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**ADDIS ABABA UNIVERSITY**

**COLLEGE OF VETERINARY MEDICINE AND AGRICULTURE**

**DEPARTMENT OF MICROBIOLOGY, PARASITOLOGY AND POULTRY  
HEALTH**



**COMPARATIVE EVALUATION OF KOEKEOK, IMPROVED HORRO AND  
DZ WHITE CHICKEN BREEDS FOR DIFFERENT TRAITS OF GROWTH  
PERFORMANCE FROM THE DAY-OLD TO AGE AT FIRST EGG-LAYING  
AT HOLETTA RESEARCH CENTER, ETHIOPIA**

**M. Sc. THESIS**

**BY**

**ZENEBECH LEMMA**

**JUNE, 2025**

**BISHOFTU, ETHIOPIA**

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DZ WHITE CHICKEN BREEDS FOR DIFFERENT TRAITS OF GROWTH  
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**A Thesis Submitted to College of Veterinary Medicine and Agriculture of Addis  
Ababa University in Partial Fulfilment of the Requirements for the degree of  
Master of Science in Poultry Health and Management**

**By**

**Zenebech Lemma**

**June, 2025**

**Bishoftu, Ethiopia**

**ADDIS ABABA UNIVERSITY**  
**COLLEGE OF VETERINARY MEDICINE AND AGRICULTURE**  
**DEPARTMENT OF MICROBIOLOGY, PARASTIOLOGY AND POULTRY**  
**HEALTH STUDIES**

As MSc research advisors, we hereby certify that we have read and evaluated this thesis prepared under our guidance by Zenebech Lemma Demissie title, **Comparative Evaluation of Koekoek, Improved Horro and DZ White Chicken Breeds for Different Traits of Growth Performance from the Day-old to Age at First Laying at Holetta Research Centre, Ethiopia**. We recommended that it can be submitted as fulfilling the MSc thesis requirement.

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## **DEDICATION**

This manuscript is dedicated to my lovely kids Nathanem Kefale and Yohanan Kefale, and my beloved husband for nursing me with affection and love and, for my dedicated parenthood in the success of my life.

## **STATEMENT OF THE AUTHORES**

First, I declare that this thesis is my bonafide work and that all source of material used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfilment of the requirements for an advanced MSc degree at Addis Ababa University, college of Veterinary Medicine and Agriculture and is deposited at the university library to be made available to borrowers under rules of the library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of academic degree, diploma or certificate. Brief quotations from this thesis are allowable without special permission provided that accurate acknowledgment of source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or part may be granted by the head of the major department or the dean of the college when in his or her judgement the proposed use of the material is in the interest of scholarship, in all other instances, however permission must be obtained from the author.

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## TABLE OF CONTENTS

<b>DEDICATION.....</b>	<b>V</b>
<b>STATEMENT OF THE AUTHORES .....</b>	<b>VI</b>
<b>BIBLOGRAPHICAL SKETCK.....</b>	<b>VII</b>
<b>ACKNOWLWDGMENT .....</b>	<b>VIII</b>
<b>LIST OF TABLES .....</b>	<b>XI</b>
<b>LIST OF FIGURES .....</b>	<b>XII</b>
<b>LIST OF ABBREVIATIONS .....</b>	<b>XIII</b>
<b>LIST OF APPENDICE.....</b>	<b>XIV</b>
<b>1. INTRODUCTION .....</b>	<b>1</b>
<b>2. LITRATURE REVIEW .....</b>	<b>5</b>
<b>2.1. EXOTIC POULTRY BREEDS IN ETHIOPIA .....</b>	<b>5</b>
2.1.1. <i>Commercial layers</i> .....	6
2.1.2. <i>Dual purpose breeds</i> .....	6
2.1.3. <i>Crossbred/hybrid</i> .....	7
<b>2.2. THE INDIGENOUS CHICKEN BREEDS.....</b>	<b>8</b>
<b>2.3. IMPROVED ETHIOPIAN CHICKEN BREEDS .....</b>	<b>9</b>
2.3.1. <i>DZ White chicken breed</i> .....	10
2.3.2. <i>Improved Horro chicken</i> .....	13
<b>2.4. ENVIRONMENTAL SITUATIONS FOR CHICKENS .....</b>	<b>18</b>
<b>2.5. FEED REQUIREMENTS OF CHICKENS .....</b>	<b>19</b>
<b>2.6. GROWTH PERFORMANCE OF DIFFERENT CHICKEN BREEDS.....</b>	<b>20</b>
<b>2.7. PRODUCTION PERFORMANCE OF DIFFERENT CHICKEN BREEDS .....</b>	<b>20</b>
<b>2.8. REPRODUCTIVE PERFORMANCES OF DIFFERENT CHICKEN BREEDS .....</b>	<b>21</b>
<b>2.9. MORTALITY RATE OF DIFFERENT CHICKEN BREEDS.....</b>	<b>22</b>
<b>3. MATERIALS AND METHODS .....</b>	<b>24</b>
<b>3.1. STUDY LOCATION .....</b>	<b>24</b>
<b>3.2. EXPERIMENTAL CHICKENS AND MANAGERMENTS .....</b>	<b>24</b>
<b>3.3. PREPARATION OF EXPERIMENTAL HOUSE AND EQUIPMENT.....</b>	<b>25</b>

<b>3.4. DATA COLLECTION AND MEASUREMENT .....</b>	<b>25</b>
<b>3.4.1. Feed intake and Feed conversion ratio: .....</b>	<b>25</b>
<b>3.4.2. Body weight and body weight gain .....</b>	<b>25</b>
<b>3.4.3. Age at sexual maturity (age at first egg laying).....</b>	<b>26</b>
TABLE OF CONTENTS (Continued.....)	
<b>3.4.4. Mortality rate .....</b>	<b>26</b>
<b>3.4.5. Egg weight at first laying .....</b>	<b>26</b>
<b>3.5. EXPERIMENTAL DESIGN .....</b>	<b>27</b>
<b>3.6. DATA MANAGEMENT AND STATISTICAL ANALYSIS .....</b>	<b>27</b>
<b>4. RESULTS .....</b>	<b>28</b>
<b>4.1. COMPARATIVE EVALUATION OF GROWTH PERFORMANCES.....</b>	<b>28</b>
<b>4.1.1. Body Weight and Weight Gain.....</b>	<b>28</b>
<b>4.1.2. Feed intake and feed conversion ratio.....</b>	<b>32</b>
<b>4.2. MORTALITY RATE .....</b>	<b>36</b>
<b>4.3. REPRODUCTIVE AND PRODUCTIVE PERFORMANCES .....</b>	<b>36</b>
<b>5. DISCUSSION.....</b>	<b>38</b>
<b>5.1. GROWTH PERFORMANCES AND FEED INTAKE .....</b>	<b>38</b>
<b>5.1.1. Body weight of experimental chickens.....</b>	<b>38</b>
<b>5.1.2. Body weight gain.....</b>	<b>41</b>
<b>5.1.3. Feed intake.....</b>	<b>42</b>
<b>5.1.4. Feed conversion ratio .....</b>	<b>44</b>
<b>5.2. MORTALITY RATE .....</b>	<b>44</b>
<b>5.3. AGE AT FIRST LAYING.....</b>	<b>45</b>
<b>5.4. EGG WEIGHT .....</b>	<b>47</b>
<b>6. CONCLUSIONS AND RECOMMENDATIONS .....</b>	<b>48</b>
<b>6.1. CONCLUSIONS .....</b>	<b>48</b>
<b>6.2. RECOMMENDATIONS .....</b>	<b>48</b>
<b>7. REFERENCE.....</b>	<b>49</b>
<b>8. APPENDIX.....</b>	<b>60</b>

## LIST OF TABLES

Table 1. Performances of DZ White chicken breed in different generations and at different on station evaluation .....	11
Table 2. Performances of Improved Horro in different generation and at different on station evaluation .....	15
Table 3. Productive performances of some chicken breeds.....	21
Table 4. Mortality rate of some chicken breeds in different production environment	23
Table 5. Experimental design arrangements and chicken breeds .....	27
Table 6. Effects of chicken genotype on body weight and daily weight gain during brooding stage, 0-8 weeks (Mean + SE).....	29
Table 7. Effect of chicken breeds on body weight and daily weight gain during grower stage, 9-18 weeks (Mean + SE) .....	31
<b>Table 8.</b> Effects of chicken breeds on feed intake and feed conversion ratio during brooder stage, 0-8 weeks (Mean + SE).....	33
Table 9. Effects of chicken breed on feed intake and feed conversion ratio during grower stage, 9-18 weeks (Mean + SE).....	34
<b>Table 10.</b> Overall growth performance, feed intake, feed conversion efficiency and mortality rate of different chicken breeds, 0-18 weeks (Mean + SE).....	36
Table 11. Effect of breed on age at first laying and egg weight (Mean + SE) .....	37

## LIST OF FIGURES

<b>Figure 1.</b> Trends of body weight during brooder stage (0-8).....	29
<b>Figure 2.</b> Trends of body weight during grower stage .....	30
Figure 3. Trends of body weight gain during brooder stage .....	30
Figure 4. Trends of body weight gain during grower stage (8-18 weeks).....	32
Figure 5. Trends of feed intake during brooder stage (0-8 weeks).....	33
Figure 6. Trends of feed intake during grower stage .....	34
Figure 7. Trends of FCR during brooder stage (0-8 weeks) .....	35
Figure 8. Trends of FCR during grower stage (8-18 weeks) .....	35

## LIST OF ABBREVIATIONS

CF	Crude Fiber
CP	Crud Protein
DM	Dry Matter
DZARC	Debre Zeyit Agricultural Research Centre
DZ White	Debre Zeyit White
EE	Ether Extract
FCR	Feed Conversion Ratio
HARC	Holetta Agricultural Research Centre
IH	Improved Horro
KK	Koekoek
PLC	Private Limited Company
SAS	Statistical Analysis System

## LIST OF APPENDICE

Appendix 1. ANOVA table for growth of chicks 0-8 weeks of age.....	60
Appendix 2. ANOVA table for growth of chicks 9-18 weeks of age.....	60
Appendix 3. ANOVA table for daily weight gain of chicks 0-8 weeks of age .....	60
Appendix 4. ANOVA table for daily weight gain of chicks 9-18 weeks of age .....	60
Appendix 5. ANOVA table for daily feed intake of chicks 0-8 weeks of age .....	60
Appendix 6. ANOVA table for daily feed intake of chicks 9-18 weeks of age .....	61
Appendix 7. ANOVA table for FRC of chicks 0-8 weeks of age.....	61
Appendix 8. ANOVA table for FRC of chicks 9-18 weeks of age.....	61

**COMPARATIVE EVALUATION OF KOEKEOK, IMPROVED HORRO AND DZ WHITE CHICKEN BREEDS FOR DIFFERENT TRAITS OF GROWTH PERFORMANCE FROM THE DAY-OLD TO AGE AT FIRST EGG-LAYING AT HOLETTA RESEARCH CENTER, ETHIOPIA**

**ABSTRACT**

*Genetic improvement of indigenous Horro and synthetic breed development of DZ White chicken breeds have been undertaken since 2008 at DZARC. The progenies of these breeds at different generations have been evaluated in different areas under different farming systems and management conditions. Through continuous selection and improvement, the generations of the breeds are now reached 17<sup>th</sup> and 14<sup>th</sup> for Improved Horro (IH) and Debre Zeyit (DZ) White parent stocks, respectively. Therefore, this study was designed to evaluate the growth and early reproductive performances of recent generations of DZ White and IH breeds compared with Koekoek (KK) breed during the different weeks of age. This study was undertaken at HARC poultry research farm. A total of 270 day old chicks, 90 from each breed obtained from DZARC were used for the experimental study. The three breeds were distributed randomly in three pens with three replications using CRD design. Data on feed intake, body weight, body weight gain, feed conversion efficiency, mortality rate, age at first laying as well as egg weight at first laying parameters were collected, analysed and interpreted. The GLM procedure of SAS 2004 version 9.0 was used to analyse the data. Linear model that breeds, replication and age in weeks were fitted as independent variable except for replication for age at first laying and egg weight at first laying. On the other hand, feed intake, body weight, body weight gain, feed conversion efficiency, mortality rate and age at first laying were assumed as dependent variables. The results showed that there was significant difference ( $p < 0.05$ ) between breeds on feed intake, body weight, daily weight gain and age at first laying traits at different growth stage. Feed intake and body weight were increased as age in week increases. The highest total body weight gain was recorded by Koekoek ( $1562.8 \pm 0.00\text{g}$ ) followed by DZ White breed ( $1544 \pm 0.00\text{g}$ ) and ( $1200 \pm 0.00\text{g}$ ) IH for the entire study period. The highest body weight (1603g) was recorded by KK and followed by DZ White (1585.13g) and IH (1239g) at the end of the experimental period. Analysis of variance showed that highest daily weight gain was observed during 16-18 weeks of age for all breed. Keokeok breed gained slightly higher weight as compared to DZ White and, IH recorded the lowest weight gain.*

*Improved Horro was the highest (1.84) overall feed conversion ratio followed by Koekoek (1.66) and DZ White breeds (1.65). The DZ White breed recorded significantly ( $P < 0.0001$ ) take lower days (129 and 133 days) to reach 5% and 10% age at first egg laying and followed by IH (136 and 140 days) and KK breeds (140 and 142 days). The DZ White breed produced heavier egg weight of 39.58g, 42.9g and 46g at first, 5% and 10% egg laying periods, respectively. This study revealed that all the three experimental breeds were grow faster, achieved better body weight gain, better feed intake and conversion efficiency, and reached early for age at first egg laying period. In conclusion, further research should be undertaken to evaluate the production and reproductive parameters of the three breeds at the later age, as well as on farm evaluation condition should be executed to promote these improved synthetic breeds under small holder farmers.*

Keywords: Age at first laying, Body weight gain, DZ White, Growth performance, Holetta, Improved Horro

## 1. INTRODUCTION

Poultry production is the most economic and easiest means of bridging the supply-demand gap of animal protein, due to their rapid growth rate and superior feed conversion (Zipporah, 2019). Chickens are good converters of feed into usable protein in the form of meat and eggs (Abanikanda *et al.*, 2007). Particularly, eggs are low cost high-quality protein food and contain essential vitamins and minerals (Mwaniki *et al.*, 2015). It is a suitable business for poor households due to the small quantity of land needed and low investment costs required to start up and run the operation (FAO, 2019). Poultry in general have short generation interval and high rate of productivity, they can also be transported with easy to different areas are relatively affordable and consumed by the rural people compared to other animals. Poultry is definitely known as livestock of the poor (Guèye, 2005) and as the production is part of most smallholder farming systems. Some scholars mentioned that in most developing countries as a result of the population growth and landlessness, poultry production has become the investment of choice due to its low land requirements (Permin *et al.*, 2001; Nduthu, 2015).

