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Original Article

Growth Performance of F_1 and F_2 Crosses of Horro, Potchefstroom Koekoek, and Bovan Brown Chicken Breeds under Intensive Management System

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ABSTRACT

This study was conducted to evaluate growth performance between F_1 and F_2 generations of Horro, Potchefstroom Koekoek, and Bovan Brown crosses under intensive management at Jimma University College of Agriculture and Veterinary Medicine (JUCAVM), Southwest Ethiopia. Totally 450 F_1 chicks were produced by crossing Horro with Potchefstroom Koekoek (HPK), Horro with Bovan Brown (HB) and Bovan Brown with Potchefstroom Koekoek (BPK) and 150 from each genotype. When F_1 generation was matured and started laying eggs, fertile eggs were collected from them and again a total 450 F_2 chicks (150 from each genotype) were produced. Both generations were managed on a phased basis and each genotype group was randomly assigned to three replications. Data were recorded on a phased basis for both generations. Dressing percentages of cockerels were taken at 16-week age for both generations. Data collected was analyzed using SAS 9.3 and SPSS. As indicated current investigation, the mean day-old chick body weight of F_1 was significantly heavier in all genotypes than F_2. In contrast to the brooding phase, only one genotype (HPK cockerels) showed significant difference ($p<0.05$) that F_1 (1969.33g) being heavier than F_2 (1818.95g) during the growing phase. Similarly, in this phase, the average body weight of pullets showed significance ($p<0.05$) for one genotype (HB) only which was F_1 (1262.00g) being heavier than F_2 (1204.11g). Reverse to the first

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two phases, the average mature body weight of F_2 was significantly heavier ($p<0.05$) than F_1 generation for both sexes during layer. The average mature body weight of $BPKF_1$ cocks attained 2967g was heavier than obtained 2520g for $BPKF_2$ cocks. The average mature body weight of $BPKF_1$ and $HPKF_1$ hens (1962.2g and 2075.6g) was heavier than the average mature body weight of $BPKF_2$ and $HPKF_2$ hens (1723g and 1915.44g), respectively. The result of body weight gain between F_1 and F_2 indicated no significant difference ($P>0.05$). Feed conversion ratio (FCR) showed a significant difference ($p<0.05$) during the grower phase for pullets that HB genotype F_2 being better than F_1. Live body weight and dressing percentage of cockerels showed no significance ($p>0.05$) between generations. The mortality rate during all phases for both F_1 and F_2 was low and significantly different between generations except BPK had no mortality during the growing phase for both generations. From present results, it was seen that crosses of these breeds up to F_2 generations showed good growth performance at on-station management. Therefore, it is important to produce crosses of these chicken breeds up to F_2 generation and recommended also to produce F_3 to investigate again with F_1 and F_2 generations.

Keywords: Bovan Brown, Horro, Potchefstroom Koekoek, Crosses, growth performance

INTRODUCTION

Chickens and other domestic birds provide an immense supply of food for the world (Hoffmann, 2005). Global poultry meat and egg production as well as trade with poultry products have shown remarkable growth since the 1970s after poultry breeding was introduced (Windhorst, 2008). The specialization of chicken production either for egg or meat through genetic improvement played a significant role in meeting the high demand for poultry products. For example, since the early 1960s, feed conversion in egg production in the USA and Canada has improved by almost 1 g, from 2.96 g feed per 1 g egg to 2.01 g feed per 1g egg. The major part of this change is due to improved breeding stock (Arthur and Albers, 2003).

Modern poultry breeding was introduced in the 19th century and a wide variety of breeds have emerged by using pure breeds. Modern specialized chicken breeds and lines have been developed since the 1950s in developed countries to increase productivity. So, poultry breeder companies have successfully benefited in superior birds by exploiting heterosis in the next generation (Hoffmann, 2005). Crossbreeding of different pure breeds of chicken is one of the tools for exploiting genetic variation. The intention of crossbreeding of chickens is often to create chickens that share the traits of both parent lineages and producing chickens with hybrid vigor (Saadey *et al.*, 2008). Therefore, it is beneficial allowing the combination of desirable traits of the chicken breeds involved in the cross while masking undesired traits and arising hybrid vigor.

