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Effect of Crossbreeding on Growth Performance of Improved Horro Crosses with Koekoek and Kuroiler Chicken Breeds

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Abstract

The study was designed to evaluate the growth performance of exotic dual-purpose chicken breed of Koekoek (K) and Kuroiler (Ku) crosses with an improved Horro (H) chicken under reciprocal mating to select potential crosses for development of a synthetic breed in Ethiopia. The experiment was carried out on seven genotypes, including three pure lines (i.e., Horro, Koekoek, Kuroiler) and their direct (K × H, Ku × H) and reciprocal crosses (H × K and H × Ku). A total of 446one-day-old chicks from the seven genotypes were randomly distributed between pens using a completely randomized design with three replications (experiment period?). Data on body weight at hatch (DO), 4, 8, 12, 16 and 20 weeks of age, body weight gain, feed conversion rate (FCR) and mortality rate were calculated during the experiment. The crossbreeding effects were estimated to select the best genotype as a dam or a sire line in the synthetic breed for the next generation. The result showed that the highest mean body weight ($P < 0.05$) and body weight gain were related to Horro×Kuroiler crossbred chicken that followed by Ku×H, and pure Ku at most of studied ages. Average feed intake was comparable among genotypes. Additive (A^e), maternal and heterosis effects for body weight were significantly ($P < 0.05$) positive at most ages for both crosses. Additive effects range from 1.79 to 10.1% for Horro-Koekoek crosses, whereas it ranges from 1.6 to 44% for Horro-Kuroiler crosses. In Horro-Koekoek crosses, the highest positive contribution of maternal effect was observed for body weight at eight weeks (8.22 %). Estimates of heterosis effects (H^e) were positive and ranged from 6.54 to 13.79%. In the Horro-Kuroiler crosses, estimates of maternal additive (M^e) and the heterosis effects on body weight were positive and significant ($P < 0.05$) at 8- and 12-weeks of age. Generally, the positive and significant additive effects suggest merits of the sire line in the growth performance which favors use of Kuroiler and Koekoek as sire lines to improve the body. Positive values and significant contribution of heterosis indicate the substantial effect of crossbreeding on body weight at most of the studied ages. From this study it can be recommended that crossbred hens sired by improved Horro (H × Ku) can be used for growth performance potential in the forthcoming synthetic breed development program.

Introduction

Egg and meat are sources of animal protein obtained from poultry production. Despite their better adaptability to the low input production system, Indigenous chicken genotypes havea low performance in terms of growth and egg production (Wondmeneh, 2015). On the other hand, improved exotic chickens yield a higher number of eggs and more meat than indigenous ecotypes, however,their poor adaptability to a tropical environment is still a

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major challenge .In other words, they are not suited or adapted to harsh environmental conditions such as high temperature, disease and feed shortage (Ali *et al*., 2000; Islam and Nishibori, 2009).

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 resistant to harsh tropical climate conditions while producing intermediate egg and meat yields (Mekki *et al*., 2005). Selection of the indigenous chicken may result in productivity improvement **(**Halima, 2007), although the progress is slow. The genetic potential of the local chicken could be improved by crossing them with selected but still robust exotic breeds (Wondemeneh, 2015). The ideal crossbred chicken would have a higher feed conversion efficiency, growth rate, reproductive efficiency and carcass yield than local chicken without losing adaptability to the local environments (Adebambo, 2011). However, the traditional crossbreeding program demands the continued importation of improved exotic chicken breed lines. A synthetic breed is cost-effective alternative for family poultry production because it does not need a continuous supply of improved exotic line once the synthetic breed is developed.

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 the synthetic breed and/or devise appropriate crossbreeding systems. Thus, the present study was designed to evaluate the growth performance of exotic dual-purpose chicken breeds (Koekoek and Kurioler) crosses with an improved Horro chicken under reciprocal mating as a step towards synthetic breed development.