Like other many developing countries, chickens are widely kept in Ethiopia (Halima *et al.*, 2006) mostly in the backyard poultry production and this is significantly contributed to the national economy in general and the rural economy in particular. It plays important role in terms of generating employment opportunities, improving family nutrition by providing affordable protein and empowering women (Abraham and Yayneshet, 2010; Tamir *et al.*, 2015). The Ethiopian poultry population is estimated to be 58 million, which consists of indigenous (88.19%), exotic (5.36%), and hybrid (6.45%) (CSA, 2018). These statistical values shows that the most dominant chicken types reared are local ecotypes, which show a large variation in body colour, comb type and productivity. The genetic potential of the indigenous chickens is under exploited and these chickens are important reservoirs of genomes which may be used in the future to produce hybrid chickens.

The village or backyard chicken's production system is dominated by the indigenous chickens which possess desirable characters such as better egg and meat flavour, hard

eggshell, and high dressing percentage (Abdelqader *et al.*, 2007). However, they are very poor in egg production that is 34-80 eggs annually per hen on average with a very small size egg of about 45g (Nigussie, 2011; Melkamu and Andargie, 2013). Consequently, Ethiopia is frequently importing hybrid commercial chicken breeds in an effort to enhance growth and egg production potential (Aman *et al.*, 2017). For instance, many exotic chickens, Rhode Island Red, Australoup, New Hampshire, White Leghorns, Fayoumi, Koekoek, Kuroiler, Sasso, Bovans browns, Issa brown, Babcock, Cornish and Light Sussex were imported to the country long years ago (Solomon, 2007; Nigussie, 2011; Tesfa and Usman, 2018). However, they demanded high feed, veterinary care, energy cost and poorly adapted to the low-input chicken management systems that dominate the rural area of the country. Only few exotic chicken breeds are surviving well and have better performances in the country. These may be due to dissemination of inappropriate technologies without understanding of production environments under which indigenous chickens are kept and lack of information on breeding objectives and farmers' trait preferences (Nigussie *et al.*, 2010).

Indigenous chicken genotypes have a better adaptability to the low input scavenging/semi scavenging system; despite producing fewer eggs and growing more slowly (Wondmeneh, 2015). Selection of the indigenous chickens improves their productivity (Halima, 2007) although the progress is slow. The genetic potential of the local chicken could be improved by crossing them with selected, but still robust exotic breeds (Wondmeneh, 2015). Currently, the indigenous Horro has been a subject of improvement through selective breeding for live body weight and egg number in the past. Promising results have been registered through selective breeding of the breed, but it still requires a long period of time to put it on a level ground with the performance of improved exotic breeds. On the other hand, improved exotic chickens yield a higher number of eggs and more meat than indigenous chicken ecotypes, but the major challenge is a tropical climate. They are not suited or adapted to harsh environmental conditions such as high temperature, disease and shortage of feeds (Ali *et al.*, 2000; Islam and Nishibori, 2009).

Recognizing the great contributions of poultry in changing the lives of low-income people, the Ethiopian government has been exerting many efforts to improve the

sector and plans to raise chicken egg and meat respectively to 9 billion and 240 metric tons in 2025/26 GC. To achieve this plan, the government is encouraging private owners and government organizations to invest on chicken production. The selection of pure line indigenous chicken, development of local adaptive exotic chicken and synthetic breeding to produce dual purpose chicken breeds for family production systems is crucial to solve the shortage of productive chicken breeds in addition to introducing, evaluating and identifying high-performance exotic breeds that can adapt to Ethiopia's extensive management conditions. Currently, the Debre Zeyit Agricultural research Center (DZARC) has been improving the indigenous Horro chicken through pure line selection. According to Wondmeneh *et al.* (2016) the breeding program of the indigenous Horro chicken at the DZARC successfully increased egg production by 123 percent and body weight by 95 percent during the first 8 generations. The centre also designed a breeding programme since 2009 to develop a synthetic breed named as DZ-white. The name DZ-white is to re-call the center Debre Zeyit and white is to refer the feather colour and have been synthesized from Lohman Silver, Koekoek and Rhode Island White (RIW) line. The main purpose of crossing these chickens was to develop breeds for the semi-intensive or the suboptimal production system for contributing to the improvement of living conditions of Ethiopian women and youth farmers.

The Horro and DZ White synthetic breed development works are part of an on-going project to produce more productive chicken type through pure line selection and cross breeding schemes. The improved Horro and DZ-white in the breeding program has made tremendous progress within ongoing evaluations made at DZARC for more than 10 Improved Horro (IH) and 8 DZ-white generations. The performances of 10<sup>th</sup> Improved Horro and 5<sup>th</sup> DZ White generations have also been tested around Debre Berhan, Melka Werer and Mekelle, at on station and on farm levels (Samrawit, 2020). Moreover, the 11<sup>th</sup> Improved Horro and 9<sup>th</sup> DZ White generations were evaluated and documented in western Ethiopia, Nekemte (Hundie *et al.*, 2022). Nevertheless, the evaluation of these improved Horro and/or DZ-white chickens is limited to specific agro ecological zones across the country, necessitating additional research to obtain accurate performance data on the breeds as their generation progresses. Furthermore, due to on-going selection of Horro and DZ White associated with the environmental dynamics, the phenotypic performances of recent generations of these improved

breeds should be evaluated and documented out of their experimental location. Thus, the aim of this study was to evaluate the growth performance of the two improved chicken breeds from the day-old to the age of sexual maturity in comparison to earlier introduced Koekoek, an ancestor of improved/synthetic DZ White breed in the cool tropical highland of Ethiopia under on station research condition.

Specific objectives;

- To evaluate the growth performances of Improved Horro, DZ White and Koekoek chickens.
- To evaluate the early productive and reproductive performances of Improved Horro, DZ White and Koekoek chickens.

## **2. LITRATURE REVIEW**

There are three main categories of chicken breeds: pure commercial breeds, hybrid breeds resulting from cross-breeding and local breeds or land races. However, among the three chicken breed types indigenous chickens are dominant having large population size. While those of exotics are insignificant in number in Ethiopia. The commercial, hybrid and local breeds can be reared into the three major production systems (large scale commercial, small scale commercial and village/backyard) based on some selected parameters such as breed, flock size, housing, feeding, health, technology, biosecurity and other input levels in the country.

### **2.1. Exotic Poultry Breeds in Ethiopia**

Modern specialized breeds and lines have been developed since 1950s in developed countries to increase production in one or a few major traits. These modern specialised breeds are exotic breeds genetically possess fast growth rates and better egg production potentials but are susceptible to a number of potential diseases that plague the industry today (Onwurah and Nodu, 2006). Thus, these exotic chicken breeds are mostly for commercial poultry production system as they are input intensive based. Commercial breeds are either layers or broilers. There are so many types of layers, broilers, dual-purpose and local chicken breeds available in the world and so many breeder companies are producing huge amount of day-old chicks per day for their customers (Dawud, 2019).

The commercial poultry breeds are used primarily for egg, meat or for both productions in large scale commercial and small-scale commercial poultry production systems. Currently, highly productive exotic breeds such as Rhode Island Red, Australorp, New Hampshire, and White Leghorns are well known and being kept in backyard chicken production systems with certain inputs. Most of the time, the eggs of the parent stock are imported. Then the generations are used for their egg production while the parent stock is used for hatchery purposes. Other breeds such as Bovans Brown, Issa Brown, Fayoumi, Koekoek, Sasso, Red barred, Lohmann Dual, Novo Color, Lohmann Brown, Dominant Sussex, and Novo Brown are currently available in the country.

### 2.1.1. Commercial layers

These breeds are used primarily for egg production. Most of the time, the eggs of the parent stock are imported. Then the generations are used for their egg production while the parent stock is used for hatchery purposes. Exotic poultry breeds (Rhode Island Red, New Hemisphere, White Leghorn, Bovans Brown and Isa brown) are listed as some of commercial layer breeds introduced to Ethiopia to increase egg production and productivity. Currently there are just three breeds (White Leghorn, Bovans Brown and Issa Brown) are used for egg production (USAID, 2012).

### 2.1.2. Dual purpose breeds

Broilers are chicken breed raised specifically for meat production in the modern commercial poultry production system. Broilers are specially bred for large scale, efficient meat production and grow much faster than egg laying hens or traditional dual-purpose breeds. They are noted for having very fast growth rates, a high feed conversion ratio, and low levels of activity. Babcock is the chicken breed that is currently imported in Ethiopia and used for fattening purpose (McKay, 2008). Additionally, there are chicken breed that is imported to Ethiopia from Egypt namely Fayoumi breed. The Fayoumi breeds were less susceptible to avian leucosis complex. The Fayoumi breed had also been imported to Ethiopia with the expectation of better productivity performance, adaptation and disease resistance than the other exotic breeds (Wilson, 2010). As they are known for their best adaptability in the harsh, hot and arid environment of Egypt, they have been testing their performance in lowlands of Ethiopia by Ethiopian Institute of Agriculture Research. Furthermore, the extension department of the Ministry of Agriculture of Ethiopia had preferred Rhode Island Red breed that could be serving as a dual-purpose for both egg and meat production. Sasso and Koekoek were repeatedly reported as dual-purpose chicken breeds. However, these breeds are being used for egg production more than meat production. In most rural areas, farmers Favor a breed that combines both growth and egg production traits. Iraqi *et al.* (2005) described dual-purpose chickens as breeds that give reasonable numbers of meat and eggs in the rural area.

### 2.1.3. *Crossbred/hybrid*

Hybrids or crossbreds result from combining special lines or strains of chickens developed for this purpose. The aim is to combine the adaptive attributes of the local with the high producing abilities of the exotic chickens. The commercial poultry industry widely used crossbreeding to exploit the complementarity of different breeds or strains and make use of heterosis (Simm, 1998). Dual-purpose crossbreds from commercial cocks and indigenous hens in Ethiopia can best perform in village poultry production systems because the crossbreds benefit from the adaptation trait from scavenging birds (Bekele *et al.*, 2010).

Crossbreeding between commercial cocks and indigenous hens may provide a way to produce productive dual-purpose chickens that can cope with harsh environments. The two exotic chicken breeds (Fayoumi and Rhode Island Red) as dam line and the two indigenous chicken breeds (Naked neck and local Netch; a white feathered chicken) are good examples to produce crossbred/hybrid in Ethiopia. The indigenous breeds were used as sire line to produce the hybrids Fayoumi x Necked neck and Rhode Island Red X White feather chicken. Growth and egg production performance of the crosses were compared with each other and with the exotic pure line performance (Fasil *et al.*, 2010). Additionally, a local breed, Horro crossed with exotic breed fayoumi was reported to perform well even under extensive chicken management condition (Matiwos *et al.*, 2013). Crossbreeding can be overcome the negatively correlated traits (growth and egg production) in which may happen during within breed selection.

Recently, an ongoing crossbreeding experiment is being conducted with the objective of producing dual purpose synthetic chicken for village poultry production in Ethiopia. In the mid-2000s, DZARC introduced the Lohman Silver and Koekoek breeds. Then the genetic improvement program has been initiated by the national poultry research institute to improve the productivity of local chickens through selective breeding in order to improve the livelihood of people along with conserve the existing genetic diversity (Nigussie *et al.*, 2010). The Lohman Silver did not adapt to the village production system while Koekoek performed well in several villages (Wondmeneh *et al.*, 2016). The Potchefstroom Koekoek chicken breed is a composite

breed of the White Leghorn, Black Australorp and Bared Plymouth Rock bred at the Potchefstroom agricultural college, in South Africa during the 1950's.

## **2.2.The Indigenous Chicken Breeds**

The indigenous chickens are widely distributed across the world, and they are held under a variety of economic regimes, as well as agro-ecological zones and production systems. In the tropics specially in Africa, there are few breeds that have been properly described, and most indigenous chickens lack unique phenotypic pattern that can be distinguished by one or more features such as a naked neck or feather colour. In Ethiopia, less than 5% of local birds are internationally recognized breeds (Wilson, 2010). In most of the time, local chickens are chosen for adaptation and disease tolerance rather than for increased production (Hoffmann, 2005). There are indications to show that the indigenous breed performance may be improved genetically. However, they cannot compete under optimized conditions with highly selected commercial hybrids. There are number of indigenous chicken breeds with unique genetic characteristics that could be used to boost local chicken productivity. The Naked Neck strain and fayoumi breed are well-known among these chicken breeds for its superior performance and has been extensively selected for increased egg production.

In Ethiopia, the bulk of poultry raised is indigenous ecotypes, which display a large difference in body position, comb type, plumage color, and productivity (Belay *et al.* 2018). Indigenous chickens lack phenotypic standard, and their names were given based on their plumage colors called as Tukor, Gebsuma, and Netch (Bogale,2008). According to Tadelle (2003) and Nigussie (2011) local chickens are named as Farta, Konso, Mandura, Horro, and Sheka, and Tilili, Horro, Chefe, Jarso and Tepi respectively, based on their agro ecological area of distribution. Their distributions indicated their adaptive potential to different environmental conditions, diseases and other stresses (Halima, 2007). These indigenous chickens had a lot of conserved traits that fit to cultural, socio economic and environmental condition of the areas Reta (2009).

Most of the chickens kept by smallholder farmers are unimproved indigenous flocks, well-adapted to the local environments but having slow growth rates and very poor

egg productivity. Generally, to say that they are poor in their reproductive and productive performance (Nigussie, 2011). Efforts to develop high yielding indigenous chicken breeds are still insufficient (FAO. 2019). The breeding program involving indigenous or local breeds should identify alternative breeding goals and capitalize on the breed's specific attribute. The breeding goal would be to improve the efficiency of indigenous population raised under village conditions. This implies improving performance, reproduction capacity and liveability or survival (Besbes, 2009). However, breeding programs for indigenous chickens in Africa and around the world are very few.

### **2.3.Improved Ethiopian Chicken Breeds**

The past genetic improvement efforts of the Ethiopian village chicken via exotic chicken extension were constrained by lack of comprehensive poultry technology package and extension to the end users (Nigussie *et al.*, 2010). The agricultural extension services and efforts exerted on chicken breed improvement activities were not participatory. Adoption of improved poultry production practices may involve the transfer of appropriate new technologies and local experiences to be used in improving productivity of the stocks. The high cost of commercial poultry feed also discourages farmers from supplementing local chicken with commercial chicken feed supplements. For example, a study by Tadelle and Ogle (1996) in the central highlands of Ethiopia demonstrated that the introduction of exotic breeds in different study villages at various times and in different forms (*viz.* through the introduction of cockerels, pullets or fertile eggs) has minimal impact in upgrading the genetic status of village stock. Because parallel improvement in feeding, housing and health care were not implemented. Then after, these approaches have had ill effect because of reducing the brooding ability of local hens, reducing adaptation to low input feeding system and endangering the genetic base of indigenous chicken population due to the extensive and random distribution of exotic chicken breeds, as genetic dilution in indigenous poultry has been faster and wider due to their shorter generation interval (Tadelle *et al.*, 1999).