Indigenous chickens in the tropics have low productive and reproductive performances. However, due to long natural selection, they have higher adaptation to adverse environmental conditions such as high incidence of diseases and parasites, poor quality and quantity of feed, and extreme weather conditions (Tadelle *et al.*, 2000; Khan, 2008; Besbes, 2009; Islam and Nishibori, 2009). On the other hand, exotic chickens have more production potential than indigenous chickens but have difficulties in adaptation to the tropical environment.

So, the high productivity characteristics of exotic chickens and higher adaptation attributes of indigenous chickens can be combined by crossbreeding (Khan, 2008). Crossbreeding between local and exotic chicken breeds has been done to produce F_1-crosses in some tropical countries by some researchers (Siwendu *et al.*, 2012). From these works, crossbreds contributed a positive and high magnitude of heterosis for production performance (Safalaoh 2001; Saadey *et al.*, 2008; Siwendu *et al.*, 2012). Also, crossbreds from local and exotic chicken breeds showed low mortality rate than exotic in the tropic countries (Njenga (2005).

In Ethiopia, there was little genetic improvement work done by agricultural research institutes and colleges on indigenous chickens through crossbreeding with exotic chicken breeds. These attempts are insignificant when compared with the huge number of chickens in the country (Bekele *et al.*, 2010). In addition to this, limited information is available on the comparative growth performance of F_1 and F_2 generations cross of exotic chicken with indigenous chicken breeds. Therefore, the current study was designed to evaluate the growth performance of F_1 and F_2 generations by crossing two different improved chicken breeds (Potchefstroom Koekoek and Bovan Brown) with one phenotypically characterized indigenous Horro chicken breed under on station management situation.

MATERIALS AND METHODS

Experimental site

This experiment was conducted at Jimma University College of Agriculture and Veterinary Medicine (JUCAVM) poultry farm located 357 Km South West of Addis Ababa the capital city of Ethiopia. The geographical location of the area is between 7º 33" N latitude and 36 º 56" E longitudes. The altitude of the area is 1700 meters above sea level. The climate of the area is tropical humid and has a mean annual rainfall of 1500mm. The mean annual minimum and maximum temperature are 11.4ºC and 26.8ºC respectively, (BPEDORS, 2000).

Acquisition of female and male parental lines and mating plan

The parental lines of Potchefstroom Koekoek and Bovan Brown were brought from Debre Zeit Agricultural Research Center and Horro indigenous chickens from Horro Zone to JUCAVM poultry farm. From these parental lines, 450 F_1 generation chicks were produced by crossing: Horro [♂] x Potchefstroom Koekoek [♀], Horro [♂] x Bovan Brown [♀] and Bovan Brown [♂] x Potchefstroom Koekoek [♀] and recorded their growth performance. When these F_1 generations became mature, again a total of 450 F_2 generation chicks of Horro x Potchefstroom Koekoek (HPK), Horro x Bovan Brown (HB), and Bovan Brown x Potchefstroom Koekoek (BPK) chicks were produced (150 chicks from each genotype) and recorded their growth performance. Each group was randomly assigned to three replications totally being nine replications and put in well prepared pens. Both generations were managed on phase basis as indicated below.

Brooder phase

The bodyweight of the unsexed day-old chicks was weighed using measuring balance. The chicks were vaccinated against Newcastle disease (NCD). An equal amount of starter ration was given for each genotype group chicks for eight weeks and recorded their daily feed intake. The body weight measurement was taken weekly and brooder period weight gain was calculated at the end of this phase. The mortality of chicks was checked daily and recorded. For the first four days, chicks were placed on sawdust covered with clean newspaper and it was removed daily. The house of chicks was wood partitioned concrete floor housing, which was covered with deep sawdust litter. Each pen was properly cleaned, disinfected, well ventilated, and heated electrically. Clean water was made available all the time.

