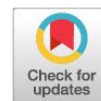


Research Article



Crossbreeding Components for Growth Traits in Crosses between Marshall Parent Stock Broilers and Nigerian Local Chickens

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Abstract | This study was designed to investigate the effect of cross-breeding local and exotic chickens, along with their reciprocal crosses, on growth performance. A crossbreeding experiment was carried out between two genotypes: Nigeria (normal-feathered light ecotype Lc × Lc) and exotic chicken (Marshall parent stock broiler or Ex × Ex), along with their reciprocal crosses (Ex × Lc) and (Lc × Ex). Four hundred and fifty-six (456) chicks, comprising 114 Ex × Ex, 114 Lc × Lc, 114 Ex × Lc, and 114 Lc × Ex, were utilized. All the birds were raised from day-old to 22 weeks of age, and parameters such as body weight gain, feed intake, direct additive maternal breed effects, and direct heterosis were measured. The genotype effect was significant ($P < 0.05$) for all the parameters studied. The crossbred groups Ex × Ex and Lc × Ex were significantly superior ($P < 0.05$) to the local chickens. The effects of heterosis were significant ($P < 0.05$). The results obtained for Lc × Ex in comparison to Ex × Lc confirmed the reciprocal effect in the analysis. Local chicken sires × exotic chicken dams were superior to exotic chicken sires × local chicken dams. This study suggests that using local sires to cross exotic dams results in better heterosis than using exotic males with local females. The outcome of this study could allow for higher genetic gains in a shorter time due to the maternal effects of exotic chickens, thus achieving the desired objective more quickly when exotic dams are mated to Nigerian normal-feathered sires.

Keywords | Growth performance, Crossbreeding, Heterosis, Maternal effects, Local sires, Reciprocal crosses

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INTRODUCTION

Nigerian tropical normal-feathered chickens are renowned for producing very little meat or eggs (Amao, 2017). Despite their poor productivity, they are well adjusted to tropical weather, resistant to diseases; poor management, shortages of feed and is also very tolerant to most common diseases and parasites (Amao, 2017). Conversely, exotic chickens produce greater numbers of eggs and additional meat than the Nigerian normal feathered chickens, though the tropical climate is a great problem affecting

their optimum productivity. Exotic chickens do not adapt very well to the tropical climate, known for high temperatures, disease, and poor feed availability. In the interim, the genetic assortment distinction between Nigerian normal feathered chicken and exotic broiler chicken breeds could be used in cross-breeding structures. Crossbreeding is an important tool for manipulating genetic variation. The key purpose of crossing in poultry is generally to create superior crosses (hybrid vigor) to expand fitness and fertility characteristics and also to bring different traits that the crossed strains were worth (Iraqi *et al.*, 2011). The aim will then be

to have a new hybrid or breed that is very tolerant to the harsh tropical conditions and in the same vein, produces a good amount of meat (Mekki *et al.*, 2005; Amao, 2017).

Studies have shown that meat production at the smallholder level could be doubled in the already existing production arrangement through the intervention of crossbreeding in a semi-scavenging poultry arrangement (Egahi *et al.*, 2010). It has been reported that the performance of cross-breeds was better than that of either the native or exotic parents under similar production conditions (Sola-Ojo and Ayorinde, 2011).

Nigerian local chicken is mainly influenced by their genotype and the rearing system they are adapted to; since small-scale and mostly semi-intensive, to extensive rearing system associated with small-scale production system is the most prevalent management system of local chickens in Nigeria. Bassey *et al.* (2022) reported higher values for crossbred progenies of Marshall Parent stock and Nigerian local chickens than crosses of pure bred Nigerian local chickens for body weight and other growth traits under local conditions. Rome *et al.* (2023) reported that maternal additive effects impact early growth traits such as hatching, body weight, and post hatching early growth traits in chickens; hence, an estimation of cross-breeding components, taking into account all the crossing outcomes from sire and dam components, could be a veritable tool in predicting the performance of local genotypes of birds with lesser genetic potentials than their exotic counterparts.

In addition, crosses between chicken strains improved performance traits like body size, egg weight, egg number, and egg mass once equated with those of pure breeds (Amin, 2008). A recent report (Ige, 2013; Amao, 2017) showed the possible influence of Fulani ecotype chickens used for breeding programs in tropical environments. Ogbuagu *et al.* reported that no specific attention is required with regards to breed choices for sires and dams in the improvement of turkey, however, (Waleed 2020; Assefa *et al.*, 2021; Tadesse *et al.*, 2022; Khalil *et al.*, 2022; Hailemariam *et al.*, 2023), all indicated that improving growth traits, maternal and direct heterosis, requires using specific sires and dams in the crossbreeding schemes in Egyptian chickens. These good qualities of the mentioned chickens can therefore be put to use in tropical environments like Nigeria. Therefore, the present study was conducted to evaluate the performance of crosses between Nigerian local and exotic broiler chickens and their reciprocal crosses under local conditions of Southern Nigeria.