Materials and Methods

Experimental Location

The study was carried out at the Debrezeit Agricultural Research Center National Poultry Research Farm, located 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 breeds: Potchefstroom Koekoek and Kuroiler chicken breeds. Kuroiler chicken,a large dual-purpose synthetic breed India,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 initiated 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 20 weeks in the rearing house. In the first generation of the crossbreeding experiment, hens 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, hen of improved Horro chicken were mated artificially with semen of cocks from the two exotic breeds. Artificial insemination was required because of the big size differences between improved indigenous Horro and the other exotic chicken breeds.

The cocks were trained for semen collection by abdominal and back massage. The vent of cocks were cleaned before semen collection (Kharayat *et al.*, 2016*)*. During insemination, hens were restrained, and artfificially inseminated by inserting a micropipette containing semen into the oviduct. Within the same breed, male to female ratios of 1 to 5 were used in pen natural mating arrangements. The cocks were assigned to mate the hens at random, but a restriction was made to prevent birds which 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 mating (H×H, K × K and Ku × Ku) and reciprocal crosses (H× K and K × H, H × Ku and Ku × H) mating design as indicated in the Table 1. To get adequate semen for artificial insemination, two cocks were used per replication (a total of six cocks) for each type of cross instead of only one cock per replication in the pure mating as indicated in Table 2. 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 identify their breed and crossbred groups, the hatched chicks were wing tagged until 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 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 schemes implemented in the study

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

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

Management of the Experimental Chicken

The birds fed with a standard diet and water was provided *ad-libitum*. Chicks were fed on a ration containing 20% of CP and 2,950 kcal/kg ME for up to 8 weeks, whereas grower ration with 18% CP and 2,850 kcal/kg ME was fed from 9 to 20 weeks. Feeder and waterer were placed whithin pen with proper spacing. The experimental house was open-sided with deep litter of 15 cm of *teff* (*Erogrostis teff*) straw on a concrete floor. The pen size was 1.5 m × 2 m. As the birds continued to increase in size, the brooding guard was similarly increased by drawing the brooding guard backward until it was removed entirely. During the brooding stages 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 recommendations.

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

Feed consumption and growth performance

The amounts of feed offered and refused per pen were recorded for 40 weeks. Average daily feed intake per bird was calculated as the difference between the weight of feed offered and the refusal divided by the number of chickens. The chicken's live body weight was measured in a group per pen using digital sensitive balance to the nearest of 0.01gram accuracy. Body weight was taken at hatching (d 1) and bi-weekly, then after up to 40 weeks of age. Average body weight per pen per chicken 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 rate (FCR) was calculated via dividing the daily feed intake by daily weight gain.

Crossbreeding Parameters

Crossbreeding effects including direct additive effect **(**A^e**),** maternal additive effect **(**M^e**)** and direct heterosis **(**H^e**)** on body weight were calculated using the model of Dicksin (1969) (Dickerson, 1969) with the following formulae:

- 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)], 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 × H)] – [(H × H) + (Ku × Ku)] For Kuroiler and Horro crosses

Percentages of each crossbreeding effects (% A^e, M^e and H^e) for body weight were calculated using a mean estimate of each crossbred effect (additive, maternal, heterosis) divided by the mean of the pure line multiplied by 100. Mean values for age and breeds were compared using a t-test for the presence of significant differences at $P < 0.05$.

Experimental Design and Data Analysis

All data collected during the experimental period were recorded in a spreadsheet of Microsoft excel. Preliminary data analysis, including normality test, homogeneity test, and screening of outliers, was undertaken before performing the core data analysis using General Linear Models (GLM) Procedure of Statistical Analysis System (SAS, 2002). 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 $Y_{ij} = \mu + T_j + e_{ij}$

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.

Means and their related standard error 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 $P<0.05$.

