooden-boxes, clay-pots, worn-tires and jery-cans were used for egg laying, incubation and chick brooding with a bedding material made of straw, grass-hay and sometimes cloth mattresses. About 63.1% of producers did not practice selection of eggs for incubation; rather layer hens were allowed to incubate their own eggs.

Traditionally, eggs in the study area were left on laying boxes until layer hens sit on eggs for incubation as local chickens in the study areas are known by their broody characteristics in agreement with the report by Horst (1990) who documented indigenous hens have a predominant inclination to broodiness and are good mothers. It was believed that hatching eggs should not touched by hand as it was thought that eggs would get rotten if people may touch or collect eggs and store before the end of the clutch cycle. Carton boxes, woven cages, home wall corners, wooden-boxes, worn-tires, clay-pots and jerry-cans were the most commonly used incubation materials used with beddings in order of preference in the present study areas. Carton boxes were the materials most frequently used by the majority (50.65%) of producers for eggs' incubation where as the least proportion (0.33%) of respondents use jerry-cans.

Poultry producers use traits of local chickens, which have ideal mothering, good sitting, excellent foraging, hardy, and possessing better natural immunity against common poultry diseases for natural incubation inline with the report documented by Mathur *et al*. (1989). It was thought and believed that to collect and store eggs before the layer hen sit-on eggs for incubation may make eggs get rotten in addition to this, hens may stop laying if eggs are collected every day after lay. Therefore, the eggs planned for hatching were kept in the egg laying nests until the broody hen sit on egg for incubation.

Survey result and retrospective animal health data collected from the three district veterinary clinic casebooks revealed that Newcastle disease, Fowl typhoid and Marek's diseases (known by different local names based on their morbidity symptom and acuteness) were the most epidemics and fowl poxes were also reported in rare cases. These diseases and some other unknown poultry infectious diseases were the most virulent diseases in the area recorded to obliterate even up to the whole flocks of chicken. The finding on poultry health in the current study agrees with the report by Aini (1990); Bishop (1995); Nigussie *et al*. (2003); Moreki (2003); Serkalem *et al*. (2005); Nwanta *et al*. (2008); Sonaiya (2009) where Newcastle disease (NCD) was highly infectious diseases in the tropics that spreads rapidly through the flock and mortality could reach up to 100%. Age of chicken and production characteristics also determines animal susceptibility to diseases where, chicks and brooders together were the most vulnerable group in the flock according to the current study followed by chicks.

The per-flock breed composition was predominantly indigenous in the present study areas where per flock local breed chickens accounts for about 87.37% chicken population. The proportion of local (indigenous) chickens in the flock composition of these study areas was lower than the report by Dana *et al*. (2010) who documented more than 95% of the total chicken populations of Ethiopia comprised of the indigenous genotypes and an FAO (2011) report where about 97% of chicken population in Ethiopia were indigenous ones. The per household flock size documented in the current study areas also is in agreement with the report by Addis and Malede (2014) where the overall mean per household chicken flock population was (16.43 ± 0.92) at Quara, Alefa and Tach Armachiho districts of North Gonder zone in the North western Ethiopia.

The highly significant differences ($P<0.01$) in reproductive performance and productivity of chicken and variation in breed distribution among the three agro ecologies of the current study areas depicted the effect of climatic difference on poultry production in accordance with the report by Assefa (2007) who documented that climatic difference is among the major threats to poultry production and chickens cannot tolerate a wide range of climatic variations, which affects their production and reproduction. The result also is in accordance with the report by Muchadeyi *et al*. (2007) who had shown a high influence of agro-ecology exist on village chicken production systems in Zimbabwe.

5.2. Reproductive and Productive Performance of Unimproved Horro Chickens

In spite of numerical and economic importance of indigenous chickens, the overall productivity of local chickens is low owing to low egg production performance, slow growth rate, late sexual maturity and extended periods of broodiness and high chick mortality. In the present study areas, the mean egg per clutch, clutch per year and length of single lay in days were significantly different among the three agro-ecologies in agreement with the reports documented by Tadelle *et al*. (2000); FAO (2004); Halima (2007) and Fisseha *et al.* (2010) who described a local scavenging hen on average lays about 36–40 eggs/year, and average productivity of 9–19 eggs/clutch with 2–3 clutch periods/hen per year. The report of the current study also agrees with the average number of eggs/clutch of local hens in Burkina Faso which was estimated 12 eggs reported by Kondombo (2005) and, however, it was higher than the 10 eggs/clutch reported by Mourad *et al*. (1997) in Guinea and the 9 eggs/clutch reported by Kuit *et al*. (1986) in Mali, respectively. The computed mean egg/hen/year 42, 45 and 53 for Bako-Tibe, Leka-Dullecha and Horro districts respectively, is in the range of an average total egg production ranged from 18–57 eggs/year per hen for local hens in North-West Ethiopia reported by Halima, (2007). The current result is also slightly higher than the average lay of 36-40 egg/hen/year reported by Tadelle *et al*. (2000) and FAO (2004).

Chicken population, mainly the number of chicks was highly fluctuating with season of production and with probable occurrence of disease outbreaks. Producers in the current study areas were not allowing their hens for incubation during summer (wet) season of the year due to high disease prevalence, moisture (high humidity) and chilly environment in the area. During the wettest season of the year mainly from June to August, the weather gets cooler for incubation and predators (mainly cat-family) rob chicks if they would have hatched during summer when they lack other preys to feed. Crop fields also favour the preys to hide in field crops and rob chicken during this wettest season of the year in agreement with the reports by Eshetu *et al*. (2001) who documented on the most common chicken diseases among which the infectious diseases such as NCD, salmonelloses, coccidioses and fowl pox were considered to be the most important causes of mortality in local chicken while predators were also an additional causes of loss as reported by Tadelle (2001).

The overall mean clutch per year (3.93) examined in the present study is inline with the mean and standard error cluch per year 3.78 ± 0.07 reported in Guinea by Mourad *et al*. (1997), however, it is higher than the 2–3 clutch periods/hen per year reported by Halima, (2007). The variation in number of hatch per year and inter-clutch length in days was non-significant ($P>0.05$) across the agro-ecologies. However, the statistical difference in mean number of chick per hatch, age in weeks at weaning of chicks, number of weaned chicks per hatch and cockerels' age at marketing was highly significant ($P<0.01$) across the agro-ecologies (highland, mid-altitude and lowland).