MATERIALS AND METHODS

ETHICAL STATEMENT

Guidelines provided by the Department of Animal Sci-

ence Research Board of Delta State University were strictly followed for animal management and welfare.

EXPERIMENTAL LOCATION

The poultry breeding units of the Teaching and Research Centre of Delta State University, Asaba Campus, were used to carry out this research work at Delta State, Nigeria. The vegetation of the Asaba area is from the Guinea-Savanna region of Nigeria (Udeh and Ogbu, 2011).

EXPERIMENTAL BIRDS AND MANAGEMENT

Twenty cocks and two hundred hens belonging to two separate strains were used for the research. The two strains were the Nigerian Normal feathered chicken (Hen: 100; active cocks: 10) and Marshall Strains of broiler parent stock-chicks (hens: 100; cocks: 10). The Nigerian local chickens used as parents's stock were sourced from local markets within the study location, while the Marshall strain of broiler parents stock was procured from a reliable farm. All the birds were purchased at an age range of 15–18 weeks. The chicks were separately wing-tagged for the purpose of identification. Cocks were properly skilled for semen gathering by systematically applying little pressure at the back towards the tail ten to twenty times daily before semen collection. The feathers within the sire's vent were properly shaved at two-week intervals, and semen collection started at 154 days when they were fully mature.

EXPERIMENTAL FEEDS AND FEEDING

The chickens were fed ad libitum with a commercial breeder diet containing 22.4% crude protein and 2750 kcal of metabolizable energy. Fresh water was supplied ad libitum throughout the period of experimentation. Vaccinations and medications were carried out as described by Oladunjoye *et al.* (2006).

EXPERIMENTAL MATING

The mating system adopted for mating the hens was artificial insemination (AI). The massage technique was to get the semen from the cocks of Marshall Broilers and Nigerian local birds. The collected semen was inseminated into a doughnut shape in the left vent of the dams. The insemination was carried out every evening, twice weekly. Each dam received 0.1 ml of undiluted semen each time. The mating procedure is as shown below.

- Nigerian Local (sire) × Nigeria Local (dam) 1= Pure Crosses
- Marshall Parent stock broiler (sire) × Marshall Parent stock broiler (dam) 2 = Pure Crosses
- Marshall Parent stock broiler (sire) × Nigerian Local (dam) 3 = Straight Reciprocal
- Nigeria Local (sire) × Marshall Parent stock broilers (dam) 4 = Reciprocal

Eggs from inseminated hens were collected according to their pedigree records along genotype lines and stored in a cool room at 18 oC for five days before the eggs were taken to the hatchery for incubation. Cabinet-type incubators were used to set the eggs at a commercial hatchery. The eggs collected were set along the genotype lines at a temperature between 26 and 39 oC with a relative humidity of 54-57% for eighteen days, and then the temperature was increased to 29-41 oC with a relative humidity of 71-76% from the nineteenth day to hatching time. The eggs were also turned automatically through 90° in the incubator.

PROCESS OF CANDLING

On the 18th day of incubation, candling was carried out to identify fertile eggs. The conduit process was carried out in a dark room using a candle fixed with a neon fluorescent tube. Eggs were placed on the candler in order for the light to penetrate through the eggs, and the eggs were viewed against the source of the light. Fertile eggs were seen as cloudily dense and opaque with vein networks, meaning that embryos are developing within eggs. Records of infertile and embryonic mortality were recorded. Once candling was done, the fertile eggs were transferred into the hatching unit, which conferred on the chick's genotype line, and placed in the hatchery tray for three days. As soon as the chicks are hatched, they are left in the hatchery until normal, weak, abnormal, or dead chicks are recorded.

MANAGEMENT AND HOUSING OF CHICKS

All resulting chicks from each genotype were carefully identified by tagging with the aid of industrial galvanized aluminum tags at the wing web at one day of age. The day-old birds were later transferred to a separate, already disinfected brooder pen. Each batch was brooded for four weeks. The research was conducted in accordance with the guidelines of the university animal care user committee. Commercial chick mash was fed to the chicks, which supplied 22% crude protein and 2750 kcal/kg metabolized energy up to 6 weeks of age. Later, they were fed with a commercial growers' ration that supplied 16% crude protein and 270kcal/kg metabolized energy. Fresh water was supplied ad libitum, and medication and vaccination were carried out when due, as described by [Oladunjoye et al. \(2016\)](#).