Results

Growth Performance of F_1 Crossbreeds and Pure Breeds

The mean values for body weight, and weight gain at various age intervals for different genotype groups are shown in Table 3. Body weight at different ages was significantly (P < 0.05) affected by genotypes. The highest average body weight on d1was recorded for H × Ku (37.30 g) followed by Ku × Ku (37.17 g). The lowest average body weight was recorded for improved Horro chicken (29.82g) followed by Koekoek chicken breed (30.59 g). In comparing the crossbred genotypes, H × Ku had significantly (P < 0.05) igher body weightthan other crossbreed chicken at hatch. In comparing purebred, Kuroiler (37.17g) showed significantly (P<0.05) higher body weight than improved Horro (29.82 g) and Koekoek (30.59 g) chicken breeds at hatch.

Table 3. Mean body weight and weight gain traits at different ages of improved Horro (H), Koekoek (K), Kurolier (Ku) breeds and their crosses.

Traits	Age (week)	Genotype combinations							
		H × H	H × K	K × H	K × K	H × Ku	Ku × H	Ku × Ku	*SEM*
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 in the same row with different superscript letters are significantly (P < 0.05) different. H×H:Horro × Horro, H×K: Horro × Koekoek, K×H: Koekoek × Horro, K×K: Koekoek × Koekoek, H×Ku: Horro × Kuroiler, Ku×H: Kuroiler × Horro, Ku × K: Kuroiler × Kuroiler. ADG: Average daily gain. SEM: The standard error of the mean.

The highest average body weight at week 4 was recorded in pure line Ku × Ku (224.87 g) followed by Ku × H (208.37 g). The lowest average body weight was recorded for improved Horro chickens (152.73 g). In the current report, in comparing the reciprocal crossbred genotypes, Ku × H (208.37 g) showed significantly (P<0.05) better growth performance than H × Ku (198.65 g). Similarly, H × K (193.05 g) showed better growth performance than crossbred chicken of K × H (187.30 g) crosses. The highest average body weight at week 8 was recorded in H × Ku (1106.82g) and Ku × H (1073.07g). The lowest average body weight was recorded for improved Horro chicken (605.19 g) followed by K × H (707.54 g) chickens. Considering crossbred genotypes, H × Ku (1106.82 g) chickens showed better growth performance of Ku × H (1073.07 g) birds atweek 8. Similarly, H × K (818.42 g) crossbreds showed significantly (P < 0.05) better growth performance than chickens of K × H (707.54 g) chicks at earlier ages.

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

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 4. A non-significant (P > 0.05) difference in overall mean feed consumption was observed among the seven genotypes at all age intervals. Still, a significant difference was observed for some age points among the genotypes ($P < 0.05$). Mean feed intake at 4- weeks of age showed a significant difference ($P < 0.05$) for H × Ku and Ku × Ku compared to other genotypes. As shown in Table 4, a significant ($P < 0.05$) difference were observed in feed conversion ratios among genotypes in which the H x H cross had the highest value followed by H × K and K × H. A significant genotype effect was found for feed conversion ratio at different weeks of age. In comparing the pure genotypes, Ku × Ku chicken breeds show significantly ($P < 0.05$) higher feed conversion ratio at all ages.. While, in comparing all genotypes, Ku × H genotype had significantly ($P < 0.05$) higher feed conversion potential than all others. In all genotypes, feed conversion ratio at week 8 was better than earlier and later ages.

Table 4. Average daily feed intake and feed conversion ratio of the improved Horro (H), Koekoek (K), Kurolier (Ku) chicken breeds and their crosses**.**

Traits	Age (week)	Genotype combinations							
		H × H	H × K	K × H	K × K	H × Ku	Ku × H	Ku × Ku	*SEM*
ADFI	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 in the same row with different superscript letters are significantly (P < 0.05) different.FCR: feed conversion ratio, ADFI:Average daily feed intake, H ×H: Horro × Horro, H × K:Horro × koekoek, K × H: Koekoek × Horro, K × K: Koekoek × Koekoek, H × Ku: Horro × Kuroiler, Ku × H: Kuroiler × Horro, Ku × Ku: Kuroiler × Kuroiler. SEM: The standard error of the mean.

