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Orginal Article

Egg Production Performance of Improved Horro Chicken Crossed with Koekoek and Kuroiler Breeds

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ABSTRACT

Evaluation of cross-breeding effect on egg production traits of improved Horro chicken crossed with Koekoek and Kurioler chicken in direct and reciprocal mating was carried out for one generation at Debrezeit Agricultural Research Center. The experiment was done by mating foundation lines of improved Horro (H) and Koekoek(K) and Kurioler (Ku) chickens to obtain seven genotypes such as three pure lines (H), (K), (Ku) and their crosses (K×H, Ku×H, H×K, H×Ku). Day-old chicks from the seven genetic groups were randomly distributed between pens using a completely randomized design with three replications. The chickens were raised in a deep litter system for 40 weeks of age during which data on feed intake, age at first egg (AFE), bodyweight at first egg (BWFE), egg laid, average egg weight, and mortality rate were recorded. The hen-day egg production (HDEP), hen-housed egg production (HHEP) and feed conversion rate (FCR) were calculated. The result showed that genotype had significant effect on most egg production traits studied.

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Older age at first egg was recorded in improved Horro (156) followed by crossbred H×K (150.33) whereas the lowest number of days for AFE for was recorded for crossbred H×Ku (153) followed by K×H (136.67) and Ku×H (139.33). In comparing crossbred, the heaviest bodyweight at first egg was registered for crossbred pullet H×Ku (2448 g) followed by Ku×H (2372.33 g) whereas the lowest body weight was recorded for K×H (1726.33 g) followed by H×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 the lowest egg weight was registered for improved Horro chickens. Estimates of maternal effects (M^e) were significantly ($P< 0.05$) positive only for age at first egg while additive (A^e) and heterotic effect (H^e) were non-significant with negative values. Positive and significant effect values were reported for bodyweight at first egg. From this study, it can be recommended that crossbred hens be sired by improved Horro (H x Ku) for egg production potential genotypes for the family poultry production system in the forthcoming synthetic breed development program.

Keywords: Additive effect, Crossbreeding, Egg production, Improved Horro, Heterotic effect

Introduction

Poultry production is a common rural enterprise in developing countries with significant economic, social, and cultural benefits. Egg and meat are key sources of animal protein obtained from poultry production. Most tropical countries are mainly based on scavenging chicken production systems, which make 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 to increase sustainable poultry production which is suitable for the 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 are low (Wondmeneh, 2015). The selection of the indigenous chicken can indicate productivity improvement (Halima, 2007) although the progress is slow. On the other ways, 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 feed (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 and preferences of small-scale poultry farmers are not guaranteed.

The overall effort to improve the poultry productivity in Ethiopia by the introduction of high-performing commercial chickens, except in 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. Hopeful results have been registered through selective breeding of the breed, but it still requires a long period to put it on level ground with the performance of improved exotic breeds. Crossing Horro with an exotic line (Dominant Red Barred) sired by Horro showed improvement in most egg production traits (Kedija *et al.,* 2020).

The genetic diversity of indigenous and exotic chicken breeds could be utilized by cross-breeding to produce a new breed of 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 to improve the program of livestock in general and poultry (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 crossbreed chicken would have a 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 country's 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. 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. Thus, the present study was designed to evaluate the egg production performance of improved Horro crosses with Koekoek and Kurioler exotic chicken breeds under reciprocal mating as a step towards synthetic breed development.

MATERIALS AND METHODS

Description Experimental Area

The study was carried out at the Debrezeit Agricultural Research Center National Poultry Research Farm, which is located 45 kilometers southeast of Addis Ababa, at an altitude ranging between 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

April. The average annual rainfall, maximum and minimum temperatures for the area are 892 mm, 28.3 °C and 8.9 °C, respectively.

