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EVALUATION OF RECIPROCAL CROSSES OF IMPROVED HORRO CHICKEN WITH KOEKOEK AND KUROILER CHICKEN BREEDS

M.Sc. thesis

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MSc Program in Animal Production

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Bishoftu, Ethiopia

EVALUATION OF RECIPROCAL CROSSES OF IMPROVED HORRO CHICKEN WITH KOEKOEK AND KUROILER CHICKEN BREEDS

A Thesis Submitted to the College of Veterinary Medicine and Agriculture of Addis Ababa University in Partial Fulfillment of the Requirements for the Degree of Master of Science in Animal Production

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APPROVAL SHEET

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As members of the Examining Board of the Final MSc open defense, we certify that we have read and evaluated the Thesis prepared by**: Shambel Taye Fulla.** Entitled: "Evaluation of Reciprocal Crosses of Improved Horro Chicken with Koekoek and Kuroiler Chicken Breeds", and recommend that it be accepted as fulfilling the thesis requirement for the degree of **Master of Science in Animal Production**.

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DEDICATION

This thesis is dedicated to my parents for their sustained assistance, encouragement and affection in the success of my life.

STATEMENT OF THE AUTHOR

First, I declare that this thesis is my original work and that all sources of material used in this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for M.Sc. Degree at the Addis Ababa University College of Veterinary Medicine and Agriculture and is deposited in the University/College library to be made available to borrowers under the rules of the library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

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BIOGRAPHY

The author, Shambel Taye, was born from his Father Taye Fulla and his Mother Gadise Abera in Oromia Regional State of Ethiopia North Shewa Zone Kuyu Woreda Liban Kura Kebele on October 31, 1990. He attended his elementary school at Kare Kura in Kuyu woreda from 1999 to 2006. Then, he attended secondary and preparatory school in Gebre Gurracha town from 2007 to 2010. He joined Mizan Tepi University in 2011 and graduated with a Bachelor of Science in Animal science with great distinction in June 2013.

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LIST OF ABBREVIATION AND ACRONYM

ACGG	African Chicken Genetic Gains
A^e	Additive effects
AFE	Age at First Egg
AFI	Average Feed Intake
AH	Albumen Height
ANOVA	Analysis of Variance
BW	Body Weight
BWFE	Body Weight at First Egg
BWG	Body Weight Gain
CSA	Central Statistical Agency
CRD	Completely Randomized Design
DW	Dwarf
DAGRIS	Domestic Animal Genetic Resources Information System
DOC	Day old chicks
EL	Egg Length
EM	Egg Mass
EN	Egg Number
EST	Egg Shell Thickness
ESI	Egg Shape Index
EW	Egg Width
Ewt	Egg Weight
FCR	Feed conversion ratio
F	Feathering Structures
F_1	First Filial Generation
FAO	Food and Agriculture Organization
Fay	Fayoumi
GCA	General Combining Ability
GLM	General Linear Model
g	Gram
HDEP	Hen -Day Egg Production
H^e	Heterosis effects
HHEP	Hen -Housed Egg Production
HU	Haugh Units
H	Horro
H × K	Horro × Koekoek
H × Ku	Horro × Kuroiler
K x H	Koekoek x Horro
Ku x H	Kuroiler x Horro
M^e	Maternal effects
Na	Necked Neck
RIR	Rohde Island Red
SCA	Specific Combining Ability

WLH	White Leghorn
YH	Yolk Height
%	percentage
^oC	Degree centigrade

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ABSTRACT

The study was designed to evaluate the performance of exotic dual purpose chicken breed (Koekoek and Kurioler) crosses with an improved Horro chicken under reciprocal mating. The experiment was carried on seven genotypes, including three pure lines (H), (K), (Ku) and their direct (KxH), (Ku x H) and reciprocal crosses (H x K) and (H x Ku). A total of 446-day-old chicks from the seven genotypes were distributed randomly between pens with three replications using a completely randomized design. Data on body weight at hatch (DO), 4, 8,12,16 and 20 weeks of age, body weight gains, feed conversion ratio, egg fertility and hatchability in %, age at first egg (AFE), body weight at first egg, egg production until 40 weeks of age, egg quality and mortality were observed during the experimental period. Crossbreeding effects were estimated using the information on mode of inheritance of chosen traits to select potential cross combination for development of a synthetic breed. The result showed that highest (P< 0.05) mean body weight and body weight gain was recorded in crossbred chicken HxKu followed by Ku×H, and purebred Kuroiler at 8- and 12-weeks age. Moreover, genotype had significant effect on most egg production traits studied. Older age at first egg was recorded in improved Horro (156) followed by crossbred Hx K (150.33) whereas the lowest number of days for AFE was recorded for crossbred HxKu (135) followed by KxH (136.67) and Ku x H (139.33). In comparing crossbred, the heaviest body weight at first egg was registered for crossbred pullet Hx Ku (2448 g) followed by Ku x H (2372.33 g) whereas the lowest body weight was recorded for K x H (1726.33 g) followed by Hx K (1777.78 g) crossbred pullet. In comparing all the genotypes, HxKu crossbred hen showed superior (P<0.05) performance in HHEP, HDEP, egg number except egg mass. However, egg weight was higher for Kuroiler, Ku×H and H×K with comparable values but lowest egg weight was registered for improved Horro chickens. The estimates of the direct additive (A^e) and heterosis effects (H^e) for body weight were significantly (P<0.05) positive at most of studied age for both crosses. The present study showed that exotic gene of the Kuroiler and Koekoek chicken breeds had attributed a significant role in the improvement of improved Horro chicken. From this study it can be recommended that crossbred hens sired by improved Horro (H x Ku) for growth and egg production potential in the forthcoming synthetic breed development program. However, more research is needed in the areas of morphometric traits characterization, carcass characteristics evaluation, alertness score trait examination, and genotype adaptation.

Keywords: Body weight, Breed, crossbreeding effect, egg production, Heterosis

1. BACKGROUND AND JUSTIFICATION

Globally human population is expected to increase to about 9 billion in the year 2050, perhaps 70% increase accompanied in demand for animal proteins (FAO, 2011). Poultry farming is a common rural enterprise in developing countries with a significant economic, social and cultural benefits. It also plays a significant role in family nutrition. Egg and meat are a key source of animal protein that are obtained from poultry production. Most of tropical countries are mainly based on scavenging chicken production systems, which makes considerable contributions to household food security throughout the developing world (Muchadeyi *et al*., 2007). Indigenous chicken still contributes meaningfully to poultry egg and meat production as well as consumption in emerging countries, where they make up to 90% of the total poultry population (Pym *et al*.,2012). Increasing world population and urbanization, with decreasing number of people directly involved in agriculture and increasing demands for animal protein, needs increase and sustainable poultry production which are suitable for family production system (Thornton, 2010).

Indigenous chicken genotypes, despite their better adaptability to the low input scavenging/ semi-scavenging system their production in terms of egg and growth is low (Wondmeneh, 2015). Selection of the indigenous chicken can indicate improvement in productivity **(**Halima, 2007) although the progress is slow. 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). Furthermore, the continuous importation of these genetically superior breeds makes us reliant on a small number of primary breeding firms, and the availability of these genetically superior breeds to meet the demand of poultry producers is not guaranteed. Moreover, they do not suit the breed preferences of small-scale poultry farmers. Most of these exotic breeds are developed considering intensive management practices.

The overall effort to improve poultry productivity in Ethiopia by the introduction of high performing commercial chickens, except in the commercial production, was found to have limited success. Very recently a local chicken called 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 require a long period of time to put it on a level ground with the performance of improved exotic breeds. Crossing Horro with exotic line (Dominant Red Barred) sired by Horro showed improvement in most egg production traits **(**Kedija *et al.,* 2020).

Genetic improvement can be performed by crossbreeding through upgrading to a superior parent breed by frequent backcrossing, or through with in-line selection (Link and Sauer, 2016). The crossbreeding approach usually entails a two-way cross between a local breed and improved exotic, with the intention of combining the better production quality of the improved exotic with the local chicken breed adaptability to harsh environments. This system also maximizes the expression of heterosis in the cross normally mirrored improved fitness characteristics (Alonso *et al.,* 2009). Crossbreeding has been a key tool for the creation of present-day commercial chicken breeds (Adeleke *et al*., 2012; Alewi *et al*., 2012), and likewise could be used to improve the rural chicken productivity.

As a result, the genetic diversity of indigenous and exotic chicken breeds could be utilized by cross breeding to produce a new breed or synthetic line that is resistant to harsh tropical climate conditions while producing intermediate egg and meat yields (Mekki *et al*., 2005). As clearly shown by the Ethiopian livestock master plan, crossbreeding is taken as one of the ways in improvement program of livestock in general and poultry in particular (Shapiro *et al*., 2015). The genetic potential of the local chicken could be improved by crossing them with selected, but still robust exotic breeds (Wondemenh *et al*., 2015). The ideal crossbred chicken would have a better feed conversion efficiency, higher growth rate, reproductive and carcass yield than local chicken without losing adaptability to the local environments (Adebambo, 2011).

The traditional crossbreeding program demands the countries continued importation of improved exotic chicken breed lines. This one presents a major obstacle to a sustainable breeding plan due to a lack of foreign currency in developing countries. The lack of foreign currency is a great limiting factors to acquire exotic stocks in Ethiopia, and it was one of the reasons for previous failures to establish a sound and sustainable breeding program. As a consequence, a sustainable alternative cross breeding program is clearly needed. The development of synthetic breeds by crossbreeding is the solution to this issue. Synthetic breeds are the most cost-effective and best alternative for family poultry production because it does not need a continuous supply of improved exotic line.

Relatively, little research has been carried out on synthetic breed development from indigenous chicken ecotypes and improved exotic chicken breeds in Ethiopia. Testing the performance of the exotic dual-purpose chicken breed crosses with the improved Horro chicken breed helps to identify potential breeds that can be used in the development of synthetic breed and/or devise appropriate crossbreeding systems. The crossbreeding of indigenous chickens with appropriate exotic chicken breeds can bring solutions to the development of productive and adaptive dual-purpose chicken breeds that are suitable for family poultry production. Thus, the present study was designed to evaluate of the performance of improved Horro crosses with exotic dual-purpose chicken breeds (Koekoek and Kurioler) under reciprocal mating as a step towards synthetic breed development with following specific objectives

- To evaluate reciprocal crosses of improved Horro chicken with Koekoek and Kuroiler chicken breed for productive and reproductive performance.
- To quantify crossbreeding effects and understand the mode of inheritance of responsible genes; and
- To select potential cross combination for development of a synthetic breed.

2. LITERATURE REVIEW

2.1. Origin, Domestication and Distribution of Chickens in World

Chicken is one of several poultry species raised specifically for the purpose of producing meat and eggs for human consumption. Domestic chickens (*Gallus domesticus*) may come from one of four living wild birds. Red jungle fowl (*Gallus gallus*), Javan jungle fowl (*Gallus varius*), grey jungle fowl (*Gallus sonnerati*), and Singalese jungle fowl (*Gallus lafayetti*) are the four species of jungle fowl identified in in Southeast Asia (Crawford, 1993). The red jungle fowl is the most closely related species to chickens and is considered as the primary ancestor, while it is not the only one (Crawford, 1995). Although the exact place and period of domestication are not fully resolved, and chickens were domesticated somewhere in Southeast Asia (Payne, 1990). Nonetheless, based on archeological evidence from various parts of the world (West and Zhou, 1989), it was discovered that chickens were domesticated from red jungle fowls in Southeast Asia sometime before the sixth millennium BC, and then later moved to north and become established in China by 6000 BC.

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. Their numbers are enormous, and they are perhaps the most significant of all domesticated birds and mammals in terms of human diet contribution (Hoffmann, 2005). Poultry, which includes chickens and other domestic birds, provides an enormous amount of food for the world's population. Since the 1970s, global production of poultry meat and eggs, as well as trade in poultry products, has increased significantly.

Since there is no clear information on the breed types that have contributed to chicken production systems, origins, and populations in the developing countries around the world, some of them are referred to as non-descript breeds (FAO, 2011). Ethiopia is a developing country with chickens that are closely linked to red Jungle fowl. Breed characteristics, on the other hand, are non-descriptive and vary in color, comb shape, body conformation, and weight (Tadelle and Alemu, 1997). As a result, indigenous chickens lacks phenotypic standard, and their names were given based on their plumage colors named them as Tukor, Gebsima, and Netch (Bogale,2008.

According to Nigussie (2011) and Tadelle (2003) named as Farta, Konso, Mandura, Horro, and Sheka, and Tilili, Horro, Chefe, Jarso and Tepi respectively, based on the area where they are found. Apart from that, they are distinguished by pronounced broodiness, slow growth, late sexual maturity, and low production and reproduction potential (Tadelle, 2003). The haploid count of chromosomes in the domestic chicken genome is 39. Chickens, like other avian species, differ from mammals in that the female is the heterogeneous sex and the male is the homogeneous sex, the *Z* and *W* chromosomes showing heteromorphism (Singh, 2000).

2.2.Chicken Genetic Improvement

In various developing countries, there is fast economic growth consequences in growing income for human population. As a result, people devote a significant portion of their food budget to animal protein. Intensive farming systems satisfy the increased demand for animal protein in general, and poultry meat and eggs in particular (Hoffmann, 2005). Specializing of the chicken production either for egg or meat by genetic improvement also plays an important role in meeting the growing high demand for poultry meat and eggs. Modern specialized breeds and lines have been developed since 1950s in developed countries to increase production in one or a few major traits.

Poultry breeding companies have effectively secured their intellectual property investment in superior birds by manipulating heterosis and deleterious segregation of hybrid stocks in the next generation (Hoffmann, 2005). Since the 1950s, poultry breeding companies have become smaller and larger in size due to increased foreign competition and the high cost of sustaining modern breeding, marketing, and distribution systems relative to potential profits. The number was also decreased as a result of a series of acquisitions and mergers. In the 1980s, for example, there were 20 breeding companies around the world. The international laying hen industry is currently dominated by three groups of primary breeders, and there are four broiler breeding companies worldwide (Flock and Preisinger, 2002).

In Africa, there are few breeds that have been properly described, and most indigenous chickens lack unique a phenotypic pattern that can be distinguished by one or more features such as a naked neck or feather color. Because of their ability to tolerate certain diseases and parasites, as well as their ability to survive in tropical environments, local chicken is chosen for adaptation and disease tolerance rather than for increased production (Hoffmann, 2005). While there is evidence that the performance of indigenous breeds can be enhanced genetically, they cannot compete under optimal conditions with highly selected commercial hybrids There is indication to show that the indigenous breed performance may be improved genetically, but they cannot compete under optimized conditions with highly selected commercial hybrids. The breeding goal should thus be to improve their efficiency under village condition (Besbes, 2009).

However, in a tropical climate, there are local chicken breeds with unique genetic characteristics that could be used to boost local chicken productivity. The Naked Neck strain is well-known among these chicken breeds for its superior performance. Fayoumi is another indigenous chicken that has been extensively studied and increased egg production. It's an Egyptian breed with a small body size that's adaptive to the harsh tropical climate and can produce up to 200 eggs per year with proper management (Hasnath, 2002). Furthermore, because of the taste and color of the meat as well as the yellow yolk of the eggs, many people can choose indigenous chickens.

Under farmers management conditions, a simple crossbreeding of indigenous with improved exotic chicken varieties can increase chicken productivity (Khan, 2008). Rhode Island Red (RIR), New Hampshire, and Plymouth Rock are examples of exotic breeds with high productivity and hardiness (Gueye, 1998). In Bangladesh, for example, a crossbred known as Sonali was created by crossing RIR cock and Fayoumi hen, and it has proven to be the highest yielding and most productive breed combination under semi-scavenging conditions. Simple crossbreeding, on the other hand, requires a continuous source of pure breeds, which could be extremely expensive for many farmers in developing countries. The development of synthetic or composite chickens, which are a single population that is a mixture of different breeds created by performing one or a few crosses between two or more populations, is an alternative method for combining desirable properties from improved exotic chicken breeds and indigenous chicken breeds (Nicholas, 2010).