Growth performance of H × K and K × H crossbreds

Direct additive, maternal and heterosis effects of body weight at different ages (0-12 weeks**)** of improved Horro, Koekoek and their crossbreds chicken are indicated in Table 5. 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 of age and it ranged from 8.87 to 10.1%. The highest percentage of positive additive effect was found for BW4 (10.1%) while the lowest percent contribution of additive effect on body weight was found for BW8 (1.79%).

Table 5. Estimation of additive (A^e), maternal (M^e) and heterosis (H^e) effects (Mean± SEM) 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	percent	M^e	percent	H^e	percent
BW_0	$0.6^{ns} \pm 1.21$	2.28	$-0.21^{ns} \pm 1.17$	-0.73	$2.10^{*} \pm 1.57$	6.54
BW_4	$17.38^{*} \pm 3.7$	10.1	$2.89^{ns} \pm 2.44$	1.62	$17.22^{*} \pm 6.25$	10.08
BW_8	11.12 ± 2.04^{ns}	1.79	$55.78^{*} \pm 14.00$	8.22	$91.23^{*} \pm 27.36$	13.79
BW_{12}	128.64* ±15.02	8.87	$1.51^{ns} \pm 0.60$	0.74	$83.29^{*} \pm 16.65$	8.88

BW0, BW4, BW8, BW12:body weight at hatch, 4, 8, 12 weeks of age, respectively. A^e: Additive affect, M^e: Maternal effects, H^e: Heterosis effect, SEM: standard error of means. statistically significant at P < 0.05, , ns: non-significant.

The estimates of maternal additive effects of improved Horro chicken (H), Koekoek (K) chicken breed and their crossbred chickens were positive and significant ($P < 0.05$) for BW8. Negative (-0.73) and positive (0.74) non-significant values ($P > 0.05$), were observed for BW at 0 and 12-weeks, respectively. 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 have shown positive values and substantial effect on body weight at most studied ages. Estimates of heterosis effects (H^e) for BW were positive and ranged from 6.54 to 13.79 % at 0, 4, 8 and 12 weeks. The highest percentage of heterosis effects contribution was reported at BW8 (13.79%) followed by BW4 (10.08%) whereas the lowest percentage contribution was for heterosis at hatch (6.54%).

Growth performance of H × Ku and Ku × H crossbreds

Direct additive, maternal and heterosis effect of body weight at different ages (0-12 weeks) of improved Horro chicken (H), Kuroiler (Ku) chicken breed and their crossbred chickens are presented in Table 6. Additive effects (A^e) for body weight indicated that there were positive and significant ($P < 0.05$) effects for BW at 4, 8 and 12 weeks of age among the genotypes and it ranged from 15.13 to 44.4%. The higher positive additive effects were found for BW4

(44.40%) and the lowest was found at BW0 (1.6%). In the present study, the maternal additive effects (M^e) for body weight was positive and significant ($P < 0.05$) for BW12 (7.45%), while it was not significant for weight at other ages. The estimated heterosis effect has shown a positive and significant ($P < 0.05$) effect on body weight at 8 and 12 weeks. The higher positive contribution was observed for BW12 (16.11 %), followed BW8 (15.37%). However, heterosis estimates have shown a positive and non-significant ($P > 0.05$) effect for BW0- and BW4.

Table 6. Estimation of additive (A^e), maternal (M^e) and heterosis (H^e) effects (Mean± SEM) and their percentage for body weight at different ages of improved Horro chicken (H), Kuroiler (Ku) chicken breed and their crosses.