DATA COLLECTION AND STATISTICAL ANALYSIS

Every weight of the two hundred and twenty (220) chicks was documented at hatch (BWO) and subsequently weighed on a 4-week basis, up to 22 weeks of age, to compute the weight gain. The data generated for each age period were analyzed using ANOVA (analysis of variance) with the aid of the SPSS statistical package in a completely randomized design (CRD) with a breeding group as the

real source of variation. Statistically significant means were separated using the Duncan multiple range test. The statistical model for the experimental design is shown below;

$$X_{ij} = U + T_i + e_{ijk}$$

Where;

X_{ij} is an observation made on the kth bird belonging to the ith strain. U is the overall population mean, common to all observations and treatment. T_i is the effect of the ith strain (i=1.....4). e_{ijk} is the random error associated with the experimental procedure.

ESTIMATION OF CROSSBREEDING EFFECTS

The estimates of direct additive, maternal additive, and direct heterosis were computed using the contrast statement in multiple-trait derivative free restricted maximum likelihood (MTDFREML) program ([Boldman, 1995](#)). Estimates of each component were computed according to the techniques of [Dickerson \(1993\)](#) as stated in the equations below.

Direct Additive (G¹):

$$\{(Ex \times Ex - Lc \times Lc) - (Ex \times Lc - Lc \times Ex)\} \text{ Equation 1}$$

Maternal Additive (G^M):

$$\{Lc \times Ex - Ex \times Lc\} \text{ Equation 2}$$

Direct Heterosis (H¹):

$$\{(Ex \times Lc + Lc \times Ex) - (Ex \times Ex + Lc \times Lc)\} \text{ Equation 3}$$

Percentages were calculated as follows;

Percentages of G¹ were computed as (estimate of G¹):

$$\frac{(Lc \times Lc) \times (Lc \times Ex)}{2} \times 100$$

Percentages of G^m were computed as (estimate of G^m):

$$\frac{(Ex \times Ex + Lc \times Ex)}{2} \times 100$$

Percentages of H¹ were computed as (estimate of H¹):

$$\frac{(Lc \times Lc + Ex \times Ex)}{2} \times 100$$

RESULTS AND DISCUSSION

BODY WEIGHT PERFORMANCE OF THE FOUR GENETIC GROUPS

The means and standard errors for body weights of exotic and local chickens with their crosses for both sexes are presented in [Table 1](#). The Nigerian local chicken was signifi-

cantly ($P < 0.05$) inferior to the exotic genotype and their crosses in both males and females at 0–22 weeks of age, except in the males, where the body weight of the main crosses ($Ex \times Lc$) was similar ($P > 0.05$) to the Nigerian local parent ($Lc \times Lc$) at 4–8, and 12–16 weeks, respectively. The body weight indicated that the crossing of Nigerian chickens with the Marshal Parent stock of broiler was effective in bridging the gap in body size performance between the $Ex \times Ex$ (exotic) and $Lc \times Lc$ (local) chickens. The reason could be due to the local chickens' slow growth rate relative to the exotic and its crossbred. The better performance of the exotic as compared to local chickens was expected and was in line with the report of Fotsa (2008). This better productive performance of the marshal parent stock broiler is a result of genetic improvement practices being carried out on the marshal parent stock of broiler chickens. Consequently, Nigerian chickens are less efficient at nutrient utilization than Marshal Parent stock chickens. The local chickens in this experiment were consistently inferior to the $Lc \times Ex$ and $Ex \times Ex$ throughout the growth period, which may be due partially to the hybrid or heterotic effect of crossing that is inherent in the $Lc \times Ex$ and mainly to maternal influence and egg size.

Hailemariam *et al.* (2023) reported positive heterosis for egg productions traits, which is in tandem with earlier reports by Tullet and Burtan (1982), that exotic parent eggs are larger than those from local parents and that the body size and weight of chicks at birth are influenced by the dam's mature weight of eggs and egg size. For the $Lc \times Lc$ group, the important factor responsible was breed effect, but considering the $Ex \times Lc$ crosses, three factors are suggested that could be related to one another: the dam's breed effect, mature egg weight, or egg size of the dam. It implies that for the main cross, the expected crossbreeding effects and sire influence were conspicuously absent or were suppressed by the overpowering maternal influence. The observed intermediate weight attainment of the crossbred chicks in this study was consistent with the view of Pederson (2002). According to their study of crossing cocks Cobb N500 and local hens of Zimbabwe, at 8 weeks, the chickens of stock Cobb N500 weighed 3308g and the local chickens group weighed only 688g, whereas the average weight of crossbreeds was 1400g. The same trend was observed by Gnakari *et al.* (2007) after having observed that exotic chicks grew more rapidly than African tropical chicks; at the end of 8 weeks of breeding, the exotic broiler had an average live weight of $1658 \pm 7g$ against $700 \pm 6g$ for African chicken. More so, the present study showed that the crossbred had an improved growth level than those of the local chicken, and it agrees with the work of Obike *et al.* (2002), who noted that breed differences exists within offspring for productive traits and that Ross 308 $\times$ Brown local dams is preferred for upgrading the Nigerian local chicken.