Currently, one of the extension options to attempt is the use of full packages jointly with improved exotic breeds that are better in terms of productivity. So far, other alternatives have been implementing like producing own synthetic breed and improve

the indigenous chickens targeted to increasing growth and productivity of chicken in the adapted local environment through within selection and/or up grading with exotic breeds.

### *2.3.1. DZ White chicken breed*

DZ-white is a synthetic breed developed in 2009 at Debre Zeyit Agricultural Research Cener, Ethiopia. DZ-white has been synthesized from Lohman silver, Koekoek and Rhode Island White (RIW) lines (Wondmeneh *et al.*, 2016). The main purpose of crossing DZ-white chickens was to develop breeds for the semi-intensive or the substandard production system for contributing to the improvement of living conditions of Ethiopian women and youth farmers. This is an ongoing project and to produce a continuous synthetic chicken population through crossbreeding scheme. The DZ-white obtained in the breeding program has made tremendous progress within ongoing evaluations made at DZARC for continuous generations. Apart from the on-station performance, the DZ White synthetic chicken shows outstanding growth, survival and production performances in different agroecology in Ethiopia at on station and on farm levels (Mulugeta *et al.*, 2020; Samrawit, 2020; Hundie *et al.*, 2022).

**Table 1.** Performances of DZ White chicken breed in different generations and at different on station evaluation

Generation	Parameters					Location	Reference	
	Growth/g 8,16 52weeks	at and	Survival/mortality rate %	Body weight gain/g	Feed conversion ratio	Age at first laying (days)		
5 <sup>th</sup> generation		Mortality%						
Initial weight	34.9±0.2						D/Birhan Samrawit, (2020)	
	35.1±0.2						M/Werer	
	34.9±0.2						Mekele	
0-8 weeks	564.2±12		6.3±0	529.3±12	4.02±0.11		D/Birhan Samrawit, (2020)	
	501.3±7		13.6±5	466.3±6.5	3.73±0.09		M/Werer	
	556.8±6		2.17±2	521.9±5.9	2.56±0.10		Mekele	
8-16 (weeks)	1269.9±5		2.27±1	705.7±11.4	4.73±0.05		D/Birhan Samrawit, (2020)	
	1121.7±5		12.5±5	620.4±39.7	4.76±0.10		M/Werer	
	1166.4±2		1.48±1	609.6±16	4.74±0.13		Mekele	
16-52 (weeks)	1932.0±4		3.01±3	662.1±43.5	4.24±0.43		D/Birhan Samrawit, (2020)	
	1700.7±2		22.4±2	578.9±27.7	4.47±0.26		M/Werer	
	1783.4±2		19.2±5	616.9±29.7	3.77±0.09		Mekele	
Age at first laying (days)						146.3±1.3	D/Birhan Samrawit, (2020)	
						147.7±1.5	M/Werer	
						142.7±2.7	Mekele	
9 <sup>th</sup>		Survival rate %					Average	Feed

<b>generation</b>		daily weight gain/g	conversion efficiency %		
At hatching	28.74			Nekemte	Hundie <i>et al.</i> (2022)
At 8 weeks		97.63		Nekemte	Hundie <i>et al.</i> (2022)
At10 weeks	423.35±24			Nekemte	Hundie <i>et al.</i> (2022)
At12 weeks	520.8±32	6.65 ± 0.44	16.99 ± 2.71	Nekemte	Hundie <i>et al.</i> (2022)
At14 weeks	629.55±38	8.05 ± 0.39	19.09±0.72	Nekemte	Hundie <i>et al.</i> (2022)
At16 weeks	816.85±39	11.55 ± 0.23	19.83±1.62	Nekemte	Hundie <i>et al.</i> (2022)
At18 weeks	901.80±48	11.28±1.86	17.31±1.24	Nekemte	Hundie <i>et al.</i> (2022)
Overall mean		8.69 ± 2.07	17.47±2.79	Nekemte	Hundie <i>et al.</i> (2022)

Note: This growth and production performances review are only for female DZ White chicken

### 2.3.2. *Improved Horro chicken*

Selection for growth and production traits within a given population is the best method to improve the productivity of local chicken (Besbes, 2009). However, due to the slow progress achieved in production traits the uses of selection schemes are limited. The within breed selection of indigenous chickens has the potential to develop a well-adapted, dual-purpose chicken. However, developing a dual-purpose chicken through selective breeding can be difficult because of the negative genetic relationship between the egg and growth traits. The within breed selection was used to genetically improve local chicken in some African countries like Egypt, Nigeria and South Africa. In Ethiopia, the indigenous chicken ecotype, on the other hand, will take three to six years of selection under an intensive management scheme to reach 1.3kg body weight at 16 weeks of age.

The within selection of the Horro indigenous chicken ecotypes began in 2008 at Debrezeit Agricultural Research Centre and has been effective in improvement of egg production and body weight (Wondmeneh, 2015). The Horro is an indigenous chicken type named after the geographic region of origin located in the western part of Ethiopia near the Blue Nile gorge and is more adapted to low management systems. The Horro chicken was considered very low in egg production performance, attributed to their poor genomic potential, and for this reason, efforts have been made to upgrade the poor genetic potential of the breed through pure line selection and crossing to exotic chick strains. The egg production performance of unimproved Horro chicken was  $66.5 \pm 2.5$  eggs per year under improved management system (Wondmeneh *et al.*, 2016) and 34 eggs under scavenging condition.

The performance of the current generation of the improved Horro breed still does not meet the expectations of farmers, but considering the rate of improvement, it is expected that future generations will fulfil the needs of the farmers (Wondmeneh, 2015). The body weight and egg production of the base generation chicken population were 701 (528g) in males (females) and 34 eggs in 6 months after onset of egg laying (Nigussie, 2011). After 6 generations of selection, the egg production was increased to 76 eggs in 6 months after the onset of egg laying and the analysis revealed positive genetic changes over generations (Wondmeneh *et al.*, 2016). Currently, improved Horro breed can produce about  $171 \pm 0.57$  and  $149 \pm 0.88$  eggs per year under on station

and on-farm performance evaluations, respectively. They also added that average egg weight for improved Horro under on station performance is  $52.3 \pm 0.3\text{g}$  (Wondmeneh *et al.*, 2016).

**Table 2.** Performances of Improved Horro in different generation and at different on station evaluation

Generations	Parameters				Location	Reference
	Growth (g) at 8, 16 and 52weeks	Mortality/survival %	Body weight gain/g	Feed conversion efficiency (FCE) %		
<b>Base population</b>	701					
<b>4<sup>th</sup> generation</b>	Body weight					
Week 12	516				DZARC	Wondmeneh (2015)
Week 16	689				DZARC	Wondmeneh (2015)
<b>6<sup>th</sup> generation</b>						
Week 12	572				DZARC	Wondmeneh (2015)
Week 16	1211				DZARC	Wondmeneh (2015)
<b>7<sup>th</sup> generation</b>	Growth /g	survival %		FCR	AFL (days)	
Week 8	428.9±0.9			3±0	DZARC	Wondmeneh (2015)
Week 12	742.7±7.7			3.6±0.03	DZARC	Wondmeneh (2015)
Week 16	873.4±1.9			6±0	DZARC	Wondmeneh (2015)
Week 20	964.2±1.4	98.8±0		12.4±0.01	DZARC	Wondmeneh (2015)

Age at first laying (days) 153±0.3 DZARC Wondmeneh (2015)

10 <sup>st</sup> generation		Mortality %	Feed conversion ratio			
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Initial weight	29.77±0.29				D/Birhan	Samrawit, 2020
	28.75±0.22				M/Werer	
	29.28±0.10				Mekelle	

0-8 weeks or at 8 weeks	479.4±18.8	3.69±1.08	449.59±19	4.17±0.21	D/Birhan	Samrawit, 2020
	444.7±21.7	8.00±2.00	415.9±21	4.11±0.19	M/Werer	
	484.61±4.4	2.38±1.37	455.3±4.4	2.96±0.01	Mekelle	

8-16 weeks or at 16 weeks	1009.7±19.9	2.47±2.47	530.3±33	5.37±0.22	D/Birhan	Samrawit, 2020
	966.3±11.7	22.82±8.3	521.6±33	5.46±0.31	M/Werer	
	1039.6±13.6	3.27±0.80	554.9±13	5.06±0.10	Mekelle	

16-52 weeks or at 52 weeks	1518±9.6	4.28±2.50	508.3±13	5.76±0.09	D/Birhan	Samrawit, 2020
	1492.4±26.6	25.31±3.8	525.7±21	5.84±0.21	M/Werer	
	1518.3±30.3	24.13±1.9	479.1±23	5.27±0.30	Mekelle	

Age at first laying (days)					154.9±2	D/Birhan	Samrawit, 2020
					154.3±2	M/Werer	
					137±1	Mekelle	

11 <sup>th</sup> generation	Growth /g	Survival/%	Daily weight	Feed conversion efficiency/%	Age at first laying	Location	Reference
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	gain/g		(days)			
hatching	28.83				Nekemte	Hundie <i>et al.</i> (2022)
weight						
At 8 weeks	281.87	91.03				Hundie <i>et al.</i> (2022)
At 10 weeks	306.5±22.9				Nekemte	
At 12 weeks	370.6±27.6		4.43±0.2	10.92±0.13	Nekemte	Hundie <i>et al.</i> (2022)
At 14 weeks	449.2±26.4		7.57±0.1	13.67±0.35	Nekemte	Hundie <i>et al.</i> (2022)
At 16 weeks	540.1±27.1		7.73±2.9	12.33±2.45	Nekemte	Hundie <i>et al.</i> (2022)
At 18 weeks	659.8±28.6		8.52±2	13.98±1.76	Nekemte	Hundie <i>et al.</i> (2022)
Overall mean			7.75±2.9	13.56±2.74	Nekemte	Hundie <i>et al.</i> (2022)

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Note: This growth and reproductive performances review are only for female Horro chicken

## 2.4.Environmental Situations for Chickens

Poultres are particularly endangered to climate change due to a range of thermal conditions which affects the birds behavioural and physiological activities (Ayo-Enwerem *et al.*, 2017). The environmental conditions include temperature/heat stress, relative humidity and light can impact on poultry productivity at a given time (Pragya *et al.*, 2014). Significant reduction of egg weight by 3.24%, eggshell thickness by 1.2 %, eggshell weight by 9.93% and eggshell percent by 0.66 % (Ebeid *et al.*, 2012). Environmental temperature can also depress growth rate and production as a result of a down-turn in voluntary feed intake in birds (Sohail *et al.*, 2012).

Temperature is one of the most significant that determine the poultry productivity. High temperature has tremendous effect on prevalence of zoonotic diseases and increase the insect vectors, prolong transmission cycles, increase the importation of vectors and animal reservoirs (Uzoma *et al.*, 2019). Hence, birds can only tolerate narrow range of temperature to sustain the peak of their production for human consumption. For any deviation from the range, they need triggers their thermoregulatory mechanisms for survival which have negative consequence on their performance. The ideal temperature range for poultry production is between 12.8–23.9 °C. At this range the performance is optimum. Temperature between 23.9–29.4 °C, there is a slight reduction in feed consumption and increase in water intake. The birds cope with it with adequate nutrient intake. For example, the ideal temperature in houses of Bovans Brown layers should be around 21 to 24 °C. Negative effects on layer behaviour and production are expected if the ambient temperatures exceed 28 °C (Kirunda, *et al.*, 2001). However, supplementing vitamins A and E in the layer diets would be good results in alleviating the harmful impacts of high ambient temperature (Mohamed *et al.*, 2019). Furthermore, increasing the nutrients density such as limiting amino acids and vitamins is very important to alleviate the deleterious effects of high ambient temperature on feed consumption and metabolic requirements (Habibian *et al.*, 2015).

Generally, high temperature results in reduction of poultry live weight, growth rate and high mortality in addition to a decrease on productivity, hatchability and quality of eggs (Ozbey and Ozcelik, 2004). When the temperature falls below the thermo-neutral zone of 12.8 °C, the egg production and efficiency of laying hens are affected

(Elijah and Adedapo, 2006). During the heat stress period the increase in body temperature has a negative effect on the fertilization process (Karaca *et al.*, 2002). The general reduction in performance of poultry under the influence of heat is attributable mainly to an inability to give off the entire excess heat. The higher an animal's productivity, the higher is its metabolic rate and thus the amount of heat generated. Excessive heat affects the entire organs by disrupting several physiological processes and factors. The balance between heat production and heat loss, and the effect of food intake on this balance are central to the effect of the physical environment on animal performance. The major direct effects of temperature are through maintenance of this balance.

Humidity is another most significant environmental factor that determine performance of poultry birds (Elijah and Adedapo, 2006). The optimum humidity range was found to be between 50-75%, which may vary with breeds. Also, relative humidity level above 75% causes reduction in egg laying (Elijah and Adedapo, 2006). Moreover, the housing environment may affect the performance of birds as well as its wellbeing. Aerial ammonia in poultry houses is usually found to be the most abundant air contaminant. Depending on the temperature, humidity, animal density and ventilation rate, the concentration of ammonia is varied.

## **2.5. Feed Requirements of Chickens**

Different poultry feeds give different results in terms of growth and egg production. To attain the exact quantities of nutrients, it is important to balance the ration of diets (Mohammad *et al.*, 2014). Poultry diets are made primarily from a mixture of several feedstuffs such as cereal grains, soya bean meal, and animal by-product meals, fats and vitamin and mineral premixes (Alimon and Hair-Bejo, 1995). A poultry diet is expected to contain three essential nutrients of protein, vitamins, and minerals as well as provides adequate metabolizable energy (ME). Minerals are needed for formation of the skeletal system, for general health, as components of general metabolic activity, and for maintenance of the body's acid-base balance. Calcium and phosphorus are necessary for the formation and maintenance of the skeletal structure and for good egg-shell quality (Velmurugu, 2017).

Poultry feed and nutrition is one of the most critical constraints to poultry production under both the rural small holder and large-scale systems in Ethiopia. The quality of mixed feed for commercial poultry production is generally poor in Ethiopia. The problem is mainly associated with lack of processing facilities, inconsistent availability and distribution and sub-standard quality of processed feeds, when available (Tadelle *et al.*, 2002). Most formulations available do not have vitamin/mineral premixes. Ingredients and processed feeds vary in nutritive value and there is no regular quality control mechanism in the country. Unavailability of feed quality legislation and laboratory facilities for chemical analysis also contributes greatly to the poor quality of processed feeds (Tadelle *et al.*, 2003). There is no purposeful feeding of chickens under the village conditions in Ethiopia and scavenging is almost the only source of diet. Scavenging feed resource base for local birds are inadequate and variable depending on season.