Even though crossbreeding may increase productivity, it has also resulted in a dilution of native birds and the loss of important characteristics such as broodiness and other morphological traits. Furthermore, where main production inputs such as feeds and medicine are not readily available, crossbreeding for village conditions can be too complicated (Besbes, 2009). Crossbreeding on an indiscriminate basis may result in the decline or even extinction of indigenous chickens before they are even recognized (Enyew and Workneh, 2001). According to Besbes (2009) suggested that selection for production traits within a given population is the best method to improve the productivity of local chicken. However, due to the slow progress achieved in production traits the uses of selection schemes are limited. However, due to the slow progress achieved in production traits the uses of selection schemes are limited.

2.2.1. Development of native stock through pure breeding

Within-breed selection was used to genetically improve local chicken in some African countries, including Egypt, Nigeria, and, very recently, Ethiopia. In Ethiopia, at the Debrezeit Agricultural Research Centre, selection within the Horro indigenous chicken ecotypes began in 2008 and has been effective in increasing egg production and body weight (Wondmeneh *et al.,* 2015). By generation five, Horro chicken egg production had increased by 123.5 percent to 75 eggs at week 45, and the age at first egg had decreased to 148 days from 203 days (Tadelle *et al.,* 2013). The Horro chicken breeding program was developed to increase the productivity of village chickens through selective breeding. The Horro chickens were identified using a participatory method, and the breeding goals for this improvement plan are egg number and body weight at 45 weeks and 16 weeks (Nigussie *et al.,* 2010). 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 fulfill the needs of the farmers (Wondmeneh *et al*., 2015).

According to Nigussie (2011), there is a close relationship between body weight at 16 weeks and egg production from 21 to 28 weeks in the Horro chicken during selection program in Ethiopia. Furthermore, the low to moderate heritability estimates for various traits indicate that with the appropriate selection program, Horro chicken performance can be improved. As a result, the breeding program to improve the performance of indigenous chicken breeds through selection is greatly useful to farmers in rural areas who want to increase their income from indigenous birds. According to Padhi (2016), the low production performance of indigenous chicken breeds can be improved through better management practices, better health care, and supplementary feeds through selection. The advantages associated with additive gene action are captured by selection. A large 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. When selecting within a breed, this means that a significant amount of time and money will be required to achieve the desired genetic improvement of indigenous chickens (Munisi *et al*., 2015).

2.2.2. Cross breeding of chicken

Poultry breeding systems use selection and crossbreeding plans to increase the genetic potential of newborn chicks (Narinc *et al*., 2014). Crossbreeding is a key method for developing promising individuals affected by a variety of genetic and non-genetic factors. It's also useful for averaging breed effects and achieving intermediate values between the two extremes (Yongjun *et al*., 2006). Attempts have been made to increase the efficiency of indigenous chickens, both in terms of egg and meat production, by crossbreeding local hens with exotic commercial cocks (FAO, 2009). Indigenous chickens provide genetic resources as base form for the research on genetic improvement and diversification of chickens during the development of new breeds (Saadey *et al*., 2008). One of the methods used to investigate genetic variation among breeds is crossbreeding of indigenous and exotic breeds. The main goal of crossbreeding is to create superior breeds, develop health and improve fertility traits, and combine different economic characteristics (Razuki & Al-Shaheen, 2011).

Because of the negative genetic relationship between growth and egg traits, developing a dual-purpose chicken breed through selective breeding can be difficult. The use of crossbreeding could overcome the difficulties with negative correlated traits. Crossbreeding between commercial cocks and indigenous hens may provide a means of producing productive dual-purpose chickens that can cope with harsh environments. In village poultry production systems crossbred chicken from commercial cocks and indigenous hens can best perform because the crossbreds benefit from the adaptation trait from scavenging birds (Bekele *et al*., 2010). The Rhode Island Red (RIR), for example, has long been the most popular commercial line for producing dual-purpose chickens by crossing with native birds (Bekele *et al*., 2010). The exploitation of genetically diverse indigenous chickens for improving economic traits, such as body weight is one of the approaches driving the breeding program of chickens (Saadey *et al*., 2008). The crossbreeding in poultry is performed by artificial insemination and natural mating using a standard ratio of cocks to hens. Both the mating frequency and the mating efficiency of cocks vary widely with little relationship between the traits and fertility. The mating dynamics in large commercial flocks of breeders are highly complicated, according to these findings. The ratio of 1 cock to 10 hens gives the best fertility results. The decrease in broiler cock fertility after 50 weeks of age has been observed, with the theory that this is due to the cocks' conformation preventing cloacal interaction rather than a reduction in libido (Hocking, 2010). Crossing of indigenous chicken varieties with exotic varieties can be a major intervention tools for improving productivity (Rothschild and Plastow, 2014). Grading up, rotational crossing or crisscrossing, and the formation of synthetic breeds are the three primary methods of crossbreeding (Steyn, 2013).

*2.2.2.1***.** *Grading up through back-crossing*

In most parts of the tropics, grading up is a traditional crossbreeding technique. In terms of productive and reproductive characteristics, the first cross generation (F_1) does perform very well. Grading up normally entails mating an indigenous breed with an exotic breed. This results in the first generation (F_1) having generally better performance than the indigenous, but performance can be variable due to significant differences in environmental conditions and genotypes involved. It also entails backcrossing using males of one breed, or a crossbred form, on females of the breed intended to be graded and then on consecutive generation of crossbred progeny which obtained from the mating (Abegaz and Awgichew, 2008). Grading up is the commonest method of crossbreeding, with the aim of combining and maximizing their strengths and minimizing the weaknesses in both, to create a breed that has more positive potentials than its parents (Khawaja *et al*., 2013). For example, the production of eggs and meat can be increased through the crossing of the exotic birds with the locally adapted ones under improved rearing conditions.

Crossing enhances the expression of heterosis in the cross, resulting in improved characteristics (Hoffmann, 2005). In Malawi, Safalaoh (2001) conducted a Desi chicken upgrading program in which he crossed Australorp males with indigenous female chicken. The up graded progenies had significantly higher body weight, fertility rate, hatchability, and sexual maturity at a young age. When Black Australorp female flocks were mated with indigenous males, the study found slightly higher body weight gains at 8, 20, and 28 weeks of age, fertility rates (77 percent vs. 91 percent), hatchability (84 percent vs. 92 percent), and sexual maturity (158 days vs. 153 days).

Regular backcrossing of female progeny with the superior-performing male parent breed, or cockerel exchange schemes in which improved male breed are provided to smallholders, have not been successful to improve chicken genetics. Separate populations of parent birds must be maintained in both circumstances, and the offspring often lack brooding capacity. Separate populations of parent birds are especially vital to conserve, as the progeny often lacks the ability to brood, and their offspring cannot hatch. This is a severe problem considering the purpose for which the birds are being bred. Furthermore, improved breed males' survival has been hindered by their lack of tolerance for the climate and related risks. One of the most serious risks is that these birds are attractive to other farmers, resulting in regular thefts for breeding or feeding.

According to Besbes (2008) several studies have recorded the impact of cockerel exchange in terms of their contribution to plumage variation without changing their base populations. These findings are in line with Kayitesi (2015) who was reported that under circumscribed range conditions in Rwanda, the Kuroiler chicken breed and its crossbreds with local hens had a higher mean hatchability and chick survival rate.

2.2.2.2. Rotational crossbreeding

When males from two or more breeds pair with crossbred females, this is known as rotational crossbreeding. Over time, each breed would have contributed equally to the strengths and weaknesses of the group. In rotational crossing at least two breeds are used. Purebred males are still present. One breed is used first, followed by the second, and so on until the series is complete. The process then repeats itself, starting with the first breed used. Only the first generations of breeding are purebred females to whom the males are mated. In subsequent generations, crossbred females are included (Abegaz and Awgichew, 2008). In Pakistan, growth patterns in chickens of reciprocal RIR and Fayoumi breeds revealed that hybrid chickens of Fayoumi male and RIR female outperformed than hybrid chickens of Rohde Iceland Red and male Fayoumi female in all traits. From the crossbreeding of Fayoumi males with RIR females, two-way crossbred females of FIRI were retained and mated to the third breed for improved production performance. As a result, a three-way crossbred chicken, the Rural Leghorn (RLH) was synthesized through crossing White Leghorn males with FIRI females. White Leghorn (50 percent), RIR (25 percent), and Fayoumi chickens are all included in RLH chickens (25 percent). In rotation, hybrid vigor is slightly lower than in three-way crossbreeding (Devi *et al.*, 2005).

2.2.2.3. *Synthetic breeding*

Synthetic breeding is the process of crossing two or more populations of chickens to form a single population of chickens, followed by selection within the crossbred population (Munisi et al., 2015). With synthetic breeding, it is necessary to maintain only one population with all desirable traits, instead of two or more parental populations needed in regular crossing programs. Several levels of heterosis would be expected, depending on the genetic diversity between the parental breeds. However, enough information on the attributes and capabilities of different breeds of chickens is essential before initiating any breeding strategy in order to select the proper breeds/genetic stocks (Munisi et al., 2015). New breeds formed from two or more constituent breeds are called synthetic lines. New breeds can be synthesized from crosses combining breeds in virtually any proportion, first crosses or various back-crosses of two breeds, or combinations of more than two breeds (Abegaz and Awgichew, 2008).

Table 1. Example of synthetic breeds developed by cross breeding

Synthetic breeds	Their crosses	Origin
Dokki 4	Fayoumi × Barred Plymouth Rock	Egypt
Golden Montazah	Dokki 4 × Rhode Island Red	Egypt
Mandarah	Dokki 4 × Alexandria	Egypt
Matrouh	Dokki 4 × White Leghorn	Egypt
Alexandria	White Leghorn× Barred Plymouth Rock × Rhode Island Red × Fayoum	Egypt
Potchefstroom Koekoek	Black Australorp × White Leghorn × Barred Plymouth Rock	South Africa
DZ-White	Rohde Island White x Lohman Silver x Koekoek	Ethiopia (not released)

Source: Domestic Animal Genetic Resources Information System (DAGRIS, 2007)

Therefore, In Ethiopia the 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

2.3. Importance of Chicken Cross Breeding

The role of crossing is the reverse of the inbreeding effects. individual in the crosses are more heterozygous than individuals in a pure-bred population. In comparison to inbreeding, where there is a linear negative association with fitness and production character and the degree of inbreeding, it is impossible to predict about the effect of crossbreeding. Crossing can be used to create crossbred poultry, improve native chickens, or create a new breed that incorporates desirable traits at least from two breeds (Galukande *et al*., 2013). Crossbreeding allows heterosis, complementarity, and breed variability to be maximized.

2.3.1. Breed complementarity

Crossbreeding is required for a various of reasons, one of which is to combine the best features of two or more breeds of different types in a complementary manner. This is the process of making a more suitable offspring by crossing breeds that are genetically different but have complementary qualities. It's the consequence of combining and matching the average breeding values of different biological types of breeds. The combination of tropical breed adaptation with enhanced temperate breed productivity and their influence is additively genetic. Complementarity refers to the ability to incorporate characteristics from two or more breeds into a single hybrid. It allows for the use of desirable traits from one breed and mask undesirable traits from the other breed that are involved cross breeding. This enhances the breed's positive characteristics while concealing the breed's negative characteristics (Williams *et al*., 2002). Breed complementarity is a significant crossbreeding advantage which is a very important for the success of crossbreeding programs.

2.3.2. Heterosis

It does not seem to have a single and simple explanation for heterosis. Instead, it is likely that heterosis rises in crosses between genetically distinct individuals because of a diversity of mechanisms (Ferdous, 2013). Heterosis is caused by the interaction of multiple loci, and different loci influence heterosis for different traits and in different hybrids. Whatever the genetic explanation, hybrid vigor is a non-additive effect that involves a heterozygous genotype**.** Heterosis is hybrid vigor, which refers to the enhanced strength of various traits in hybrids, as well as the possibility of creating a genetically superior individual by incorporating the qualities of both parents. Heterosis is a dynamic biological phenomenon characterized by improved livability and productivity (Belorechkov, 2004). It is usually seen in first-generation (F_1) crosses.

The heterosis resulting from crossbreeding is an additional benefit of genetic gain by pure breeding (Sorensen, 2007). It is determined by crossing populations to produce an F_1 generation that is then compared to the parental populations. The degree of genetic similarity between parental populations is inversely related to the magnitude of heterosis, and is projected to be proportionate to the degree of heterozygosity of the crosses Because of non-additive genetic effects, heterosis can be viewed as both overall fitness and an expression of a particular trait (Wilham and Pollak, 1985).

The impact of heterosis is usually greater for reproductive traits than for growth potential (Fairfull, 1990), and it is affected by the maternal side as well as nutrition (Liu *et al*., 1995). According to Khalil *et al*. (2004), original purebred chicken lines produce fewer eggs than their crosses. Crossbred pullets were lighter than purebreds at 20 weeks of age (Malik *et al*. 2005), while crossbreds were superior to purebreds in body weight at 20 and 40 weeks of age (Singh and Singh, 2005). In addition, Iraqi *et al.* (2002) showed that the heterosis estimates for body weight of crossbred obtained from crosses between Mandarah and Matrouh chicken strains were generally positive and high. In practice, the amount of heterosis can vary dramatically due to the surrounding environment and the genotypes of the crossed populations.

Significant direct heterosis estimates could be an emphasis of the existence of non-additive genetic differences concerning estimated traits. On the other ways, negative estimates of direct heterosis could lead to determine that involvement of a maternal line, selected for egg production, in crossbreeding experiment could not increase the improvement of growth traits. However, negative direct heterosis, could be attributed to directional dominance of genes affecting these traits, as well as the nature of the data of the trait itself (Khadiga *et al.*, 2014**).** Heterosis is non-additive crossing effects normally attributed to genetic interactions within loci and between loci. However, this can be done by scale effects, in particular because of a multiplicative effect of sub traits on observed value.

2.3.3. Combining abilities of parental lines

Crossbreeding of native stock with exotic commercial birds will benefit from artificial selection for productivity in exotic birds and natural selection for hardiness in indigenous birds. A good combining ability resulting from the selection of the best performing crossbred could result in the production of birds with higher growth rates, feed conversion efficiency and reproductive traits without sacrificing adaptation to the local environment, thereby resulting in reduced cost of production. The breeding value of parental lines to produce hybrids is defined by their ability to combine. The combining ability analyses aid in the identification of desirable combiners for manipulating heterosis (Saadey *et al*., 2008). Combining ability provides useful information on the best line, breed, or strain combinations available for optimal performance of crossbred animals (Razuki and ALSoudi, 2005). General combining ability (GCA) is attributed to additive genetic variance which the average performance of genotypes in hybrids combinations with other genotypes.

Specific combining capacity (SCA) is a numerical value that expresses a specific crosses deviation from what would be expected based on the average performance of the lines involved in that cross. Also, it is used to describe situations where certain combinations perform better or worse than expected based on the average performance of the lines involved (Kabir *et al*., 2011). Both general combining ability (additive genetic effects) and specific combining ability (non-additive effects such as dominance and epitasis) were found to be highly estimates of non-additive gene effects for native breeds (Mohamed et al., 2005; Amin, 2007).

2.4. Productive and Reproductive Performance of Indigenous Chicken

As in many other parts of Africa, the indigenous chicken of Ethiopia comprises chickens with a wide range of morphologies or genetic diversity. In Ethiopia Currently, eight indigenous chickens types of Ethiopia, named after either their plumage colour or geographic origin of sampling, were reported (DAD-IS, 2017). The small number of breeds included in the database shows the shortage of data on the chicken genetic resources of Ethiopia. It also suggests that more of the diversity that existed in the locally adapted chicken populations remains undocumented. Several morphological, phenotypic and genetic characterizations (Emebet, 2015) showed that very little difference existed among ecotypes and that most of the variation in the indigenous chickens are given to differences within individual populations.

The ecotypes of indigenous chickens have desirable traits such as heat tolerance, disease resistance, good egg and meat taste, hard egg shells, high fertility and hatchability, and a high dressing percentage (Aberra, 2000). According to Nigussie and Ogle (2000) the average annual egg production of indigenous chicken ecotypes under the village was 30-60 eggs which could be improved to 80-100 eggs on station with improved feeding, housing and health care. Studies of native ecotypes in the tropics have revealed that their capacity for egg production and growth is very poor under small-holder farmer management. The average body weight gain of native chickens of Ethiopia on station management was higher than traditional management and also described that local chicken egg production performance was increased after six generations of selection, and the analysis revealed significant genetic changes over generations intervals. (Wondmeneh *et al*., 2015).