Grower phase

At the age of 8 weeks, the sex of chicks was identified and transferred from brooder house to grower house. During this stage, cockerels and pullets were put separately for each genotype group to avoid the competition of cockerels over pullets for feed consumption. The number of replications for each sex was three while being six for each genotype and a total eighteen replications. An equal amount of growers' ration was given for all genotype groups from their age of start of the ninth week up to sixteen weeks and recorded their daily feed intake. Individual bodyweight record separately for cockerels and pullets was taken at this stage. The body weight record was taken weekly and weight gain was also calculated at the end of this phase. The death of both cockerels and pullets was recorded also in this phase. They were kept in wire-mesh and wood partitioned deep sawdust litter floor housing. When the litter got wet, the room was cleaned and the new dry and clean sawdust was replaced. Each pen was properly disinfected, well ventilated, and the light was made available for them. Fresh, clean and potable drinking water was provided all the time for them.

Layer phase

At the age of 16 weeks, chickens were transferred from grower house to layer house. A similar amount of layer feed was offered for each genotype chicken. The cock and layer hen mature body weight was weighed at the hens' age of the first egg. The death of chickens was recorded here also throughout this experimental period. The chickens were kept in wire-mesh and wood partitioned deep litter floor house, which was covered with sawdust litter material. Each pen was properly cleaned, disinfected, well ventilated and lean water was made available all the time.

Method of Data collection and Data types

Data of each cross chicken were collected using record format. The types of variables in which data were collected are hereunder:

Body weight and gain

Body weight record was carried out with weighing balance to evaluate the growth performance of crosses. It was taken at weekly intervals for the brooder and grower phase and ended with weighing the mature body weight of cocks and hens. Daily body weight gain per head was calculated at the end of the phases. It was calculated by dividing body weight change by total days during a phase.

Dressing percentage

At the 16-week age of cockerels, 18 cockerels (6 from each genetic group and 2 from each replication) were taken randomly and slaughtered to evaluate dressing percentage. The cockerels were slaughtered as recommended by Moran (1995) after being starved for 16 hours. Before slaughtering, the live body weight of cockerels was measured. Then after dressing percentage was calculated as percent of the live body weight of cockerels.

Feed intake

The daily feed consumption of the chickens was calculated as the difference between the amount of feed offered and refused. The feed leftover was weighed after the removal of the external contaminants.

Feed conversion ratio

Feed conversion ratio (FCR) for each genetic group of brooder and grower was determined by dividing mean total dry matter intake (DMI) to mean total body weight gain (BWG).

Mortality rate

Deaths in each phase of the experiment for each genetic group were recorded as mortality and expressed as percent mortality at the end of each experimental phase.

Statistical data analysis

The type of statistical analysis used varied depending upon the nature of the data. Analysis of body weight, weight gain, and carcass yield data was done by t-test mean comparison using Statistical Analysis System SAS 9.3 (2014) software. Data on mortality rates were analyzed using descriptive statistics and a chi-square (x^2) test was carried out to assess the statistical difference between generations. Statistical model used for analyzing data was:

$Y_{ij} = \mu + g_i + e_{ij;}$

Where:

Y_{ij} = performance of the j^{th} individual of the i^{th} genetic group

μ = overall mean of the parameter

g_i = fixed effect of generatios = 2 (F1 and F2)

e_{ij} = residual error

RESULTS AND DISCUSSION

Body weight and gain at different phases

The average body weight and gain at different phases of F_1 and F_2 generation are presented in Table 1.

Brooder body weight

The average body weight of day-old chick between generations was significantly ($p<0.05$) different. For all crossbreed chicks, the average body weight of day-old F_1 chicks were significantly higher (44.77g for HB, 43.49g for BPK, and 41.03g for HPK) than the average body weight of day-old F_2 chicks (41.19g for HB, 39.96g BPK and 39g for HPK). Alewi and Melesse (2012) reported comparable results (40.1g) for crosses of Kei x RIR with current results obtained from both generations. But these authors obtained lower brooder body weight (29.7g) for crosses of Kei x Fayoumi than current results. The decline of body weight in this study from F_1 to F_2 crosses assumed to be heterosis decline when F_1 developed to F_2. The current finding is in agreement with those of Munisi *et al.* (2015) who revealed that F_1 cross between Black Australorp and broiler stocks was significantly heavier than the F_2 crosses by their hatching body weight in Tanzania under on station management system.