## **2.6.Growth Performance of Different Chicken Breeds**

Information on growth performance available so far indicates that average weight of local birds to an age of 22 weeks ranged from 1.0 to 1.5 kg in males and from 0.6 to 0.9 kg in females (Halima, 2007). This shows that lower performance of local chickens in terms of growth compared to improved breeds like RIR which weighed on average 1.7 (males) and 1.3 kg (females) under the same age and management regime.

## **2.7.Production Performance of Different Chicken Breeds**

The local chicken breeds in Ethiopia are entirely nondescript breeds showing a great variation in their body size, plumage color and conformation (Tadelle *et al.*, 2000) and generally characterized by poor performance of local chicken in terms of egg production, small egg size, slow growth rate, late maturity, an instinctive inclination to broodiness and high mortality of chicks (Solomon *et al.*, 2013). The annual average egg production performance of these local non descriptive breeds are 30-60 eggs under farmer's management with an average egg weight of 38-46g but under on-station conditions the level of production was increased to 120 eggs per hen per year (Negussie and Ogle, 2000). Other study showed that the total egg production per year of the indigenous Horro chicken breed varied from 45 to 75 eggs and it was greater than the total eggs per year of other breeds in Ada'a Eastern Ethiopia with the values

varying from 45 to 60 eggs (ILRI, 2016). On the other hand, the annual egg production performance of Fayoumi chickens is 144 eggs, which is lower than 185 eggs of Rhode Island Red and 173 eggs of White Leghorn under a smallholder farmer's husbandry system in Northern Ethiopia (Abraham and Yaynesht, 2010). These results are extremely low when compared with production levels of exotic egg type breeds which were observed to produce over 300 eggs/hen/year with an average egg weight of 60g (Dawud, 2019).

Various interventions enhancing indigenous chicken productivity have been attempted in the past including breed substitution, crossbreeding/upgrading, and selection within population. Past attempts to improve the poultry productivity in Ethiopia through the introduction of high performing commercial chickens was not successful. The contribution of commercial chickens in improving the productivity was less than 2% (Tadelle *et al.*, 2000). Earlier study by Brannang and Persson (1990) under research station management local birds have showed poor feed efficiency and survival but it also demonstrated more constant egg production at times of higher environmental temperatures and improved fertility percentage as compared to exotic breeds.

**Table 3.** Productive performances of some chicken breeds

Parameters	Average values	Breed type	Area/location	Sources
Age at first laying	30.8; 31.9; 32.7	Fayoumi, RIR; WL	Northern Ethiopia	Getu <i>et al.</i> (2014)
''	25.33	Horro	Western Oromia	Demissu <i>et al.</i> (2018)
''	25.2; 27.7 and 25.4	Local; exotic; cross	NA	Litigebew <i>et al.</i> , 2021
Hatching weight (g)	27.2, 27.1, 27.9	Tilili, D/Alyas, Gelila, Mecha	NA	Belay <i>et al.</i> (2018)
Egg no./hen/year	173, 185, 144	WLH, RIR, Fayoumi,	NA	Getu <i>et al.</i> (2014)

## 2.8.Reproductive Performances of Different Chicken Breeds

Reproduction is one of the most important aspects of poultry breeding (Abou-Elewa *et al.*, 2017) and it is characterized by parameters, such as, age at sexual maturity (age

at first egg), body weight at first egg, fertility, hatchability, clutch size and clutch length (Addisu, 2013). Among reproduction traits, sexual maturity is paramount in terms of progress in poultry breeding (Chiemela *et al.*, 2018). Age at sexual maturity refers to age at which the reproductive system achieves its complete development and it has long been considered as an important factor that determines fecundity trait and affects subsequent performance (Forment *et al.*, 2009). The age at first egg is also an important economic trait as it has a direct effect on egg production and sexual maturity. Furthermore, body weight at first egg is another important trait that determines the future productive performance of a hen (Aman *et al.*, 2017). Early matured pullets laid their first egg before 136 days, while late pullets matured when they were 152 days of age or more (Amira, 2008). Recent research result revealed that the body weight at first egg and mean age at first egg for Potchefstroom Koekoek was 1100g and 142 days in Areka, Southern Ethiopia (Aman *et al.*, 2017).

## **2.9.Mortality Rate of Different Chicken Breeds**

The Ethiopian indigenous flocks are said to be relatively disease resistant and adapted to their environment. However, survival rates of chicks kept under natural brooding conditions is considered to be very low. Raising indigenous chickens in confinement in Ethiopia also resulted in high morbidities and mortalities (Besbes, 2009). Disease and predators are known to be the major causes of mortality in the country. Many reports showed that Newcastle disease (ND), Infectious Bursal disease (IBD) or Gumboro, Marek disease (MD), Fowl typhoid, Cholera, Mycoplasmosis and Coccidiosis are widely distributed in most African countries, Ethiopia is not exception to this situation (Alem, 2014). Losses attribute to Newcastle disease is estimated at about 57.3% of the overall annual chicken mortality whereas fowl pox, coccidiosis, and predation accounts for about 31.6%, 9.4% and 1.7% of the total annual flock mortality respectively. A survey conducted in Southern Ethiopia identified Fowl cholera followed by New Castle Disease, Coccidiosis, Fowl influenza (Infectious Bronchitis), Fowl pox, Fowl typhoid and Salmonella to be the major poultry diseases respectively.

**Table 4.** Mortality rate of some chicken breeds in different production environment

Breed	Age group	Mortality (%)	Research environment	Sources
DZ White		29.8	On farm	Samrawit (2020)
IH		25.5	On farm	Samrawit (2020)
IH	0-40	0.00-0.09	On station	Shambel (2021)
Koekoek	0-40	0.00-0.2	On station	Shambel (2021)
Kuroiler	0-40	0.00-0.1	On station	Shambel (2021)
Koekoek	0-44	0.46	On station (DZARC)	Dawud (2019)
Koekoek	0-44	0.08	On station (Hawassa)	Dawud (2019)
Koekoek	0-44	0.55	On farm	Dawud (2019)
Koekoek	0-20	1.79-4.47	On station (Haramaya)	Yosef <i>et al.</i> (2022)

### 3. MATERIALS AND METHODS

#### 3.1. Study Location

The study was conducted at Holetta Agricultural Research Center in the compound of poultry research farm unit. Holetta is located in the central highland of Ethiopia at 29km west of Addis Ababa. The study area is situated at 3°24'N to 14°53'N latitude and 33°00'E to 48°00'E longitude with an altitude of 2400 meter above sea level. The average annual rainfall of the study area is 1100mm and average annual temperature is 15°C with minimum 6°C and maximum 24°C respectively. The average monthly relative humidity is 60% (Getahun *et al.*, 2019).

#### 3.2. Experimental Chickens and Managements

Three breeds of chickens (Improved Horro, DZ White and Koekoek) were used for the study. A total of 270 day-old chickens (90 from each genotype) were obtained from a national poultry research centre (Debre Zeyit Agricultural Research Centre/DZARC). The experimental chickens were evaluated for brooder and grower growth performance until age at first egg. The chickens were vaccinated against major poultry viral and bacterial diseases including Marek's disease, Newcastle, and infectious bursal disease (Gumboro) according to the schedule provided by the DZARC. The vaccines were obtained from National Veterinary Institute (Bishoftu, Ethiopia) and administered by professional workers at the center. Routine disease inspection was also undertaken throughout the study period.

Experimental chicken breeds were reared on a deep litter system under the same management condition. They were raised in separate pens according to breeds. Feed and water were offered *ad libitum* for all breeds. The experimental diet was provided twice daily in a group for chickens in each pen. The chickens were fed on identical brooder and grower ration purchased from Alema koudijs feed processing plant. The lighting program is set as recommended for brooder and grower age groups throughout the experiment. The litter material sawdust (5-8cm depth) purchased from local market was used for bedding purpose.

### **3.3.Preparation of Experimental House and Equipment**

Experimental house and pens were prepared and temporarily partitioned into six pens using wire mesh. The experimental pens were carefully cleaned then the floor of all pens was covered by sawdust litter materials. The house was disinfected using biosafe (hydrogen peroxide) before receiving experimental chickens. All pens were installed with two infrared bulbs and necessary watering and feeding troughs were also placed in each experimental pen before chickens received.

### **3.4.Data Collection and Measurement**

The study was conducted to evaluate the breed's traits such as body weight, feed intake, egg weight at first egg lay, body weight gain, feed conversion ratio and mortality which are described as follows:

#### *3.4.1. Feed intake and Feed conversion ratio:*

Feed was weighted and offered twice daily and refusal was collected the next morning and weighed. The offered and refused feeds were recorded for each replication. Feed intake was determined as the difference between the feed offered and refused as follows:

$$\frac{\text{Daily feed offered} - \text{Daily feed refusal}}{\text{Number of chickens in pen}}$$

Feed conversion ratio (FCR) was calculated for all breeds at different age (day-old to age at first egg laying) groups. FCR for brooder (0-8 weeks) and grower (9-18 weeks) chickens were determined by dividing the cumulative feed intake by body weight gain of chickens every one week as follows:

$$\text{Feed conversion ratio(FCR)} = \frac{\text{Average daily feed intake (g)}}{\text{Average daily body weight gain(g)}}$$

#### *3.4.2. Body weight and body weight gain*

Live weight of chickens was measured starting from day-old to age at first egg lay every week. Random representative sample of 5 chickens from each replication from

all breeds were weighted by digital sensitive balance. Two ways of weighting system was followed during this study. During the brooding stage (1-8 weeks of age), 5 chickens from each replication was weighted in a group. In the second phase (grower stage 9-18 weeks), 5 chickens from each replication were weighted individually. Then, the weighted data from each replication was assumed as representative to the whole experimental chicken and average body weight was computed by taking average values for each breed. The live weight was used to calculate body weight gain as follows:

$$\text{Average Daily weight gain (ADG)} = \frac{\text{Body weight gain}}{\text{Number of experimental days}}$$

Weekly body weight gain of the experimental chickens was obtained by the weight difference between two weeks. On the other hand, total body weight gain was calculated by the weight difference between day old weight and the subsequent body weight measured.

#### **3.4.3. Age at sexual maturity (age at first egg laying)**

Ages at sexual maturity was estimated in days from hatching up to the day at which each breed group of pullets reached 5% of egg production (Shafik *et al.*, 2013).

#### **3.4.4. Mortality rate**

The chicken's mortality was recorded every day, and the mortality rate was calculated by using the following formula:

$$\text{Mortality rate} = \frac{\text{Number of dead chickens}}{\text{Total number of chicken at the beginning of the experiment}} \times 100$$

#### **3.4.5. Egg weight at first laying**

A total sample of 60 eggs (15 eggs at first, 15 eggs at 5% and 30 eggs at 10% laying) were randomly selected and individually weighted using an electronic digital sensitive balance. To elaborate more about the sample, 5 eggs during first laying, 5 eggs during 5% laying and 10 eggs during 10% laying from each breed were randomly selected and measured every week until chicken was enough to reach 10% laying age.

### 3.5. Experimental Design

The three genotypes were randomly replicated into three groups each with thirty chickens.

**Table 5.** Experimental design arrangements and chicken breeds

Chicken breeds	Number of replication	Chickens/ Replication	Total chickens
Improved Horro	3	30	90
DZ White	3	30	90
Koekoek	3	30	90

*DZ white; Debre Zeyit White chicken breed*

### 3.6. Data management and Statistical Analysis

Data entry and management were made using Microsoft Excel sheets and imported to SAS for analysis using the GLM procedure of SAS (2004) version 9.0. Duncan's Multiple Range Test was used to determine whether there were any significant differences between the means (Duncan, 1955) at  $\alpha < 0.05$ . In order to estimate body weight and linear body measurements (LBM), the following model is used

The model use for data analysis was:

$$Y_{ij} = \mu + A_i + e_{ijr}$$

Where;  $Y_{ij}$ : the  $j^{\text{th}}$  observation of the  $i^{\text{th}}$  Breed

$\mu$ : the overall mean;

$A_i$ : effects of the  $i^{\text{th}}$  breed (improved Horro, DZ White and Koekoek);

$e_{ijr}$  : random errors

## 4. RESULTS

### 4.1. Comparative Evaluation of Growth Performances

#### 4.1.1. Body Weight and Weight Gain

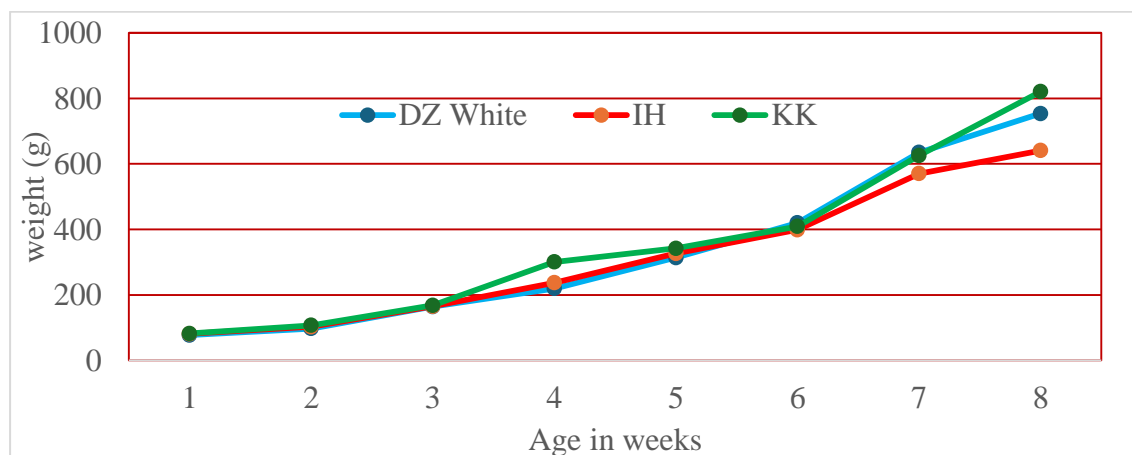
The average day-old and brooder (0-8) chicks body weight is presented in table 6. The result revealed that chicken body weight was significantly influenced by breed/genotype ( $P < 0.0001$ ). The Improved Horro (IH) chicken had significantly recorded lowest body weight at hatching, 7<sup>th</sup> and 8<sup>th</sup> week of age. During the first two weeks and at 5<sup>th</sup> week the DZ White chicken breed recorded the lowest body weight. The Koekoek chickens recorded highest body weight except at 7<sup>th</sup> week whereas the IH recorded the lowest body weight from 6-8 weeks. Trend results of body weight across 0-8 weeks showed successive increment for all genotypes starting from the day old (Figure 1). The overall body weight during the brooder stage was also significantly highest for Koekoek and lowest for Improved Horro breeds.