According to FAO (2005), the age at which local Ethiopian chicken ecotypes Tukr, Melata, Kie, Gebsim, and Netch laid their first egg was 173, 204, 166, 230, and 217 days, respectively. Tukur, Melata, Kai, Gebsima, and Netch, Ethiopian chicken ecotypes, had fertility rates of 56, 60, 57, 53, and 56 percent and hatchability rates of 42, 42, 44, 39, and 39 percent respectively (FAO, 2004). According to Bogale (2008) an average of 13 eggs were incubated per hen, with an average of 11 chicks hatched. A laying hen needs 120-130 days, including 40-50 days of laying, 21 days of incubation, and 60 days for brooding chicks to accomplish one production cycle (Tadelle, 2003).

2.5. Productive and Reproductive of Performance Crossbred and Exotic Chicken

The crossbreeding between Aseel x Dahlem Red increased the number of yearly eggs crossbreed offspring from 91 to 189 eggs (Padhi, 2016). Under village management conditions, the egg production potential of exotic breeds, produces around 250 eggs/hen/year with around 60g egg weights in Ethiopia. According to Lemlem and Tesfay (2010) reported that White Leghorn, Red Island Red, and Fayoumi chickens produced 173 eggs, 185 eggs, and 144 eggs per year, respectively, under village management conditions. Demeke (2004) also reported that under rural management conditions with supplementary feeding, White Leghorn produce 82 eggs per hen.

Geleta (2013) had reported that the egg weight of Fayoumi chickens raised at Adami Tulu Research Centre (44.3 g) was similar to Fayoumi (43 g), but lower than the egg weights of Rhode Island Red (52.5 g) and White Leghorn (52.1 g) recorded by other researchers (Lemlem and Tesfay, 2010). Demeke (2004) was reported that there was no significant difference in rate of maturity between Leghorn and local pullets allocated to household conditions with or without supplementation, as measured by age at first egg. The production performance of indigenous, exotic and their crossbred chickens in Ethiopia, revealed different mean ages of sexual maturity for indigenous at seven months, crossbred at six months and exotic at five months (Habte *et al*., 2013). Crossing Horro with exotic line (Dominant Red Barred) sired by Horro have showed improvement in most egg production traits (Kedija *et al.*, 2020**)**. Wondemenh *et al.* (2015) were reported that crossbreeding between Rohde Iceland x Horro showed superior body weight performance than improved Horro at all ages.

The hybrid layers, usually start laying eggs at around 19 weeks of age and during the first cycle peak egg production is reached. Commercial hybrids lay annually an average of 180-200 eggs per hen in areas where the climate is hot and humid, while commercial layer can lay in range of 250 and 300 eggs annually per birds in more temperate climates. Breed, mortality rate, body weight, laying house lighting schedule, feed, and culling are all factors that may influence the egg production cycle (North and Bell, 1990). One of the significant phenotypic traits that influences egg quality and reproductive fitness of chicken parents is egg weight. The thickness of the eggshell is a significant factor in hatchability. Egg shell thickness should be between 0.33 and 0.35 mm for best hatchability, but only a few eggs with a shell thickness less than 0.27 mm will hatch **(**Khan *et al*., 2004**).**

According to Aklilu *et al.* (2013) reported that the Potchefstroom Koekoek chicken breed performed better than indigenous chickens reared in a village production system in the Afar Region. Tadesse *et al.* (2013**)** had stated that the exotic chicken such as Bovans Brown, Potchefstroom koekoek and Isa Brown showed good productive performance under farmers' management conditions. Dirsha (2009**)** reported that Rhode Island Red (RIR) chickens gives better production performance under farmer management conditions. According to Haftu (2016), in the availability of adequate feed, exotic breed and cross breed chickens can produce more number of eggs.

2.6. Status of Chicken Production in Ethiopia

In Ethiopia, the term poultry is almost synonymous with chicken. Guinea fowl, geese, turkeys, and ducks are not popular poultry species in the country. The improved chicken breeds are thought to have been introduced to Ethiopia by missionaries sometime in the mid-nineteenth century (Meseret, 2010). Solomon (2007) was reported that under a USAID project, four exotic chicken breeds (Rhode Island Red, Australop, New Hampshire, and White Leghorns) were introduced to Jimma and Haramaya in 1953 and 1956, respectively. Due to the low production performance of local chicken breeds, highly productive exotic chicken breeds were introduced into urban, peri-urban, and rural areas across the country (Matawork, 2016). According to Central Statistical Agency of Ethiopia (2009/2010) the total poultry population at the country level was estimated to be about 42 million. About 96.6% of the total population is reported to be indigenous and the rest are exotic pure breeds and hybrids. There have been fluctuations in the estimation of poultry population in Ethiopia. For example, the Central Statistical Agency of Ethiopia reported 33.35, 37.76 and 31 million of poultry population in the Ethiopia in 1996, 2000 and 2005, respectively.

Alemu (1995) reported that other organizations such as the International Livestock Research Institute reported 56.5 million total poultry population in 1993. According to the CSA (2015) indigenous chickens account for the majority of chickens raised in the country, with crossbreds and exotic chickens accounting for a small percentage. (CSA, 2016) also reported that Ethiopia's total poultry population is projected to be about 60.5 million, with 94.3, 3.2, and 2.5 percent indigenous, cross, and exotic poultry, respectively, in backyard, small-scale operation and large-scale commercial production systems.

No detail reasons were given for the large deviations of chicken population in different years projected by different organizations and researchers, but possible reasons could be the difference in sampling methods, sampling period of the year, absence or presence of epidemic diseases during sampling year, etc. It was reported by Solomon (2008**)** that during some epidemic periods mortality of up to 80% was observed in village chickens which can significantly decrease chicken population. The Sampling period of the year is also very important because of the sharp increase of chicken slaughtering on national holidays such as New Year, Christmas, and Easter.

Traditional village poultry production is practiced by almost all rural family other than the nomadic population. It is characterized by minimum input, average flock size per household of chickens that are scavenging most of their food, and no investment beyond the birds. Some farmers made simple separate night enclosures, but most chickens stay the night in the family's house. A small number of exotic birds are distributed to farmers by Ministry of Agriculture, non-government organizations and some higher educational institutions, otherwise village farmers keep mostly indigenous chickens. Indigenous chicken ecotypes that live in different agro-ecological zones have names based on either their area of origin, plumage colors or type of combs (Reta, 2009). Tadelle *et al.* (2000) cited some researcher reports and the average annual egg production of indigenous chickens under village condition could be as low as 30 eggs and up to 80 eggs/year if chickens are provided with improved feed, housing and health care. Body weight for males can reach 1.5 kg at six months of age and females about 30% less. Although village poultry production may appear primitive, it can make economic sense. This is because that even if the yield from indigenous chicken is very low, the inputs are even lower and sometimes can be non-existent (Tadelle *et al*., 2000).

On the other hand, private and government commercial poultry farms are in their early stage of growth and mainly distributed in limited urban locations due to the presence of electricity and other infrastructures. Some private poultry farms are a major source of breeding stock and commercial feed for the modern private poultry farms (Solomon, 2008). The current status of chicken population in Ethiopia estimated around 59.495 million (CSA, 2017)**.**

3. MATERIALS AND METHODS

3.1.Experimental Location

The study was carried out at Debrezeit Agricultural Research Center's National Poultry Research Farm, which is located at 45 kilometers southeast of Addis Ababa, at an altitude in the range of 1900 to 1995 meters above sea level and at 8.44°N latitude and 39.02° E longitude. The area has a bimodal rainfall pattern with a long rainy season from June to mid-September and a short rainy season from February to May. The average annual rainfall, maximum and minimum temperatures for the area are 892 mm, 28.3 °C and 8.9 °C, respectively.

3.2. Experimental Chicken Breed Description

Improved Horro

Horro is an indigenous chicken of Ethiopia. The strain is now considered as dual-purpose chicken as the growth and eggs performance has shown significant improvement during the short-term mass selection (Wondmeneh *et al.*, 2015). In the first six months after the start of egg laying, the base population produced 34 eggs (Nigusse *et al*., 2011). After 6 generations of selection, the egg production was increased to 76 eggs in 6 months after the onset of egg laying which indicating positive genetic changes over generations (Wondmeneh et al., 2014). For the cross breeding in this study, selected birds of the 12th generation were used.

Potchefstroom koekoek

The Potchefstroom Koekoek chicken genotype is a hybrid of three European poultry breeds: White Leghorn, Black Australorp, and Bared Plymouth Rock. This genotype was bred for both egg and meat production and has a black and white speckled color pattern (Mutibvu *et al.*, 2019). The breed was developed to be a dual-purpose chicken with free-range laying capabilities and a large structure for meat production. The breed is known for its black and white speckled color patterns, which are also known as barred (Grobbelaar, 2010). On station production potential of KK shows the specific production traits of brown shell eggs, 200 eggs per hen per year, 55.5 gm weight of eggs, deep yellow attractive carcasses colored skin, heavy weight of male (2.653kg) and female (1.873kg) at the end of productions (Grobbelaar *et al.,* 2010; Wondmeneh *et al.,* 2011). The breed has sex-linked gene that is very useful for color sexing. The breed is known for its ability to hatch its own offspring's.

Kuroiler

Kuroiler chicken is a large dual-purpose synthetic breed developed in India and imported as ACGG project component in 2015. It was developed by Vinod Kapur of Kegg Farms Private Ltd. in the early 1990s. Kuroiler chicken was created by crossing either White Leghorn roosters with Rhode Island Red hens, or colored broiler roosters crossed with Rhode Island Red hens. According to Ahuja *et al*. (2008), Males reach 4 kg in 12 months and weigh at least 1kg at about three months, and Hens reach 2.5 kg in 12 months, begin laying eggs at five to six months, and lay 150–200 eggs during their 12–16-month egg laying period. Based on this performance, it's expected to produce dual purpose which is suitable for family poultry production in terms of both egg and meat production. Intermediate production performance and adaptability are the main reason for the selection of the breed for crossbreeding.

3.3. Breeding Plan and Mating Techniques

The chickens required for the study were obtained from the descendants of the stock used for on station evaluation of chicken breeds by the African Chicken Genetic Gains (ACGG) project at the Debre Zeit Agricultural Research Center. The crossbreeding study was started by randomly picking of 105 hens and 33 cocks as foundation parental breeds. Mating was started at 21 weeks of age using the two exotic breeds (Koekoek and Kuroiler) and improved Horro chicken as a parental-line. In the first generation of the crossbreeding experiment, Hens of each of the two exotic breeds and improved Horro were randomly divided into three breeding groups. The first group of hens of each of the three breeds was naturally mated with cocks of their own breed while the second group was artificially inseminated with semen of cocks from improved Horro chicken. Similarly, hen of improved Horro chicken mated artificially with semen of cocks from two exotic breeds. Artificial insemination was required because of the big size difference between improved indigenous Horro and the other exotic chicken breeds.

The cocks were trained for semen collection by abdominal and back massage for about one minute and their vents was cleaned prior to semen collection (Kharayat *et al.*,2016). During insemination hens were restrained, and then pressure was applied to the left side of the abdomen around the vent. This causes the cloaca to evert and the oviduct to protrude so that a micropipette was inserted into the oviduct and the appropriate amount of semen deposited. The pressure around the vent was released as the inseminator ejected the semen which assisting the hen in maintaining spermatozoa in the oviduct. Within the same breed, male to female ratios of 1 to 5 were used in pen mating arrangements. The cocks were assigned to mate the hens at random, with a restriction to prevent birds from mating with common grandparents.

Accordingly, seven genetic groups of H♂ × H♀, K♂ x K♀, Ku ♂x Ku♀, H♂ x K♀, K♂ x H♀, H♂ x Ku♀, and Ku♂ x H♀ chick's combination were obtained. Sire is always written in first. The mating design was inter se (H×H, K × K and Ku × Ku and reciprocal crosses (H× K and K × H, H x Ku and Ku x H to produce the first filial (F_1) generation. To get adequate semen for artificial insemination two cocks were used per replication (a total of six cocks) for each type of cross as opposed to only one cock per replication in the pure mating (Table 3).

Eggs from each genetic group were collected on a daily basis, marked with mating combination (cross type) and kept for 10 days to be incubated to obtain uniform age groups. From all genetic groups a total of 446 unsexed day-old chicks were obtained. To keep their breed and crossbred group identities, the hatched chicks were wing tagged. Using a completely randomized design with three replications chicks from each genotype were distributed randomly into pens. The day-old chicks were kept in a brooding house. At week 12, sexing and differentiation of the males from the females were carried out phenotypically via external characteristics.

Table 2. Mating schemes of study animals under pure mating and reciprocal crosses.

Genotype	Horro (♂)	Kuroiler (♂)	Koekoek (♂)
Horro (♀)	×	×	×
Kuroiler (♀)	×	×	-
Koekoek (♀)	×	-	×

×- indicates crossing, ♀-designates female, ♂- designates Male

3.4. Management of the Experimental Chicken

Standard feed were given to the chickens according to their growth stage requirements, with water available *ad libitum*. For up to 8 weeks, starting chicks were fed a ration containing 20% CP and 2,950 kcal/kg, and from 9 to 18 weeks, grower chicks were fed a ration containing 18% CP and 2,850 kcal/kg. At the start of the 19-week period, a layer's ration containing 17.5% CP and 2,750 kcal/kg was formulated. A ration for each genotype was formulated using Feed Win software® according to the recommendations and the following ingredients were used: white maize (*Zea mays*), noug (*Guizotia abyssinica*) seed cake, soybean meal, wheat middling, bone and meat meal, limestone, DL-methionine, L-lysine, vitamin-premix and salt were used. Feeder and waterer was placed in the house per pen with proper space.

The experimental house was open sided with deep litter of 15cm of *teff* (*Erogrostis teff*) straw on the concrete floor. The pen size was 1.5m x 2 m. As the birds continue to increase in size the brooding guard was similarly increased by drawing the brooding guard backward and after brooding time finished it was completely removed. During brooding stages brooding heat was supplied by using an infrared bulb. All chickens were inspected daily for their health status and vaccinations were given against provided against common disease likes Marek's, Newcastle diseases,Gumbro, and Fowl Tyipoid at respective ages based on and veterinarian recommendation.

Table 3**.** Number of sires, dams and their progenies used for the analysis of study parameters of purebred and crossbred genotypes.

Genotypes	Sires	Dams	Progenies
H× H	3	15	60
H × K	6	15	58
K × H	6	15	55
K × K	3	15	57
H × Ku	6	15	52
Ku × H	6	15	92
Ku × Ku	3	15	72
Total	33	105	446

3.5. Data Collection

3.5.1. Productive performance

The amounts of feed offered and refused per pen were recorded daily during the experimental period for 40 weeks. Daily feed intake was calculated as the difference between the weight of feed offered and the refusal divided by number of chickens. Live body weight of chicken was measured in a group per pen using sensitive balance. Body weight was taken at hatching (0 day) and bi-weekly then after up to 40 weeks of age. Average body weight per pen was calculated for weights at hatch, 4, 8, 12, 16, and 20 weeks. Body weight gain was calculated as the difference in body weight values between two consecutive measurements divided by the number of days elapsed. Feed conversion ratio (FCR) was calculated by dividing the feed intake to weight gain.

Age at first egg, body weight at sexual maturity, egg weight and number of eggs on a daily basis were taken as egg production parameter. The age of each individual chickens was taken and age at first egg was recorded as number of days between the date of hatching and the date of their first egg. The age at first egg was used to determine the sexual maturity of birds. Egg productions were then managed in four-week interval for egg laying period of 21 to 24, 25 to 28, 29 to 32, 33 to 36, and 37 to 40 weeks of age. Each of these 4-week intervals helped to aggregate the monthly egg production. Then, based on these data, hen-housed and hen-day egg production were determined monthly from point of lay to 40 weeks of age using the method recommend (Hunton, 1995). Percentage of hen day egg production was calculated by dividing the number of eggs collected per day for the number of hens present on that a day and multiplied by 100. Percentage of hen housed egg production was calculated by dividing the number of eggs collected in the period for number of hens originally housed times number of days and multiplied by100.