Hatchability (83.38%) calculated from chick per hatch and survival rate (64.39%) computed from weaned chick per hatch identified during the current study from follow-up study was inline with the local chicken hatchability rate (83.1%) reported by Mourad *et al*. (1997) in Guinea as documented by Fisseha *et al.* (2010). The mean number of chicks hatched (10.39) among the eggs incubated under natural incubation in the current study areas also agrees with the report by Bogale (2008) who documented the average number of eggs incubated/hen was 13 from which on average 11 chicks were hatched.

5.3. On-station and On-farm Growth Performance of Improved Horro, the Koekoek and DZ White-feathered chicken Breeds

According to the current study, the day old weight of the Improved indigenous Horro, the exotic Koekoek and DZ White-feathered had slight numerical difference but they had statistically non-significant (P>0.05) variation as opposed to the difference in mean egg weight difference among the three breeds. The result disagrees with the report by Teketel (1986) and Shanwany (1987) who documented that the hatching weights of chicks followed the egg weight pattern in the parental population. The non significant chicks' day old weight difference recorded in the current study also disagrees with the report by Halima (2006) who documented that significant ($P<0.05$) differences in day-old and final body weights were observed within the indigenous and between the indigenous and RIR chicken lines, with the highest body weight being recorded in the control (RIR) line.

The significant effects of breed, age in week and interactions of breed × age in week (P<0.001) for mean body weight gain of the chicks identified in the current study areas agrees with the report by Alewi and Melesse, (2013) where the overall mean body weight of RIR-crosses was significantly higher (p<0.05) than those of Fayoumi-crosses and Kei for both sex groups in the south western Ethiopia. Haile-Mariam (1998) and Melesse *et al*. (2005) also documented that the overall performances of the crosses were better than either the native or the exotic parents under the prevailing management condition.

The mean body weight (281.87g) recorded for Improved indigenous Horro chicks at the end of their eight weeks age was lower than the mean weight of Koekoek and DZ White-feathered chicks grown under the same management. However, the weight gain recorded for this Improved Horro chicks was much higher that the mean weight 157g reported by Tadelle and Olge, (2001) for local chicks under farmers' management and the mean weight 212g reported by Tadelle *et al*. (2003) for different local chicken ecotypes studied on-station.

The growth performance of Improved Horro, the koekoek and DZ White-feathered chicks and their respective 281.87, 309.59 and 320.85g mean body weight at the end of their eight weeks age is higher than the 183g (male) and 153g (female) local kei chicks, 206 (male) and 167g (female) kei × Fayoumi chicks and 222g (male) and 179g (female) kei (local red color plumage) × RIR chicks' body weight gain reported by Alewi and Melesse (2013) in Ethiopia. The survival rate 97.63% for DZ White-feathered chicks, 91.03% for Improved Horro chicken and and 88.26% recorded for Koekoek chicks till their eight weeks age was higher than the survival rate reported by Besbes (2009) where the death rate of local breeds under traditional management was up to 40-60% of the hatched chicks lose during the first eight weeks of age mainly due to disease and predators attack in Ethiopia.

The experimental result of the current study revealed that the DZ White-feathered chicks were superior to both Koekoek (exotic) and Improved Horro (local) chicks in chicks' survival rate both on-farm and on-station. On-farm mortality rate 16.67% for koekoek and 15.33% for DZ White-feathered chicks in the current study was comparable to the mortality rate recorded for Fayoumi-crosses (15.8%) and it was much lower than the mortality rate recorded for RIR-crosses

(25.9%) which was reported on the study conducted in South western Ethiopia by Alewi and Melesse (2013). However, the death rate (28%) recorded at the same study area for Improved Horro chicken during their 10-20 weeks age is much higher than the mortality rate documented for local Kei chickens (17.8%) in south western Ethiopia by Alewi and Melesse (2013).

The lower survival rate of Improved Horro chicken identified in the current study agrees with the report by Thornton (2010) who documented that in developing countries, the suboptimal environment has the potential to negatively impact the performance of the breed. This result is contrasting the conclusion made by Hoffmann, (2005) who documented that due to the ability of tolerating some diseases and parasites, and their ability to survive under harsh environmental condition, indigenous chickens are targeted for selection more on adaptation and resistance to disease rather than for enhanced production.

The high death rate recorded for Improved Horro both on-farm and on-station in comparison to the survival rate recorded for local Kei on-farm by Alewi and Melesse (2013) and for Improved Horro at Debre zeit Agricultural Research Center by Wondimeneh *et al*. (2014) might be because of the climatic difference among the study areas, and successive selection of Horro chickens on own performances for increased productivity. The continuous self breeding among best performing Horro chickens under the study for generations might also affect the adaptive capacity of Improved Horro chickens. In agreement with this report, Besbes (2009) documented that successful selective breeding program requires sufficiently large population, pedigree recording, accurate measurement of individual performances and the capacity to minimize environmental variation.

Feed conversion ratio (FCR) is a measure of how efficient the birds are on a particular feed utilized to gain weight. The efficiency of feed conversion varies with diet, environmental conditions and genotype among others. Accordingly the daily body weight gain and growth performance traits measured in the current study revealed that the daily weight gain for both the exotic Koekoek (10.67±5.29) and the DZ White-feathered chickens (8.69±2.07) were superior to the Improved indigenous Horro chicks whose overall mean daily weight gain was (7.75±2.90).

However, the daily feed consumption for the Improved Horro chicken breed was getting higher and higher as the age of chicken was increasing in week.

During those growing periods, mainly from week (10-18), the overall mean daily weight gain (10.67±5.29) for the Potchefstroom Koekoek chicken breed was the highest followed by DZ White-feathered (8.69±2.07) and the lowest (7.75±2.90) was recorded for Improved Horro. The result of mainly the daily weight gain of Improved indigenous Horro chicks is comparable with the report by Dessie *et al*. (2003) and Alewi and Melesse (2013) who documented that under intensive management condition, an average daily weight gain for local chickens of between six and twelve weeks age was 7.2gm.

The breed and sex of chicks and age of chickens in the current study had showed no significant effect ($P>0.05$) on mean body weight gain of chicks during their 10 – 18 weeks of age as opposed to the report by Alewi and Melesse (2013), who recorded, 'there were significant effects ($P<0.001$) of breed, week and breed×week interactions'. However, the daily body weight gain, cumulative feed intake and feed conversion ratio examined in the current study is in agreement with the report by Wondmeneh *et al*. (2014), who documented that the daily feed consumption, daily weight gain and feed conversion efficiency of the chicken breeds was not significant.