Chicken genotype had significant effect ( $p < 0.0001$ ) on the daily body weight gain except in the first two weeks (Table 6). The highest body weight gain was recorded in Koekoek (KK) from 2-4 and 6-8 and, the lowest was at 4-6 weeks from the same breed. The DZ White genotype gained the highest weight from 4-6 weeks. The study revealed that the overall body weight gain (0-8 weeks) was significant ( $p < 0.05$ ) among the different chicken genotypes. Trend results for body weight gain (BWG) showed slightly increased throughout the brooder stage for both DZ White and IH chicken breeds. However, the BWG in the first four weeks for KK steeply increased then gradually declined until the 6<sup>th</sup> week and then after it sharply increased (Figure3).

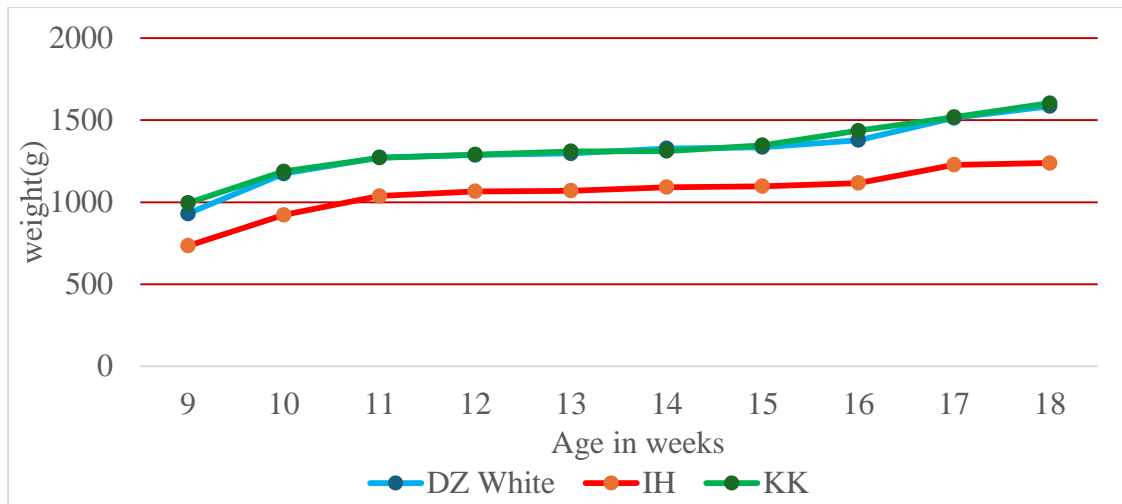
**Table 6.** Effects of chicken genotype on body weight and daily weight gain during brooding stage, 0-8 weeks (Mean  $\pm$  SE)

Age (weeks)	Breed			P-value	SL
	DZ White	IH	KK		
Day-old weight (g)					
	40 $\pm$ 0.00 <sup>a</sup>	38.8 $\pm$ 0.00 <sup>b</sup>	40.5 $\pm$ 0.00 <sup>a</sup>	0.03	*
Body weight (g/bird)					
1	77 $\pm$ 3.00 <sup>c</sup>	80.87 $\pm$ 0.58 <sup>ab</sup>	82.13 $\pm$ 0.99 <sup>a</sup>	0.001	***
2	97.07 $\pm$ 3.09 <sup>c</sup>	102.53 $\pm$ 1.26 <sup>b</sup>	106.8 $\pm$ 1.72 <sup>a</sup>	0.001	***
3	164.23 $\pm$ 4.62 <sup>b</sup>	165.3 $\pm$ 2.59 <sup>ab</sup>	167.8 $\pm$ 1.27 <sup>a</sup>	0.001	***
4	219.37 $\pm$ 9.56 <sup>c</sup>	236.93 $\pm$ 3.22 <sup>b</sup>	300.3 $\pm$ 0.34 <sup>a</sup>	0.0001	***
5	313.53 $\pm$ 2.99 <sup>c</sup>	326.6 $\pm$ 1.53 <sup>b</sup>	341.97 $\pm$ 9.0 <sup>a</sup>	0.0001	***
6	419.63 $\pm$ 3.68 <sup>a</sup>	398.83 $\pm$ 1.17 <sup>b</sup>	409.07 $\pm$ 5.2 <sup>a</sup>	0.001	***
7	634.97 $\pm$ 0.09 <sup>a</sup>	570.33 $\pm$ 0.1 <sup>c</sup>	625.8 $\pm$ 5.73 <sup>b</sup>	0.0001	***
8	753.47 $\pm$ 15.4 <sup>b</sup>	640.8 $\pm$ 9.5 <sup>c</sup>	820.7 $\pm$ 4.33 <sup>a</sup>	0.0001	***
0-8	334.91 $\pm$ 48.86 <sup>b</sup>	315.28 $\pm$ 40.86 <sup>c</sup>	356.82 $\pm$ 50.42 <sup>a</sup>	0.0001	***
Body weight gain (bird/day/g)					
0-2	4.08 $\pm$ 0.03 <sup>a</sup>	4.55 $\pm$ 0.04 <sup>a</sup>	4.74 $\pm$ 0.04 <sup>a</sup>	0.063	ns
2-4	11.59 $\pm$ 0.11 <sup>b</sup>	12.37 $\pm$ 0.11 <sup>b</sup>	16.72 $\pm$ 0.1 <sup>a</sup>	0.001	***
4-6	18.38 $\pm$ 0.30 <sup>a</sup>	16.12 $\pm$ 0.33 <sup>b</sup>	12.50 $\pm$ 0.3 <sup>c</sup>	0.001	***
6-8	35.44 $\pm$ 0.66 <sup>b</sup>	29.65 $\pm$ 0.54 <sup>c</sup>	46.12 $\pm$ 0.86 <sup>a</sup>	0.0001	***
0-8	17.37 $\pm$ 6.69 <sup>a</sup>	15.67 $\pm$ 5.25 <sup>b</sup>	20.02 $\pm$ 9.05 <sup>a</sup>	0.047	*

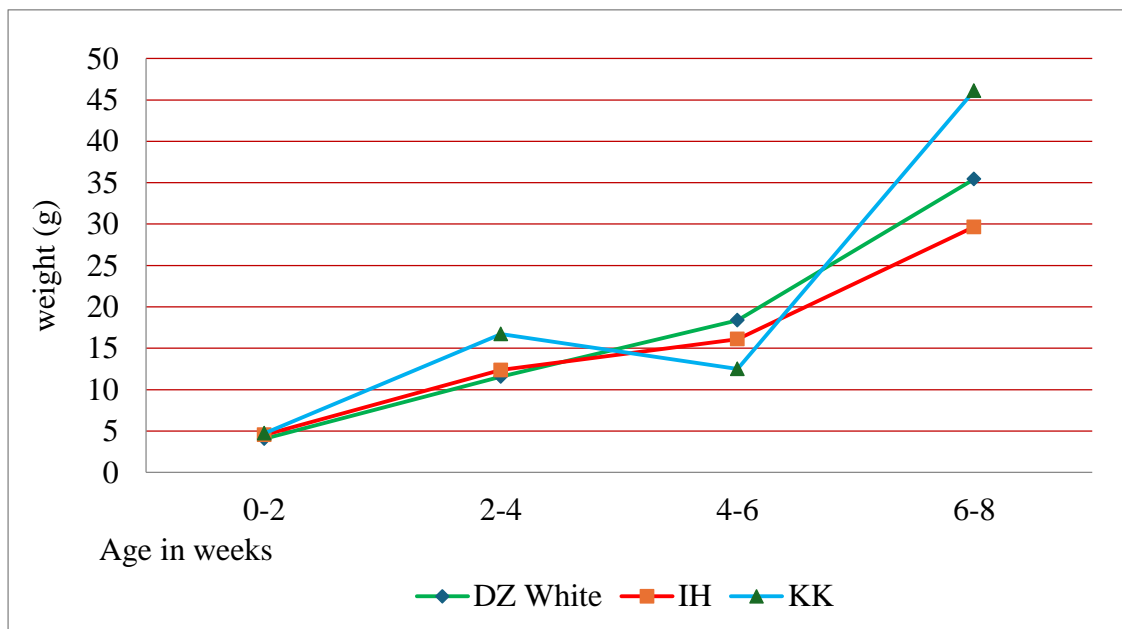
<sup>a, b, c</sup> Means within a row not followed by a common letter between weeks/breeds are significantly different at  $p < 0.05$ ; KK, Koekoek; DZ White, Debre Zeyit White; IH, Improved Horro; SL, Significant Level



**Figure 1.** Trends of body weight during brooder stage (0-8 weeks)



**Figure 2.** Trends of body weight during grower stage (8-18 weeks)



**Figure 3.** Trends of body weight gain during brooder stage (0-8 weeks)

The body weight and body weight gain for grower stage (8-18 weeks) of the study breeds are depicted in table 7. The result showed that IH had recorded significantly the lowest weight during the grower stage of 9-18 weeks. However, no weight variation recorded between KK and DZ White except at 9<sup>th</sup> 16<sup>th</sup> and 18<sup>th</sup> weeks. The overall body weight result during the grower stage (9-18 weeks) was significantly different ( $p < 0.0001$ ) among the experimental breeds and the highest (1327.01g) was recorded for KK and lowest (1060g) was for IH chickens. Trend results of body weight across weeks during the grower stage showed gradual increment from 9 to 18 weeks for all genotypes (Figure 2). The DZ White and KK chicken breeds were showed higher upper line trends and IH showed lower trend line.

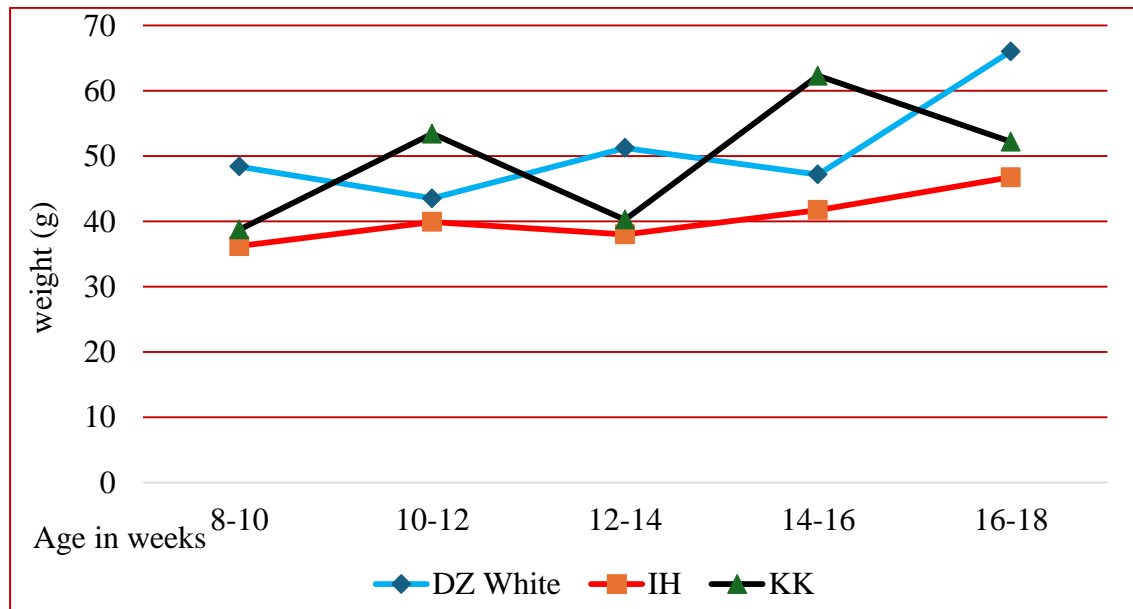
**Table 7.** Effect of chicken breeds on body weight and daily weight gain during grower stage, 9-18 weeks (Mean  $\pm$  SE)

Age (weeks)	Breed			P- value	SL
	DZ White	IH	KK		
Body weight (g/bird)					
9	930.33 $\pm$ 4.2 <sup>b</sup>	734.8 $\pm$ 16.08 <sup>c</sup>	995.73 $\pm$ 8.55 <sup>a</sup>	0.0001	***
10	1174.07 $\pm$ 5.0 <sup>a</sup>	922.27 $\pm$ 11.0 <sup>b</sup>	1188.2 $\pm$ 9.86 <sup>a</sup>	0.0001	***
11	1273.13 $\pm$ 0.2 <sup>a</sup>	1037.87 $\pm$ 0.6 <sup>b</sup>	1271.07 $\pm$ 2.3 <sup>a</sup>	0.0001	***
12	1287.53 $\pm$ 0.7 <sup>a</sup>	1066.3 $\pm$ 3.1 <sup>b</sup>	1290.6 $\pm$ 2.9 <sup>a</sup>	0.0001	***
13	1297.5 $\pm$ 1.32 <sup>a</sup>	1070.23 $\pm$ 3.9 <sup>b</sup>	1309.67 $\pm$ 0.9 <sup>a</sup>	0.0001	***
14	1327.4 $\pm$ 17.9 <sup>a</sup>	1091.43 $\pm$ 8.0 <sup>b</sup>	1311.83 $\pm$ 0.67 <sup>a</sup>	0.0001	***
15	1335.7 $\pm$ 16.1 <sup>a</sup>	1097.57 $\pm$ 5 <sup>b</sup>	1346.67 $\pm$ 26.8 <sup>a</sup>	0.0001	***
16	1378.5 $\pm$ 11.5 <sup>b</sup>	1116.5 $\pm$ 1.7 <sup>c</sup>	1436 $\pm$ 12.66 <sup>a</sup>	0.0001	***
17	1513.33 $\pm$ 4.4 <sup>a</sup>	1228.33 $\pm$ 30. <sup>b</sup>	1519 $\pm$ 38.22 <sup>a</sup>	0.0001	***
18	1585.13 $\pm$ 8.6 <sup>b</sup>	1239 $\pm$ 25.5 <sup>c</sup>	1603.3 $\pm$ 11.9 <sup>a</sup>	0.0001	***
9-18	1310.26 $\pm$ 31.57 <sup>b</sup>	1060.44 $\pm$ 25.97 <sup>c</sup>	1327.21 $\pm$ 30.22 <sup>a</sup>	0.0001	***
Body weight gain/bird/day/g					
8-10	48.42 $\pm$ 0.65 <sup>a</sup>	36.22 $\pm$ 0.59 <sup>b</sup>	38.75 $\pm$ 0.60 <sup>b</sup>	0.001	***
10-12	43.54 $\pm$ 0.49 <sup>b</sup>	39.94 $\pm$ 0.58 <sup>c</sup>	53.43 $\pm$ 0.76 <sup>a</sup>	0.0001	***
12-14	51.27 $\pm$ 0.69 <sup>a</sup>	38.02 $\pm$ 0.46 <sup>c</sup>	40.27 $\pm$ 0.48 <sup>b</sup>	0.0001	***
14-16	47.20 $\pm$ 0.66 <sup>b</sup>	41.74 $\pm$ 0.59 <sup>c</sup>	62.30 $\pm$ 0.76 <sup>a</sup>	0.0001	***
16-18	66.03 $\pm$ 0.77 <sup>a</sup>	46.76 $\pm$ 61 <sup>c</sup>	52.22 $\pm$ 0.64 <sup>b</sup>	0.0001	***
8-18	51.29 $\pm$ 3.88 <sup>a</sup>	40.54 $\pm$ 1.81 <sup>c</sup>	49.40 $\pm$ 4.40 <sup>a</sup>	0.0001	***

<sup>a, b, c</sup> Means within a row not followed by a common letter between weeks/breeds in the different superscript letters are significantly different at  $p < 0.05$ ; KK, Koekoek; DZ White, Debre Zeyit White; IH, Improved Horro; SL, significant Level

The mean values for daily body weight gain during the grower phase is indicated in table 7. There were statistically significant ( $p < 0.0001$ ) variations in body weight gain among chicken genotypes. Moreover, the overall body weight gain (8-18 weeks) was significantly different and the highest was recorded for DZ White. Throughout this stage of growth, lowest body weight gain was noted for IH. The DZ White breed was the highest BWG during the week 8-10, 12-14, 16-18 and overall grower stage whereas the KK breed achieved its highest weight gain during 10-12 and 14-16 weeks of age. During the grower stage (8-18 weeks), body weight showed significant variations, and all genotypes increased body weight as shown in the growth trends (Figure 4). However, IH slightly increased successively throughout the grower stage.