Traits	A^e	percent	M^e	percent	H^e	percent
BW0	0.47^{ns} ±1.08	1.6	3.20^{ns} ± 0.94	9.62	0.6 $1.^{ns}$ ±1.8	2.18
BW4	52.53^{*}± 6.2	44.40	-16.53^{ns} ± 8.25	-8.89	3.11^{ns} ±0.32	1.67
BW8	117.06*±41.69	15.44	17.04^{ns} ±27.72	2.58	164.50^{*}±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., SEM= standard error of means. P-value, * statistically significant differences at P < 0.05, ns: non-significant

Mortality

Mortality rate for genotypes at different ages is presented in Table 7. There was no significant ($P > 0.05$) genotype effect on mortality except H × K which showed a significant ($P < 0.05$) difference during brooding phases. Higher mortality rate was registered for Koekoek pure line followed by Ku × H during the growing phases, while the other genotypes have shown comparable mortality rate. However, the mortality percentage was very low at most of the growing phases for pure line and crossbred genotypes.

Table 7. Mortality rate (%) of the improved Horro (H), Koekoek (K), Kurolier (Ku) chicken breed and their crosses.

	Genotype Combination							
Age (week)	H × H	H × K	K ×H	K × K	H × KU	Ku × H	Ku × Ku	*SEM*
0-8	0.05^{b}	0.13^{a}	0.0	0.04^{b}	0.0	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

$^{a-b}$ Within each row figures with different superscript letters are significantly (P < 0.05) different. H ×H: Horro × Horro, H × K-Horro Koekoek, K × H:Koekoek × Horro, K × K: Koekoek × Koekoek, H ×Ku: Horro × Kuroiler, Ku × H: Kuroiler × Horro, Ku × Ku: Kuroiler × Kuroiler. SEM: The standard error of the mean.

Discussions

Growth Performance of F_1 Crossbreds and Pure breeds

Bodyweight 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). In the current study, body weight gains during different weeks of age were positively 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 hatch weight . Likewise, Bekele *et al.* (2010) have reported an improvement in hatch weight of local Kei chickens crossed with Rohde Iceland Red and Fayoumi. Halima *et al.* (2006) also found that higher day-old body weight for exotic chicken (35.2 g for RIR) than local chicken of Ethiopia (ranged from 25.5 to 29.3 g). A comparable result was also reported by Kedija *et al*. (2018) that body weight at hatch for exotic chicken, Dominant Red Barred (DRB, 42.25 g) was higher than Horro chicken ecotype. Teketel (1986) indicated that body weight at hatch follows the 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 (29.82 g) was noted compared to the reports of Dana *et al*. (2011) and Kedija *et al*. (2018) with 28.70 and 24.7 g, respectively. A significant (*P < 0.05*) difference in body weight gain the current reportswere in agreement with Wondemenh (2015), who 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). In contrast, H × DRB and DRB × H achieved better growth performance than crossbred in the present studies at the ages above. Mulugeta *et al.* (2020) reported a body weight of 469.5 g for Horro chicken ecotype at eight weeks of age under farmer management condition which is not comparable with the 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 preferred 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 age are in disagreement with the report of Kedija *et al.* (2018) on the crossbred growth performance in the crossing between Horro × DRB 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.

Feed intake and feed conversion ratio

An efficient utilization of feed is affected by many factors like growth rate, metabolizable energy content of ration and nutrient adequacy including environmental conditions along with the bird genotypes itself. 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 *et al*., (2013) reported 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 a similar age. In comparing whole genotypes, better feed conversion was registered at eight weeks than the later ages. In the present study, Kuroiler chickens had a 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 have more efficient 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 four weeks disagrees with the report of Kedija *et al.* (2018), who reported a better feed conversion ratio. The feed conversion ratio of chickens might depend on the genotypes and growing age of chickens. Exotic chicken breeds and crossbred have a better feed conversion ratio than local chickens as reported by Binda *et al.* (2012)which is in line with the current findings. Comparison of crossbreds showed that Ku × H showed a better feed conversion ratio than the other crosses during the 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.