Feed intake in chickens has great impacts on production since it is a key in determining the nutrient intake levels (Mbajiorgu *et al*., 2011). According to NRC (1994) it was reported that birds principally eat to satisfy their energy needs and will adjust their feed intake according to their metabolizable energy requirement. Feed conversion ratio is also reported as a complex process and a highly aggregate trait which is the result of the interaction of behaviour, level of production, appetite and other factors. The negative correlation among daily feed consumption (intake) and feed conversion efficiency with body weight gain of Improved indigenous Horro chickens in comparison with their Koekoek and DZ White-feathered chicken counterparts might therefore, have implied the effect of genotype on chicken productivity.

Though slight difference in feed consumption per day was recorded among the three breeds of chickens in the current study, the variation was non significant (p>0.05) that agrees with the report by Alewi and Melesse (2013), in Southern Regional State of Ethiopia, who documented no significant difference was observed in feed consumption between Kei (a local red colored breed) and Fayoumi-crosses. However, the overall mean difference in the per day feed consumption (53.89±14.37, 50.28±10.50 and 52.70±12.43) documented for Koekoek, DZ White-feathered and Improved Horro chicken, respectively were inline with the report by Fassil *et al*. (2008) who documented RIR chickens consumed more feed than Fayoumi and Fayoumi was higher in egg mass and utilised feed more efficiently.

Body weight at maturity was measured when chickens were 24 weeks of age when both male and female chickens begun mating for reproduction, and when some hens among the stock begun laying eggs in accord with the reports documented by Teketel (1986); Tadelle (1996); Aberra (2000) and Halima (2007). The difference in growth performance and mature age mean body weight among chicken breeds showed the significant effect of breed of chicken and climatic differences on chickens' body weight attained at maturity by different breeds of chickens under varied agro-ecologic locations and management systems.

Male chickens of all breeds showed sign of maturity and desire for mating (courtship) at an earlier age in comparison to their female contemporaries. With respect to age at mating, both the Potchefstroom Koekoek and DZ White- feathered pullets showed sign of desire for mating by sitting (to accept males for mating) infront of the males during the males' courtship on average on the same day and same mean age while the indigenous Improved Horro pullets were slightly late. Though the Improved Horro chickens were sluggish in growth and lighter in their mature body weight in comparison to their Potchefstroom Koekoek and DZ white-feather counterparts, the difference in the age at maturity and mating was very small. The Potchefstroom Koekoek hens among the three breeds of chickens and lowland chickens among the chicken breeds of the three agro-ecologies had recorded shorter age at first egg on-farm.

The highest overall relative performances in mean mature age weight of all breeds of chicken recorded at the lowland agro-ecology in the present study indicated that the lowland environment

favoured chickens more since the performance status was declining from the hot to cool environment.The result is therefore, in agreement with the report by Wondimeneh *et al.* (2013) who documented significant effects of village×breed interactions showed the presence of genetic by environment interactions between farms. The result also agrees with the report by Okere (2013) who documented that genotype × environment interaction is used to describe the situation where, different genotypes (breeds, lines, strains) respond differently to different environments.

The higher overall mean weight gain and survival rate of DZ White-feathered chickens compared with the exotic Koekoek and Improved indigenous Horro chicken breeds indicated that crossbreds performs higher than both the local and exotic chickens in accordance with the report documented by Haile-Mariam (1998) and Melesse *et al*. (2005) who stated that the overall performances of the crossbreds was better than either the native or the exotic parents under the existing management condition.

5.4. Carcass and Egg Quality Characteristics

5.4.1. Carcass Characteristics of Improved Horro, Koekoek and the DZ White-feathered Chicken Reared under on-station

The dramatic changes in the market forms for poultry in recent years, from a predominantly whole bird commodity to modern highly diversified industry focused on cut up, deboned meat, and ready-to-eat further processed products that resulted in a change of quality expectation. Apart from the quantities of meat that must be produced, the quality of the products mustbe maintained in order to satisfy the demand under quality and health conditions. In the present study therefore, thirty male Improved Horro, Potchefstroom Koekoek and DZ White-feathered chickens; ten cocks from each breed were slaughtered to determine the carcass charecteristics of chicken breeds under the study and to compare the meat yield of Improved Horro chicken with the exotic Potchefstroom Koekoek and DZ White-feathered chickens produced under the same management.

The mean liveweight and the gizzard weight (one of the edible offals evaluated) were significantly ($P<0.01$) higher for the Koekoek and DZ White-feathered chickens amongst the three chicken breeds. However, the variation in hot carcass weight, chilled carcass weight, thigh weight, drumstick and breast yield though had variation in weight, the difference was not statistically significant ($P>0.05$). As opposed to the report by Halima (2007) who documented that the carcass weight of local chickens at maturity in Ethiopia varies from 1045 to 1292g for male and from 642 to 874g for female, the mean hot carcass weight of male Improved Horro chicken in the current study was 951.20g.

The negative correlation between the breast weight and gizzard might be because of a well developed breast muscel of the Improved Horro chickens' carcass when compared with breast yield of the remaining two breeds under the study as opposed to the lighter gizzard they hold when compared with a hevier gizzard of the Koekoek and DZ White-feathered chickens. Breed of chicken therefore, affect the weight of gizzard in agreement with the report by Hermiz *et al*. (2016) in Iraq who documented gizzard was not different in Ross and in cob while Hubbard strain estimates were significantly ($P\leq0.05$) different from both strains. Higher dressing percentage (62.63%) was recorded for Improved Horro chicken when compared with the lower dressing percentage 57.38 and 56.47% of the Koekoek and DZ White-feathered respectively, in contrast to higher percentage 67.6 and 65.3% reported for Ovambo and Potchefstroom Koekoek, respectively by Ramokone *et al*. (2015) in south Africa. Higher dressing percentage of Improved Horro chicken in addition to the smaller gizzard size and lower weight of Horro chicken might have resulted in a non significant difference in carcass weight among the three chicken breeds and the cuts is in accordance with the report by Teketel (1986) who found higher dressing percentage in indigenous chickens raised under station conditions compared with White Leghorns.

The non significant differences in hot carcass weight (HCW), chilled carcass weight (CCW), thigh weight, drumstic and breast yield among the three breeds of chicken on the present study is in accordance with the report by Ramokone *et al*. (2015) in South Africa, who documented the values for LW, HCW, CCW, dressing percentage, breast and thigh weight of Ovambo and Potchefstroom Koekoek breeds did not differ significantly between them. This report also agrees

with the report by Chen *et al.* (1987) who examined and reported the mass and slaughter yields of genotype had no significant influence on the examined properties, as opposed to sex and age. The other quality determining factor examined under the present study was the pH (a measure how acidic or basic a solution is).