However, KK increased from 8-12 and 14-16 weeks and decreased from week 12-14 and again from 16-18 weeks in a zigzag manner. Similarly, DZ White decreased from 8-12 and 14-16 weeks then sharply increased.



**Figure 4.** Trends of body weight gain during grower stage (8-18 weeks)

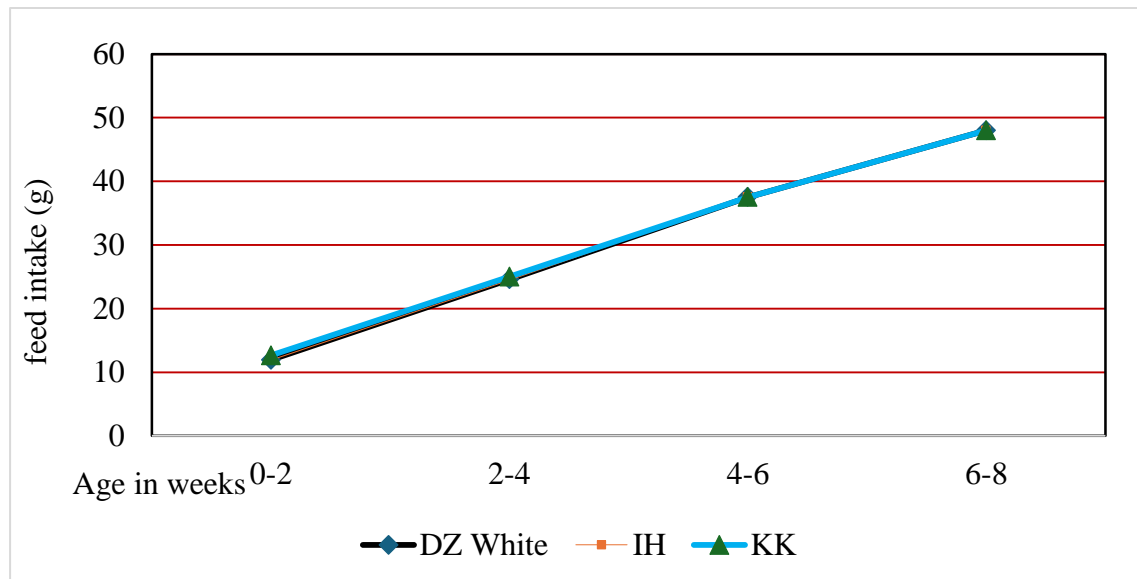
#### 4.1.2. Feed intake and feed conversion ratio

The overall mean and standard errors of average daily feed intake and feed conversion ratio during the brooder and grower stages are given in table 8 and 9, respectively. Breed had no significant ( $p>0.05$ ) effect on feed intake during the brooder and grower stage except during the first two weeks in which KK breed consumed highest volume of feed. This could be associated with the highest body weight of KK breed during the first weeks of age as revealed in table 6. The feed intake trend showed slightly increased for all genotypes with their age increment (Figure 5 and 6). This is directly associated with body weight increment of chickens.

**Table 8.** Effects of chicken breeds on feed intake and feed conversion ratio during brooder stage, 0-8 weeks (Mean  $\pm$  SE).

Age (weeks)	Breeds			P value	SL
	DZ White	IH	KK		
<b>Feed Intake (g/bird)</b>					
0-2	11.92 $\pm$ 0.05 <sup>b</sup>	11.93 $\pm$ 0.05 <sup>b</sup>	12.63 $\pm$ 0.05 <sup>a</sup>	0.04	*
2-4	24.58 $\pm$ 0.11 <sup>a</sup>	24.50 $\pm$ 0.12 <sup>a</sup>	25.00 $\pm$ 0.12 <sup>a</sup>	0.80	ns
4-6	37.50 $\pm$ 0.00 <sup>a</sup>	37.50 $\pm$ 0.00 <sup>a</sup>	37.50 $\pm$ 0.00 <sup>a</sup>	0.89	ns
6-8	48.00 $\pm$ 0.00 <sup>a</sup>	48.00 $\pm$ 0.00 <sup>a</sup>	48.00 $\pm$ 0.00 <sup>a</sup>	0.95	ns
0-8	30.50 $\pm$ 7.83	30.48 $\pm$ 7.83	30.78 $\pm$ 7.66	0.14	ns
<b>Feed Conversion Ratio (g/bird)</b>					
0-2	2.92 $\pm$ 0.00 <sup>a</sup>	2.62 $\pm$ 0.00 <sup>a</sup>	2.67 $\pm$ 0.00 <sup>a</sup>	0.08	ns
2-4	2.12 $\pm$ 0.00 <sup>a</sup>	1.98 $\pm$ 0.00 <sup>a</sup>	1.50 $\pm$ 0.00 <sup>b</sup>	0.048	*
4-6	2.04 $\pm$ 0.00 <sup>b</sup>	2.33 $\pm$ 0.00 <sup>b</sup>	3.00 $\pm$ 0.00 <sup>a</sup>	0.047	*
6-8	1.35 $\pm$ 0.00 <sup>ab</sup>	1.62 $\pm$ 0.00 <sup>a</sup>	1.04 $\pm$ 0.00 <sup>b</sup>	0.049	*
0-8	2.11 $\pm$ 0.32	2.14 $\pm$ 0.22	2.05 $\pm$ 0.47	0.08	ns

<sup>a, b</sup> Means within a row not followed by a common letter between weeks/breeds in the different superscript letters are significantly different at  $p < 0.05$ ; KK, koekoek; DZ White, Debre Zeyit White; IH, Improved Horro; SL, Significant Level; ns, not significant



**Figure 5.** Trends of feed intake during brooder stage (0-8 weeks)



**Figure 6.** Trends of feed intake during grower stage (8-18 weeks)

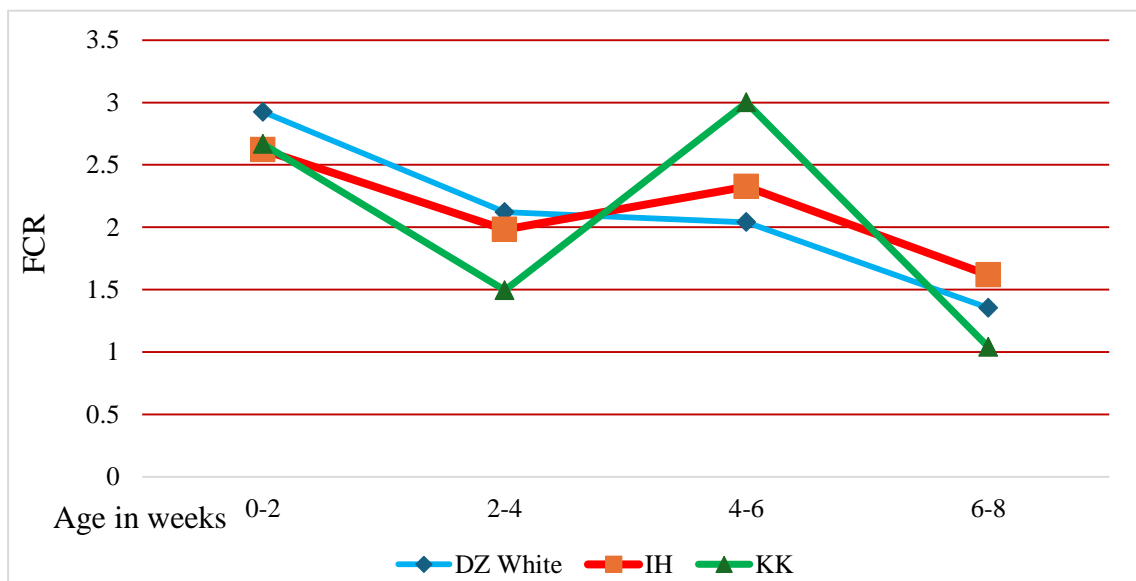
The average feed conversion ratio during the brooder and grower period is presented in table 8 and 9, respectively. The chicken genotype had no significant influence ( $p>0.05$ ) on feed conversion ratio (FCR) during the first two weeks of age. However, significant ( $p<0.05$ ) differences were noted from 2<sup>nd</sup> to 8<sup>th</sup> weeks of age and throughout the grower period (8-18 weeks). The best FCR was recorded for KK during 2-4 and 6-8 weeks whereas DZ White and IH recorded the best FCR during 4-6 weeks. The FCR trend result indicated the decreasing for all genotypes as their age increasing (Figure 7 and 8).

**Table 9.** Effects of chicken breed on feed intake and feed conversion ratio during grower stage, 9-18 weeks (Mean  $\pm$  SE).

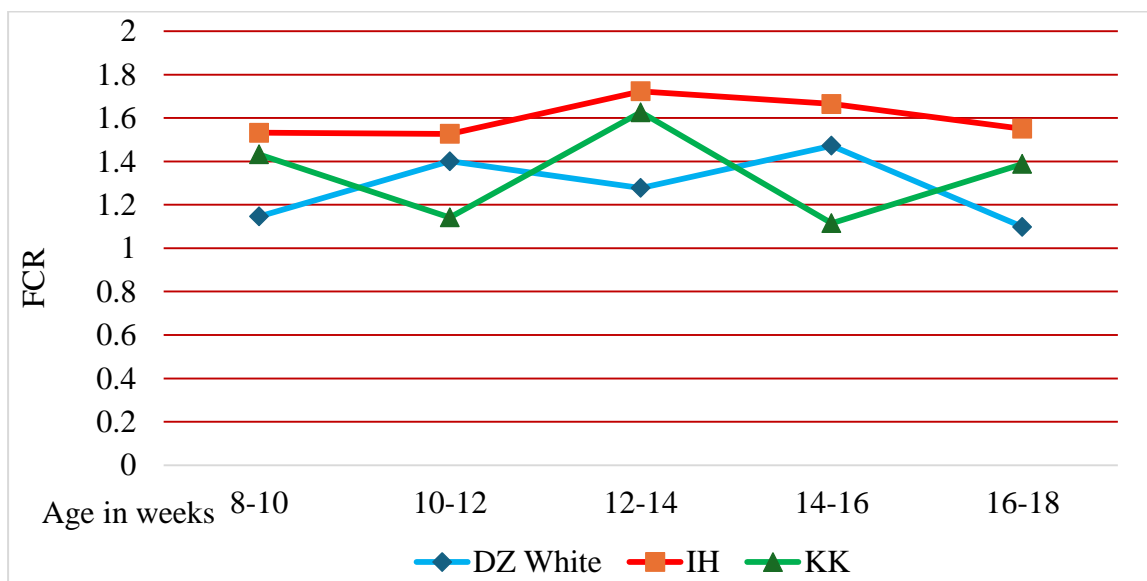
Age (weeks)	Breeds			P value	SL
	DZ White	IH	KK		
Feed intake (g/bird)					
8-10	55.50 $\pm$ 0.00 <sup>a</sup>	55.50 $\pm$ 0.00 <sup>a</sup>	55.50 $\pm$ 0.00 <sup>a</sup>	0.86	ns
10-12	61.00 $\pm$ 0.00 <sup>a</sup>	61.00 $\pm$ 0.00 <sup>a</sup>	61.00 $\pm$ 0.00 <sup>a</sup>	0.98	ns
12-14	65.50 $\pm$ 0.00 <sup>a</sup>	65.50 $\pm$ 0.00 <sup>a</sup>	65.50 $\pm$ 0.00 <sup>a</sup>	0.96	ns
14-16	69.50 $\pm$ 0.00 <sup>a</sup>	69.50 $\pm$ 0.00 <sup>a</sup>	69.50 $\pm$ 0.00 <sup>a</sup>	0.96	ns
16-18	72.50 $\pm$ 0.00 <sup>a</sup>	72.50 $\pm$ 0.00 <sup>a</sup>	72.50 $\pm$ 0.00 <sup>a</sup>	0.97	ns
8-18	64.80 $\pm$ 3.02	64.80 $\pm$ 3.02	64.80 $\pm$ 3.02		
Feed Conversion Ratio (g/bird)					
8-10	1.15 $\pm$ 0.00 <sup>b</sup>	1.53 $\pm$ 0.00 <sup>a</sup>	1.43 $\pm$ 0.00 <sup>a</sup>	0.03	**
10-12	1.40 $\pm$ 0.00 <sup>a</sup>	1.52 $\pm$ 0.00 <sup>a</sup>	1.14 $\pm$ 0.00 <sup>b</sup>	0.03	**

12-14	1.28±0.00 <sup>b</sup>	1.72±0.00 <sup>a</sup>	1.63±0.00 <sup>a</sup>	0.02	**
14-16	1.47±0.00 <sup>a</sup>	1.67±0.00 <sup>a</sup>	1.12±0.00 <sup>b</sup>	0.02	**
16-18	1.10±0.00 <sup>b</sup>	1.55±0.00 <sup>a</sup>	1.39±0.00 <sup>ab</sup>	0.03	**
8-18	1.28±0.07 <sup>b</sup>	1.60±0.03 <sup>a</sup>	1.34±0.09 <sup>ab</sup>	0.04	**

<sup>a</sup> means within a row not followed by a common letter between weeks/breeds in the same superscript letters are not significantly different at  $p < 0.05$ ; KK, Koekoek; DZ White, Debre Zeyit White; IH, Improved Horro; SL, Significant Level; ns, not significant



**Figure 7.** Trends of FCR during brooder stage (0-8 weeks)



**Figure 8.** Trends of FCR during grower stage (8-18 weeks)

## 4.2.Mortality Rate

Mortality was not recorded for all genotypes during the whole experimental period (0-18 weeks). This may be due to an extensive care given to chickens during the study and also there was no disease outbreak during the study period. However, due to cannibalism two (2.22%) of Improved Horro chickens had died during the grower age (14-16 weeks).