Table 1: Mean and standard error of body weight (g) for

male/female genotypes and their crosses.

Sex	Age (wk)	Genotype		Crosses	
Male		$Ex \times Ex$	$Lc \times Lc$	$Ex \times Lc$	$Lc \times Ex$
	0	43.87 $\pm$ 0.44 ^a	25.97 $\pm$ 0.46 ^d	31.53 $\pm$ 0.50 ^c	36.43 $\pm$ 0.39 ^b
	4	748.36 $\pm$ 14.48 ^a	118.49 $\pm$ 2.94 ^d	260.20 $\pm$ 4.50 ^c	298.53 $\pm$ 10.34 ^b
	8	2311.67 $\pm$ 61.57 ^a	401.72 $\pm$ 8.69 ^c	447.90 $\pm$ 23.04 ^c	650.00 $\pm$ 39.15 ^b
	12	4025.00 $\pm$ 66.47 ^a	581.11 $\pm$ 9.97 ^d	710.50 $\pm$ 3.67 ^c	1063.30 $\pm$ 10.37 ^b
	16	4845.00 $\pm$ 100.34 ^a	774.33 $\pm$ 18.54 ^c	904.33 $\pm$ 2.58 ^c	2131.73 $\pm$ 35.26 ^b
	20	5315.67 $\pm$ 124.31 ^a	961.33 $\pm$ 18.51 ^d	1308.00 $\pm$ 49.88 ^c	2907.53 $\pm$ 17.84 ^b
	22	5080.00 $\pm$ 69.67 ^a	1029.33 $\pm$ 21.50 ^d	1913.33 $\pm$ 29.44 ^c	3399.63 $\pm$ 19.72 ^b
Female					
	0	40.09 $\pm$ 0.15 ^a	21.29 $\pm$ 0.15 ^d	28.18 $\pm$ 0.39 ^c	31.30 $\pm$ 0.27 ^b
	4	566.61 $\pm$ 8.48 ^a	96.20 $\pm$ 1.10 ^d	176.33 $\pm$ 2.94 ^c	237.50 $\pm$ 1.63 ^b
	8	2125.60 $\pm$ 20.84 ^a	247.89 $\pm$ 4.69 ^d	427.55 $\pm$ 2.19 ^c	537.62 $\pm$ 5.50 ^b
	12	3416.67 $\pm$ 29.93 ^a	369.06 $\pm$ 7.92 ^d	615.86 $\pm$ 1.79 ^c	950.20 $\pm$ 4.79 ^b
	16	3921.43 $\pm$ 45.47 ^a	555.36 $\pm$ 9.51 ^d	882.67 $\pm$ 1.85 ^c	2096.38 $\pm$ 3.46 ^b
	20	4297.61 $\pm$ 55.60 ^a	711.17 $\pm$ 8.33 ^d	1101.55 $\pm$ 1.79 ^c	2756.49 $\pm$ 14.10 ^b
	22	4388.69 $\pm$ 40.07 ^a	782.64 $\pm$ 9.60 ^d	123.29 $\pm$ 12.69 ^c	3236.96 $\pm$ 13.96 ^b

abcd: Means with different superscript letters in a row are significantly ($P < 0.05$) different. **Key:** $Ex \times Ex$: Exotic; $Lc \times Lc$: Local; $Ex \times Lc$: Main cross; $Lc \times Ex$: reciprocal crosses.

ESTIMATE OF CROSSBREEDING COMPONENTS FOR GROWTH TRAITS BETWEEN $Ex \times Ex$ AND $Lc \times Lc$ GENOTYPE AND THEIR CROSSBRED

Estimates of direct additive (G^i), maternal breed additive (G^m) effect, and direct heterosis (H^i) for growth traits are obtainable in Table 2 for both sexes. The results of the estimate of direct additive and their percentages for growth traits indicates that direct additive was high and significantly different ($P < 0.05$) for body weight in males and females. The observed high and positive significant estimates of direct additive effects for growth traits in both sexes and the crosses indicate that $Ex \times Ex$ genotype could be used as a sire breed to achieve improvement in chicks with heavier body size than local chickens. This result suggests that the exotic ($Ex \times Ex$) sires effectively transmitted the favorable genes to their progenies. Lalev *et al.* (2014) reported positive and highly significant ($P < 0.01$) estimates of direct additive effects in crosses between two white Plymouth Rock lines (L and K), that ranged from 4.89 to 15.23%. Similar-

ly, *Iraqi et al. (2001)* reported high direct additive for the growth of crosses between Mandarah (MN) and Matrouh (MA) strains of Egyptian local chickens that ranged from 2.17 to 10.63%.

Table 2: Estimates of sire/dam direct additive, maternal additive, direct heterosis, and their growth rates and percentages.