The pH of chicken cuts among the three breeds of chicken and meat storage time were not significantly different as opposed to the report by Ristic and Damme (2003) the pH value of meat is influenced by various factors such as genetics – breed, lines, gender, the manner of holding animals, transport, lairage conditions and time - pre-slaughter stress, method of slaughter, technological parameters and post-mortem handling, storage time of meat, etc. Slightly higher pH of meat cuts of Improved Horro chicken meat and a slight higher pH of chicken meat pH during the 24hrs post slaughter recorded in the present study is in agreement with the report by Ramokone *et al.* (2015) who documented the same result for Ovambo and Potchefstroom Koekoek, the South African indigenous chicken breeds.

5.4.2. ***Egg quality Characteristics of chickens produced on-station and under on-farm management***

Various egg quality traits were considered in the current study, on the external and internal local chickens' egg quality characteristics while comparing the effects of breed of chicken and agro-ecology on egg quality characteristics. The mean egg weight, egg length, and egg width had highly significant differences ($p<0.001$) among the Potchefstroom Koekoek, DZ White-feathered, Improved Horro and local Horro chicken breeds in agreement with the report by Rajkumar *et al.* (2009) who documented Naked neck chickens laid heavier eggs with higher mean length and width than the White Leghorn strain at 40 weeks of age. Egg weight variations in different genetic groups were reported by many authors (Washburn 1990; Padhi *et al.*, 1998; Chatterjee *et al.,* 2007). The egg shape indices of the Koekoek (72.7%), DZ White-feathered 73.5%) and Improved Horro chickens (73.9%) are in between the normal and standard range of egg shape index 72-76% reported by Altuntas and Sekeroglu (2007).

For local chickens produced under traditional management, the overall mean egg weight of local Horro chicken produced under village management system was in the range between 37.38g at the highland agro ecology to a 43.55g at the mid-altitude. The result agrees with the report by; Brannang and Persson (1990) and Asuquo *et al*. (1992) who documented 38.0g average egg weight of local hens around Arsi and the mean egg weight 41.65±0.4g reported by Wondimeneh *et al.* (2011) for the local Horro chickens' egg under improvement at Debre Zeit Agricultural Research Center in Ethiopia, and 40.0g light ecotype's egg weight in Nigeria. However, the mean egg weight reported in the current study is lower than the 46.0g mean egg weight reported by Forssido (1986) for local chicken in Ethiopia.

The overall mean egg length (51.76±0.21)mm recorded for the local Horro chicken in the present study is smaller than the egg length (53.6) reported by Asuquo *et al*. (1992) for light ecotypes in Nigeria. The difference in the rate of egg shape index amongst chicken breeds was not large that 72.7, 73.5, 73.9 and 70.9% were recorded for the Koekoek, DZ White-feathered, Improved Horro and local Horro chickens' respectively, though the highest rate was recorded for Improved Horro and the lowest for the local Horro chicken. Chatterjee *et al.* (2006) had reported a higher shape index, 80.76±1.32 for IWK and lower indices for IWI (73.77±3.08) and IWH (72.67±7.56) strains of White Leghorn in agreement with the preent result where as similar shape indices were reported among some of the indigenous poultry breed of Andaman (Chatterjee *et al.*, 2007) in India. Padhi *et al.* (1998) also reported lower shape indices in White, Brown, Black Nicobari birds, Naked neck and White Leghorn compared to the crosses studied in the same country.

The mean egg shape index (71.06%) documented for on-farm local Horro chickens produced under traditional management is also slightly lower than the normal range setted 72-76% and reported by (Altuntas and Sekeroglu, 2007) and lower than the 76% egg shape index reported for light chicken ecotypes in Nigeria. On the other hand, the result revealed that the shape of the local Horro chicken is more oval than those whose egg shape index was larger. The overall mean egg-shell weight (4.33±.08)g and shell thickness (0.36±0.04)mm of Horro chicken in the present study is lower than the egg-shell weight 6g and higher than the egg-shell thickness 0.32mm respectively, reported by Pradeepta *et al*. (2015).

Haugh unit is the measure of albumine quality which determines the quality of the egg protein. The respective overall mean yolk weight (14.36±0.41) and albumen weight (22.3±0.25) measured and (73%) Hough Unit (HU) computed in the current study is lower than the reports by Momoh *et al*. (2010), who documented 18.3g yolk weight, 31.1g albumen weight, 79.1% HU for light ecotype, and 17.9g for yolk weight, 30.2g for albumen weight and 78.3% HU recorded for heavy ecotypes in Nigeria. However, the mean 14.32±0.21g yolk weight and 22.30±0.25g recorded in this study is higher than the 12.3g mean yolk weight and 17.8g mean albumen weight reported by Gebreselassie *et al*. (2015) for local chicken in Tigray region in Ethiopia.

The variation in overall egg quality characteristics among the three agro-ecologies of the current study areas agrees with the report by Babinszky *et al*. (2011) who documented that the levels of performance of poultry, does not depend only on inherited capacity but, also to a great extent upon the environment and the report by Stadelman (1977) who described egg quality as the characteristics of an egg that affect its acceptability to the consumers. Sauter *et al.* (1954) and Washburn (1990) also documented a result that accord with the above finding where many factors influence the egg quality i.e., breed/ strain/ variety, temperature, relative humidity, rearing practices and season were concluded.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

Chicken production system in these study areas was an extensive village production system where chickens were part of the livestock under mixed crop-livestock agriculture. Indigenous chickens dominate the flock of chickens reared and the management system was mainly unimproved with low attention given to improve chicken management and housing. The feeding systems practiced were totally a scavenging type where majority of producers irregularly offer feed-supplements of different sources. The low-input/low-output system was common practice because of less accessability and high cost of chickens' commercial feeds, poor housing management and unsatisfactory poultry diseases prevention and control.

The bigger the family size, higher livestock and cropland holding in the area, the better was the socio-economic status of household and more labour, feed access and housing management allowed to other livestock, however, no significant difference was observed in chicken flock population size and productivity among the large and small family size in these study areas rather households with better economic status were providing less attention to chicken management.

Separate chicken housing was not common in the current study areas which might be because of the small flock size and due to fear of theft and predation as houses had openings through which preys may get into homes and rob chickens. Therefore, majority of chickens were kept in the family homes during the night for security which may result in disease and parasite communication between chickens and people in the family.

Selection of best performing chicken ecotypes among the indigenous chickens for the appropriate chicken breed improvement strategy and cross breeding with those fitting to the prevailing agro-ecology, and improved management is vital to realize successes in adopting improved poultry production and sustain chicken breed improvement. However, chicken breeding practices in the current study areas were indiscriminate that flocks of every family had

a chance of travelling to neighbors in any directions and have chances to mate with any cocks in the surrounding. The existence of bigger sized commercial broilers and dual purpose exotic chicken males distributed to the areas were also reducing a chance of local males to mate hens that intern resulted in production of infertile eggs.