Growth performance of H × K and K× H crossbreds

Additive effects (A^e) for body weight were positive and had a significant ($P < 0.05$) contribution for BW4 and BW12 among the genotypes and ranged from 8.87 to 10.1%. According to Kedija *et al.* (2018), crossing between Dominant Red Barred and Horro ecotypes 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 the superiority of the sire line in the growth performance indicating that the use of Koekoek as a sire line improves the body weights. Iraqi *et al.* (2012) have reported that additive genes had a positive effect on growth with ranges between 2.22 and 10.4% on body weight from 1 to 10 weeks of age. Maternal additive effects (M^e) estimate on body weight was positive and significant ($P < 0.05$) for BW8 (8.22%). The negative and significant maternal effects might indicate the suitability of improved Horro as dam line to improve body weights. The present value disagreed with the Kedija *et al.* (2018) who reported a negative and non-significant contribution of additive genes at BW4 (-6.45%) and BW8 (-4. 75%).

In the present study, estimates of heterosis effects (H^e) were positive and ranged from 6.54 to13.79%. The highest percentage of heterosis contribution was reported at BW8 (13.79%) followed by BW4 (10.08%) whereas the lowest percentage contribution was at hatch (6.54%). Iraqi *et al*. (2011) also reported that heterosis percentage 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 percentage was recorded for body weight at 4 and 8 weeks which suggest the superiority of crossbred over their parental strains. Likewise, Kedija *et al.* (2018) stated that heterosis percentage 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 suggest that the trait was mostly governed by additive gene effects.

Growth performance of H × Ku and Ku × H crossbreds

Within the present study, additive effects (A^e) for body weight indicated that there was significant (P < 0.05) difference at 4- and 12-weeks of age among the genotypes. Some of studies reported the additive genes had a positive effect on growth performance at most of studied ages (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 a sire line to improve the body weights. Maternal additive effects (M^e) estimate on body weight was positive and significant (P < 0.05) for BW8 and BW12, whereas for BW0 and BW4, non-significant positive and negative values, respectively, were observed. The present results are in line with Kedija *et al*. (2018) who reported a negative and non-significant effect of maternal additive genes for BW at 4 weeks but disagree with the negative maternal effect value reported for bodyweight 8 weeks of age. Maternal effect is the influence of the maternally provided environment on the phenotype of her offspring by the dam. The significant and adverse 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 effects were found to have a positive and significant (P < 0.05) effect on body weight. Bodyweight at 12 weeks (16.11%) had the highest positive heterosis contribution, followed by body weight at 8 weeks (15.37%). Similarly, Kedija *et al*. (2018) reported a positive heterosis percentage for body weights with estimations ranging from 3.28 to 21.89%. 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 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.

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). The number of studies reveal that crossbreds had higher livability than purebreds (Iraqi *et al*., 2005). During the brooding and growing phase Horro chicken ecotype showed the lowest mortality rate compared to crossbred and other purebred (Kedija *et al*., 2018), whose reports are similar to the present findings. Likewise, in the current reports, Kuroiler and improved Horro didnot show a significant difference in mortality rates at all ages except at growing phases (Kayitesi, 2015). 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 adaption of genotypes to the environmental condition of the study area and proper management of the chicken during experimental periods

Conclusion

The findings showedthat indigenous crossbred with Kuroiler and Koekoek had significantly (P < 0.05) higher body weight and weight gain in comparison with improved Horro chickens, but no significant differences (P > 0.05) were noted on mortality rate at most of studied ages. It can be concluded that the exotic gene of Kuroiler and Koekoek chicken breeds might play a significant role in the improvement of improved Horro chicken. The positive additive effects on both crosses for bodyweight suggest the substantial contribution of Koekoek and Kuroiler chicken breed to enhance growth performance. Implementation of two ways of crossbreeding under reciprocal mating may provide the opportunity to exploit variation among genetic groups and use to establish sound breeding schemes along with farm practice and market condition. Hence, the study suggested H × Ku be the best genotype line for future breeding schemes for synthetic breed development in improving growth traits for family poultry production in the country. However, further studies are needed in morphometric characterization, carcass traits evaluation and adaptability of genotypes to various on-farm conditions**.**

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