Sex	Age wk	Direct additive	%	Maternal Addictive	%	Direct Heterosis	%
Male							
	0	6.63 ±0.51	4.70	2.40 ±0.34	5.98	-0.981 ±0.38	-2.81
	4	330.75 ±9.76	57.25	-18.55 ±5.91	-3.68	-300.50 ±8.72	-69.33
	8	855.30 ±31.06	61.45	99.55 ±4.71	6.92	-807.28 ±31.62	-59.51
	12	1545.42 ±34.61	53.21	176.68 ±6.64	6.95	-1411.06 ±33.36	-61.27
	16	1420.94 ±50.73	97.74	613.26 ±17.35	17.58	-1287.06 ±54.60	-45.81
	20	1368.13 ±66.24	70.73	798.73 ±26.52	19.43	-1019.90 ±65.80	-32.50
	22	1260.26 ±45.64	57.27	752.08 ±21.15	17.74	-391.71 ±37.54	-12.82
Female							
	0	7.82 ±.291	3.36	1.56±0.26	1.87	-0.92 ±0.24	-3.00
	4	205.36 ±4.481	81.25	29.94 ±1.80	7.45	-212.65 ±4.44	-64.26
	8	883.67 ±10.85	44.45	55.033.04	4.13	-703.08 ±11.49	-59.24
	12	1354.39 ±16.62	48.70	166.96 ±2.47	7.65	-108.05 ±15.06	-58.54
	16	1082.40 ±23.41	82.26	596.82 ±1.97	19.90	-756.16 ±23.29	-33.78
	20	964.26 ±27.89	55.61	828.19 ±7.04	23.48	-573.93 ±27.87	-22.90
	22	806.11 ±23.01	40.11	999.09 ±9.40	26.20	-349.86 ±25.05	-13.53

Key= %: Percentage.

The maternal influence showed positive and significantly ($P<0.05$) higher values. Breed maternal impact was in favour of Ex × Ex dams. The observed positive and highly significant estimate for maternal stimulus for growth during these experimental periods in both sexes means that; it might be seen that utilizing (Ex × Ex) genotype as a dam line improved body size throughout the experimental periods with their crossbred. This observation is in line with the report of *Sabri et al. (2000)* who found that maternal effects on growth and weight gains are significantly positive ($P<0.05$) and ($P<0.01$). The maternal breed impact

percentage for growth at early ages for both sexes (averaging 4.04% and 15.36%) at 0 to 12 weeks are slightly better than later weeks (averaging 42.92% and 52.11%) at 16 – 22 age period.

Direct heterosis estimates are accessible in *Table 2*. In general, estimates were generally negative and significantly higher. The highly significant negative direct heterosis found in this study, and means of reciprocal crossbreds can be ascribed to superior genetic distance that existed within tested genotypes. The results are in agreement with the works of *Fosta et al. (2010)* who observed that the parental lines were generally bigger when compared to F_1 crossbred in parameters like daily weight gain, food consumption, and consumption index.

The weak or negative heterosis observed in this study could be explained further by a high difference in growth and conformation performance existing between the local chicken and the exotic breed. The reciprocal effect calculated gave a better advantage to the cross among local roosters and exotic females; similar observation was reported by *Iraqi et al. (2011)*. These differences between the two genetic groups (LC × Ex and Ex × Lc) can be explained by likely genotypic differences amongst Lc × Ex and Ex × Lc as conveyed either by the father's or mother's line. Consequently, the use of local fowls can be recommended as sire breeds when planning crossbreeding in the tropics. The percentages of direct heterosis for the male ranged from -2.81 to -69.83, while that of the female ranged from -3.00 to -64.26 for body weight.

BODY WEIGHT GAIN OF THE FOUR GENETIC GROUPS

Mean value accessible in *Table 3* shows results of weight gain for males and females of the four genetic groups. The weight gain were significantly ($P<0.05$) different among genotypes from 0 to 22 weeks. Exotic genotype had highest DG_{0-4} , DG_{4-8} , and DG_{8-12} than other genotypes. Lc × Ex crossbred had higher weight gain and superiority for DG_{12-16} , DG_{16-20} and DG_{20-22} in both sexes when compared to main crossbred (Ex × Lc) and (Lc × Lc) genotype across ages.

Similar significant genotypic effects for daily weight gain were reported by several researchers (*Aly and Abou El-Elila, 2006; Iraqi et al., 2013*). *Table 3* showed that there were significant differences for DG from hatch to 22 weeks with exception to DG_{12-16} in males. At DG_{12-16} there were similarity between local (Lc × Lc) and main crosses (Ex × Lc) genotypes. While among female genotypes, there were significant differences in weight gain from hatch to 22 weeks, except DG_{0-4} (*Table 3*), where there was statistical similarity between reciprocal crosses (Lc × Ex) and main crosses (Ex × Lc). The local (Lc × Lc) genotypes were

not statistically different from main crossbred (Ex × Lc) genotypes. In intensive management, Dessie *et al.* (2003) reported a daily gain of 75.09g between DG₀₋₄ for local chickens, which was comparable with that of local (Lc × Lc) genotype chickens in our study.