There was no significant difference between the average body weight of F_1 and F_2 generations at the end of the brooding phase (8 weeks). The result of this study is in agreement with the finding of Munisi *et al.* (2015) who reported that F_1 and F_2 crossbreds resulted from Black Australorp and broiler stocks had no significant difference for body weight at 8th weeks of age. Alewi and Melesse (2012) obtained quite low body weight at this stage for crosses of Kei x RIR (200.5g) and Kei x Fayoumi (186.8g) than results obtained from the current study for both generations.

Grower body weight

The present study indicated a significant difference ($p<0.05$) between the body weight of HPK cross cockerels in F_1 and F_2 generation at 16 weeks of age. F_1 HPK cross cockerels had a significantly heavier average body weight (1969.33g) than F_2 HPK cross cockerels (1818.95g) at 16 weeks of age. The decline of body weight from F_1 to F_2 for HPK cross indicates heterosis decline from F_1 to F_2. This result from the current study is in agreement with Munisi *et al.* (2015), who revealed that F_1 cross between Black Australorp and broiler stocks had significantly higher cockerels' body weight than the F_2 generation cockerels from Tanzania under on station management system. However, there was no significant difference between F_1 and F_2 generations for the rest two genotypes at16 weeks of age.

From the present study, a significant difference ($p<0.05$) was observed between body weight of HB pullets in F_1 and F_2 generation at 16 weeks of age. F_1 generation of HB pullets had a heavier average body weight (1262.00g) than F_2 generation HB pullets (1204.11g) at 16 weeks of age. The decline of body weight from F_1 to F_2 HB cross indicates heterosis decline from F_1 to F_2. The current study is not in agreement with Munisi *et al.* (2015) who reported that F_1 cross between Black Australorp and broiler stocks had significantly lower pullets' body weight than the F_2 generation pullets from Tanzania under on station management system. However, there was no significant difference between bodyweight of HPK pullets in F_1 generation (1484.32g) and F_2 generation (1474.60g). Similarly, significant variation was not observed between BPK pullets in F_1 generation (1370.25 g) and F_2 generation (1360.20g) in the current study at16 weeks of age. These current results from both generations are higher than that Ibrahim *et al.* (2019) reported 1007.9g, 875.8g and 902.5g body weight for crosses of Dominant Red Barred D922 x Potchefstroom Koekoek, Dominant Sussex D104 x Dominant Red Barred D922, and Potchefstroom Koekoek x Dominant Sussex D104 respectively, for pullets at 16 weeks.

Mature body weight

The result indicated that there was a significant difference ($p<0.05$) between the average mature body weight of BPK cocks of F_1 generation and F_2- generation. The average mature body weight of F_2 generation BPK cocks was heavier (2967g) than the average mature body weight of F_1 generation BPK cocks (2520g). Nevertheless, there was no significant difference between body weight of HPK cocks between F_1 generation (2975g) and F_2 generation (3036g). Similarly, significant variation was not observed between HB cocks between F_1 generation (2579.2g) and F_2 generation (2644.4g). The average live body weight of HB cocks in both F_1 and F_2 generations of this study are comparable with the result of Tabinda *et al.* (2013) who reported that the average cock body weight 2600g for RIR crossed with Fayoumi chicken breeds under on-station management in Pakistan. But this authors' result is lower than obtained from the current study for HPK and BPK crosses.

The average mature body weight of F_1 and F_2 generations hens showed a significant difference ($p<0.05$). The average mature body weight of F_1 generation BPK and HPK hens were lighter (1723g and 1915.44g, respectively) than the average mature body weight of F_2 generation BPK and HPK hens (1962.2g and 2075.6g, respectively). The current result agrees with the finding of Bekele *et al.* (2010) who reported higher mature body weight in F_2 than F_1 generation of local Sidancho chickens crossed with exotic Fayoumi and RIR chickens under on-station management. But this result is not in agreement with Amira *et al.* (2013) who found a significantly higher mature body in F_1 than F_2 for Alexandrian egg line and meat line chicken crosses.