**Table 10.** Overall growth performance, feed intake, feed conversion efficiency and mortality rate of different chicken breeds, 0-18 weeks (Mean  $\pm$  SE)

Variables	Breeds			P value	SL
	DZ White	IH	KK		
Total body weight gain (g/chick)	1544.5 $\pm$ 0.00 <sup>a</sup>	1200.2 $\pm$ 0.00 <sup>b</sup>	1562.8 $\pm$ 0.00 <sup>a</sup>	0.0001	***
Average daily weight gain (g/bird)	36.22 $\pm$ 6.87 <sup>a</sup>	29.49 $\pm$ 4.96 <sup>b</sup>	36.34 $\pm$ 6.76 <sup>a</sup>	0.0001	***
Feed intake (g/bird)	49.56 $\pm$ 2.74 <sup>b</sup>	49.55 $\pm$ 2.74 <sup>ab</sup>	49.69 $\pm$ 2.71 <sup>a</sup>	0.006	***
FCR	1.65 $\pm$ 0.19 <sup>b</sup>	1.84 $\pm$ 0.13 <sup>a</sup>	1.66 $\pm$ 0.23 <sup>b</sup>	0.049	*
Mortality rate (%)	0.00 $\pm$ 0.0	2.22 $\pm$ 0.0	0.00 $\pm$ 0.0	0.87	ns

<sup>a, b</sup> Means within a row not followed by a common letter between breeds in the different superscript letters are significantly different at  $p < 0.05$ ; KK, Koekoek; DZ White, Debre Zeyit White; IH, Improved Horro; SL, Significant Level

The overall body weight gain, feed intake, feed conversion ratio and mortality rate for the whole experimental period (0-18 weeks) are given in table 10. The result showed that chicken genotype had significantly ( $p < 0.0001$ ) influenced the total weight gain, daily weight gain, and daily feed intake however FCR and mortality rate were not affected. The IH showed the lowest values for total body weight and body weight gain whereas DZ recorded the lowest value for feed intake. There was no significant difference between DZ and KK in terms of total body weight and body weight gain but there was slight difference in feed intake between them.

## 4.3.Reproductive and Productive Performances

The productive and reproductive performances were presented in table 11 There was strong statistical significant difference ( $p < 0.0001$ ) in all productive and reproductive performances among the genotypes. The earliest age at egg laying was noted in KK

however this breed had taken longer days to reach age at 5 and 10% egg production. The earlier start of egg laying is associate to the fast growth rate (higher body weight gain during the earlier age) of the breed. Nevertheless, the earliest age at 5 and 10% egg production was reached in DZ. The IH lately started egg laying which is due to the lower growth rate and genotype of the breed. The study revealed that there was significant difference ( $p < 0.001$ ) among genotype of chickens in egg weight measured at different age. The DZ White was significantly laid the heaviest egg weight measured at age at first lay, 5 and 10% egg production. The IH chickens were comparable to KK chickens by their egg weight at age at first laying ( $P > 0.05$ ) however variation was noted between the two at 5 and 10% egg production. The egg weight was showed increased trend for all genotypes as age and percent of egg laying increased.

**Table 11.** Effect of breed on age at first laying and egg weight (Mean + SE)

Variables	Breeds			P value	SL
	DZ White	IH	KK		
Age of first laying (Days)	124±0.00 <sup>b</sup>	127±0.00 <sup>a</sup>	122±0.00 <sup>c</sup>	0.0001	***
Age at which 5% of egg production reached (Days)	129±0.00 <sup>c</sup>	136±0.00 <sup>b</sup>	140±0.00 <sup>a</sup>	0.0001	***
Age at which 10% of egg production reached (Days)	133±0.00 <sup>c</sup>	140±0.00 <sup>b</sup>	142±0.00 <sup>a</sup>	0.0001	***
Egg weight at first laying (g)	39.58 ±0.00 <sup>a</sup>	35.00±0.00 <sup>b</sup>	35.75±0.00 <sup>b</sup>	0.0001	***
Egg weight at 5% of egg production (g/egg)	42.9±0.00 <sup>a</sup>	39.59±0.00 <sup>c</sup>	41.22±0.00 <sup>b</sup>	0.0001	***
Egg weight at 10% of egg production(g/egg)	46.01±0.00 <sup>a</sup>	43.04±0.00 <sup>c</sup>	44.6±0.00 <sup>b</sup>	0.0001	***

<sup>a, b, c</sup> Means within a row not followed by a common letter between weeks/breeds in the different superscript letters are significantly different at  $p < 0.05$ ; KK, Koekoek; DZ White, Debre Zeyit White; IH, Improved Horro; SL, Significant Level

## 5. DISCUSSION

### 5.1. Growth Performances and Feed Intake

#### 5.1.1. Body weight of experimental chickens

The overall least means for Koekoek live-body weight during the brooder (0-8 weeks) and grower (9-18 weeks) stages were significantly higher in comparison to the weight of the other two strains. This shows the fast growth rates and adaptability of the breed to Ethiopian agro ecology. Tables 6 and 7 demonstrate how much better the two crossbred strains (Keokeok and DZ White) performed than the indigenous Improved Horro. For example, during the brooder and grower stages, Keokeok and DZ White respectively weighed more than the live body weight of the indigenous Improved Horro chicken. The discrepancy may result from variations in each genotype's initial or hatchling body weight. The Keokeok and DZ White breeds' superior live body weight is linked to their genotype, which favors feed intake and rapid weight gain. This finding aligns with the results of earlier study reported by [Setegn \*et al.\* \(2021\)](#), who observed the live body weight for indigenous Improved Horro at Debre Zeyit Agricultural Research Center ( $1279.00 \pm 57.4$ g) and Haramaya University stations ( $1085 \pm 59.1$ g) at 17 weeks of age. The results of this author for Keokeok ( $1669.00 \pm 54.7$  and  $1475 \pm 57.0$  g) at 17 weeks at the two stations are also different in comparison to the current study (1519g of weight). The Improved Horro chicken's live-body weight at the Debre Zeyit Agricultural Research Center (DARC) at 17 weeks is slightly greater than the Holetta station of current study result (1228.33g). This could be the result of weather variations because Holetta Station is highland, so chicken spends more energy for maintenance which reduce growth rate. This result is also in line with the findings of [Amusan \*et al.\* \(2020\)](#), who observed increased growth traits and feed intake as birds grew older and a significant effect of chicken genotype on all growth traits and feed consumption characteristics. The exotic chicken crosses (Koekoek and DZ White) showed a superior body weight, which implies that they have a higher potential for growth than the Improved Horro through selection. This could be because, in contrast to Improved Horro solely through selection, these breeds (Koekoek and DZ White) had undergone several rounds of improvement through both crossbreeding and selection for higher body weight and growth rate. The lower values

recorded for Improved Horro can be attributed to the fact that the breed is categorized as light breeds.

The average initial body weights (day-old weight) recorded for all genotypes (Table 6) in this study were higher than the initial weight recorded for the same breed elsewhere (Samrawit, 2020; Hundie *et al.*, 2022). This difference of day-old body weight for the same breed shows the selection impact of the breeds. Likewise, several researchers (Halima *et al.*, 2006; Ewonetu and Kasaye, 2020; Balcha *et al.*, 2021; Shambel, 2021; Yosef *et al.*, 2022) reported lower average day-old weight for different breeds and genotypes. These differences might be due to the result of egg size used for hatching, breed, genetic and environmental interactions. However, the day old weight of Koekok and DZ White used in this study were close to the report of earlier study noted by Solomon (2004) for White Leghorn chicken 40g.

Trend analysis showed that body weight was increased as age of chicken advances (Figure 1 and 2) which simply shows that body weight and age are positively correlated. This directly reflected the growth of chicken which ultimately influences the production and reproduction traits of chickens. In this study, significant body weight differences were observed among the breeds both at brooder and grower stages. Koekoek was recorded the highest body weight at the end of grower stage (18<sup>th</sup> week) followed by DZ White and Improved Horro. This body weight difference among the breeds might be due to the different genetic contribution of each breed in utilization of feeds for growth. The growth performances of the two breeds (DZ White and Improved Horro) at the end of grower stage (16-18 weeks) were higher than the earlier study reports (Mulugetat *et al.*, 2020; Samrawit, 2020; Hundie *et al.*, 2022) for the same breeds of the same source of parent stocks but different generations. For example, the body weight of DZ White and Improved Horro recorded values in this study were 14 and 10% respectively, higher than the report of Samrawit (2020) at the age of 16 weeks while 43.2 and 46.8% superior to the report of Hundie *et al.* (2022) at the age of 18 weeks. This superiority might be the result of continuous and intensive selection at the source of parent stock and the favourable environment at Holetta in which chickens would be able to express their genetic potential. Dawud (2019) reported 1233.5g of body weight for Koekoek parent stock breed at 16 weeks of age at two different experimental sites (DZARC and Hawassa) which were lower as

compared to values of the current body weight (1436g) for the same breed and age, but the on-farm trial of body weight reported by this author was higher (1626g).

The significant difference of body weight among different breeds/genotypes were also reported by many scholars (Halima *et al.*, 2006; Wendemeneh *et al.*, 2016; Dawud, 2019; Mulugeta *et al.*, 2020; Samrawit, 2020; Balcha *et al.*, 2021; Hundie *et al.*, 2022; Yosef *et al.*, 2022). Shambel (2021) and Yosef *et al.* (2022) reported lower body weight at early age (4, 8 and 12 weeks) for Koekoek and their crosses of Horro and White leghorn breeds. The growth performance of different indigenous chicken breeds reported by Halima *et al.* (2006) at the age of 22 weeks were lower and did not comparable to the body weight values of this study results taken at the 18 weeks of age.

The geographical location and management practices are influencing the body weights of different chicken breeds at different growth period. The same breed/genotype might also be performed differently under the same/different location and management practices. The body weight recorded for DZ White and Improved Horro at 12 weeks of grower age was comparable with the same breeds studied at 16 weeks of age (1269.93g for DZ White and 1009.7g for Improved Horro) at Debre Berhan under on station management and, at 20 weeks of age in three locations of on farm experiment (1234.69g for DZ White and 1059.73g for Improved Horro) that reported by (Samrawit, 2020). As compared to this study, Mulugeta *et al.* (2020) also reported similar body weight for DZ White (1372.47g) and Improved Horro (1179.87g) at similar age (16 weeks) under on station management. Similar body weights were also reported by Shambel (2021) and Yosef *et al.* (2022) for Koekoek and IH at the age of 12 and 16 weeks, respectively. The Koekoek, DZ White and Improved Horro breeds were evaluated on station until 18 weeks of age at Nekemte (Hundie *et al.*, 2022). Accordingly, their growth performances were lower and could not compare with the current study in the whole experimental weeks. The study conducted by Gutu *et al.* (2021) under on farm evaluations of Koekoek and Improved Horro in western Ethiopia showed that the body weight of the two breeds at 20 weeks of age were 1183g and 1074g, respectively, which is comparable with the value recorded at 10 weeks of Koekoek and 12 weeks of Improved Horro.

### 5.1.2. Body weight gain

Daily weight gain was affected by breed during the grower and the brooder age as shown in table 6 and 7. Statistically DZ White was fastest body weight gain than the two breeds during the grower stage. On the other hand, there was no significant difference between Koekoek and DZ White breeds on overall average daily body weight gain during the entire study period (0-18 weeks). However, Koekoek showed slightly highest weight gain values during the brooder stage as well as the overall average. This would be the genetic superiority of Koekoek over DZ White and Improved Horro chickens. Improved Horro was showed lowest growth rate in both brooder and grower stage as compared to Koekoek and DZ White breeds. This difference might be attributed to genetic attribution of the three experimental breeds. Nigussie (2011) suggested that the growth of chicken is somewhat depends on the genetic attribute of chickens. The average daily body weight gain of the three experimental chickens in this study was recorded variable results and not constant across the weeks. As shown in figure 3 and 4 there was increasing trend during the brooder stage but variable during the grower phase. The highest daily weight gain was observed from 16-18 weeks during grower stage for both DZ White and Improved Horro breeds, but Koekoek recorded highest values of body weight gain (from 14-16 weeks) of age.

The experimental results showed different weight gain at stage of brooder and grower age. An experimental result reported by Samrawit (2020) shows that total body weight gain of DZ White (505.8g) and Improved Horro (440.28g) during the brooding stage (0-8 weeks) were lower as compared to this study but slightly higher results reported from 8-16 weeks (645g and 535g) for the same breeds. In comparison to this study result, Mulugeta *et al.* (2020) reported lower average daily weight gain for DZ White and Improved Horro breeds at the age of 8 and 16 weeks. Another experimental study conducted by Hundie *et al.* (2022) reported lower average daily weight gain at the age of 12, 14, 16 and 18 weeks for Koekoek and DZ White breeds. Moreover, the overall mean weight gains (10.67g, 8.69g and 7.75g) for Koekoek, DZ White and Improved Horro during the whole experimental weeks (from day-old to 18 weeks) reported by Hundie *et al.* (2022) were lower than the current study results (36.34g, 36.22g and 29.49g) for the same breed, respectively. Lower results were also

reported by Gutu *et al.* (2021) for Koekoek and Improved Horro at the age of 12-16 and 16-20 weeks under farmer management system. The difference observed in the same breed might be associated with the environmental situations, experimental management of chicken breeds and efficiency of feed intake in different age classes.

Experimental study of crossbred on body weight gain reported by different authors shows variable and inconsistent with the current study. Shambel (2021) reported lower average daily weight gain for Koekoek, Improved Horro and their crosses with Kuroiler breeds at the age of 5-8 and 9-12-weeks. Similarly, Yosef *et al.* (2022) also reported lower average daily body weight gain for koekoek, White Leghorn and their crosses at different age classes. This difference might be due to the breed, management practices and environmental situations of the experimental chicks. The present total body weight gain (1562.8g, 1544.5g and 1200.2g) of Koekoek, DZ white and Improved Horro throughout the experimental period (0-18 weeks) were higher than the values (1013-1229g) of seven indigenous chicken breeds reported by (Halima *et al.*, 2006).