Average egg weight per replication per genotype was calculated to obtain the monthly average egg weight and was computed by dividing the total egg mass to the number of eggs. Egg mass per hen was calculated as total egg mass from each pen divided by number of hens. The number birds died and survived during the experimental period were recorded and general health status was monitored throughout the experiment. Mortality percentage was calculated by subtracting the number of dead birds from number live bird and divide for live birds at the beginning and multiplied by 100.

3.5.2. Fertility and hatchability measurements

Incubated eggs to produce experimental chicks were evaluated for fertility and hatchability. The temperatures and humidity in the egg storage room were kept at an optimum level 12°C to 14°C and 75% respectively. The eggs were incubated in Pass Reform incubators with standard temperature and humidity facilities of 99.5 to 99.75 º F and 55-60% for 18 days in setter compartment. Subsequently, the temperature was decreased to 98.5ºF whereas a relative humidity was increased to 65-70% in the hatchery compartment, from the 19th day to hatching time. The eggs were also turned automatically through 45° in the incubator. On the 18th day of incubation, egg candling was performed to identify fertile and clear eggs. Candling was performed with a mass candler in a dark room. The eggs were mounted on the candler so that light could easily penetrate them, and the eggs could be seen against the light source. The fertile eggs were seen to be opaque, with a system of veins indicating the embryo's development inside the egg, whereas the infertile eggs were translucent under the light. After candling, infertile eggs were counted and discarded and those with live embryo were transferred to the hatchery compartment as per genotype labels for three days. After hatching, the day-old chicks were carefully chosen for very weak, abnormal or dead in shell, and if obtained, they were discarded appropriately.

The Percentage of fertility from the total egg set per pen was calculated as the number of set egg minus the number of infertile eggs at candling per pen divided by the number of set eggs per pen times 100. The percentage of the hatchability of total egg set was calculated from the number of day-old-chick divided by the total number eggs set times 100. The percentage of hatchability of fertile eggs were calculated from the number of day-old chicks divided by the difference between the number of eggs set and the number of eggs found to be infertile at candling, times 100.

3.5.3. External and internal egg quality measurements

Egg quality parameters were measured at the 32 weeks age. The temperature and humidity in the egg storage room were set at an optimum point of 12°C to 14°C and 75% respectively to slow down the post-harvest loss in quality. Data were taken from the stored eggs on the second day after collection. Fifteen (15) eggs per pen or genotypes were randomly selected and used for analysis. Egg weight, yolk weight and shell weight measurement were determined by sensitive balance. Egg shape (width and length), yolk width and albumen width were measured by digital caliper whereas albumen height and yolk height were measured at the height of the chalazae at the midway point between thinner and outer circumference of the white with a Micrometer gauge.

The internal egg quality measurements were made by carefully making a hole around the sharp end of the egg that was wide enough to enable both the albumen and the yolk to move through without mixing their contents. The yolk was removed from the albumen with care and weighed in a petri dish. Before the next weighing, the petri dishes were washed in clean water and cleaned with a dry cloth (Veena *et al*., 2015). After the shell membrane was removed, the thickness of the shell was measured with a digital caliper at the sharp-end, epicenter, and wide-end regions, and the mean values of these three points were taken. The egg width (W) and length (L) were used to measure egg shape index with the formula ESI=W/L*100 (Anderson *et al.,* 2004). Yolk index was calculated from the height (YH) and width (YW) of the yolk with the formula YI=(YH/YW) *100 (Doyon et al, 1986). The Haugh Unit score was calculated for individual eggs by using the following formula: $HU = 100 \log_{10} (H + 7.5 - 1.7W^{0.37}$ Where: H, W = recorded height of the albumen in mm and weight of egg in grams, respectively (Haugh, 1937).

3.6. Crossbreeding Parameter

Crossbreeding effects direct (additive effect **(**A^e**),** maternal additive effect **(**M^e**) and** direct heterosis **(**H^e**))** on body weight, age at first egg and body weight at first egg were calculated using the model of (Dickerson, 1969) with following formula: -

- Direct Additive Effect **(**A^e**):** ½ [(K ×K)- (H × H)] - [(H ×K) - (K× H)]
- Maternal Additive Effect **(**M^e**):** ½ [(H ×K) - (K× H)]
- Direct Heterosis **(**H^e**):** ½ [(H × K) + (K x H)] – [(H × H) + (K × K)], For Koekoek and Horro crosses and
- Direct Additive Effect **(**A^e**):** ½ [(Ku ×Ku)- (H × H)] - [(H ×Ku) - (Ku× H)]
- Maternal Additive Effect **(**M^e**):** ½ [(H ×Ku) - (Ku× H)]
- Direct Heterosis **(**H^e**):** ½ [(H × Ku) + (Ku x H)] – [(H × H) + (Ku × Ku)] For Kuroiler and Horro crosses

Percentage of each crossbreeding effects (% A^e, M^e and H^e) for body weight, age at first egg and body weight at first egg were calculated using a mean estimate of each crossbred effect (additive, maternal, heterosis) divided by mean of the pure line multiplied by 100. Mean values were compared using t-test with significant differences at P<0 .05 for age and breeds.

3.7.**Experimental Design and Data Analysis**

All data collected during the experimental period were recorded in spread sheet of Microsoft Excel. Preliminary data analysis like normality test, homogeneity test and screening of outliers were undertaken before performing the core data analysis using General Linear Models (GLM) Procedure of Statistical Analysis System (9.0 version). The experimental design was a Completely Randomized Design (CRD) with the genetic groups as treatment and pen as replications.

The model of the design was $Yij= \mu + T_j + e_{ij}$

were,

Y_{ij}= Record on the i^{th} observation of j^{th} genotypes

μ = overall mean of traits.

T_j = the fixed effect of the j^{th} genotypes (j=1, 2...7)

e_{ij} = random error.

The model 2. $Y_{ik} = \mu + S_k + e_{ik}$

were,

Y_{ij}= Record on the i^{th} observation of K^{th} Sex of j genotypes

μ = overall mean of traits.

S_k= the fixed effect of the k^{th} sex (k= Male and Female) at 16- and 20-week ages.

e_{ik} = random error.

Means and their related standard error for measured parameters were calculated. When significant differences were detected, treatment means were compared by Duncan's Multiple Range Test (Duncan, 1997). All statements of statistical differences were based on $P<0.05$.

4. RESULTS

4.1.Growth Performance of F_1 Crossbreeds and Pure Breeds

4.1.1. Body weight and body weight gain

The mean values for body weight, and body weight gain at various age intervals for different genotype groups are shown in Table 4. The result indicated that body weights at different ages were significantly (P<0.05) affected by genotype. The highest average day-old weight recorded was for H x Ku (37.30g) followed by Ku x Ku (37.17g). The lowest average body weight was recorded for improved Horro chicken (29.82g) followed by Koekoek chicken breed (30.59g). In comparing the crossbred genotypes, H x Ku significantly (P<0.05) scored better body weight at hatch than crossbred chicken. In comparing purebreds, Kuroiler (37.17g) significantly (P<0.05) showed better body weight at hatch than improved Horro (29.82 g) and Koekoek (30.59 g) chicken breeds.

Table 4. Mean ±SE body weight and weight gain traits at different ages of Improved Horro (H), Koekoek (K), Kurolier (Ku) chicken breed and their crosses.

Traits	Ages(week)	Genotype combination							
		H x H	H x K	K x H	K x K	H x Ku	Ku x H	Ku x Ku	SE
Body weight	At hatch	29.82^{b}	31.87^{b}	32.30^{b}	30.59^{b}	37.30^{a}	30.89^{b}	37.17^{a}	2.06
	4	152.73^{d}	193.05^{bc}	187.30^{c}	193.20^{bc}	198.65^{b}	208.37^{ab}	224.87^{a}	9.35
	8	605.19^{e}	818.42^{bc}	707.54^{d}	738.97^{cd}	1106.82^{a}	1073.07^{a}	873.38^{b}	52.81
	12	1041.9^{c}	1256.9^{bc}	1253.9^{bc}	1302.2^{b}	1665.8^{a}	1461.9^{ab}	1652.9^{a}	137.85
ADG	0-4	4.39^{d}	5.75^{bc}	5.53^{bc}	5.80^{bc}	4.93^{cd}	6.34^{ab}	6.70^{a}	0.48
	5-8	16.15^{d}	21.69^{bc}	18.580^{cd}	19.49^{cd}	33.27^{a}	30.37^{a}	23.16^{b}	1.89
	9-12	15.59^{b}	15.63^{b}	19.51^{ab}	20.11^{ab}	19.96^{ab}	16.15^{b}	27.84^{a}	4.51
	Overall	12.05^{d}	14.58^{cd}	14.54^{cd}	15.14^{bc}	19.38^{a}	17.63^{ab}	19.23^{a}	1.59

$^{a-e}$ Means between genotypes in the same row with different superscript letters are significantly (P<0.05) different; HxH-Horro x Horro, HxK-Horro x Koekoek, KxH-Koekoek x Horro, KxK-Koekoek x Koekoek, HxKu-Horro x Kuroiler, KuxH-Kuroiler x Horro, KuxK-Kuroiler x Kuroiler.ADG-Average daily gain, SE-standard error of mean.

The highest average body weight at 4-week of age was recorded in pure line Ku x Ku (224.87g) followed by Ku x H (208.37g). The lowest average body weight was recorded for improved Horro chickens (152.73g). In the current report, in comparing the reciprocal crossbred genotypes, Ku×H (208.37g) showed significantly (P<0.05) better growth performance than H×Ku (198.65g). Similarly, H x K (193.05g) showed better performance than crossbred chicken of K x H (187.30g) in Koekoek -Horro crosses.

Significantly (p<0.05) the highest average body weight at 8-weeks of age was recorded in H x Ku (1106.82g) and Ku x H (1073.07g). The lowest average body weight was recorded for improved Horro chicken (605.19g) followed by K x H (707.54g) crossbred chicken. In comparing the crossbred genotypes, H×Ku (1106.82g) showed better growth performance than crossbred chickens of Ku x H (1073.07g) at 8-week age. Similarly, H x K (818.42g) showed significantly (P<0.05) better performance than crossbreed chicken of K x H (707.54g) at aforementioned ages.

The highest average body weight at 12-week ages was recorded in Ku x Ku (1652.9g) and H x Ku (1665.8g) followed by Ku x H (1461g). The lowest average body weight was recorded for improved Horro chicken (1041.9g). In the current report, in comparing the crossbred genotypes, H x Ku (1665.8) showed better growth performance than crossbred chickens of Ku x H (1461 g) at 12-week ages. The overall mean values for body weight gain at all the ages studied were higher for Ku x Ku and crossbred H x Ku than other genotypes. Improved Horro chicken showed significantly (P <0.05) lower body weight gain than other genotypes at all ages.

4.1.2. Feed intake and feed conversion ratio

The mean values for feed intake, and feed conversion ratio of various age intervals for different genotype groups are indicated in Table 5. A non-significant (P>0.05) difference in overall mean feed consumption were observed among the seven genotypes at all age intervals, but a significant difference were observed for some age points among the genotypes (P<0.05). Mean feed intake at 4- weeks age showed a significant difference at (P<0.05)) for H x Ku and Ku x Ku over the other genotypes.

As reported in Table 5, A significant (P<0.05) difference in feed conversion ratio was observed among genotypes in which the H x H cross had the highest value followed by H x K and K x H. A significant genotype effects for feed conversion ratio at different weeks of age was found. In comparing the pure genotypes, significantly (P< 0.05) Ku x Ku chickens show higher feed conversion ratio at all ages. While, from the crossbred genotypes at all weeks of age Ku × H followed H x Ku and K x H showed better feed conversion potential than all crossbred genotypes. While, in comparing all genotypes, significantly (P<0.05) Ku x Ku showed higher feed conversion potential than all genotypes in the overall performance. In all genotypes feed conversion ratio at 8 weeks age was better than earlier and later ages.

Table 5. Average feed intake (g/chicken/day) and feed conversion ratio (g feed intake /g weight gain) of the Improved Horro (H), Koekoek (K), Kurolier (Ku) chicken breed and their crosses.

		Genotype combination							
Traits	Ages(week)	H x H	H x K	K x H	K x K	H x Ku	Ku x H	Ku x Ku	SE
AFI	4	19.52^{c}	19.97^{bc}	20.02^{abc}	17.50^{d}	20.68^{a}	20.32^{ab}	20.68^{a}	0.36
	8	50.04	41.03	43.23	39.55	43.39	43.85	41.85	0.89
	12	60.24^{b}	60.89^{ab}	60.96^{ab}	60.34^{ab}	60.37^{a}	61.31^{a}	60.72^{ab}	0.52
	Overall	38.04	40.72	40.73	39.09	41.48	41.80	41.09	4.71
FCR	4	4.46^{a}	3.47^{b}	3.62^{b}	3.01^{b}	4.31^{a}	3.20^{b}	3.09^{b}	0.37
	8	3.09^{a}	1.91^{bc}	2.23^{b}	2.03^{bc}	2.29^{b}	1.41^{c}	1.83^{bc}	0.34
	12	3.93^{a}	4.14^{a}	3.23^{ab}	3.35^{ab}	3.03^{ab}	3.82^{a}	2.20^{b}	0.79
	Overall	3.83^{a}	3.18^{b}	3.03^{b}	2.80^{bc}	3.21^{b}	2.82^{bc}	2.38^{c}	0.30

[a-c] Means between genotypes in the same row with different superscript letters are significant (p<0.05) different; FCR-feed conversion ration, AFI-Average feed intake, HxH-Horro x Horro, HxK-Horro x koekoek, KxH-Koekoek x Horro, KxK-Koekoek x Koekoek, HxKu-Horro x Kuroiler, KuxH-Kuroiler x Horro, Ku x Ku-Kuroiler x Kuroiler.SE-standard error of mean.

4.1.3. Body weight, gain, feed intake and feed conversion ratio at 16 and 20 weeks of age

The mean values for body weight, and weight gain at 16- and 20-weeks of age for different genotype groups are indicated in Table 6. The highest average male body weight was recorded for Ku x Ku (2212g) followed by H x Ku (2086.67g) and Ku x H (1790g). The lowest female body weight in female was registered for H x H (1389.96g) followed by K x K (1555g) at above-mentioned age. In comparing crossbred K x H (1725g) showed a significant (P<0.05) difference from H x K (1590g) in body weight. The highest average body weight in female was recorded for Ku x Ku (1695g)) followed by H x Ku (1470g). The lowest female body weight was registered by H x H (1002.50g) followed by K x K (1555g). However, the crossbred H x K, K x H and Koekoek showed comparable performance, which was not significantly ($P>0.05$) different.

Table 6. Mean $\pm$SE of body weight, weight gain, feed intake and feed conversion ratio traits at 16- and 20-weeks ages of Improved Horro (H), Koekoek (K), Kurolier (Ku) chicken breed and their crosses.

Traits	Ages (week)	Sex	Genotype combination							
			H x H	H x K	K x H	K x K	H x Ku	Ku x H	Ku x Ku	SE
BW (g)	16	Male	1389.96^{e}	1590^{cd}	1725^{bc}	1555^{d}	2086.67^{a}	1790^{b}	2212^{a}	87.22
		Female	1002.50^{d}	1187.50^{c}	1317.33^{c}	1227.33^{c}	1470^{b}	1325^{c}	1695^{a}	72.97
BW (g)	20	Male	1682.4^{c}	2387.3^{b}	2672.2^{ab}	2411^{ab}	2574.3^{ab}	2566.2^{ab}	2776.7^{a}	197.2
		Female	1290.04^{e}	1786.78^{d}	1820.47^{d}	1777.26^{d}	2483.10^{a}	2385.48^{b}	2110.6^{c}	119.4
ADG(g)	16-20	Male	10.46^{d}	28.47^{abc}	38.59^{a}	30.57^{ab}	17.41^{cd}	28.79^{abc}	20.16^{bcd}	6.66
		Female	10.26^{c}	21.40^{b}	17.96^{b}	24.77^{b}	36.18^{a}	30.04^{ab}	14.99^{b}	8.13
AFI (g)	16-20	Male	85.77^{b}	92.24^{a}	92.54^{a}	93.91^{a}	92.41^{a}	94.49^{a}	93.13^{a}	5.23
		Female	82.32^{b}	92.11^{a}	92.64^{a}	93.37^{a}	92.41^{a}	92.93^{a}	92.39^{a}	2.10
FCR	16-20	Male	8.2^{a}	3.27^{cd}	2.44^{d}	3.23^{cd}	5.44^{b}	3.84^{bcd}	4.84^{bc}	1.08
		Female	8.02^{a}	4.3^{ab}	4.51^{ab}	4.78^{ab}	2.56^{c}	3.09^{ab}	6.16^{b}	1.55

$^{a-e}$ Means between genotypes in the same row with different superscript letters are significantly ($p<0.05$) different; HxH-Horro x Horro, HxK-Horro x Koekoek, KxH-Koekoek x Horro, KxK-Koekoek x Koekoek, HxKu-Horro x Kuroiler, KuxH-Kuroiler x Horro, Ku x Ku-Kuroiler x Kuroiler, BW-16(Body weight at 16 weeks, BW-20(Body weight at 20 weeks) SE-standard error of mean

In male during the growing phase at 20 weeks age, highest average body weight was recorded for Kuroiler (2776.7g) and lower average body weight was recorded for improved Horro (1682.24g) that showed a significant($P<0.05$) difference between two genotypes. In female crossbred chicken H x Ku (2483.10g) showed a significant ($P<0.05$) difference followed by Ku x H (2385.48g) and Ku x Ku (2110.6g). Ku x Ku, showed significantly better performance than the H x K, K x H and K x K which were shown similar growth patterns.