Table 3: Mean and standard error of male/female body weight gain (dg) for ex × ex and lc × lc genotypes with their crosses.

Sex	Age (wk)	Genotype		Crosses	
		Ex × Ex	Lc × Lc	Ex × Lc	Lc × Ex
Male	0-4	691.60 ± 19.34 ^a	92.53 ± 2.90 ^c	267.07 ± 10.30 ^b	223.77 ± 4.43 ^c
	4-8	1563.31 ± 58.13 ^a	283.24 ± 9.55 ^c	147.73 ± 11.06 ^d	389.80 ± 8.63 ^b
	8-12	1713.33 ± 75.96 ^a	179.44 ± 12.18 ^{cd}	264.40 ± 5.82 ^c	413.30 ± 14.90 ^b
	12-16	820.00 ± 112.79 ^b	193.17 ± 20.43 ^c	193.67 ± 4.81 ^c	1068.43 ± 34.56 ^a
	16-20	470.67 ± 154.59 ^{bc}	187.00 ± 29.60 ^d	403.67 ± 49.82 ^{bc}	775.80 ± 43.20 ^a
	20-22	235.67 ± 165.21 ^c	68.00 ± 28.47 ^b	608.33 ± 60.13 ^a	492.10 ± 21.31 ^a
Female	0-4	586.11 ± 59.33 ^a	74.92 ± 1.96 ^{dc}	151.81 ± 3.07 ^{bc}	206.20 ± 1.69 ^b
	4-8	1499.40 ± 64.14 ^a	151.69 ± 5.20 ^c	248.11 ± 3.73 ^b	300.12 ± 6.14 ^b
	8-12	1291.07 ± 34.77 ^a	121.17 ± 9.61 ^d	189.36 ± 3.07 ^c	412.29 ± 7.04 ^b
	12-16	504.76 ± 57.03 ^b	186.30 ± 12.05 ^{dc}	205.08 ± 2.98 ^c	1126.18 ± 5.93 ^a
	16-20	376.19 ± 62.82 ^b	155.81 ± 12.79 ^{dc}	218.88 ± 2.53 ^c	680.11 ± 14.66 ^a
	20-22	423.21 ± 337.99 ^a	71.48 ± 12.66 ^c	136.74 ± 12.72 ^b	480.48 ± 24.14 ^a

abcd: Means with different superscript letters in a row are significantly (P<0.05) different. **Key:** Ex × Ex: Exotic; Lc × Lc: Local; Ex × Lc: main crosses; Lc × Ex: reciprocal crosses.

ESTIMATE OF CROSSBREEDING COMPONENT FOR WEIGHT GAIN AMONG THE FOUR GENOTYPES

DIRECT ADDICTIVE: Estimates of direct addictive effects for weight gain of both sexes indicated that most estimates were positive and highly significant for DG₀₋₄, DG₄₋₈, and DG₈₋₁₂, being 321.19, 519.01, and 692.50 (Table 4). Therefore, exotic (Ex × Ex) sires had better performance than local (Lc × Lc) sires for DG₀₋₄, DG₄₋₈, and DG₈₋₁₂; same observation was obtained by Asefa *et al.*, 2021. However, highly significant negative direct addictive effects for DG₁₂₋₁₆, DG₁₆₋₂₀, and DG₂₀₋₂₂ are presented in Table

Table 4: Estimation of sire/dam weight gain (dg) direct additive, maternal additive, direct heterosis, and their percentages

4. This means that direct addictive effects were pronounced in favor of local sires for previously mentioned traits. The negative daily gain results of addictive effects in the current research were similar to the reports of Waleed (2020) and Iraqi *et al.* (2013), when they crossed Bandamah as a sire with Gim as a dam.

MATERNAL ADDICTIVE EFFECTS FOR WEIGHT GAIN:

Estimates of maternal effects and their percentages were positive and significantly higher for daily weight gain during experimental periods ranging from 26.01 to 430.55. Amin *et al.*, (2013) reported similar trend of positive maternal effects. Conversely, Aly and Abou El-Ella (2006) reported negative maternal effect for DG₀₋₁₂ in the cross of Bandarah × Gim. As for maternal addictive effects, it could be seen that using exotic (Ex × Ex) strain as dam line improved daily weight gain (DG) during the intervals of 0-4, 4-8, 8-12, 12-16, 16-20 and 20-22 weeks in this present study. Maternal effects for males were negative and significant during DG₀₋₄ and DG₂₀₋₂₂, being -21.65 and -58.12, but positive for DG₄₋₈, DG₈₋₁₂ and DG₁₆₋₂₀ (Table 4). A positive significantly higher maternal effect was observed at 8,12,16 and 20 weeks period varying between 3.88 and 32.30% (P<0.05), for males and females throughout the experiment were in favour of exotic (Ex × Ex) line. Assefa *et al.* (2021) reported negative maternal and reciprocal effects for body weight at 20 weeks and point of lay, while Barbato and Vasilatos-Younken (1991), reported that maternal effects in chickens changed with time, their considerable influence at a later age might be owing to endoplasmic inheritance, which plays a role in the manifestation of specific maternal effects within strain.