### 5.1.3. Feed intake

Feed intake from day-old to 8 weeks of age (brooder phase) as well as 9-18 weeks of the grower stage showed in table 8 and 9 were different. Feed intake during the first two weeks of age showed significant variations among the breeds. This variation might be due to the tendency of breeds for adaptation of the new feed environment. The initial body weight can also be affected the feed intake during the initial weeks. According to Mendes (2011), feed intake was significantly related to initial body weight. Abiola *et al.* (2008), also suggested that variation in daily feed intake could be related to difference in body weight and breed. However, comparable non-significant feed intake noted among Koekoek, DZ White and Improved Horro from 4-6 and 6-8 weeks of age during brooder periods. In the grower stage, feed intakes among the three breeds were not significant and it was increased as the age in weeks became advanced. This similarity might be due to the uniform management practices in all pens, absence of disease and the environmental conditions of the area made the birds favouring their normal physiological activity. The average daily feed intake values recorded during the brooder stage in this study is agreed with the report's different authors (Halima *et al.*, 2006; Halima, 2007; Wendemeneh *et al.*, 2016;

Dawud, 2019; Samrawit, 2020; Shambel, 2021 and Hundie *et al.*, 2022) who reported increasing daily feed intake over the weeks.

The feed consumption of Koekoek, DZ White and Improved Horro during the brooder (2-4 and 6-8 weeks) stage and grower stage (10-12 weeks) was almost close to findings of Shambel (2021) who reported 19.52g, 50.04g and 60.24g at 4, 8 and 12 weeks for Improved Horro chicken breed. Samrawit (2020) reported an average daily feed intake of 30.94g and 70.41g for DZ white and, 29.24g and 66.89g for Improved Horro from 0-8 and 8-16 weeks of age which was comparable to the present study findings. A similar breed comparison study on feed intake was done by Hundie *et al.* (2022) in the western part of Ethiopia. Accordingly, the author reported lower daily feed intake for the three breeds at 12, 14, 16 and 18 weeks of ages as compared to the present study.

Despite geographical locations, efficient feed intake can be affected by breed (genotype). The present study revealed that feed intake of the three breeds were lower than the values reported for indigenous Gallilia and D/Elias breeds evaluated at 0-5 weeks of age. As compared to the findings of this study, indigenous breeds such as Tilili, Mello Hamusit, Gassay and Mecha breeds were recorded lower values of daily feed intake at both 0-5 and 5-8 weeks of age in the northern Ethiopia (Halima *et al.*, 2006). The author also reported higher (86-91g) mean daily feed intake for seven indigenous breeds over the study periods (0-22 weeks) which were significantly higher than the present average 46.5-46.6g of feed intake per day/chicken for 0-18 weeks. Daily feed intake during the brooder and grower stage at different weeks for three breeds were also higher than the report of Shambel (2021) for different crossbred chickens namely KK, Kuroiler and their reciprocal crosses at 4, 8 and 12 weeks of age and Balcha *et al.* (2021) for White leghorn, Fayoumi and their reciprocal crosses at 0-4, 4-8, 8-12 and 12-16 weeks of age. However, it was lower than the pure White Leghorn breed 49g and 71g at the age of 4-6 and 6-8 weeks reported by (Ewonetu, and Kasaye, 2020) and pure White Leghorn, Koekoek and their crosses at 13-16 weeks reported by (Yosef *et al.*, 2022). These comparisons were done to the parallel weeks of brooder and grower stage of the current study.

#### 5.1.4. Feed conversion ratio

The overall average feed conversion ratio of all breeds in the present study were significantly ( $P < 0.05$ ) different but the non-significant differences were observed in the early age points during the brooder stage. Significant differences among experimental breeds were reported by several authors (Mulugeta *et al.*, 2020; Samrawit 2020; Shambel, 2021). Improved Horro was the highest (1.84) overall feed conversion ratio followed by Koekoek (1.66) and DZ White breeds (1.65). Feed conversion ratio of the three breeds in the grower stage showed an improvement over the brooder stage. The environmental condition, chicken management, types of feed offered and feed intake could be the source of this variation.

This study further showed that feed conversion ratio at different age of weeks was not constant and variable results for all the three breeds. Regarding the age classification, high feed conversion ratios was recorded during brooder stage for all experimental breeds. The proportion of average daily feed intake to daily weight gain might be influenced the present results at the indicated weeks. In comparison to the current grower stage, Shambel (2021) found higher feed conversion ratio for Koekok, Improved Horro, Kuroiler and their crosses during 4, 8 and 12 weeks of age. Samrawit (2020) found an average of 3.44 and 3.74 feed conversion ratio for DZ white and Improved Horro breeds during 0-8 weeks of age interval and 4.75 and 5.30 values at the age of 8-16 weeks interval, respectively at on station experimental condition somewhat higher than the present findings. Yosef *et al.* (2022) reported higher feed conversion ratio of Koekoek, White Leghorn and their crosses at different age classes. However, lower feed conversion ratio for White Leghorn, Fayoumi and their crosses during different age classes were reported by (Balcha *et al.*, 2021).

#### 5.2.Mortality Rate

The very lower mortality rate at different weeks in this study was agreed with the findings of earlier study report (Shamble, 2021). However, this result was not agreed with the finding of (Mulugeta *et al.*, 2020; Samrawit, 2020; Yosef *et al.*, 2022). No significant differences were also observed among Koekoek, DZ White and Improved Horro during the brooder and grower phases. The mortality or survival rate of chickens is depending on the physiological state and environmental adaptability of the

breeds to the prevailing environments. The present on station mortality rate of the Koekoek and DZ White chicken breeds were nil. Relatively, higher mortality rate was counted in Improved Horro breed which was because of cannibalism. This shows that the better management towards the chicken helps them protected from different disease outbreaks. Moreover, the breeding objective of parent stock (disease resistant as one the selection index) at DZARC would be successfully achieving the target.

The geographical area can be influencing the survival rate of different chicken breeds. Earlier on station experimental study results in different geographical locations showed that the intensity of mortality was different in different weeks of age (stage of growth) for the same breed. Wondmeneh (2015) reported 1.2% of mortality for improved Horro during the 20 weeks of growing period. Samrawit (2020) reported higher average mortality rate of 7.36% and 4.69% during the 0-8 weeks and, 5.42% and 9.52% during 9- 16 weeks of age for DZ White and Improved Horro breeds, respectively. Other on station study by Hundie *et al.* (2022) in western Ethiopia, at Nekemte reported 11.74%, 2.33% and 8.97% of mortality rate for Koekoek, DZ White and Improved Horro chicken breeds, respectively. Shambel (2021) at Debre Zeyit noted very lower rate of mortality for Koekoek and different crossbred in the range of 0.00-0.05% during 0-8 weeks of brooding phase and 0.06-0.21% during the growing phase (9-20 weeks). However, higher rate of mortality was reported for Indigenous, purebred and crossbred chickens at different on station locations (Halima, 2007; Ewonetu and Kasaye, 2020; Yosef *et al.*, 2022). The mortality rate recorded in this study was lower which shows the breed adaptability to the study area, good management practices and proper implementation of effective biosecurity measures.

### **5.3.Age at First Laying**

Chickens laid their first egg at a younger age suggest that egg production would be expected to increase over the course of their lifetime. The significant difference between age at first laying was inconsistent with the finding of Samrawit (2020) who reported non-significant differences for the same breed but agreed with the findings of many scholars (Dawud, 2019; Balcha *et al.*, 2021; Gutu *et al.*, 2021; Shambel, 2021; Yosef *et al.*, 2022). The DZ Whites were lay their egg 7 and 11 days earlier than Improved Horro and Koekoek at 5% laying age, respectively. However, Koekoek breed was laid 2 and 5 days earlier than first of DZ White and Improved Horro

breeds. This difference under the same management would be associated with the genetic tendency of breeds towards this reproductive trait.

Age at first egg can be depends on body weight and management of chickens. The values of the current age at 5% and 10% laying of the three experimental breeds were lower than the values reported in different locations. In comparison to the same breed, Samrawit (2020) reported average age at first laying of 155 and 162.6 days for DZ White and Improved Horro breeds, respectively which were longer by 26 and 26.6 day as compared to the current study. This might be because of the successful intensive and on-going selection on DZ White and Improved Horro that has been achieving the required trait improvement. Wondmeneh *et al.* (2016) reported higher age at first laying (153 days) for Improved Horro under on station management. Dawud (2019) evaluated different parent stock breed trials in different agro ecology (Debre Zeyit, Hawassa and on farm management). The author reported higher values of age at first laying for Koekoek breed at DZARC and Hawassa on station trails and lower values at on farm trials. Other study conducted by Gutu *et al.* (2021) found higher values of age at first laying (23.2 and 24.4 weeks) for Koekoek and Improved Horro, respectively under on farm management. Shambel (2021) reported higher (145 days) age at first laying for Koekoek under on station management at DZARC. Yosef *et al.* (2022) also found 160, 161 and 163 days age at first, 5% and 10% rate of production for Koekoek at Haramaya University on station management which was higher than the present finding.

Despite management and growth rate, age at first laying can be affected by breed/genotype. The present age at first laying for Koekok, DZ White and Improved Horro breeds were lower than the different values for the on station experimental crossbred and pure exotic chickens that reported by several researchers (Dawud, 2019; Ewonetu and Kasaye, 2020; Balcha *et al.*, 2021; Shambel, 2021; Yosef *et al.*, 2022). However, the present DZ White and Improved Horro breeds were close to similar results at 5% rate of production as compared to the 5 commercial layer breeds of chicken namely Dominant Red Barred, Dominant Sussex, Lohmann Brown, Novogen Brown and Novgen color at on farm experimental level reported by (Dawud, 2019).

#### 5.4.Egg Weight

Analysis on the preliminary egg weight traits shows that there was significant difference among breeds at first, 5% and 10% egg laying periods. As shown in table 12, the DZ White chicken breed was produced relatively heavier average egg weights as compared to Koekoek (35.75, 41.22 and 44.6) and Improved Horro (35g, 39.59g and 43.04g) at first, 5% and 10% laying periods, respectively. This might be the genetic superiority of DZ White breed manifested towards intense selection on egg production and egg weight. The values of age at first laying for Koekoek and Improved Horro were similar to the report of Balcha *et al.* (2021) 34g for Fayoumi breed but lower than White Leghorn and their crosses with Fayoumi. Few research reports were found on the early egg weight traits (egg weight at first, 5% and 10% laying). Samrawit (2020) reported an average egg weight of 52.47g and 44.93g for DZ White and Improved Horro over 52 weeks of laying period. Gutu *et al.* (2021) reported an average egg weight in the range of 45-55g for Koekoek and 41-49.2g for Improved Horro during 28-44 weeks egg laying periods. Another study by Ewonetu and Kasaye (2020) reported 49.1g of egg weight for White Leghorn chicken at the beginning (22-24 weeks) and it was increased to 56.12g at the end of laying periods (48-50 weeks). The present study results on the three breeds early egg weight traits were achieved comparable egg weight as compared to some late laying chickens which is found in the literatures and these will be increased their egg weight as the laying period advanced.

## **6. CONCLUSIONS AND RECOMMENDATIONS**

### **6.1. Conclusions**

The present comparative study was designed to evaluate different parameters (feed intake, body weight, body weight gain, FCR, age at first laying, mortality rate and egg weight at early age) among Koekoek, DZ White and Improved Horro chicken breeds at HARC. Breed and stage of growth were significantly affected the majority of traits. Lower age at first laying and mortality rate were observed for all studied genotypes. In different age classes, experimental chicken breeds showed different performances as the result of genetic difference. Koekoek has the highest feed intake, body weight and body weight gain as compared to DZ White and IH breeds. Significant difference was observed among the three breeds in age at first laying. The best FCR was recorded for Koekoek during 2-4 and 6-8 weeks whereas DZ and IH recorded the best FCR during 4-6 weeks. There was strong statistical significant difference ( $p < 0.0001$ ) in age at first, 5% and 10% egg laying as well as egg weight performances among the genotypes. The earliest age at egg laying was noted in KK. However, the breed had taken longer days to reach age at 5 and 10% egg production (the required number of hens were not reached the early age). Nevertheless, the earliest age at 5 and 10% egg production was reached in DZ. The DZ White breed was significantly laid the heaviest egg weight measured at age at first lay, 5 and 10% egg production. The lower body weight, weight gain, egg weight, high FCR and extended age at first laying recorded for improved Horro can be attributed to the fact that the breed is categorized as light breeds. In general, the three experimental breeds were well adapted the existing environment (Holetta highland weather condition) of Ethiopia and well performed in almost all observed parameters under on station.

### **6.2. Recommendations**

With this preliminary evaluation, further study should be conducted for extended period on egg production and other reproductive traits at both on station and on farm.

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## 8. APPENDIX

Appendix 1. ANOVA table for growth of chickens 0-8 weeks of age

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	676475.3534	135295.0707	67.35	<.0001
Error	6	12053.4578	2008.9096		
Corrected Total	11	688528.8112			

$R^2 = 0.98$  and  $CV = 11.94$

Appendix 2. ANOVA table for growth of chickens 9-18 weeks of age

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	480840.8773	80140.1462	68.89	<.0001
Error	8	9306.0001	1163.2500		
Corrected Total	14	490146.8774			

$R^2 = 0.98$  and  $CV = 2.7$

Appendix 3. ANOVA table for daily weight gain of chickens 0-8 weeks of age

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	1754.137296	350.827459	15.68	0.0022
Error	6	134.244090	22.374015		
Corrected Total	11	1888.381386			

$R^2 = 0.93$  and  $CV = 26.74$

Appendix 4. ANOVA table for daily weight gain of chickens 9-18 weeks of age

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	709.135902	118.189317	2.52	0.1134
Error	8	375.622615	46.952827		
Corrected Total	14	1084.758516			

$R^2 = 0.65$  and  $CV = 14.55$

Appendix 5. ANOVA table for daily feed intake of chickens 0-8 weeks of age

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	2001.341160	400.268232	20168.4	<.0001
Error	6	0.119078	0.019846		
Corrected Total	11	2001.460237			

$R^2 = 0.99$  and  $CV = 0.42$

Appendix 6. ANOVA table for daily feed intake of chickens 9-18 weeks of age

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	512.4000000	85.4000000	Infty	<.0001
Error	8	0.0000000	0.0000000		
Corrected Total	14	512.4000000			

$R^2 = 1$  and  $CV = 0$

Appendix 7. ANOVA table for FRC of chickens 0-8 weeks of age

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	3.51923395	0.70384679	4.67	0.0438
Error	6	0.90508187	0.15084698		
Corrected Total	11	4.42431582			

$R^2 = 0.8$  and  $CV = 18.5$

Appendix 8. ANOVA table for FRC of chickens 9-18 weeks of age

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	0.36750139	0.06125023	2.05	0.1708
Error	8	0.23881243	0.02985155		
Corrected Total	14	0.60631383			

$R^2 = 0.61$  and  $CV = 12.28$