In male during the growing phase at (20 week) the significant difference in the body weight gain was observed the among genotypes. Male crossbreed KxH chicken showed the highest body weight gain followed by purebred Koekoek chicken, whereas the lowest weight gain was observed for male improved Horro chicken. In case of female, crossbred obtained from Kuroiler crosses on both sides showed a significant ($P<0.05$) difference over the other genotypes including purebred. The difference in the average feed intake was not shown to be a significant ($P>0.05$) among genotypes except for improved Horro that showed significant ($P<0.05$) difference in both sexes. Feed conversion ratio was shown to be a significant ($P<0.05$) different among the genotypes at 20 weeks age. In male crossbred chicken, higher value observed for improved Horro chicken followed by crossbred H x Ku and purebred Kuroiler. The lowest value obtained for crossbred K x H followed by purebred Koekoek and crossbred Ku x H. In case of female crossbred, the higher value observed for improved Horro followed by purebred Kuroiler chickens whereas the lower value observed for crossbred H x Ku.

4.2. Egg Production Performance of F_1 Crossbreds and Pure breeds

4.2.1. *Egg number, hen day egg production and hen housed egg production*.

Genotype had a significant effect on egg number (EN), hen day egg production (HDEP) and hen housed egg production (HHEP) over five-month period as shown in Table 7. The highest egg number was recorded in H x Ku and Ku x H and lowest egg number was registered for improved Horro chicken over the study period. The other genotypes produce comparable egg numbers among themselves. The highest hen day egg production and hen housed egg production was recorded in crossbreed hen between Horro and Kuroiler (Hx Ku and Ku x H).

However, the difference with Koekoek, Kuroiler and crosses of HxK was not significant. The lowest hen day egg production and hen housed egg production was recorded in an improved Horro chicken.

Table 7. Mean±SE for monthly egg number, hen day egg production and hen housed egg production.

Traits	Ages(week)	Genotype Combination							
		HxH	HxK	KxH	KxK	H xKu	Ku x H	Ku x Ku	SE
EN	21- 24	2.7^{cd}	0.73^{d}	5.2^{cb}	4^{c}	8.86^{a}	8.66^{a}	7.2^{c}	1.56
	25-28	8.8^{b}	9.4^{b}	18.06^{a}	12.8^{ab}	17.06^{a}	17.66^{a}	15.73^{a}	3.11
	29-32	9.66^{b}	14.00^{ab}	16.40^{a}	15.13^{a}	18^{a}	16.58^{a}	15.6^{a}	2.68
	33-36	13.067^{a}	16.46^{a}	13.06^{a}	15.26^{a}	15.26^{a}	18.50^{a}	16.20^{a}	2.81
	37-40	8.46^{b}	13.06^{ab}	14.53^{a}	14.33^{ab}	15.20^{a}	13.58^{ab}	13.67^{ab}	3.05
	Overall	43.33^{c}	53.66^{bc}	67.28^{ab}	61.53^{ab}	75.46^{a}	75.00^{a}	68.40^{ab}	9.57
HDEP	21- 24	9.763^{cd}	2.62^{d}	18.57^{bc}	14.28^{c}	31.66^{a}	30.95^{a}	25.71^{ab}	5.57
	25-28	31.40^{b}	33.57^{b}	64.52^{a}	45.71^{ab}	60.95^{a}	63.09^{a}	56.18^{a}	11.13
	29-32	34.52^{b}	50.00^{ab}	70.32^{a}	54.04^{ab}	64.28^{a}	59.22^{a}	55.71^{a}	11.05
	33-36	46.66	58.8	46.66	54.52	58.33	59.22	55.71	10.06
	37-40	30.23^{b}	46.66^{ab}	51.98^{a}	51.19^{ab}	54.28^{a}	48.01^{ab}	48.80^{ab}	10.91
	Overall	30.95^{c}	38.33^{bc}	50.41^{ab}	43.95^{ab}	53.90^{a}	53.57^{a}	48.85^{ab}	7.20
HHEP	21- 24	9.76^{c}	2.62^{d}	18.57^{c}	14.28^{c}	31.67^{a}	24.76^{ab}	25.71^{a}	5.48
	25-28	31.42^{b}	33.57^{b}	64.52^{a}	45.72^{ab}	60.09^{a}	63.09^{a}	56.19^{a}	11.13
	29-32	34.52^{b}	50.00^{ab}	58.57^{a}	54.04^{a}	64.28^{a}	59.22^{a}	55.71^{ab}	9.58
	33-36	48.81^{ab}	58.81^{ab}	41.42^{b}	54.52^{ab}	58.33^{ab}	66.07^{a}	57.85^{ab}	11.38
	37-40	30.24	46.67	47.54	51.19	54.29	48.51	48.81	12.76
	Overall	30.95^{c}	38.33^{abc}	46.12^{ab}	43.95^{abc}	53.90^{a}	52.33^{a}	48.12^{ab}	6.64

$^{a\text{-}d}$ Means between genotypes in the same row with different superscript letters are significantly ($p<0.05$) different; HxH-Horro x Horro, HxK-Horro koekoek, KxH-Koekoek x Horro, KxK-Koekoek x Koekoek, HxKu-Horro x Kuroiler, KuxH-Kuroiler x Horro, KuxKu-Kuroiler x Kuroiler. SE-standard error of mean.

In comparing crossbred to pure line (Kuroiler, Koekoek and improved Horro), crossbred hen showed better egg production performance than pure lines in terms of egg number, hen day egg production (HDEP) and hen housed egg production (HHEP) over the study period. The reason for similarity between HDEP and HHEP in most genotypes is absence of mortality or low level of mortality occurring towards the end of the laying period. This led to a situation where the number of hens to be considered for hen day egg production to be somehow similar to the average number of hens to be considered for hen housed egg production.

4.2.2. *Age and body weight at first egg*

The mean values for body weight at first egg and age ag at first eggs of seven genotypes were given in Table 8. Genotype had a significant (P<0.05) effect on AFE in the current study. The highest number of days for age at first egg was recorded in improved Horro chicken (156) followed by crossbred H x K (150.33) whereas the lowest number of days was recorded by crossbred H x Ku (135) chicken followed by crossbred K x H (136.67) and Ku x H (139.33) chickens. Crossbred hens of H x Ku genotype have attained sexual maturity early followed by crossbreds of Ku x H and K x H genotypes. Hens of H x K genotype and Horro, Koekoek and Kuroiler have shown longer days to lay first egg than the other genotypes. Among this group, the improved Horro matured later followed by crossbred H x K and pure line Koekoek chicken breeds in the present work. In comparing crossbreed, the present result indicated that age at first egg was reduced through cross breeding in the case of crosses and reciprocal crosses of Kuroiler and Horro than the purebred genotypes. But, comparison of crosses and reciprocal crosses of koekoek-Horro crosses with the purebred showed improvement over both purebreds in the case of crossbred hen sired by Koekoek chicken, with those crosses sired by improved Horro showing older age than the pure Koekoek. Comparison of the seven genotypes have shown that hens from crosses and reciprocal crosses of Kuroiler by Horro have attained sexual maturity early than the other genotypes.

Table 8. Mean$\pm$ SE for age (days) at first egg and body weight (g) at first egg among the genotypes

	Genotype Combination							
Traits	H x H	H x K	K x H	K x K	H x Ku	Ku x H	K x Ku	SE
AFE	156^{a}	150.33^{ab}	136.67^{c}	145.33^{abc}	135.00^{c}	139.33^{c}	141.67^{bc}	5.81
BWFE	1376.34^{f}	1814.78^{d}	1826.33^{d}	1683.26^{e}	2448.0^{a}	2372.33^{b}	2110.67^{c}	19.73

$^{a-f}$ Means between Genotypes in the same row with different superscript letters are significantly (p<0.05) different; AFE-Age at first egg, BWFE-body weight at first egg, HH-Horro x Horro, HxK-Horro Koekoek, KxH-Koekoek x Horro, KxK-Koekoek x Koekoek, HxKu-Horro x Kuroiler, KuxH-Kuroiler x Horro, KuxKu-Kuroiler x Kuroiler. S-male are listed first in the crosses, SE-standard error of mean.

Genotypes had significant (P<0.05) difference in body weight at first egg. In comparing crossbred, the highest body weight was scored by crossbred H x Ku (2448 g) followed by crossbred Ku x H (2372.33 g) chicken whereas the lowest body weight was observed for H x K (1814.78 g) followed by K x H (1826.33 g). In comparing purebred, the highest body weight at first egg was recorded for Kuroiler chicken breed (2110.67) followed by Koekoek chicken (1683.26 g) whereas the lowest body weight at first egg was recorded for improved Horro chicken. In comparing the whole set of genotypes, H x K cross registered highest body weight at first egg whereas lowest body weight was recorded for improved Horro chicken hens.

4.2.3. *Egg mass and feed conversion ratio of egg production*

Egg mass and feed conversion ratio for purebred and their corresponding reciprocal crosses are presented in Table 9. The total egg mass produced in overall five months of laying period was significantly (P<0.05) affected by genotypes. In the overall laying period, the highest total egg mass produced by an average alive hen was (574.51g) for crossbred H x Ku followed by Kuroiler (547.2 g) and crossbred Ku x H (464.82g) chicken. The lowest total egg mass produced was (288.59 g) for improved Horro followed by Koekoek (406.10g) chicken breed during the laying period. But the crossbred genotypes obtained from Koekoek-Horro crosses showed comparable total egg mass production with their correspondence purebred Koekoek chicken. The feed conversion ratio (FCR) for egg production was significantly (P<0.05) affected by genotypes at most of studied ages. In comparing crossbred there were a significant difference among genotypes in feed conversion ratio at most of studied ages but no significant differences were observed in FCR of the overall laying periods, except for H x Ku that showed a significant difference (P<0.05). H x Ku crossbred not efficient in the conversion of feed for egg production during laying periods as compared to other crossbred genotypes. In comparing pure line improved Horro showed better FCR for the overall laying periods followed by Koekoek chicken breeds. Significantly highest feed conversion ratio was found for improved Horro whereas the lowest FCR was found for Kuroiler chicken breeds in the overall laying period.

Table 9. Means ±SE for Egg mass and feed conversion ratio among the genotypes

Traits	Age	Genotype							
		H x H	H x K	K x H	K x K	H x Ku	Ku x H	Ku x Ku	SE
Egg Mass (EM)	21-24	107.25[b]	129.47[b]	138.06[b]	142.53[b]	349.65[a]	282.88[a]	345.79[a]	70.11
	25-29	380.50[c]	420.6[c]	748.30[ab]	540.4[bc]	857.9[a]	656.6[abc]	775.9[ab]	152.01
	30-32	208.89c	286.17[bc]	391.80[b]	311.55[bc]	495.53[a]	339.15[b]	389.19[b]	57.44
	33-36	467.6[b]	709.3[a]	398.2[b]	532.5[ab]	525.8[ab]	484.2[ab]	612.6[ab]	122.51
	37-40	278.39[c]	621.15[ab]	398.50[bc]	503.50[ab]	643.71[a]	561.30[ab]	612.09[ab]	122.03
	Overall	288.59[c]	413.32[bc]	414.97[bc]	406.10[bc]	574.51[a]	464.82[ab]	547.12[ab]	74.94
FCR	21-24	2.07[b]	3.57[a]	4.00[a]	2.44[b]	3.3[a]	2.88[a]	3.3[a]	0.75
	25-29	3.52[b]	3.91[b]	4.6[a]	4.9[ab]	5.26[ab]	5.77[ab]	5.76[ab]	1.30
	30-32	2.95[bc]	2.44[bc]	3.14[b]	2.67[bc]	4.22[a]	2.99[bc]	3.37[ab]	0.52
	33-36	4.12[b]	6.12[a]	3.7[b]	4.5[ab]	4.47[ab]	4.35[ab]	5.25[ab]	1.01
	37-40	2.56[b]	5.40[a]	3.37[ab]	4.28[ab]	5.38[a]	4.79[a]	5.15[a]	1.05
	Overall	3.04[c]	4.29[ab]	4.16[ab]	3.76[bc]	4.93[a]	4.16[ab]	4.76[ab]	0.65

[a–c] Means between Genotypes in the same row with different superscript letters are significantly ($p<0.05$) different; FCR-Feed conversion ratio, HxH-Horro x Horro, HxK-Horro Koekoek, KxH-Koekoek x Horro, KxK-Koekoek x Koekoek, HxKu-Horro x Kuroiler, KuxH-Kuroiler x Horro, KuxKu-Kuroiler x Kuroiler, SE-standard error of mean

4.3.Mortality

Mortality rate for genotypes at different ages is presented in the table 10. There was no significant (P>0.05) genotype effect on mortality except H x K which showed significant (P<0.05) difference during brooding phases. Relatively High mortality rate was registered for Koekoek pure line followed by Ku x H during the growing phases, while the other genotypes have shown comparable mortality rate. At laying phases no mortality was registered in most of the genotypes except for H x K, H x Ku and Ku x H crossbred genotypes which showed a significant difference (P<0.05). However, the mortality percentage was very low at most of the growing phases for both pure line and crossbred genotypes.

Table 10. Means ±SE for a mortality rate (%) of the Improved Horro (H), Koekoek (K), Kurolier (Ku) chicken breed and their crosses.

	Genotype Combination							
Age in weeks	H x H	H x K	K x H	K x K	H x KU	Ku x H	Ku x Ku	SE
0-8	0.05^{b}	0.13^{a}	0.00	0.04^{b}	0.00	0.02^{b}	0.04^{b}	0.02
9-20	0.09^{b}	0.06^{b}	0.14^{ab}	0.21^{a}	0.06^{b}	0.21^{a}	0.13^{ab}	0.04
21-40	0.00	0.00	0.11^{ab}	0.00	0.06^{bc}	0.20^{a}	0.00	0.05

$^{a-c}$ Means between Genotypes in the same row with different superscript letters are significant (p<0.05) different. HxH-Horro x Horro, HxK-Horro Koekoek, KxH-Koekoek x Horro, KxK-Koekoek x Koekoek, HxKu-Horro x Kuroiler, KuxH-Kuroiler x Horro, KuxKu-Kuroiler x Kuroiler. SE-standard error of mean.

4.4. Fertility and Hatchability

Fertility and hatchability traits of different genotypes is presented in Table 11. In comparing fertility of crossbreds, no significant (P>0.05) differences were observed among genotypes and the fertility rate ranged from 86.2% for Ku X H to 91.44% for HxK. For purebreds, there was a significant (P<0.05) difference between genotypes. Koekoek has shown the highest fertility percentage followed by improved Horro, and Kuroiler chicken breed. Egg fertility on the 18th day of candling among crossbred and pure line were showed a significant difference (P<0.05). As indicated in aforementioned table, improved Horro (78.5%) and Kuroiler chicken breeds (70.27%)

have shown significant difference (P<0.05) in fertility between themselves and with the other genotypes.