Breeding Plan and Mating Techniques

The present work was done on one improved local chicken called Horro which was selected for twelve generations, and two exotic chicken breeds named Potchefstroom Koekoek and Kuroiler. Kuroiler chicken is a large dual-purpose synthetic breed developed in India and was imported by African Chicken Genetic Gains (ACGG) project in 2015. The chicken required for the study was obtained from the descendants of the stock used for on-station evaluation of chicken breeds by the ACGG project at the Debreziet Agricultural Research Center, National Poultry Research Program. The crossbreeding study was started by randomly picking 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. Chicks of the parental stock were raised to the age of 20 weeks in the rearing house. 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 from their breed while the second group was artificially mated with semen of cocks from improved Horro chicken. Similarly, hens of improved Horro chicken have mated artificially with semen of cocks from the 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. Vent of cocks was cleaned before semen collection (Kharayat *et al.,* 2016*)*. During insemination, hens were restrained, and standard procedure of semen deposition by inserting a micropipette containing semen into the oviduct. Within the same breed, male to female ratios of 1 to 5 was used in pen natural mating arrangements. The cocks were assigned to mate the hens at random, but a restriction was made to prevent birds that are closely related (common parents).

Accordingly, chicks of seven genetic groups namely: H♂×H♀, K♂×K♀, Ku♂×Ku♀, H♂×K♀, K♂×H♀, H♂×Ku♀, and Ku♂×H♀ which were obtained from inter se (H×H, K×K and Ku×Ku) and reciprocal crosses (H×K and K×H, H×Ku and Ku×H) mating design. 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. Eggs from each genetic group were collected daily, marked, and stored for 10 days to be incubated to get uniform age groups. A total of 446 unsexed day-old chicks were obtained from all genetic groups. To keep their breed and crossbred group identities, the hatched chicks were wing-tagged until they were 12 weeks old. Chicks from each genotype were distributed randomly between pens using a completely randomized design with three replications. The day-old chicks were kept in a brooding house and reared for 12 weeks. At week 12, sexing and differentiation of the males from the females were carried out phenotypically via external characteristics and kept in the ratio of 1 male to 5 females in each pen.

Table 1: Purebred and reciprocal crossbreeding mating schemes executed in the study

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

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

Management of the Experimental Chicken

The birds were provided with water *ad libtum* and standard feed as per the requirement at each specific growth stage. Starting chicks were fed on a ration containing 20% of CP and 2,950 kcal/kg for up to 8 weeks whereas grower's ration which contain 18% CP and 2,850 kcal/kg was fed to chickens from 9 to 20 weeks. The feeder and waterer were placed in the house per pen with proper spacing. The experimental house was open-sided with deep litter of 15cm of *teff* (*Erogrostis teff*) straw on a concrete floor. The pen size was 1.5m×2m. As the birds continue to increase in size the brooding guard was similarly increased by drawing the brooding guard backward until it was completely removed. During brooding stages brooding heat was supplied by using an infrared bulb. Additionally, the standard lighting program was given based on the age of the birds. All chickens were inspected daily for their health status and vaccinations were provided against common disease namely: Marek's, Newcastle diseases, Gumbro, and Fowl Typhoid. The vaccines were given based on the respective ages of the chicks and veterinarian's recommendation.

Table 2: Number of sires, dams, and their progenies used in the study.

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

Data Collection

Egg production performance

The experimental period elapsed for 40 weeks. Measurements recorded for egg production traits were age at first egg, body weight at sexual maturity, egg weight, and the number of eggs daily. The age of each chicken was taken and age of the first egg was recorded as the number of days between the date of hatching and the date of their first egg. The daily egg productions were then managed in the four-week interval the 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 methods of (Hunton, 1995). Percentage of hen day egg production was calculated by dividing the number of eggs collected per day for a number of hens present on that 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 by 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 by the number of eggs. Egg mass per hen was calculated as the total egg mass from each pen divided by number of hens. The number of birds that died and survived during the experimental period was recorded and general health status was monitored throughout the experiment. The mortality percentage was calculated by subtracting the number of dead birds from number of live birds and dividing for live birds at the beginning and multiplying by 100.