Body weight gain during brooding

The result of daily body weight gain for F_1 and F_2 brooding chicks indicated no significant difference ($P>0.05$) between the average daily body weight gain of F_1 and F_2 generations at the end of the brooding phase (8 weeks). An F_1 gained daily 13.79g, 11.46g, and 14.21g for HPK, HB, and BPK respectively; while an F_2 gained 13.63g, 11.53g, and 13.74g daily for respective genotypes during this period. The result of this study indicated that the mean daily body weight attained by all three genotypes for both generations at an age of 8 weeks were higher than the mean daily body weight gain reported for exotic chicken breeds (8.8 g/h) for RIR kept under intensive management in North West Ethiopia at an age of eight week (Hassen *et al.*, 2006). Similarly, lower values 9.54g/h, 9.56g/h and 9.14g/h than obtained for crosses of current study were reported for Novo Brown, Dominant Sussex and Lohman Brown exotic chicken breeds respectively, kept under intensive management in Jimma at this age (Yigzaw *et al.* 2020). The higher daily weight gain from current study on crosses than reported for exotic chicken breeds may be attributed from higher feed consumption and good management.

Body weight gain during the growing phase

The result of body weight gain between F_1 and F_2 generation cockerels showed no significant difference ($p>0.05$). The average daily body weight gain for F_1 cockerels was 18.87g for BPK, 18.66g for HPK, 17.69g for HB. whereas, F_2-cross cockerels had

18.88g, 19.53g, and 17.11g for HPK, BPK, and HB, respectively. Ibrahim *et al.* (2019) reported daily body weight gain 21.59 g and 20.97g for crosses of Dominant Red Barred D922 x Potchefstroom Koekoek and Potchefstroom Koekoek x Dominant Sussex D104 respectively, which were higher than obtained current for cockerels of both generations. However, these authors reported lower (13.29g) daily weight gain for the cross of Dominant Sussex D104 x Dominant Red Barred D922 than current results obtained for both generations.

Table 1: LSM (±SE) for body weight and body weight gain of F_1 and F_2 generations

Phases	Parameters	Genotype	Generations		p-value
			F_1	F_2	
Brooding	Day old chick BW(g)	HPK	41.08±0.45*	38.93±0.34	0.03
		HB	44.56±0.55*	41.27±0.53	0.03
		BPK	43.67±0.59*	39.92±0.31	0.04
	Eight weeks old BW(g)	HPK	813.32±15.38	801.89±11.97	0.21
		HB	686.35±14.40	686.69±14.05	0.98
		BPK	839.50 ±25.16	809.36±12.73	0.08
	(0-8 week) Daily BWG (g)/chick	HPK	13.79±0.86	13.63±10.00	0.65
		HB	11.46±1.10	11.53±0.85	0.66
		BPK	14.21±.1.30	13.74±0.83	0.43
Growing	The 16th-week cockerel BW(g)	HPK	1969.33±44.61*	1818.95±41.17	0.02
		HB	1760.62±49.29	1756.43±47.96	0.08
		BPK	2036.77±57.31	2043.50±40.12	0.10
	Daily BWG (g)/cockerel	HPK	18.66±0.70	18.88±0.71	0.20
		HB	17.69±0.80	17.06±0.60	0.21
		BPK	18.87±0.50	19.53±0.90	0.22
	The 16th-week pullet body weight(g)	HPK	1484.32±19.65	1474.60±18.44	0.18
		HB	1262.00±15.20*	1204.11±17.43	0.02
		BPK	1370.25 ±11.75	1360.20±10.52	0.08
	Daily BWG /pullet (g)	HPK	13.98±0.43	13.92 ±0.41	0.42
		HB	10.75 ±0.38	11.19±0.48	0.34
		BPK	11.99±0.52	12.35±0.36	0.41
Laying	Mature BW of cock (g)	HPK	2975.00±103.20	3036.00±101.90	0.11
		HB	2579.20±66.61	2644.40±76.91	0.16
		BPK	2520.00±67.23	2967.00±73.65*	0.02
	Mature BW of hen (g)	HPK	1915.44±30.44	2075.60±32.50*	0.03
		HB	1720.00±32.20	1752.04±25.20	0.76
		BPK	1723.00±51.20	1962.2±49.64*	0.03