Table 11. Fertility, hatchability of total eggs set and fertile eggs of the improved Horro (H), Koekoek (K), Kurolier (Ku) chicken breed and their crosses.

	Genotype Combination							
Traits	H x H	H x K	K x H	K x K	H x K	Ku x H	K x Ku	SE
Fertility (%)	78.54^{b}	91.44^{a}	90.12^{a}	88.31^{a}	87.48^{a}	86.62^{a}	70.27^{c}	4.43
HFE (%)	80.73^{ab}	73.75^{ab}	79.23^{ab}	58.42^{b}	82.61^{ab}	76.83^{ab}	86.02^{a}	13.41
HTES (%)	63.36	67.21	71.48	51.60	71.99	65.88	60.44	11.21

$^{a-c}$ Means between Genotypes in the same row with different superscript letters are significant (p<0.05) different; HFE-Hatchability from fertile eggs, HTES-Hatchability from total egg set, %-percentages, HxH-Horro x Horro, HxK-Horro x koekoek, KxH-Koekoek x Horro, KxK-Koekoek x Koekoek, HxKu-Horro x Kuroiler, KuxH-Kuroiler x Horro, KuxKu-Kuroiler x Kuroiler, SE-standard error of means.

Kuroiler-crosses and Koekoek-crosses have shown comparable percentages for hatchability of fertile eggs, but highest hatchability was registered in Kuroiler (86.02%) and the lowest percentage was observed in pure line Koekoek (58.42%) chicken breeds. In comparing purebred there were significant difference (P<0.05) among genotypes in hatchability from fertile eggs. The highest hatchability from fertile egg recorded for Kuroiler (86.02%) followed by improved Horro (80.73%). No significant (P>0.05) difference was observed between Kuroiler and Koekoek crosses for hatchability from fertile eggs. There was no significant difference (P>0.05) in hatchability from total eggs set (HTES) for crossbred and purebred.

4.5. Internal and External Egg Quality Measures

Effect of genotypes on external and internal Egg quality traits at peak of the egg production stage were presented in Table 12. No significant differences were observed among the genotype for all egg quality traits, except for egg weight, shell weight and albumen width. In comparing the pure genotypes, significantly higher (P<0.05) egg weight, and albumen width (P<0.05) were scored for pure line Kuroiler and Koekoek chicken breeds than improved Horro chicken. In comparing crossbreed chickens, significantly higher (P<0.05) egg weight was observed for Ku x H and H x K followed by H x Ku and K x H crossbred hen. Also, a significant difference (*P*<0.05) was recorded in albumen width for crossbred H x K followed by H x Ku and K x H. In comparing whole genotypes, significantly highest (P<0.05) egg weight was observed for Ku x Ku, Ku x H and Hx K crossbred hens whereas the lowest egg weight was observed for improved Horro. and the other genotypes have shown comparable performance for most studied egg quality traits including egg weight. The present results showed that crossing did not well improve egg quality parameter except for egg weight that showed tendency of improvements.

Table 12. Means ± SE for Exterior and interior egg quality traits for chicken genotypes.

Traits	Genotype combination							
	H x H	H x K	K x H	K x K	H x Ku	Ku x H	Ku x Ku	SE
EWT (g)	46.18^{b}	52.68^{a}	49.44^{ab}	49.33^{ab}	49.33^{ab}	$52.0.5^{a}$	54.00^{a}	2.60
EL (mm)	53.25	54.53	55.00	54.27	53.98	53.77	55.96	2.26
EW (mm)	40.13	41.66	42.77	42.10	40.40	40.60	41.38	2.15
SW (g)	4.59^{ab}	5.02^{a}	4.75^{ab}	4.48^{ab}	4.78^{ab}	3.8^{b}	4.78^{ab}	0.60
ST (mm)	0.39	0.38	0.37	0.34	0.36	0.38	0.36	0.034
ESI	75.42	76.41	77.17	77.55	74.83	75.49	73.93	2.17
YH (mm)	17.30	17.93	17.43	18.50	17.96	17.46	18.20	1.09
AW (mm)	48.32^{b}	67.13^{ab}	66.36^{ab}	71.35^{a}	70.86^{a}	61.52^{ab}	71.60^{a}	10.97
YW	37.64	38.39	37.91	38.23	39.44	39.53	38.71	1.07
YWT (g)	14.60	15.22	14.97	15.22	16.34	15.74	16.62	1.34
AH (mm)	6.90	6.42	5.91	5.98	6.44	5.89	6.01	0.68
YI	0.46	0.47	0.46	0.48	0.45	0.44	0.47	0.028
HU	87.05	81.96	79.40	80.26	82.34	79.51	79.30	4.45

a- b Means between Genotypes in the same row with different superscript letters are significantly (p<0.05) different; HH=Horro x Horro, HxK=Horro Koekoek, KxH=Koekoek x Horro, KxK=Koekoek x Koekoek, HxKu=Horro x Kuroiler, KuxH=Kuroiler x Horro, KuxKu=Kuroiler x Kuroiler. EWT=egg weight (gm); EL= egg length (mm); EW= egg width (mm); SW= Shell Weight (g), ST= Shell Thickness, ESI = egg shell index; YH=yolk height (mm), Albumen width, YW = yolk width, Yolk width, Yolk weight, AH= albumen height (mm), YI= yolk index), ST= Shell Thickness, HU= Haugh Unit.

4.6. Estimates of Crossbreeding Effects

4.6.1. *Crossbreeding effects on growth performance of H x K and K x H*

Direct additive, maternal and heterosis effect of body weight at different ages (BW0-12**)** of improved Horro (H), Koekoek (K) chicken breed and their crossbred chickens were indicated in Table 14. Additive effects (A^{e}) for body weight indicated that there were positive values with significant (P <0.05) effects among genotypes at 4- and 12-weeks age and it ranges from 8.87 up to 10.1%. Higher positive additive effects were found for BW4 (10.1%) while lower contribution of additive effect on body weight were found for BW8 (1.79%).

Table 13**.** Estimation of additive (A^e), maternal (M^e) and heterosis (H^e) effects (Mean± SE) and their percentages for body weight(g) at different ages of improved Horro chicken (H), Koekoek (K) chicken breed and their crosses.

Traits	A^e	%	M^e	%	H^e	%
BW_0	0.6 ±1.21 ^{ns}	2.28	-0.21±1.17^{ns}	-0.73	2.10±1.57*	6.54
BW_4	17.38±3.7*	10.1	2.89±2.44^{ns}	1.62	17.22±6.25*	10.08
BW_8	11.12±2.04^{ns}	1.79	55.78±14.00*	8.22	91.23±27.36*	13.79
BW_{12}	128.64±15.02*	8.87	1.51±0.60^{ns}	0.74	83.29±16.65*	8.88

*BW0, BW4, BW8, BW12 =body weight at hatch, 4,8,12 weeks of age respectively. % (percentage), A^e -Additive affect, M^e- Maternal effects, H^e-Heterosis effect SE= standard error of means. P-value statistically significant differences at P <0.05, * Significant, ns- non-significant.*

The estimates of maternal additive effects of improved Horro chicken (H), Koekoek (K) chicken breed and their crossbred chickens was positive and significant (P<0.05) for BW 8. Negative and positive non-significant values (P>0.05), -0.73 to 0.74%, respectively were observed for BW at 0 and 12-weeks. The highest positive contribution of maternal effect was observed for body weight at 8 weeks (8.22 %). The heterosis effects (H^e) estimated in the current study shown a positive values and substantial effect on body weight at most of the studied ages. Estimates of heterosis effects (H^e) were positive and ranged from 6.54 to 13.79 % for BW at 0,4,8 and 12. The highest percentage of heterosis effects contribution was reported at BW 8 weeks of age (13.79%) followed at BW 4 weeks (10.08%) whereas the lowest percentage contribution was for heterosis at hatch (6.54%).

4.6.2. *Crossbreeding effect on growth performance of H x Ku and Ku x H*

Direct additive, maternal and heterosis effect of body weight at different ages (BW0-12) of Improved Horro chicken (H), Kuroiler (Ku) chicken breed and their crossbred chickens were presented in table 15. Additive effects (A^e) for body weight indicated that there were positive and significant (P <0.05) effects at BW 4, 8 and 12 among the genotype and it ranges from 15.13 to 44.4 %. The higher positive additive effects was found for age at BW4 (44.40%) and the lowest of contribution of additive effect on body weight was found at BW0 (1.6%).

In the present study, the maternal additive effects (M^e) estimate for body weight was positive and significant (P<0.05) for BW 12 (7.45%) weeks except for 0, 4 and 8 -week which was non-significant. The estimated heterosis effect was shown a positive and significant (P<0.05) effect on body weight at 8 and 12 weeks. The higher positive contribution was observed at BW 12 (16.11

%), followed BW 8 (15.37%). However, estimates of heterosis effect has shown a positive and no significant (P>0.05) effect has shown at 0- and 4-week.

Table 14. Estimation of additive (A^e), maternal (M^e) and heterosis (H^e) effects (Mean± SE) and their percentage for body weight at different ages of improved Horro chicken (H), Kuroiler (Ku) chicken breed and their crosses.

Traits	A^e	%	M^e	%	H^e	%
BW0	0.47 ±1.08^{ns}	1.6	3.20 ± 0.94^{ns}	9.62	0.6 1. ±1.8^{ns}	2.18
BW4	52.53± 6.2*	44.40	-16.53± 8.25^{ns}	-8.89	3.11 ±0.32^{ns}	1.67
BW8	117.06±41.69*	15.44	17.04±27.72^{ns}	2.58	164.5±43.22*	15.37
BW12	202.36±43.26*	15.13	103.13±59.85*	7.45	215.28±34.06*	16.11

*BW0, BW4 BW8, BW12 =body weight at hatch, 4,8,12 weeks of age respectively. %-percentage, SE= standard error of means. P-value statistically significant differences at P <0.05, * Significant, ns, non-significant*

4.6.3. *Crossbreeding effects for AFE and BWFE for H x K and K x H*

Crossbreeding effects on age at first egg and body weight at first egg traits were indicated in Table 16. The current result of additive effect (A^e) for AFE was negative and significant (*P*<0.05). Additive effects for BWFE was positive (8.17%) and significant (P<0.05). In present study estimated maternal effects ($M^{e)}$ were positive (4.56%) and significant(P<0.05) for AFE. But, positive (1.69%) and non-significant for bodyweight at first eggs. Estimates of heterotic effects for AFE was negative and non-significant (P>0.05) while it was positive (14.76%) and significant(P<0.05) for BWFE.

Table 15. Estimation of Additive (A^e), maternal (M^e) and heterosis (H^e) effects (Mean± SE) and their percentage for age at first egg and bodyweight at first egg of improved Horro chicken (H), Koekoek (K) chicken breed and their crosses.

Traits	A^e	%	M^e	%	H^e	%
AFE	-12.17±1.87*	-8.1	6.83±1.36*	4.56	-7.16±6.39^{ns}	-4.65
BWAFE	124. 74±7. 27*	8.17	25.72±9.43^{ns}	1.69	225.26±8.84*	14.76

AFE=Age at first egg; BWAFE=Body weight at first egg; A^e *-Additive affect,* M^e*- Maternal effects,* H^e*-Heterosis effect, p-value statistically significant differences at P <0.05, * significant, ns =Non-significant, SE= standard error of means.*

4.6.4. *Crossbreeding effects for AFE and BWAFE for H x Ku and Ku x H*

Crossbreeding effects for age at first egg and body weight at first egg traits were presented in table 17. The additive effect (A^e) for AFE was negative (-3.36%) with non-significant effects while for BWFE it was positive (18.43%) with significant (P<0.05) effects. Similarly in the present study estimates of maternal additive effect for AFE was negative (-1.45%) and non-significant (P>0.05) while it was positive (2.17%) and significant (P<0.05) for BWFE. Estimates of heterosis effect for AFE was negative (-7.84%) and non-significant (*P*>0.05), but positive (38.25%) and significant (P<0.05) for BWFE.

Table 16. Estimation of Additive (A^e), maternal (M^e) and heterosis (H^e) effects and their percentages (Mean± SE) for age at first egg and bodyweight at first egg of improved Horro chicken (H), Kuroiler (Ku) chicken breed and their crosses.

Traits	A^e	%	M^e	%	H^e	%
AFE	-5±3.01^{ns}	-3.36	-2.16±0.88^{ns}	-1.45	-11.67±2.77^{ns}	-7.84
BWFE	322.67±13.48*	18.43	37.833±4.20*	2.17	666.67±13.91*	38.25

*AFE=Age at first egg; BWFE=Body weight at first egg; A^e-Additive effect, M^e-Maternal effects, H^e -Heterosis effect. P-value statistically significant differences at P <0.05; SE= standard error of means, * significant, NS, Non-significant*

5. DISCUSSION

5.1. Growth Performance of F_1 Crossbreeds and Pure breeds

5.1.1. Body weight and gain of crossbreeds and pure breeds

Body weight and body weight gain are important traits in chicken breeding because they have a critical economic impact. Growth can be considered as a direct fitness trait that boosts productive efficiency and lowers production costs (Iraqi *et al*., 2013). As indicated in Table 3 that body weight gains during different weeks of age was significantly (P<0.05) affected by genotypes.

The highest body weight recorded in both Koekoek and Kuroiler chicken breed crosses at hatch indicated that crossing of improved Horro chickens with Koekoek and Kuroiler chicken breeds had a significant improvement in the body weight at hatch. Likewise, an improvement in body weight at hatch of local Kei chickens crossed with RIR and Fayoumi (Bekele *et al*., 2010). Halima *et al.* (2006) also found that higher day-old body weight for exotic chicken than local chicken of Ethiopia which ranges from 25.5 to 29.3g. Comparable result was also reported by Kedija *et al*. (2018) that body weight at hatch for exotic chicken, Dominant Red Barred (42.25g) was higher than Horro chicken ecotype. Teketeal (1986) indicated that body weight at hatch follows egg weight pattern. Thus, the large day-old chick size might be due to the large egg size of Kuroiler and Koekoek chicken breeds used in the present crosses. The weight of chicks composes 62 to 78 % of egg weight and egg weight loss affects chick weight at hatch (Wilson, 1991). In the present study higher day-old chicken weight for improved Horro chicken (29.82g) was observed than day-old weight reports of Dana (2011) and Kedija *et al*. (2018) which was 28.70 and 24.7 g, respectively. A significant (*P*<0.05) difference in body weight gain were recorded at most of studied age intervals among genotypes in the current reports. The present results were in agreement with Wondemenh (2015) who were reported noticeable strain difference for body weight gain.

According to the report of Kedjia *et al.* (2018) Horro chicken ecotypes scored lower body weight (134.63 g) than the current findings at 4-week of ages (152.73 g), whereas H x DRB and DRB x H were shown better growth performance than crossbred in the present studies at aforementioned ages. Mulugeta *et al.* (2020) reported a body weight of 469.5g for Horro chicken ecotype at 8 weeks age under famer management condition which is not comparable with present results (605.19 g).

The better body weight observed in Kuroiler-crosses compared to pure line chickens might be attributed to the genetic superiority of the Kuroiler in body weight that is a highly heritable trait, and known for its non-additive genetic contribution to crossbreeding. Additionally, the Kuroiler chicken breed is a large size dual-purpose chicken breed predictable for better weight gain compared with egg layer type breeds. The present findings of crossbreds of Kuroiler-crosses and Koekoek crosses growth performance at 12 weeks of are in disagreement with the report of Kedija *et al*. (2018), on the crossbred growth performance in the crossing between Horro x Dominant Red Bared under similar crossing methods. In the present results there was better growth performance at aforementioned ages. In general, crossbred chickens have shown improved growth performance than the pure line improved Horro chicken at all studied ages. A significant (P<0.05) increase in body weight was observed for all genotype groups as the birds grew older.