Crossbreeding Parameter

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

For Koekoek and Horro crosses

- 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×H)] – [(H×H) + (K×K)], and

For Kuroiler and Horro crosses

- 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×H)] – [(H×H) + (Ku × Ku)]

Percentages of each crossbreeding effect (% A^e, M^e and H^e) for body weight and age 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.

Experimental Design and Data Analysis

General Linear Models (GLM) procedure of Statistical Analysis System (SAS version 9.0) was used for mean comparison of traits among genotypes. When significant differences were detected, genotypes mean was compared by Duncan's Multiple Range Test (Duncan, 1997). All statements of statistical differences were based on $P<0.05$. The experimental design was a Completely Randomized Design (CRD) where the genetic groups were treatments and pens were 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.

RESULTS

Egg Production Performance of F_1 Crossbreds and Pure breeds

Genotype had a significant effect on Egg number (EN), Hen Day egg production (HDEP), and Hen housed egg production (HHEP) over five months as shown in Table 3. The highest egg number was recorded in H×Ku and Ku×H and the 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 hens between Horro and Kuroiler (H× Ku and Ku × H). However, the difference with Koekoek, Kuroiler, and crosses of H×K was not significant. The lowest hen day egg production and hen housed egg production was recorded in an improved Horro chicken.

In comparing crossbreed to pure lines (Kuroiler, Koekoek, and improved Horro), crossbred hens 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 an 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 is somehow similar to the average number of hens to be considered for hen housed egg production.

Table 3: Mean±SE for monthly egg number, hen day egg production and hen housed egg production

Traits	Ages(week)	Genotype Combination							
		H×H	H×K	K×H	K×K	H×Ku	Ku×H	Ku×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-d] Means in the same row with different superscript letters are significantly ($p<0.05$) different; HxH-Horro x Horro, HxK-Horro koekoek, KxH-KoekoeK×Horro, KxK-Koekoek x Koekoek, HxKu-Horro x Kuroiler, KuxH-Kuroiler x Horro, KuxKu-Kuroiler x Kuroiler. SE-standard error of mean.

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 4. 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×K (150.33) whereas the lowest number of days was recorded by crossbred H×Ku (135) chicken followed by crossbred K × H (136.67) and Ku × H (139.33) chickens. Crossbred hens of H×Ku genotype have attained sexual maturity early followed by crossbreds of Ku × H and K × H genotypes. Hens of H×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×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, a 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. A comparison of the seven genotypes has shown that hens from crosses and reciprocal crosses of Kuroiler by Horro have attained sexual maturity early than the other genotypes.

Table 4: Mean± SE for age (days) at first egg and body weight (gm) at first egg among the genotypes

	Genotype Combination							
Traits	H×H	H×K	K × H	K×K	H×Ku	Ku × H	K×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}	2448.00^{a}	2372.33^{b}	2110.67^{c}	19.73

$^{a-f}$ Means 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 × Horro, H×K-Horro Koekoek, K×H-Koekoek × Horro, K×K-KoekoeK×Koekoek, HxKu-Horro x Kuroiler, KuxH-Kuroiler × Horro, KuxKu-Kuroiler × Kuroiler. S-male are listed first in the crosses, SE-standard error of mean.

Genotypes had a significant (P<0.05) difference in body weight at first egg. In comparing crossbred, the highest body weight was scored by crossbred H×Ku (2448 g) followed by crossbred Ku×H (2372.33 g) chicken whereas the lowest body weight was observed for H×K (1814.78 g) followed by K × 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×K cross-registered the highest body weight at the first egg whereas the lowest body weight was recorded for improved Horro chicken hens.

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 5. The total egg mass-produced in the 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×Ku followed by Kuroiler (547.2 g) and crossbred Ku×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 the studied ages. In comparing crossbred there was a significant difference among genotypes in feed conversion ratio at most of the studied ages but no significant differences were observed in FCR of the overall laying periods, except for H×Ku which showed a significant difference (P<0.05). H×Ku crossbred is 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.