The Improved Horro chicken kept under the current study both on-farm and on-station were at their eleventh generation that passed through successive mass selection progremmes. However, survival rate, growth performance and feed conversion efficiency were lower and age at first egg was extended as compared to the exotic Potchefstroom Koekoek and the DZ White-feathered synthetic chickens. The lower performance in survival rate recorded for IH chickens might be because of a continuous mass selection undertaken while improving the productivity mainly with number of egg per hen of Improved Horro chicken as compared to local unimproved Horro chickens, on the other hand might had affected their disease resistance capacity.

All breeds of chickens studied perform differently across the three agro-ecologies both in terms of survival and growth performances. The DZ White-feathered chickens performed best amongst the three breeds of chickens and the lowland agro-ecology among the three climatic areas was the best suitable agro-climatic area for the chicken breeds both for survival and six month age weight gain that could be because of the differences in soil type, crop type and grain storage and management system, and variation in climatic conditions among the agro-ecologies. All study chicken strains, mainly the DZ White-feathered chickens in the present study areas were more favoured at the lowland agro-ecology with respect to growth performances, age at maturity, reproductive and productive performances followed by on-farm improved chickens at the mid-altitude.

6.2. Recommendations

Based on the above conclusions, the following recommendations are forwarded;

To improve the productive performance, late age at maturity, poor reproductive performance of indigenous and unimproved chickens produced under village production system, an integration

of poultry production with chicken breed improvement and preparation of home-made feeds from locally available ingredients and improving housing management will be vital.

Climatic differences across the three agro-ecologies had resulted in variation in chicken reproductive performance, productivity and a per household mean flock size differences. Therefore, introduction of breeds of chicken to a more favourable climatic zone and agro-ecology based on the will and demand of producers is recommended. In addition to the above recommendation, an adjustment of chickens' population size with season of crop harvest may also make producers more productive and chicken productivity trustworthy to the socio-economy.

The DZ White-feathered chickens amongst the chicken strains under the present study areas were the best perfoming chickens except the complaint for their succeptibility to predators because of their white colour, therefore cross breeding might be recommended as the best approach for breed improvement. The overall better performance of the DZ White-feathered chickens both on-station and on-farm in reproductive and productive performances, and product quality call for the efforts need to be exerted and policy issues on cross breeding for chicken breed and productivity improvement strategies.

The Improved Horro chicken breeds' performance even if it was lower compared with the DZ White-feathered and exotic Koekoek chicken breeds, they were much better performing than the unimproved local Horro chickens both in reproductive and productive performances. Therefore, improvement of Horro chicken ecotypes through selection should be maintained by considering improvement in productive performance, reproductive capacity and liveability or survival. broadening the base of the population of local Horro chickens out of which best performing ones could be selected for a breeding stock which should be employed by collecting additional male and female chickens from rural farms that may help to minimize the problem of inbreeding and improve the inheritance of disease resistance capacity.

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8. APPENDICES

Appendix 8.1. Survey Questionnaires

QUESTIONNAIRE ON ASSESSMENT OF TRADITIONAL POULTRY PRODUCTION SYSTEM AND PRODUCT QUALITY OF HORRO CHICKEN IN WESTERN OROMIA: HORRO GUDURU WOLLEGA, WEST SHEWA AND EAST WOLLEGA ZONES

INSTRUCTION TO THE ENUMERATORS:

Please introduce yourself by name before beginning the interview, the purpose and objective of the study. Please ask each question patiently until the respondent gets the point. For open questions, fill the farmers' response in short and for closed ones circle or mark (x) where necessary.

Date---------- ENUMERATOR'S NAME: ----------

Starting time---------- Ending time----------

A. SOCIO-ECONOMIC CHARACTERISTICS

1. Kebele: ----------

2. FARMER'S NAME: ---------- FARMER CODE: ----------

3. Level of Education of household head.

1) Illiterate 2) elementary education 3) high school and above

4. Sex of household head (1) Male (0) Female

5. Age of household head

(1) <20 (2) 20-30 (3) 31-40 (4) 41-50 (5) 51-60 (f) Above 60

6. Family size:---------- Male _____ Female _____

7. Land size and major crops grown

Land holding	Land size	Major crops grown
Rain fed		
Irrigated		

8. Livestock holding

Type of livestock	Total number	Order of importance
Cattle		
Sheep		
Goats		
Equine		
Poultry		

9. Do you have any off-farm economic activities? 1) Yes 0) No

- If yes, state the type of off farm economic activity you perform----------

- Who perform off farm work? 1) household head 2) Spouse 3)children 4) employ

NB:- circle all if more than one party is participating

10. Labor profile and ownership pattern in chicken production

Ownership of Chicken		Household head	spouse	Children		Family
				male	Female	
	Eggs produced					
	Chicken					
Ownership of income from sale	Eggs					
	Chicken					
Labor profile	Shelter construction					
	Cleaning chicken house					
	Supplementary feeding					
	Water provision					
	Treatment					
Decision making on	Selling eggs					
	Selling chicken					
	Home consumption (slaughter)					

Write down any further description relevant to the labor profile and ownership

_____

11. How long has poultry been kept in the household?

(1) Less than 2 years (2) 2-5 years (3) 5-10 years (4) Over10 years

12. Flock size and structure

Total birds	Chicks	Growers		Hens	Cocks
		Cockerels	Pullets		

- Min____ and Max_____ chicken population you had in your experience.

13. Chicken breeds' composition in the flock

Total number of birds	Breed types			
	Local	Hybrid	Exotic layers	Broilers

14. Source of foundation stock (local chicken)

1) Purchase 2) Gift 3) Custody 4) Share

- Improved breed (if any)
- 1) Purchase 2)Gift 3)extension service 4)Share

15. Sources of existing breeding female

1) Hatching only 2) purchase only 3) Gift only 4)1 and 2 5)2&3 6)1& 3 7)all

16. Sources of existing breeding cock

1) Hatching only 2) purchase only 3) Gift only 4)1 &2 5)2&3 6)1 & 3 7) all

17. For what purpose and objective you raise poultry?

1) Consumption 2) Sale 3) Festivity food 4) Saving 5) Multiplication

Rank those different uses and benefits by order of importance using numbers starting from one

18. Is there any special occasion to use chicken meat? 1) Yes 0) No

If yes, what are they? _____ _____ _____

- Criteria used in selecting cocks for sacrifice – Plumage Color, Comb type
- Which-when _____
- Criteria used in selecting pullet for sacrifice _ color, age
- Which-when _____

19. Do you use chicken products as a nutritious food supplement? 1) Yes 0) No

If yes, fill the following table in order of importance if any

Category	Meat	Egg
Family elders		
Children		
Patients		
Honored guest		

20. Do you use chicken products as a medicine? 1) Yes 0) No

If yes, fill the following table

Type of product	Form of product (raw, cooked)	Type of disease/ damage condition	Age of patient	Other
Meat				
Egg				

21. Utilization of eggs produced within the last one month

Total Eggs laid	Sold	Consumed	Stored for hatching	Set for hatching (last six month)		Others
				hatched	rotten	

22. Utilization of birds in the last six months

Total No. of birds 6 months before

Sold	Consumed	Replacement	Gift	Given for share	Bought	
					male	Female

23. On which of the following items do you spend more money for chicken rearing?

(1) Purchase of feeds (2) Purchase of birds (3) Purchase of vet. medicine (4) None at all

(5) Bird and feed (6) Others (specify):.....