5.1.2. *Feed intake and feed conversion ratio*

An efficient utilization of feed can be affected bird's genotypes including other factors likes rate of growth and environmental conditions. A slight difference in average feed intake per day was observed among the genotypes in the current study, the variation was non-significant (P>0.05) and agrees with the report of Demissu (2020) in the western part of Ethiopia who reported no significant difference in average feed intake among improved Horro, DZ- whites and Koekoek. Contrary to the current findings, Alewi and Melesse (2013) reported that a significant difference in feed intake between Kei (a local red chicken) and Fayoumi-crosses in southern parts of Ethiopia. The present daily feed intake of Koekoek-crosses chicken was comparable with that of Kuroiler-crosses at similar age class. In comparing whole genotypes better feed conversion was registered at 8 weeks than the later ages. In the present study, Kuroiler chickens had better feed conversion ratio than local chickens in the overall mean feed conversion ratio of studied ages. This agreed with report of Kayitesi (2015) who indicated that Kuroiler chicken were significantly more efficient in the feed utilization as compared to local chickens. Also, Kedija *et al.* (2018) confirmed that pure exotic breed has better feed conversion efficiency than local chickens. The low feed conversion ratio among genotypes at 4 weeks disagrees with the report of Kedija *et al.* (2018) who reported better feed conversion ration. The feed conversion ratio of chicken might be depending on the genotypes and growing age of chickens. Exotic chicken breeds and crossbred have better feed conversion ratio than local chicken as reported by Binda *et al.* (2012) that feed conversion ratio significantly differs (*P*=0.01) between exotic and local chickens. This statement is in line with the current findings. In comparing crossbred, Ku x H showed better feed conversion ratio in overall rearing period. The better feed conversion of Kuroiler-crosses might be due to their improved body weight gain performance. Koekoek chicken breed had shown significantly better feed conversion ratio than improved Horro chicken at most of the studied ages.

5.1.3. Body weight, gain, feed intake and feed conversion ratio at 16-20 weeks age

The present report indicated that genotype had a significant ($P<0.05$) effect on the potential body weight development of chicken for 16-20 weeks ages. This result was similar to Halima *et al.* (2006) who showed presence of a significant effect of genotype on growth performance of chickens. Adedokun *et al.* (2002) and Padhi (2004) had reported higher performance of crossbred chickens than local chicken at the age of 20 weeks. Likewise, a study executed by Kayitesi (2015) revealed that the genotype is one of the factors that affect body weight of chickens at all ages from day old chicks to the end of the study (20 weeks).

According to findings of Alewi and Abera (2013) crossbred chicken obtained from crosses of local Kei and Fayoumi chicken breeds indicated growth performance was improved. The crossing between Horro chicken and Dominant Red Barred also indicated that a significant change in terms of growth performance in crossbred (Kedija *et al*., 2018). As indicated in the present study, both male and female chicken showed a significant ($P<0.05$) increase in body weight from 16 to 20 weeks of age. However, the males showed better body weight development as compared to female at different ages among genotypes. Amao (2019) claimed that growth performance traits in chickens were differed due to the variations in the genetic background of chickens. Also, He reported a significant difference on the growth performance traits among the pure and crossbred chickens containing Nigerian local chickens and Rhode Island Red chickens. Padhi *et al*. (2015) reported in study involving crossbred chickens developed from exotic and local breeds under an extensive production system of rearing that the crossbred chickens performed much better than their purebreds in growth performance traits. Generally, the effect of genotypes on body weight of chicken was substantial among crossbreed and purebred at studied growing age of genotypes.

5.2. Egg Production Performance of F_1 Crossbreds and Pure breeds

5.2.1. Egg number, hen day egg production and hen housed egg production

Genotypes had a significant effect on studied egg production traits over five-month egg production period. In the present study, the reports for Hen-housed egg production and Hen-day egg production percentages had followed the trend reported by various scholars (Rahman *et al*., 2004; Wondmeneh *et al*., 2011; Amao, 2017; Kedija *et al*., 2019). They were reported better percentage for hen-housed egg production and hen-day egg production in crossbred chickens than purebred chicken breeds in the various studies. The present reports also comparable with the results of Basant *et al*. (2013) for RIR, Fayoumi and crossbred of RIR and Fayoumi where crossbred chicken were better than purebred chickens in hen-housed egg production (HHEP) and hen-day egg production (HDEP) rates. Yeasmin *et al. (*2003) shown higher egg production in exotic breeds: White Leghorn, Fayoumi, Rhode Island Red than indigenous chicken up to 42 weeks of age. They also observed rate of lay higher for exotic chicken than local chickens. Likewise, In the current reports, exotic breeds (Kuroiler and Koekoek) had shown significantly higher egg production as compared to the improved Horro chicken. Javed *et al*. (2003), also reported that RIR varieties produced a higher number of eggs than Desi local chicken hen. The more egg production of exotic varieties of chicken than local chicken might be attributed to their improved genetic potential for higher egg production. In comparing the egg production performance of exotic and local chicken that exotic breeds Fayoumi (144 eggs), Rhode Island Red (185 eggs), and White Leghorn (173 eggs) produced more than two times number eggs produced by the indigenous chickens (54.3 eggs) under smallholder farmer's management condition in northern Ethiopia (Lemlem and Tesfay ,2010). According to Amao (2017) reported that hen day egg production and hen housed egg production percentages were significantly higher for RIR x Fay crossbred hen than Fay x RIR crosses and likewise for RIR than Fay. Likewise, in the present study in comparing crossbred hen K x H scored better hen day egg production (HDEP) and hen housed egg production (HHEP) than crossbred H x K while Kuroiler-crosses showed comparable performance to each other's.

5.2.2. Age and body weight at first egg

Genotype had a significant effect on age at first egg (AFE) in the current study, which is comparable with various findings that showed a significant difference in age at first eggs among genotypes (Bekele *et al*., 2010; Amira *et al*., 2013; Wondemenh, 2015). The present study indicated that age at first egg was reduced through cross breeding between improved Horro and Kuroiler chicken breed in both direct and reciprocal crosses. Similarly crossbred sired by Koekoek (K x H) also showed improvement in the age at first eggs. Likewise, Bekele *et al*. (2010) indicated that age at first egg laid was significantly lower in the first generation of Fayoumi x Naked neck and Rhode Island Red x local Netch crosses than the pure breeds (Fayoumi and Rhode Island Red). Besides to this, age at first egg for crossbred lines were improved as compared to their pure lines (Williams *et al*., 2002). Age at first egg reported for Horro chicken ecotype (156 days) in the current report was higher than result of (Kedija *et al*., 2019) who was reported 139 days.

Age at first egg for improved Horro chicken in the present report was similar with Wondmeneh (2015) who reported 156 days and Melese *et al.* (2013) who reported that age at first egg of 156 days for Ethiopian naked-neck chickens and less than the report of Demissu (2020) and Dana (2011) who had reported 195 and 190 days, respectively. Besides to this Melesse *et al*. (2013) reported that age at sexual maturity for red feathered local chicken *(Kei Doro)* was 183 days which was higher than the current findings. Lemlem and Tesfay (2010) were also observed 245, 239 and 231 days of age at first egg laying for White Leghorn, RIR and Fayoumi chicken under the extensive production system in Ethiopia, which was higher than the present report for purebred and crossbred chickens. Age at first egg reported for Koekoek (145 days) in the current report was lower than the result of Demissu (2020) who reported 168 days. The earlier beginning points of lay was observed in chicken crossbred hen sired by Horro (H x Ku). The lower age at first egg suggests that they yield more eggs during their egg production periods.

A genotype had significant effects on body weight at first egg which is in line with report of Amira *et al*. (2013) In the present study, the higher body weight attained at first egg was recorded for crossbred hen (2448 g) sired by Horro (H x Ku) followed by crossbreed hen (2372.33 g) sired by Kuroiler (Ku x H). This finding was parallel with report of Amira *et al*. (2013) who reported higher body weight at first egg (1736 g) for crossbred hens than purebred. The lowest body weight at first egg was recorded in improved Horro hens (1376.34g) followed by Koekoek hens (1683.26 g) with significant (P<0.05) differences. The current report was agreed with Kedija *et al.* (2019) who had shown a significant improvement in body weight at first egg for crossbred chickens. Accordingly, the observed variation in age at first egg among genotypes under the present studies might be due to genetic make-up of population being crossed, which is in agreement with the findings of Fassil *et al*. (2010) and Amao (2017).

5.2.3. Egg mass and feed conversion ratio of egg production

In the present study, the total egg mass produced in most of studied period was significantly (P<0.05) affected by genotypes. Likewise, several researchers reported that a significant effect among genotypes in most studied periods of production egg mass (Kedija *et al*., 2019; Khawaja *et al*., 2014; Momoh *et al*., 2010). In contrast to this Sohail *et al.* (2013) reported non-significant effect of egg mass among the three indigenous chicken genotypes. In comparing all genotypes in over five-month egg production HxKu crossbred hen have shown higher performance in egg mass production followed by pure breed Kuroiler hen. Alewi *et al*. (2012) was reported higher total egg mass production of crossbred hen of Fayoumi and RIR with local Kie chicken than purebred hen under farmer management condition, but purebred Kuroiler hen scored higher egg mass production next to crossbred H x Ku hen. However, Kahaja *et al*. (2014) is not in confirmation with present results and aforementioned reports in that they reported non-significant effects of egg mass production between Fayoumi and local Desi chickens.

The feed conversion ratio (FCR) for egg production was significantly (P<0.05) affected by genotypes at most studied ages. Significantly higher feed conversion ratio of egg production at most of studied age was shown for improved Horro than Koekoek and Kuroiler chicken breeds. This was not confirmed with Kedija *et al*. (2019) who reported significantly higher feed conversion ratio for exotic birds than local chickens. In comparing crossbred chicken at most studied egg production ages, hen sired by Kuroiler have shown significant difference from the other crossbred genotypes in terms of feed conversion ratio. But in the overall five-month egg production, comparable feed conversion ratio was observed among the crossbred genotypes. Unlike present work, Kedija *et al*. (2019) reported significant effects of genotypes for the feed conversion ratio of hen sired by local chicken than a hen sired by exotic chickens. Several researchers confirmed that there is a significant difference in feed conversion ratio among genotypes (Kedija *et al*., 2019; Bekele *et al* 2010; Kayitesi, 2015). Higher values in feed conversion ratio for RIR layer chicken (7.10) were observed (Halima, 2007) than the current value reported for both purebred and crossbreed chicken for five-month egg production. Higher values in feed conversion for indigenous chicken in Ethiopia ranged from 10.06 to16.20. In comparing pure line improved Horro chicken showed better feed conversion ratio for the overall laying periods followed by Koekoek chicken breed. This might be due to higher live weight and lower laying performance of dual-purpose exotic breeds as compared with lower live weight of indigenous chicken.

5.3. Mortality

Livability is a composite feature concerns the question of the adaptive value for the organism. Furthermore, it relates to all physiological procedures leading from the genotype to the consequential phenotype (Iraqi *et al*., 2005). A number of studies reveals that crossbreds had higher livability than purebreds (e.g., Iraqi *et al*., 2005). Similar to the present findings Kedija *et al*. (2018) reported that during brooding and growing phase Horro chicken ecotype showed the lowest mortality rate compared to crossbred and other purebred. In the current reports Kuroiler and Improved Horro have not showed a significant difference in mortality rates at all ages except at growing phases. In opposition to the current findings, Lemlem and Tesfay (2010) reported the highest mortality in local and low in RIR breed in laying period. Kedija *et al*. (2019) reported that low mortality rate for Horro chicken ecotype which is similar to present results. Khawaja *et al*. (2013) showed that significantly low mortality rate for Desi local chicken than Fayoumi and RIR chicken breeds. The survival rate of all genotypes tested in the current experiment were found to be better than Dominant Sussex and Novo Brown, Lohman Brown chicks tested under on station management system in Jimma zone, in Ethiopia (Yigzaw *et al*., 2020). Also, the level of survival attained was better than survival in the RIR breed of chicks tested under intensive management system in Ethiopia (Halima et al., 2006) and Pakistan (Tabinda *et a*l., 2012). In comparing whole genotypes there was comparable and low mortality rate throughout the experimental period among the genotypes. This might be due to good adaptation of genotypes to the environmental condition of the study area and proper management of the chicken during experimental periods.

5.4. Fertility and Hatchability

In chickens, fertility refers to the overall actual reproductive capacity of males and females as reflected by their ability to produce progeny when mated together. In this study, the improved Horro (78.5%) and Kuroiler (70.27%) chicken breeds had a significant ($P<0.05$) higher fertility rate than others, but the rest of genotypes had comparable fertility percentages. However, H x K crosses showed a significantly ($P<0.05$) higher fertility rate followed by K x H (90.12%) crosses than all genotypes. The results agree with Dessie and Ogle (2001) who had reported the higher fertility for local chicken than exotic breeds. These results similar with Kuroiler chicken but disagree for Koekoek chicken breeds in the current study. Consequently, the fertility rate showed little improvement due to crossing of both Koekoek-crosses and Kuroiler crosses. Egg fertility on the 18th day of candling among cross bred and pure bred were shown to results a significant difference ($P<0.05$) except for Koekoek. This result was in agreement with Wondemenh (2011) who had reported that a significant difference between exotic (Koekoek and Fayoumi) and native chicken breeds (Horro). No significant difference were observed among the crossbred of both Kuroiler- crosses and Koekoek-crosses ($P>0.05$) in fertility rates.

Along with its strong relationship with chick products, hatchability is an economically important feature in chicken farming (Wolc *et al*., 2012). Egg hatchability is heritable to some extent, although it is determined by a complex genetic makeup as well as the surrounded environment. The present result showed that a slightly better fertility rate in improved Horro and Koekoek chicken breeds than the report of (Wondemenh, 2011) for the same breeds. Meanwhile, crossbred hen eggs had superior fertility rate than their counterparts. Hatchability rate were comparable among crossbred genotypes and their correspondence, except for Kuroiler chicken breeds from fertile eggs, which had a higher hatchability rate, and Koekoek chicken breeds having the lowest hatchability rate. Adedeji *et al*. (2015) reported that a significant variation among purebred and crossbred chickens progenies in hatchability rates.

5.5. External and Internal Egg Quality Measures

The external and internal quality of egg is important in egg production to determine the productive and reproductive measures of poultry. Mainly egg quality is affected by age and genotypes. A non-significant difference in yolk color in the present study is in disagreement with the finding of Alewi *et al*. (2012) but, similar with other reports Kedija *et al*. (2020) and Markos *et al*. (2017). A significant difference in egg weight, shell weight and Albumen width egg quality parameter observed in the current study were similar to the findings of Kedija *et al*. (2020). The highest egg weight in current study was observed for Kuroiler (54.00g) followed by Ku x H (52.05g) and H x K (52.08g) whereas the lowest egg weight was observed for improved Horro chicken. Similar to the current findings Alewi *et al*. (2012) and Kedija *et al*. (2020) had reported higher egg weight for Rhode Island Red and Dominant Red Barred than native chicken ecotypes, respectively. This might be due to higher body weight of Kuroiler and the other aforementioned chicken breeds. Egg weight in the current reports for Kuroiler and Koekoek were lower than RIR (58g) and DRB (55.28g) as reported by Bekele *et al*. (2010) and Kedija *et al*. (2020), respectively. But, Kuroiler showed comparable egg weight with crosses of Dominant Red Bared with Horro chicken ecotype. Average egg weight for crossbred in the current reports was lower than egg weight for crossbred of Dominant Red Bared in both direct and reciprocal crosses (54.5g and 53.46g) (Kedija *et al.*, 2020). While it is higher than Fayoumi (40g) and Rohde Iceland Red (44.2g) crosses with native Kei chicken ecotype (Alewi *et al*., 2012). Also, the average egg weight for the crosses in the current study was better than egg weights of Fayoumi crossed with a naked neck (43.7g) and RIR crossed (45.7g) with native white chicken ecotypes (Netch Doro) (Bekele et al., 2010). In the current study genotypes have not shown significant effects on most of egg quality parameters in both internal and external traits and this it in disagreement with reports of various scholars (Kedjia et al., 2020; Alewi et al., 2012; Bekele et al., 2010) who had reported a significant effect of genotype on the different egg quality parameters. In the present study some of the egg quality parameters were slightly improved through cross breeding of both Koekoek and Kuroiler-crosses with improved Horro chicken and their correspondence reciprocal crosses. The Haugh unit values recorded for both crossbred hen eggs were above 70. This shows that in both Koekoek and Kuroiler crosses can be produce eggs with higher albumen quality.