* and ** means within row show significance at P<0.05 and P<0.01 respectively; HPK= Horro crossbred with Potchefstroom Koekoek, BPK=Bovan brown crossbred with Potchefstroom Koekoek, HB= Bovan brown crossbred with Horro, F_1= first filial generation, F_2= second filial generation

Similarly, the result obtained on body weight gain between F_1 and F_2 generation pullets showed no significance (p>0.05). The F_1 pullets of HPK, BPK, and HB gained

13.98g, 11.99g, and 10.75g average daily body weight, respectively. The F_2 pullets of HPK, BPK, and HB gained 13.92g, 12.35g, and 11.19g average daily body weight respectively. Alewi and Melesse (2012) reported lower daily body weight gain 7.67g and 8.52g for crosses of Kei x Fayoumi and Kei x RIR respectively than obtained current for pullets of both generations.

Live body weight and dressing percentage of cockerels

The live body weight and dressing percentage of cockerels at 16-weeks of age are presented in Table 2. The result of this study indicated no significant difference ($p>0.05$) between cockerels of F_1 and F_2 generations for average live body weight and dressing percentage. The average live body weight of BPK cockerels in both F_1 and F_2 generations and HPK cockerels in F_2 generation of this study are comparable with the result of Tabinda *et al.* (2013) who reported that average live body weight 2600g of a cross between RIR crossed with Fayoumi chicken population under on-station management in Pakistan. The average dressing percentage of BPK cockerels in both F_1 (66.16%) generation and F_2 (67.08%) generations in this study are comparable with the results reported 68.1%, 64.0% and 68.5% for crosses of Dominant Red Barred D922 x Potchefstroom Koekoek, Dominant Sussex D104 x Dominant Red Barred D922, and Potchefstroom Koekoek x Dominant Sussex D104 respectively, by (Ibrahim *et al.*, 2019). However, Tabinda *et al.* (2013) reported a slightly lower result of average dressing percentage 62.50% for RIR crossed with Fayoumi chicken under on-station management from Pakistan.

Table 2. LSM (±SE) for live weight body and dressing percentage of F_1 and F_2 cockerels

Parameters	Genotype	Generations		P-value
		F_1	F_2	
Live BW (g)	HPK	2500.00±93.93	2433.33±92.40	0.65
	HB	2233.33±221.16	2013.30±190.12	0.66
	BPK	2666.70±152.44	2590±151.11	0.41
Dressing percentage	HPK	57.83±2.04	63.64±2.02	0.08
	HB	52.57±3.49	57.03±3.21	0.11
	BPK	66.16±1.91	67.08±2.12	0.46

HPK= Horro crossbred with Potchefstroom Koekoek, BPK=Bovan brown crossbred with Potchefstroom Koekoek, HB= Bovan brown crossbred with Horro, F_1= first filial generation, F_2= second filial generation

Feed intake and conversion ratio at different phases

Brooder feed intake

The results on feed intake and conversion ratio of F1 and F2 generations at different phases are presented in Table 3. The average daily feed intake between generations was not significantly different ($p>0.05$) for a brooder. The average daily feed intake was 40.13g, 39.04g, and 38.53 for F_1 generation chicks of HPK, HB, and BPK, respectively. Whereas in the case of F_2 generation chicks, it was 38.09g for HPK, 38.38g for HB, and 36.79g for BPK. In contrast to current results, Yigzaw *et al.* (2020) reported lower daily feed consumption 34g, 29g, and 30g for Lohman Brown, Novo Brown, and Dominant Sussex breeds of chicks, respectively. Similarly, Demeke (2004) reported a mean lower daily feed intake of 34g for White Leghorn chicks kept under intensive production system from Jimma than current figures obtained for both generations.