WEIGHT GAIN DIRECT HETEROTIC EFFECTS AND THEIR PERCENTAGES:

Estimates of heterotic outcome were significant for all traits studied in both males and females. Heterosis was negative for each DG, ranging from -654.51 to -145.65 and -405.15 to -551.44 for males and females during 0-12 weeks (Table 4). These results were confirmed with the observation of Assefa *et al.* (2021) and Mandour *et al.* (1992), who reported negative heterosis and their percentages for day old, 20 weeks, days at first egg and daily gain at 2 weeks being -3.03% respectively. Conversely, Iraqi *et al.* (2013) reported significant positive heterosis for DG₀₋₄, DG₄₋₈, and DG₈₋₁₂ as 1.27, 1.81, and 3.34%, respectively. This result means that female offspring had better transmission than their male parents for these traits under consideration. The results were not consistent with a report by Mafeni *et al.* (2005); they worked with Red German Dahilem as an exotic and crossed with Cameroon local chicken; nevertheless, they corroborated the results presented by (Fotsa *et al.*, 2010; Keambou *et al.* 2010), who reported parental superiority over their F₁ crossbred for traits like daily gain, feed intake, and feeding index.

Sex	Age (wk)	Traits	Direct additive	%	Maternal additive	%	Direct Heterosis	%
Male								
	0-4	DG	321.19 ±12.17	49.24	-21.65 ±6.01	-2.65	-146.65 ±11.67	-32.97
	4-8	DG	519.01 ±30.03	64.84	121.03 ±8.32	6.88	-654.51 ±341.37	-61.47
	8-12	DG	692.50 ±42.44	42.80	74.45 ±7.32	3.88	-607.54 ±41.72	-58.64
	12-16	DG	-123.97 ±58.70	-17.04	437.38 ±17.33	32.30	124.47 ±62.54	20.64
	16-20	DG	-44.23 ±63.76	-9.19	186.07 ±36.36	21.67	260.90 ±84.08	61.78
	20-22	DG	-93.72 ±91.04	-29.84	-58.12 ±32.90	-12.07	634.05 ±88.40	34.12
Female								
	0-4	DG	228.40 ±29.39	61.54	27.20 ±1.84	4.32	-151.51 ±29.88	-44.80
	4-8	DG	647.85 ±31.84	35.87	26.01 ±3.53	1.52	-551.44 ±32.46	-59.22
	8-12	DG	473.34 ±19.03	56.38	111.61 ±3.66	7.45	-405.15 ±18.06	-52.84
	12-16	DG	-270.63 ±29.19	-36.11	430.55 ±3.05	40.32	350.78 ±29.74	79.96
	16-20	DG	-120.42 ±31.81	-24.29	230.61 ±7.36	32.20	183.49 ±33.07	53.36
	20-22	DG	4.00± 170.39	1.28	171.87 ±13.85	51.86	61.26± 166.85	-90.34

Key: DG: Daily Body Weight; Ex × Ex: Exotic; Lc × Lc: Local; Ex × Lc: main crosses; Lc × Ex: reciprocal crosses.

Table 5: Mean and standard error of male/female feed consumption (g/wk) of exotic, local and their f1 crosses.