5.6. Estimates of Crossbreeding Effects

5.6.1. Crossbreeding effects on growth performance of H x K and Kx H

Additive effects (A^e) for body weight were positive and had a significant (P <0.05) contribution for BW 4- and 12-weeks age among the genotypes and ranged from 8.87 to 10.1%. According to Kedija *et al*. (2018) the crossing between Dominant Red Barred and Horro ecotypes was showed a positive significant contribution of additive effects on body weight development at most of studied ages ranging from 8.77 to 48.22%. In the present study, the positive and significant additive effects suggesting superiority of sire line in the growth performance which indicates that the use of improved Horro as sire line to improve the body weights. Like this, Iraqi *et al*. (2012) reported that additive genes had a positive effect on growth with ranges on body weight between 2.22 and 10.4% from 1 to 10 weeks of age. Maternal additive effects (M^e) estimate on body weight was positive and significant (*P*<0.05) for BW 8 weeks (8.22%). The negative and significant maternal effects might be indicating the favor of Koekoek as dam line to improve body weights. The present value disagreed with the report of Kedija *et al*. (2018) who reported a negative and non-significant contribution of additive genes at BW 4 and 8 weeks of age ranging from-6.45 to - 4. 75.%.

Within the present study, estimates of heterosis effects (H^e) were positive and ranged from 6.54-13.79 %. The highest percentage of heterosis contribution was reported at BW 8 weeks of age (13.79%) followed by at BW 4 weeks (10.08%) whereas the lowest percentage of contribution sated at hatch (6.54%). This might be due to heterotic effects not influences the early growth rate as later age (Fairfull, 1990). Iraqi *et al*. (2011) also reported that heterosis percentages for body weights was positive and ranged from 6.87% to 9.05% during growing phases starting from 5 to 10 weeks of age. A significant positive heterosis percentages was recorded for body weight at earlier ages 4 and 8 weeks which suggests the superiority of crossbred over their parental strains. Likewise, Kedija *et al*. (2018) stated that heterosis percentages for body weights were positive and the contribution estimates ranged from 3.28 to 21.89%. The positive and significant heterotic effects indicate the substantial impacts of crossbreeding between improved Horro and Koekoek chicken breeds to improve body weight at studied ages. The lower heterotic values might be suggesting that the trait was mostly governed by additive gene effects.

5.6.2. Crossbreeding effects on growth performance of H x Ku and Ku x H

Within the present study, additive effects (A^e) for body weight indicated that there was positively significant (*P* <0.05) difference at 4- and 12-weeks age among the genotype (Table 15). Some of studies reported the additive genes had a positive effect on growth performance at most of studied ages that (Kedija *et al*., 2018; Iraqi *et al*., 2012). In the present study, the positive and significant additive effects suggest merits of sire line in the growth performance which favors that the use of Kuroiler as sire line to improve the body weights. Maternal additive effects (M^e) estimate on body weight was positively significant (P<0.05) for BW 8- and 12-weeks age except body weight at hatch and 4 weeks old indicates negative values for body weight at 4-weks and positive values for body weight at hatch with non-significant effects. The present results in line with Kedija *et al*. (2018) who had reported that a negative and non-significant effect of maternal additive genes for BW at 4 week. But disagrees for negative maternal effect value reported for body weight 8 weeks of age. Maternal effects is the influence of the maternally provided environment on the phenotype of her offspring by mother. The significant and negative maternal effects might indicate the suitability of improved Horro as dam line to improve body weights in the crossing between improved Horro and Kuroiler chicken breeds.

For body weight at 8 and 12 weeks, the heterosis effect were found to have a positive and significant ($P<0.05$) effect on body weight (Table 15). Bodyweight at 12 week (16.11%) had the highest positive heterosis contribution, followed by body weight at 8 week (15.37%). According to Kedija *et al*. (2018), heterosis percentage for body weights was positive, with estimations ranging from 3.28 to 21.89 percent. Many researchers found evidence of favorable hybrid vigor at various life stages of chickens (Sabri *et al*., 2000; Razuki and Al-Shaheen, 2011). Heterosis in F_1 is determined by the difference in gene frequency between parents, the degree of dominance of enclosed surroundings, and the genetic makeup of the breed being crossed. The heterotic effects of chickens change with age in the current study. Similarly, Lamont and Deeb (2001) found that hybrid vigor in terms of body weight varied with age. The significant and positive heterotic effects demonstrate the major impact of crossbreeding between improved Horro and Kuroiler chicken breeds on body weight improvement.

5.6.3. Crossbreeding effects for AFE and BWFE for H x K and K x H

In the current result of additive effect (A^e) for Age at first egg was negative with significant ($P<0.05$) effects among the genotypes. In line with the present result Iraqi *et al. (*2008*)* was indicated that the direct additive effect of age at first egg was found negative (-0.5%) with non-significant contribution. In contrary to present results Kedija *et al*. (2020) and Amira et al*. (*2013*)* had found that the direct additive effect of age at sexual maturity was positive 2.43 % and 1.18% which was higher direct additive contribution than the present results. Additive effect for BWFE in the current result was significantly ($P<0.05$) positive (8.17%). Similarly, Kedija *et al.* (2020) and Amira *et al*. (2013) were found that BWSM significant and positive additive effects. Likewise, Iraqi *et al*. (2008) had reported significant and positive contribution of direct additive effects on body weight at first egg in the crossing of two Egyptian strains which had a lower contribution than the present work.

Estimated maternal effect ($M^{e)}$ were positive (4.56) for AFE, with a significant ($P<0.05$) effect in the current study. With similar to present result, maternal additive effects for body weight at first egg reported by (Kedija *et al*., 2020; Aymen and Fawzy, 2013) were positive. Likewise, Amira et al. (2013) also indicated that positive maternal gene contribution for age at first egg. Age at first egg of chickens mothered by the improved Horro was showed significant (P<0.05) effects. Then, it may be worthy to use improved Horro in maternal position in the crossbreeding programs for producing chickens with earlier age to start egg production. The estimate of heterosis effect for AFE was negative with non-significant effects, whereas Body weight at first egg (BWFE) was recorded positive heterotic contributions. In line to present results, Kedija *et al*. (2020) were found a negative estimate of heterosis effects for AFE and positive for BWFE in crossing between Horro ecotype and Dominant Red Barred chicken breeds. Negative and significant direct heterosis effects for age at first egg indicates decrement of time before reaching egg production which could be lead longer productivity of life dam line in the crossing. Hanafi and Iraqi (2001) reported that the positive heterosis estimates for body weight at first egg, but the percentage of contribution was lower than the present study. Furthermore, Iraqi *et al*. (2012) found a positive heterosis (H^e) contribution for most of production traits except for age at sexual maturity. With similar to present findings Amira *et al*. (2013) and Munisi *et al*. (2015) were reported the negative percentage of heterotic contributions (H^e) for age at sexual maturity.

5.6.4. Crossbreeding effects for AFE and BWFE for H x Ku and Ku x H

The current result of additive effect (A^e) for age at first egg (AFE) was negative (-3.36%) with non-significant effects. Like the present result Iraqi *et al. (*2008*)* indicated that the direct additive effect of age at first egg was found negative (-0.5%) with non-significant effect. It indicates that the additive gene had an insignificant contribution in improving age at first egg for Kuroiler sired crossbred hen as observed in the study. In contrary to present results Amira *et al. (*2013*) and* Kedija *et al*. (2020) were found that the direct additive effect for age at sexual maturity was positive 2.43 % and 1.18% which is higher than direct additive (-3.36%) contribution in the present results. The estimates of direct additive effect for body weight at first egg (BWFE) in the current result was significantly (P<0.05) positive (18.43%). Similarly, Amira *et al*., 2013 and Kedija *et al*. (2020) were found that BWSM were significantly positive. Also, Iraqi *et al.* (2008) was reported a significant positive contribution of direct additive effects on body weight at first egg in the crossing of two Egyptian strains.

Estimates of additive maternal effects was significant with positive (2.7%) effects for body weight at first egg. In parallel to current findings, positive maternal additive contribution for body weight at first egg were reported (Kedija *et al*., 2020; Aymen and Fawzy, 2013). The positive maternal effects for Age at first egg was reported (Kedija *et al.*, 2020; Amira et al., 2013). But, in the current study negative maternal effects was reported for age at first egg. The estimate of direct heterosis effect for age at first egg (AFE) was negative with non-significant effects, whereas body weight at first egg (BWFE) was shown positive heterotic effects. Similar to present results Kedija *et al*. (2020) was found a negative estimate of heterosis effects for AFE and positive for BWFE in crossing between Horro chicken and Dominant Red Barred. Hanafi and Iraqi (2001) also reported the positive heterosis estimates for body weight at first egg with little contribution. Furthermore, Iraqi (2008) and Iraqi *et al*. (2012) were found a positive heterotic effect (H^e) for the body weight at first egg and negative for age at sexual maturity. The current results in line with Amira *et al*. (2013) and Munisi *et al*. (2015) who were reported that the negative percentage of heterosis effect (H^e) for age at sexual maturity and positive heterosis effects for body weights at first egg. The negative direct heterosis for age at first egg was important to shorten time before reaching the start egg producing which might lead to longer productivity of crossbred hen. Whereas positive direct heterosis effects for body weight at first egg suggest superiority paternal line to improve body weight at age of starting egg producing.

6. CONCLUSION AND RECOMMENDATION

6.1. Conclusion

Within the present results, crossbred H x Ku followed by Ku x H genotypes showed better performance in growth and egg production traits with low mortality rate. It can be concluded that the exotic gene of Kuroiler and Koekoek chicken breeds can play a significant role in further improvement of the improved Horro chicken. In addition, using the same mating procedures, Kuroiler-Horro cross genotypes were found superior in growth traits than Koekoek-Horro crosses. The outstanding cross was the mating of improved Horro with Kuroiler. The positive additive effects for both crosses in body weight suggests the substantial contribution of Koekoek and Kuroiler chicken breed to improve growth performance. Positive and significant heterosis favors the considerable effects of crossbreeding on growth performance using improved Horro with Koekoek and Kuroiler chicken breeds. The negative direct heterosis for age at first egg might essential in reducing the time it took to reach the start of egg laying, which could lead to increased crossbred hen productivity. Implementation of two ways crossbreeding under reciprocal mating may be provides the opportunity to exploit variation among genetic groups and can be used to establish a sound breeding schemes along with farm practice and market condition.

6.2. Recommendation

Hence, the study suggested H x Ku to be the best genotype lines for future breeding schemes for synthetic breed development in improving growth and egg production traits for family poultry production in the country. However, further study is needed in morphometric characterization, alertness score traits investigation, carcass traits evaluation and adaptability of genotypes to various on-farm conditions.

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8. APPENDIX

Appendix 1 Analysis of variance table for bodyweight at (0days) hatch.

Source of variation	DF	Total Sum of Squares	Mean Square	F- value	Pr > F
Model	6	173.47	28.91	6.81	0.0015
Error	14	59.41	4.24		
Corrected Total	20	232.88			

CV= 6.27

Appendix 2 Analysis of variance table for bodyweight at 4 weeks.

Source of variation	DF	Total Sum of Squares	Mean Square	F- value	Pr > F
Model	6	8792.71	1465.45	16.75	0.0001
Error	14	1224.72	87.48		
Corrected Total	20	10017.43			

CV= 4.82

Appendix 3 Analysis of variance table for bodyweight at 8 weeks.

Source of variation	DF	Total Sum of Squares	Mean Square	F- value	Pr > F
Model	6	629151.29	104858.54	37.59	0.0001
Error	14	39053.59	2789.54		
Corrected Total	20	668204.88			

CV=0.94

Appendix 4 Analysis of variance table for bodyweight at 12 weeks

Source of variation	DF	Total Sum of Squares	Mean Square	F- value	Pr > F
Model	6	942616.78	157102.79	16.75	0.0006
Error	14	266056.46	19004.03		
Corrected Total	20	1208673.25			

CV= 0.77

Appendix 5 Analysis of variance table for female bodyweight at 16 weeks

Source of variation	DF	Total Sum of Squares	Mean Square	F- value	Pr > F
Model	6	870219.40	145036.56	9.54	0.0003
Error	14	74550.33	1.17698571		
Corrected Total	20	944769.73			

CV= 5.54

Appendix 6. Analysis of variance table for male bodyweight at 16 weeks.

Source of variation	DF	Total Sum of Squares	Mean Square	F- value	Pr > F
Model	6	1564884.49	260814.08	34.28	.0001
Error	14	106517.28	7608.37		
Corrected Total	20	1671401.780			

CV= 4.94

Appendix 7 Analysis of variance table for overall egg weights

Source of variation	DF	Total Sum of Squares	Mean Square	F- value	Pr > F
Model	6	143.44	23.9068413	9.15	0.0003
Error	14	36.59	2.61397		
Corrected Total	20	180.04			

CV= 3.50

Appendix 8 Analysis of variance table for overall egg mass

Source of variation	DF	Total Sum of Squares	Mean Square	F- value	Pr > F
Model	6	166458.60	27743.10	4.94	0.0065
Error	14	78632.51	5616.60		
Corrected Total	20	245091.11			

CV= 16.87

Appendix 9 Analysis of variance table for percent of eggs fertility.

Source of variation	DF	Total Sum of Squares	Mean Square	F- value	Pr > F
Model	6	1035.94	172.65	8.80	0.0004
Error	14	274.80	19.62		
Corrected Total	20	1310.74			

CV= 5.231597

Appendix 10 Analysis of variance table for percent of hatchability from fertile eggs (HFE)

Source of variation	DF	Total Sum of Squares	Mean Square	F- value	Pr > F
Model	6	1461.71	243.61	1.35	0.2989
Error	14	2520.92	180.06		
Corrected Total	20	3982.64			

CV= 17.47

Appendix 11 Analysis of variance table for percent of hatchability from total eggs set (HTES)

Source of variation	DF	Total Sum of Squares	Mean Square	F- value	Pr > F
Model	6	894.33	149.05	1.18	0.3689
Error	14	1761.67	125.83		
Corrected Total	20	2656.01			

CV= 17.37

Appendix 12 Analysis of variance table for age at first eggs (AFE)

Source of variation	DF	Total Sum of Squares	Mean Square	F- value	Pr > F
Model	6	1037.90	172.98	5.12	0.0056
Error	14	473.33	33.80		
Corrected Total	20	1511.23			

CV= 4.052656

Appendix 13 Analysis of variance table for body weight at first eggs (BWFE)

Source of variation	DF	Total Sum of Squares	Mean Square	F- value	Pr > F
Model	6	2794885.318	465814.220	1195.64	.0001
Error	14	5454.303	389.593		
Corrected Total	20	2800339.621			

CV= 1.02

Appendix 14 List of feed ingredients used in experimental diet formulation.

Ingredients	Starter ration(kg)	Grower ration(kg)	Layer ration(kg)
Maize	56	59.5	59
Wheat middiligs	10	17.5	6
Soyabean meal	22.4	10	12. 6
Nouge seedcake	5	7.6	10
Meat and bone meal	4	2	3
salt	0.4	0.5	0.5
limestone	1.3	2	8
premix	0.5	0.5	0.5
Lysine	0.25	0.25	0.25
DM-methionine	0.15	0.15	0.15
Total	100	100	100

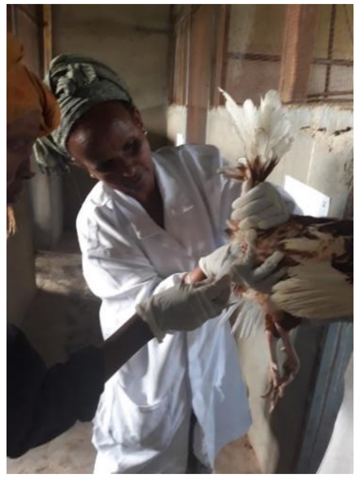
Appendix 15. Photo taken during experimental period

Figure 1 Improved Horro male crossed with Koekoek female, and Koekoek male crossed with improved Horro female during growing stages respectively at Debreziet Agricultural Research Center.

Figure 2 kuroiler male crossed with improved Horro female and improved Horro male crossed with Kuroiler female chicken breeds during experiment at Deberzit Agricultural Research Center.

Figure 3 Purebred Koekoek, Kuroiler and Improved Horro chicken breeds respectively from right to left during growing stages.


A.


B.


C.


D.

Figure 4 Training cocks ,Collecting semen and inseminating female birds, respectively from left right