Mortality

The mortality rate for genotypes at different ages is presented in table 6. There was no significant (P>0.05) genotype effect on mortality. At laying phases no mortality was registered in most of the genotypes except for H×K, H×Ku, and Ku × 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 5: Means ±SE for Egg mass and feed conversion ratio among the genotypes

Traits	Age	Genotype							
		H×H	H×K	K×H	K x K	H×Ku	Ku×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	1.07^{b}	3.57^{a}	4.00^{a}	1.44^{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	1.95^{c}	2.44^{bc}	3.14^{b}	2.67^{bc}	4.22^{a}	2.99^{a}	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	2.64^{c}	4.29^{ab}	4.16^{ab}	3.57^{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×Horro, KxK-Koekoek x Koekoek, HxKu-Horro x Kuroiler, KuxH-Kuroiler x Horro, KuxKu-Kuroiler x Kuroiler, SE-standard error of mean

Table 6: 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×H	H×K	K×H	K×K	H×KU	Ku×H	Ku×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×Horro, H×K-Horro Koekoek, KxH-KoekoeK×Horro, K×K-Koekoek × Koekoek, HxKu-Horro × Kuroiler, Ku×H-Kuroiler × Horro, KuxKu-Kuroiler× Kuroiler. SE-standard error of mean.

Crossbreeding effects for AFE and BWFE for H x K and K×H

Crossbreeding effects on age at first egg and body weight at first egg traits were indicated in Table 7. The current result of additive effect (A^e) for AFE was negative and significant (*P*<0.05). Additive effects for BWFE were positive (8.17%) and significant (P<0.05). In the 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 were negative and non-significant (P>0.05) while it was positive (14.76%) and significant(P<0.05) for BWFE.

Table 7: 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.

Crossbreeding effects for AFE and BWAFE for H×Ku and Ku×H

Crossbreeding effects for age at first egg and body weight at first egg traits were presented in table 8. 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 were 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 were negative (-7.84%) and non-significant (*P*>0.05), but positive (38.25%) and significant (P<0.05) for BWFE.

Table 8: 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

DISCUSSION

Egg Production Performance of F_1 Crossbreds and Pure breeds

Genotypes had a significant effect on studied egg production traits over a 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; Wondemenh *et al*., 2011; Amao, 2017; Kedija *et al*., 2019). They reported a better percentage of hen-housed egg production and hen-day egg production in crossbred chickens than purebred chicken breeds in the various studies. The present reports are also comparable with the results of Basant *et al*. (2013) for RIR, Fayoumi, and crossbred RIR and Fayoumi where crossbred chickens were better than purebred chickens in hen-housed egg production (HHEP) and hen-day egg production (HDEP) rates. Yeasmin *et al., (*2003) showed higher egg production in exotic breeds: White Leghorn, Fayoumi, Rhode Island Red than in indigenous chickens up to 42 weeks of age. They also observed a rate of lay higher for exotic chickens 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 chickens 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). Amao (2017) reported that hen day egg production and hen housed egg production percentages were significantly higher for RIR x FE crossbred hens than FE x RIR crosses and likewise for RIR than FE. Likewise, in the present study crossbred hen K×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 others.

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×H) also showed improvement in the age at first eggs. Likewise, Bekele *et al*. (2010) indicated that the 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 this, age at first egg for crossbred lines was 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 the first egg for improved Horro chicken in the present report was similar to Wondemenh (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 were observed in chicken crossbred hen sired by Horro (H x Ku). The lower age at the first egg suggests that they yield more eggs during their egg production periods.

A genotype had significant effects on body weight at the 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×H). This finding was parallel with a 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).