Grower feed intake

Mean daily feed intake for F_1 cockerels of HPK, HB and BPK were 100.43g, 96.90g, and 98.37g respectively; while 98.43g, 93.04g, and 101.72g were recorded for F_2 of the respective three genotypes. These feed consumptions did not show a significant difference ($p>0.05$) between generations for cockerels. Similarly, there was no significant difference ($p>0.05$) between generations for pullets on average daily feed intake consuming F_1 pullets 73.35g, 75.49g, and 76.83g for HPK, HB, and BPK, respectively and 75.86g, 74.50g, and 76.83g for F_2 HPK, HB, and BPK, respectively. Hassen *et al.* (2006) reported a higher mean daily feed intake of 83g per head for Rhode Island Red (RIR) pullets kept under intensive management from northwest Ethiopia during a growing period than that obtained from the current study. But Yigzaw *et al.* (2020) reported lower mean daily feed intake per head of pullets 71g 69g and 67g for Lohman Brown, Dominant Sussex, and Novo Brown pullets respectively, than current results obtained from both generations.

Brooder feed conversion ratio (FCR)

The current result showed no significant difference ($P>0.05$) between F_1 and F_2 generations on FCR during brooding period. The average FCR for F_1 of HPK, HB and BPK was 2.98, 3.47, and 2.92 respectively. It was 2.75, 3.41 and 2.78 for F_2 of HPK, HB and BPK, respectively. FCR obtained for both generations are better than 3.46, 3.50 and 3.84 reported for Novo Brown, Dominant Sussex and Lohman Brown respectively, during the brooding period by (Yigzaw *et al.*, 2020). Better FCR values from the current finding could be attributed to the difference in feed composition, moisture content, environmental conditions and management during this experiment.

Grower feed conversion ratio (FCR)

The present study indicated no significant difference ($p>0.05$) between F_1 and F_2 generations cockerel populations for FCR. However, pullets showed **a s**ignificant difference ($p<0.05$) between HB pullets of F_1 generation and F_2 generation on FCR. In this study, HB pullets of F_2 generation showed better FCR (6.85) than HB pullets of F_1 generation (7.91). Slightly lower FCR was reported by Haque *et al.* (1999) for the crosses of indigenous naked neck (D. Nana) X RIR (5.10) and for the crosses of D.

Nana × WLH and (5.20) than the present figures obtained for both generations and sexes in the growing period. But the same authors reported higher FCR than the current result for the crosses of D. Nana × Fayoumi (10.25) at an age of 16–17 weeks.

Table 3. LSM (±SE) for feed intake and feed conversion ratio of F_1 and F_2 generations

Phases	Parameters	Genotype	Generations F_1	Generations F_2	P-value
Brooder	Average daily FI (g)/chick	HPK	40.13±2.37	38.09±2.47	0.12
		HB	39.04±1.97	38.38±2.17	0.57
		BPK	38.53±2.17	36.79±2.50	0.12
	FCR (0-8weeks)	HPK	2.98 ±0.08	2.75±0.08	0.33
		HB	3.47 ±0.04	3.41 ±0.12	0.87
		BPK	2.92 ±0.09	2.78 ±0.07	0.11
Grower	Average daily FI (g)/cockerel	HPK	100.43±2.48	98.43±2.46	0.67
		HB	96.90±2.59	93.04±2.37	0.47
		BPK	98.37±2.47	101.72±2.47	0.41
	FCR (8-16weeks) /cockerel	HPK	5.73±0.30	5.62±0.31	0.78
		HB	7.91±0.22	6.85±0.38	0.13
		BPK	7.14±0.41	6.60±0.19	0.43
	Average daily FI/ pullet(g)	HPK	73.35±1.38	75.86±1.37	0.62
		HB	75.49±1.11	74.50±1.49	0.41
		BPK	78.21±0.92	76.83±1.84	0.07
	FCR /pullet (8-16weeks)	HPK	5.77±0.27	5.97±0.33	0.45
		HB	7.91±0.35*	6.85± 0.25	0.03
		BPK	7.14±0.21	6.6 ±0.38	0.08

* and ** means within row show significance at P<0.05 and P<0.01 respectively; HPK= Horro crossbred with Potchefstroom Koekoek, BPK=Bovan brown crossbred with Potchefstroom Koekoek, HB= Bovan brown crossbred with Horro, F_1= first filial generation, F_2= second filial generation