24. Where do you get money to finance your poultry farming?

(1) Agri. Product sale (2) private Money lender (3) Family or friends (4) Micro finance

(5) Cooperatives (6) Agri. Extension organization

B. TECHNICAL/ BIOLOGICAL DATA

I. HOUSING

25. Is there a separate housing for your chicken? 1) Yes 0) No

26. If there is no separate housing, where do your birds rest during night?

(1) Kitchen (2) Perch at one corner in the living home (3) Perch on trees (4) Hand woven basket/Bamboo cages (5) Cartoon box (6) Others (specify) ----------

27. If there is separate house, what type is it?

1). Bedded and thatch covered 2). Bedded and iron sheet covered

3). Thatch covered with perch 4). Iron sheet covered with perch 5) under house eve

27. While constructing chicken house do you consider

- The number of birds? 1) Yes 0) No
- Ventilation? 1) Yes 0) No

II. FEEDING

28. Do you give supplementary feed to your birds? (1)Yes (0) No

If yes what? Please list: (***in order of importance if more than one***)

_____ _____ _____

- Grain from home, kitchen left over, Concentrate, Green forage (Alfalfa), grain from market

29. Is there seasonal variation in feed supplementing your chicken? 1) Yes 0) No

30. State the feeding frequency per day practiced in different seasons?

Feeding Frequency/day	Seasons		Morning	Afternoon	Evening
	Winter	Summer			
(a) Once					
(b) Twice					
(c)Thrice or more					

31. Is there any special emphasis given to any class and/or sex of chicken in providing feed supplements? 1) Yes 0) No

If yes, to which classes of birds? 1) Chick and brooder 2) Growers 3) Laying hens

32. Is there any practice of finishing chicken? 1) Yes 0) No

If yes,

- How birds are selected for finishing? 1) Physical appearance 2) Pedegree test 3) By batch
- What type of feed is offered? 1) Grain 2) Concentrate 3) Roaming free and supplemented
- How frequently they are fed? 1) *Adlibtum* 2) Frequently in day 3) Thrice in day

33. Do you regularly provide water to drink? (1) Yes (0) No

34. If yes what type of trough is used? 1) Piece of clay pot 2) plastic cup 3) Metal cup 4) pit

35. Do you change water in the trough 1) yes 0) no

36. If yes how frequently in a day (No/day) _____

III. BREEDING AND REPLACEMENT

37. Do you have breeding cock/s? 1) Yes 0) No

If yes, What are the criteria's for selection? 1) Size 2) color 3) comb type 4) family history

38. Do you practice brooding hen selection? 1) Yes 0) No

- If yes, what are the criteria for selection? 1) body size 2) Mothering ability 3) family history
- How many brooding hens do you have? _____

39. Do you practice selecting the source of egg for hatching? 1) Yes 0) No

If yes, what criteria's do you use? 1. Productivity of mother hen, 2. Age of mother hen

3. Size of egg 4. Own eggs only 5. If others specify _____

40. Where do your bird's brood on eggs and what are the bedding materials used?

1) cartoon box 2) wooden box 3) woven cage 4) under any corner

- Bedding material _____, _____, _____

41. Do you have preference among seasons for brooding? 1) Yes 0) No

If yes, which season is preferred? (State the months) _____

42. Usually, how long do you store eggs for brooding?

1). 0ne week 2). Two weeks 3). 10 days 4). Till the hen is ready to brood

5). If others specify_____

43. Where do hatching eggs stored? 1) In clay pot 2) In Grain jar 3) In woven container

4) In cartoon box 5) in wooden box 6) Others specify _____

IV. CULLING

44. Do you purposely cull your birds at any time? (1) Yes (0) No

45. Factors for culling birds (1) For consumption (2) For sale (3) For sacrifice

(4) Other (specify) _____

46. Factors to cull hens? (1). Poor productivity (2). Diseased (3). Old age (5). Other (specify _____)

47. Old age for hens to be culled (in months) _____

48. To cull due to disease is to?

(1) Avoid expected disease outbreak (2) When the bird is already sick and not to lose

V. HEALTH CONDITION AND DISESE CONTROL

49. Did serious disease outbreaks occurred to your flock? (1) Yes (0) No

50. Which classes of birds were more affected? 1) Chicks 2) Growers 3) layers 4) adults 5)all

51. What are common diseases of poultry in your area? (local name & order of occurence) _____, _____, _____, _____, _____

52. Is veterinary service available in your vicinity? 1) Yes 0) No

53. Do you use veterinary services when your birds fall sick? 1) Yes 0) No

54. Do you get efficient veterinary service for your chicken? 1) Yes 0) No

55. If no, what do you do when birds fall sick?

(1) Use traditional treatment (2) Give medicine bought from market (3) Slaughter them for consumption (4) Sale them immediately (5) keep until recovery or death

56. If any state traditional treatments used at home _____

57. Is there any predator loss you have encountered this year? 1) Yes 0) No

58. If yes, what are the most common predators found in your locality? Put them in their order of Importance _____, _____, _____, _____

VI. PRODUCTIVITY

59. State the productivity of your local birds in the following table: (General for the flock)

Breed of chicken	Age at first egg (wk) (Average)	No of cluch per year /average	Length of laying period (days) per cluch	No of hatches / year (average	No of weaned chicks/hen (average)	Age at marketing of cocks (in months)	Age at slaughtering of cocks
Local							
Exotic							
Crosses							

60. Current status of laying hens

Breed of chicken	Total chicken	Hens in lay	Hens sitting on eggs	Hens looking after chicks	idle hens
Local					
Exotic					
Crosses					

61. Age at weaning of chicks (in weeks) _____

C. MARKETING

62. Where do you sale eggs?

1) Home gate 2) village market 3) to home to home middle men 4) district market

63. Where do you store eggs before sale?

1) Pot 2) In grain 3) in straw 4) in cartoon/basket

64. Who purchase your chicken product (egg)?

(1) Consumers (2) middle men (3) Shopping centers (4) Hotels (5) Others specify _____

65. Where do you sale your chicken product (live birds)?

1) Home gate 2) village market 3) to 'home to home' middle men 4) Nearby town market

66. How much was the highest and lowest price of the following products you sold at/during the last 12 months

Classes of chicken and product

Marketing time (season/Holly days)	Male		Female		Eggs	
	Min price	Max price	Min price	Max price	Min price	Max price
Eth. New year fest.						
X-Mass						
Easter						
Regular market						

67. Which marketing structure is more beneficial?

1) Sale at home 2) village market 3) Middle men 4) Nearby town

THE QUESTIONER IS COMPLETED THANK THE FARMER AND LEAVE!