Egg mass and feed conversion ratio of egg production

The total egg mass-produced at most of the studied period was significantly (P<0.05) affected by genotypes. Likewise, several researchers reported a significant effect among genotypes in most studied periods of production of egg mass (Kedija *et al*., 2019; Khawaja *et al*., 2014; Momoh *et al*., 2010). In contrast to this Sohail *et al.,* (2013) reported a 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 has shown higher performance in egg mass production followed by pure breed Kuroiler hen. Alewi *et al*., (2012) reported higher total egg mass production of crossbred hen of Fayoumi and RIR with local Kie chicken than purebred hen under farmer management conditions, but purebred Kuroiler hen scored higher egg mass production next to crossbred H×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. The significantly higher feed conversion ratio of egg mass at most-studied age was shown for improved Horro than Koekoek and Kuroiler chicken breeds. This was not confirmed by Kedija *et al*., (2019) who reported a significantly higher feed conversion ratio for exotic birds than local chickens. In comparing crossbred chickens at most studied egg production ages, hens sired by Kuroiler have shown significant differences from the other crossbred genotypes in terms of feed conversion ratio. But in the overall five-month egg production, a 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 hens sired by local chickens 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 a lower live weight of indigenous chicken.

Mortality

Livability is a composite feature that 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). Many studies reveal 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 shown a significant difference in mortality rates at all ages except in 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 the 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 was 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 systems in Ethiopia (Halima *et al.,* 2006) and Pakistan (Tabinda *et a*l., 2012). In comparing whole genotypes there was a 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.

Crossbreeding effects for AFE and BWFE for H x K and K×H

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*)* indicated that the direct additive effect of age on the first egg was found negative (-0.5%) with a non-significant contribution. In contrary to the 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 at 2.43 % and 1.18% which was a higher direct additive contribution than the present results. The 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) found that BWSM has significant and positive additive effects. Likewise, Iraqi *et al*. (2008) had reported a significant and positive contribution of direct additive effects on body weight at the first egg in the crossing of two Egyptian strains which had a lower contribution than the present work.

The estimated maternal effect ($M^{e)}$ was positive (4.56) for AFE, with a significant (P<0.05) effect in the current study. Similar to the 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 positive maternal gene contribution for age at first egg. Age at the 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 at 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 with positive heterotic contributions. In line with present results, Kedija *et al*., (2020) 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 lead to 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 positive heterosis (H^e) contribution for most of the production traits except for age at sexual maturity. Similar to the present findings Amira *et al.* (2013) and Munisi *et al.*, (2015) reported a negative percentage of heterotic contributions (H^e) for age at sexual maturity.

Crossbreeding effects for AFE and BWFE for H×Ku and Ku×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 the first egg for Kuroiler sired crossbred hen as observed in the study. Contrary to the present results Amira *et al.* (2013) *and* Kedija *et al.* (2020) found that the direct additive effect for age at sexual maturity was positive at 2.43 % and 1.18% which is higher than the 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) found that BWSM was significantly positive. Also, Iraqi *et al.,* (2008) reported a significant positive contribution of direct additive effects on body weight at the first egg in the crossing of two Egyptian strains.
Estimates of additive maternal effects were significant with positive (2.7%) effects for body weight at first egg. In parallel to current findings, positive maternal additive contributions to body weight at first egg were reported (Kedija *et al.*, 2020; Aymen and Fawzy, 2013). The positive maternal effects of Age at first egg were reported (Kedija *et al.,* 2020; Amira *et al.*, 2013). But, in the current study negative maternal effects were 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 the present results Kedija *et al.*, (2020) 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 the first egg with a little contribution. Furthermore, Iraqi (2008) and Iraqi *et al.* (2012) 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 the 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.

CONCLUSION

The present results showed that genotype had a significant effect on most egg production traits studied. The crossbred H×Ku followed by Ku×H genotypes showed better performance in egg production traits with an insignificant mortality rate. The negative direct heterosis for age at first egg might be 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 of crossbreeding under reciprocal mating may provide the opportunity to exploit variation among genetic groups. Hence, the study suggested H×Ku be the best genotype line for future breeding schemes for synthetic breed development in improving egg production traits for family poultry production in the country.

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CONFLICT OF INTERESTS

The author declares that there is no conflict of interest.

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