Sex	Age (wk)	Genotype		Crosses	
Male		Ex × Ex	Lc × Lc	Ex × Lc	Lc × Ex
	WK 0-4	2078.59±81.10 ^a	1327.73±69.96 ^c	1762.52±66.75 ^b	1846.53±71.08 ^b
	WK 4-8	7103.07±176.71 ^a	1713.84±23.67 ^d	2213.56±23.82 ^c	6456.74±269.36 ^b
	WK 8-12	5043.93±71.20 ^a	1347.84±49.52 ^d	1851.99±51.18 ^c	4498.57±95.82 ^b
	WK 12-16	5950.47±179.38 ^a	1714.60±43.86 ^d	2211.89±43.62 ^c	5271.34±201.16 ^b
	WK 16-20	5552.04±110.45 ^a	1645.74±54.82 ^c	1846.66±186.90 ^c	4734.11±165.16 ^b
	WK 20-22	5921.56±93.07 ^a	1773.51±37.76 ^d	2281.09±44.34 ^c	5094.77±175.01 ^b
Female					
	WK 0-4	5680.06±227.05 ^a	3580.40±195.81 ^c	3860.41±56.48 ^c	4687.26±197.11 ^b
	WK 4-8	19748.61±494.76 ^a	4658.74±66.28 ^b	5482.51±120.78 ^b	19222.03±487.06 ^a
	WK 8-12	13982.94±199.37 ^a	3662.53±130.42 ^c	4134.67±139.10 ^c	13145.11±174.87 ^b
	WK 12-16	16524.11±502.39 ^a	4662.47±123.30 ^b	5132.31±114.25 ^b	15454.91±516.29 ^a
	WK 16-20	15412.89±309.86 ^a	4468.07±153.52 ^c	4966.01±153.33 ^c	14565.51±286.94 ^b
	WK 20-22	16482.09±271.00 ^a	4826.63±105.28 ^d	5321.84±105.61 ^c	15196.59±135.64 ^b

abcd: Means with different superscript letters in a row are significantly (P<0.05) different. **Key:** Ex × Ex: Exotic; Lc × Lc: Local; Ex × Lc: main crosses, Lc × Ex: reciprocal crosses.

MALE/FEMALE FEED CONSUMPTION (G/WK) OF EXOTIC, LOCAL AND THEIR F1 CROSSES

Local chicken (Lc × Lc) groups were significantly inferior to other genotypes in feed consumption for both sexes (Table 5). The exotic groups had more important feed consumption than local chickens, and the crossbreds had a feed consumption intermediate between exotic and local chickens. Feed consumption increased from 0 to 8 weeks and decreased from 0 to 22 weeks in both sexes. The main crosses (Ex × Lc) were not significantly different from those of reciprocal (Lc × Ex) crosses in week 4, while in week 20, the local (Lc × Lc) genotype was also similar to the main crosses (Ex × Lc) for feed consumption. The

exotic (Ex × Ex) male genotypes significantly (P<0.05) consumed more feed throughout the period. For the female, feed consumption was not different statistically (P > 0.05) amid the reciprocal (Lc × Ex) crosses and exotic (Ex × Ex) genotypes in weeks 8 and 16. Observed high feed consumption by exotic lines (Ex × Ex and reciprocal crossbred Lx × Ex) can be credited to their high growth rate or body size as a result of long genetic improvement on Marshal broiler parent stock and their active physical activity, which could have required additional feed consumption to meet the maintenance requirement as reported by Melesse et al., (2011). Akhtar et al. (2007) and Assefa et al. (2021) also reported higher feed consumption for Fayoums exot-

ic breeds than for Lyallpur silver black local breeds. The daily feed consumption reported for Tilili, Melo-Hamusit, Guangua, and Mecha chickens from day old to 8 weeks of age, as posited by Hassen et al. (2007) under intensive management, was comparable with that of Nigerian local chickens, and the main crosses (Ex × Lc) in the current study were at a similar age.

CONCLUSION AND RECOMMENDATIONS

In conclusion, it was evident that the weight performance (daily weight gain and feed intake) of the Marshal Parent Stock Broiler was superior to that of the crossbreds, while the crossbreds outperformed the local chickens in terms of weight performance (daily weight gain and feed consumption). The local chickens had the lowest weight gain. The crossbreds had feed consumption levels that were intermediate between the parental stock broiler and the local chickens. The Lc × Ex reciprocal cross exhibited a significant amount of hybrid vigor, while the Ex × Lc main cross suffered a major setback due to maternal suppression. The inheritance pattern of heterosis in body weight favored the complete dominance and over-dominance models. For all birds, males had significantly higher age-type weights than females. The exotic rooster-local dam cross was inferior to the local rooster-exotic dam cross. This mating pattern could potentially result in higher genetic and economic improvements in a shorter time, enabling quicker achievement of the desired improvements.

NOVELTY STATEMENT

This study has contributed to the global understanding of crossbreeding exotic and local chickens. Specifically, it has identified the best mating strategy for optimizing productivity in terms of economic traits within a crossbreeding scheme involving Nigerian local chickens and exotic chickens.

AUTHOR'S CONTRIBUTIONS

Philip Okpako Akporhwarho: Conceptualization, data curation, fund acquisition project administration, supervision, writing original draft.

Ufuoma Godstime Sorhue, Adimabua Mike Moemeka and Onyinye Stella Onwumere-Idolor: Writing original draft, methodology, Editing project administration.

Ifeanyichukwu Udeh: Visualization, data curation, methodology.

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DATA AVAILABILITY STATEMENT

Subject to meaningful request, all data shall be provided by the corresponding author.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest from conceptualization to the submission of the manuscript. This article has not been published nor under review by any other journal or book. All Authors also agree to the copyright assignment form of this journal.

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