CHEEKLIST FOR DISCUSSION MADE WITH KEY INFORMANTS INTERVIEW, MEMBERS OF THE STUDY SITES

1. Name of Kebele ----------

2. Name of key informants

No	Full Name	Social Position
1.		
2.		
3.		
4.		
5.		

3. How do you rank the function of chicken?

- Source of feed
- Source of income
- Social function (ceremonies, gifts, rituals)
- Religious purpose
- Savings
- Others _____

4. What are the major chicken type found in the area _____

5. Who owns chicken in most families of the households? _____

6. Who decide the sale of live chicken and slaughter for consumption? _____

7. Who own the income collected from chicken sale?

8. For chickens owned by children, who decide the sale and where income is kept?

9. In case children own chicken, do they carry any responsibility in chicken rearing activity? If yes what are these activities?

10. What are the feed sources available for scavenging chicken at the homestead?

Season Availability (abundant, moderate, rare) Type of feed

11. What are common diseases experienced in your PA? (mention by order

Local name _____, _____, _____

Symptoms _____, _____, _____

Frequency/year _____, _____, _____

Season of severity _____, _____, _____

Mortality level (high, low, medium, none)

12. Is there problem of predator attack in your PA?

13. If yes what are the types of predators found in your locality?

14. What are the most common grains provided for chicken?

15. How frequently do you provide supplementary feed to your daily?

16. Are there any classes of chicken who are given special emphasis in supplementation? Why?

17. Do you select birds for brooding? If yes what are the criteria's for selection.

18. Is there seasonal preference for brooding? If yes, which season? Why?

19. Do you stimulate broody birds to resume laying? How?

20. Which breed you prefer to hold for production? Why?

MONITORIN AND EVALUATION CHEEK LIST FOR INDIVIDUAL BREEDING HEN REPRODUCTIVE AND PRODUCTIVE PERFORMANCE STUDY

District _____ Follow up and evaluation

HH's name	Hen ID	Age of hen	Age at 1st lay (wk)	AV. Length of single lay period(days)	Egg per cluch	Cluch per year	No of hatch/year	No of Chick /hatch AV.	weaned chick/ hatch AV.	Brooding time/cluch (days)	Weaning time/hatch (days)	Mothering ability		
												A	B	C

* AV. = average *A = strong B= good C= weak.

Appendix 8.2. ANOVA tables for the GLM procedures, Pearson correlations and tests for pair wise comparison tables

Tests of Between-Subjects Effects of breeds of chicks during their 8 weeks age

Dependent Variable: Mean weight in gm

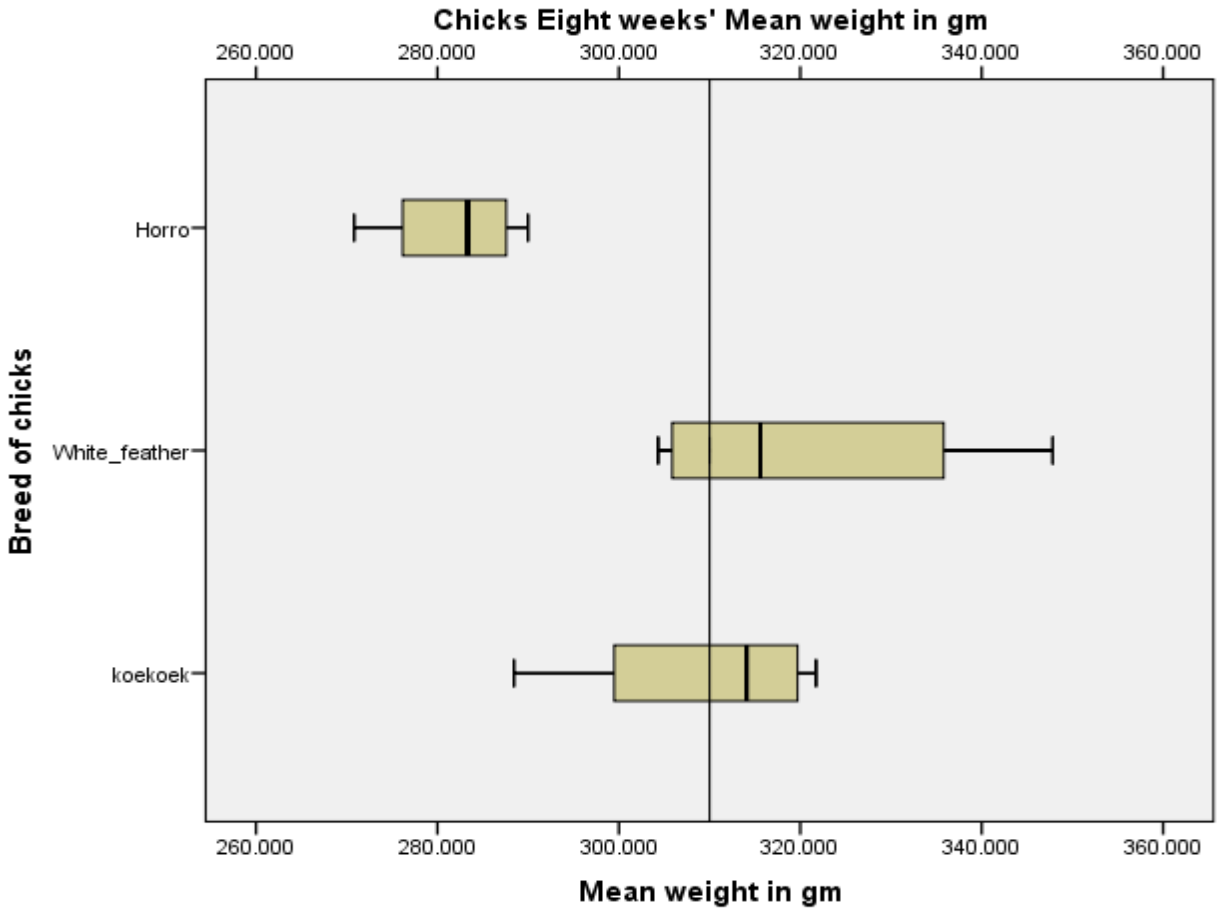
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	3218.454[a]	2	1609.227	7.070	.014
Intercept	1109758.821	1	1109758.821	4875.895	.000
Breed	3218.454	2	1609.227	7.070	.014
Error	2048.410	9	227.601		
Total	1115025.684	12			
Corrected Total	5266.863	11			

a. R Squared = .611 (Adjusted R Squared = .525)