Mortality rate at different phases

The mortality rates at different phases between generations are presented in Table 4. The X^2 test indicated that, mortality rate was significantly varied (p<0.05) between generations during brooding phase. The mortality rate recorded in F_1 generation crosses for HPK, HB and BPK was 2.7%, 11.3% and 8.7%, respectively. While in case of F_2-crosses, (0% for HPK, 0.0% for HB and 0.7% for BPK) almost all chicks were grown up to the end of the brooding phase. The result of this study indicated that relatively high mortality rate was recorded in F_1-crosses than F_2 crosses.

The mortality rate recorded during grower phase for both cockerels and pullets was low. There was significant variation (p<0.05) for mortality rate between generations. Mortality rate recorded for F_1 crosses of HPK, HB and BPK was 4%, 0% and 0% respectively and it was 2%, for HPK F_2 and HB F_2 and 0% for BPK F_2 crosses. From this study, higher mortality rate between F_1 and F_2 was recorded for HPK F_1 than HPK F_2. In contrast to this, HB F_2 had mortality while HB F_1 having no mortality.

Mortality rates record between generations of hens during laying phase were 3.6%, 6.5%, and 3.6% for HPK, BPK and HB F_1 generation, respectively. The mortality rates of 6%, 4% and 6% were recorded for HPK, BPK and HB F_2 generation, respectively. As shown below in table 4, mortality rate showed significant difference ($p<0.05$) between generations having HPK F_2 and HB F_2 higher mortality rate than HPK F_1 and BPK F_1, respectively. Unlike those two crosses, BPK showed significantly higher ($p<0.05$) mortality rate for F_1 crosses than that of BPK F_2 cross chickens. The mortality rate reported from current study for both generations in all phases are lower than reported 18.3% for RIR by Hassen *et al.* (2006), 21% for Dominant Sussex by Yigzaw *et al.* (2020), and 22.2% for Potchefstroom Koekoek by Grobbelaar *et al.* (2010) under controlled environment. The less mortality from current study may be attributed low genetic susceptibility due to crossbred effect (Chitate and Guta 2001) and management (Alfred *et al.*, 2012).

Table 4: Mortality rate between F1 and F2 generations at different phases

Parameters	Genetic group	Generations		X^2–Value
		F_1	F_2	
Mortality during brooder phase	HPK	2.70	0.00	4.05*
	HB	11.30	0.00	2.20*
	BPK	8.70	0.70	10.79*
Mortality during grower phase	HPK	4.00	2.00	8.32*
	HB	0.00	2.00	6.67*
	BPK	0.00	0.00	-
Mortality during layer phase	HPK	3.60	6.00	21.21*
	HB	3.60	6.00	21.21*
	BPK	6.50	4.00	19.34*

X^2=chi-square value, *significance, HPK= Horro crossbred with Potchefstroom Koekoek, BPK=Bovan brown crossbred with Potchefstroom Koekoek, HB= Bovan brown crossbred with Horro, F_1= first filial generation, F_2= second filial generation

CONCLUSIONS AND RECOMMENDATIONS

As current study indicated all day-old chicks showed significance on body weight between generations. Accordingly, all three genotypes of F_1 had significantly higher hatching body weight than F_2. HPK cockerel and HB pullet had significantly heavier body weight in F_1 than F_2 generations. However, mature body weight showed significance in F_2 than F_1 generations. From this, mature body weight of BPK cock and (HPK and BPK) hens were significantly heavier in F_2 than F_1 generation. FCR showed significant difference between generations for HB genotype pullets so as a result F_2 generation pullets had better FCR than HB F_1 generation pullets. From present results, it was seen that crosses of these breeds up to F_2 generations showed good growth performance at on-station management. Therefore, it is important to produce crosses of these chicken breeds up to F_2 generation under on station management and suggested to develop F_3 of these crosses to compare again with F_1 and F_2. Also it is recommended that further study to be conducted on performance of F_1 and F_2 of these genotypes under on-farm management condition.

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