Correlations among Breed of chicks, age in week and mean weight in gm of Horro, Koekoe and DZ White-feathered chicks

		Week in age	mean wt in gm	Breed of chicken
Week in age	Pearson Correlation	1	.983**	.000
	Sig. (2-tailed)		.000	1.000
	N	27	27	27
mean wt in gm	Pearson Correlation	.983**	1	-.061
	Sig. (2-tailed)	.000		.762
	N	27	27	27
Breed of chicken	Pearson Correlation	.000	-.061	1
	Sig. (2-tailed)	1.000	.762	
	N	27	27	27

**. Correlation is significant at the 0.01 level (2-tailed).


Chicks Eight weeks' Mean weight in gm
260.000
280.000
300.000
320.000
340.000
360.000
Horro
White_feather
koekoek
Breed of chicks
Mean weight in gm

Tests of Between-Subjects Effect of breed of chicken during their 12-18 weeks of age

Dependent Variable: weight in gram

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	24376629.148[a]	29	840573.419	22.045	.000
Intercept	242584405.202	1	242584405.202	6362.003	.000
Breed	3344517.663	2	1672258.832	43.857	.000
Age in weeks	19214991.840	4	4803747.960	125.983	.000
Sex of chicken	1011472.042	1	1011472.042	26.527	.000
Breed * age in weeks	419427.620	8	52428.452	1.375	.204
Breed * Sex of chicken	216408.163	2	108204.082	2.838	.059
Age in weeks * Sex of chicken	89863.667	4	22465.917	.589	.671
Breed * age in weeks * Sex of chicken	79948.153	8	9993.519	.262	.978
Error	21734208.650	570	38130.191		
Total	288695243.000	600			
Corrected Total	46110837.798	599			

a. R Squared = .529 (Adjusted R Squared = .505)

Pair wise Comparisons among chicken breeds during their 12-18 weeks age

Dependent Variable: weight in gram

(I) Breed of chicken	(J) Breed of chicken	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
KK	WF	20.635	19.527	.291	-17.719	58.989
	IH	167.685*	19.527	.000	129.331	206.039
WF	KK	-20.635	19.527	.291	-58.989	17.719
	IH	147.050*	19.527	.000	108.696	185.404
IH	KK	-167.685*	19.527	.000	-206.039	-129.331
	WF	-147.050*	19.527	.000	-185.404	-108.696

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Pair wise Comparisons of chicken breeds during their 10-18 weeks of age

Dependent Variable: weight in gram

(I) Age in week	(J) Age in week	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
10	12	-76.333*	25.209	.003	-125.848	-26.819
	14	-197.600*	25.209	.000	-247.114	-148.086
	16	-347.108*	25.209	.000	-396.623	-297.594
	18	-492.883*	25.209	.000	-542.398	-443.369
12	10	76.333*	25.209	.003	26.819	125.848
	14	-121.267*	25.209	.000	-170.781	-71.752
	16	-270.775*	25.209	.000	-320.289	-221.261
	18	-416.550*	25.209	.000	-466.064	-367.036
14	10	197.600*	25.209	.000	148.086	247.114
	12	121.267*	25.209	.000	71.752	170.781
	16	-149.508*	25.209	.000	-199.023	-99.994
	18	-295.283*	25.209	.000	-344.798	-245.769
16	10	347.108*	25.209	.000	297.594	396.623
	12	270.775*	25.209	.000	221.261	320.289
	14	149.508*	25.209	.000	99.994	199.023
	18	-145.775*	25.209	.000	-195.289	-96.261
18	10	492.883*	25.209	.000	443.369	542.398
	12	416.550*	25.209	.000	367.036	466.064
	14	295.283*	25.209	.000	245.769	344.798
	16	145.775*	25.209	.000	96.261	195.289

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Univariate Tests for loca chicken egg quality determination across the three agro-ecologies

Dependent Variable		Sum of Squares	Df	Mean Square	F	Sig.
Egg width in cm	Contrast	14.873	2	7.437	2.811	.064
	Error	367.758	139	2.646		
Egg length in cm	Contrast	96.581	2	48.290	8.123	.000
	Error	826.307	139	5.945		
Widthe to length index	Contrast	39.376	2	19.688	1.773	.174
	Error	1543.372	139	11.103		
Albumen height in mm	Contrast	2.287	2	1.143	1.832	.164
	Error	86.775	139	.624		
Shell thickness in mm	Contrast	.778	2	.389	1.945	.147
	Error	27.786	139	.200		
Yolk Diameter	Contrast	5.186	2	2.593	23.536	.000
	Error	15.314	139	.110		

The F tests the effect of Agro_ecologic Location. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

Univariate Tests for local Horro chicken egg quality determination across three agro-ecologies

Dependent Variable		Sum of Squares	Df	Mean Square	F	Sig.
Egg Weight in gm	Contrast	1046.517	2	523.258	25.347	.000
	Error	2621.766	127	20.644		
Albumen weigt in gm	Contrast	121.632	2	60.816	7.536	.001
	Error	1024.869	127	8.070		
Yolk weight in gm	Contrast	290.027	2	145.013	25.750	.000
	Error	715.216	127	5.632		
Shell weight in gm	Contrast	37.838	2	18.919	21.810	.000
	Error	110.164	127	.867		
Yolk_Alb index	Contrast	2818.891	2	1409.446	8.439	.000
	Error	21212.074	127	167.024		

The F tests the effect of Ago-ecologic Location. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

Appendix 8.3. Pictures of different activities during research works

- Chicken ration formulation and Forage supplements



Pictures on how chicken feed was formulated from; Grounded corn, Soybean, Noug-cake, Limestone, Pre-mixes, Salt and wheat.



Pictures of Alfalfa Forage and Alfalfa Hay prepared for chicken feed supplement



Hydroponic fodder of Barley malt prepared for chicken green feed supplement