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Research Article
Embryonic Development and Early Juvenile Growth of Nigerian Local Chickens in Crosses with Exotic Broiler Breeder under Humid Tropical Conditions

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Abstract
Background and Objective: Heat stress represents a major challenge for the optimal production of exotic broiler chickens in tropical environments. This study, therefore, aimed to evaluate the hatching egg characteristics, embryonic development, hatching parameters and juvenile growth of Nigeria Indigenous Chicken in crosses with exotic broiler chickens. **Materials and Methods:** A total of 1,000 day-old chicks were bred from Nigerian Indigenous Chickens (NIC) and exotic broiler breeder (Anak Titan) to obtain chicks whose genotypes were: 100% NIC+0% exotic broiler chicken (NIC), 75% NIC+25% exotic broiler chicken (TE), 50% NIC+50% exotic broiler chicken (FE) and 25% NIC+75% exotic broiler chicken (SE). At 36 weeks of age, fertile eggs were obtained from each cross with the use of artificial insemination. Hatched chicks were reared to determine the juvenile growth parameters. **Results:** The results showed no significant differences between the egg quality characteristics for the different genotypes (p>0.05). At Embryonic Day (ED) 7 of incubation, egg weight loss of TE, NIC and FE was similar but higher than those of the eggs of SE. The egg weight loss of NIC was similar to that of TE but higher than those of FE and SE at ED15. The percentage fertility of FE eggs was significantly higher than those of other treatment groups, while TE eggs were also higher than those of NIC and SE whose values were comparable. **Conclusion:** It was concluded that there could be a positive improvement in embryonic development and post-hatch growth of the local chicken by crossbreeding using the same genotype ratio (50:50).

Key words: Genotype, juvenile growth, embryonic development, egg quality, incubation

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Nigerian indigenous chickens or local chickens refer to those unimproved chickens commonly found in the local areas of Nigeria. Naked neck, frizzle feather and normal feather chickens are birds kept in many parts of the world including Nigeria and Ghana[1]. These chickens make a substantial contribution to human livelihood and contribute pointedly to food security[2]. They are economically reared as scavenging flocks, feeding on household leftovers. They need a shelter to spend their night while free-ranging during the day and their meat and eggs are preferred over those of exotic chickens[3,4]. The Nigerian Indigenous Chickens (NIC) has been a focal point for research in recent times. This can be attributed to the fact that asides its inherent ability to bridge the needed animal protein deficit to the populace, it has been shown that the genome of the native fowl is a natural reservoir of some advantageous tropically relevant major genes which are known to have productive and adaptive qualities. However, they have not been widely accepted commercially due to limitations regarding its purposeful selection and undertaking of extensive breeding programs.

They are known for their adaptation superiority in terms of their resistance to endemic diseases and other harsh environmental conditions. However, these chickens are poor performers in terms of growth rate (hence meat production) and egg production. Most of them are of small adult size and lay small-sized eggs when compared to an improved commercial broiler or layer birds respectively[1-5]. The modern broiler chicken production is an extensive and rapidly developing sector, supplying the market with relatively cheap and high-quality dietetic food. Due to contemporary selection programs, a considerable improvement of weight gain, feed conversion, slaughter yield and breast meat yields was achieved during the past decades[6,7]. The progress in the selection of meat-type chickens resulted in a significantly shorter fattening period up to 42 days of age with a slaughter weight of 2 kg[8].

Regardless of genetic improvements performed by breeders, broiler hybrids still differ with regard to their efficiency due to specific selection practices[9]. Hence, evaluation of potential crosses selected for high live weight, high weight gain, feed conversion, carcass traits and adaptation would highly contribute to the efficiency of broiler chickens produced. Many researchers have reported a substantial effect of genotype on live weight[10-12]. Therefore, this study was conducted to compare hatching egg characteristics, embryonic development, hatching parameters and juvenile growth performance of chicks of Nigeria Indigenous Chicken in crosses with exotic broiler chickens as genetic progress can be attained by selection and crossbreeding.

MATERIALS AND METHODS

Experimental location: The research was carried out between June, 2017 and May, 2018 at the Poultry Unit of the Research Farm of the Federal University of Agriculture, Abeokuta, Ogun State, Nigeria (latitude 7°13 N; longitude 3°26 E and altitude 76 m above sea level) in a prevailing tropical climate with a mean annual rainfall of 1,037 mm and annual mean temperature and relative humidity of 34°C and 82%, respectively.

Experimental procedure and management: 1,000 day old chicks were generated from Nigerian indigenous chickens (NIC) and exotic broiler breeders (Anak Titan). The broiler breeders were crossed with NIC to obtain chicks whose genotypes were: 100% NIC+0% exotic broiler chicken (NIC), 75% NIC+25% exotic broiler chicken (TE), 50% NIC+50% exotic broiler chicken (FE) and 25% NIC+75% exotic broiler chicken (SE). The birds were reared using the conventional method in which they were fed ad libitum. The diet compositions of Adeleke *et al.*[13] was adopted at different growth phases of the birds. Each bird was identified with a wing band.

At 36 weeks of age, hatching eggs were obtained from each cross by mating the sires and dams of each genotype with the use of artificial insemination as described by Adeleke *et al.*[14]. Artificial insemination was done two times in a week while hatching egg collection lasted. This study had the approval of the Animal Use and Care Committee of the Federal University of Agriculture, Abeokuta, Nigeria. The climate and location of the experiment has been previously described by Oke *et al.*[15].

Egg collection and incubation: Hatching eggs were collected from the hens daily and were labeled according to the genotype and stored in a cold room (10-14°C) up to one week (in order to obtain a considerable number of eggs) before setting in the incubator. Eggs that were devoid of physical defects were used. Ten eggs per genotype were used to determine the quality characteristics of the hatching eggs before the commencement of incubation. The weight of the eggs was taken before setting. After the cleaning, disinfection and fumigation, the eggs were set into the incubator. The hatching eggs from each genotype were replicated at 100 per replicate. The incubation protocol of Oke *et al.*[16] was followed.

During incubation, 10 eggs in each genotype were randomly selected for breakout at Embryonic Day (ED) 7, 11, 15 and 18 and data were collected on: Egg weight losses, shell weight and albumen weight.

Egg weight and shell weight were measured with the aid of Mettler top-loading weighing balance. Shell thickness was measured using the Vernier Caliper. Albumen weight was determined when the albumen was carefully separated from the yolk and was also weighed on Mettler's top-loading weighing balance. Relative embryonic weights were taken as the weights of the embryo extracted from the eggshell at the end of each embryonic day and were weighed using Mettler's top-loading weighing balance. Incubation weight loss was computed as:

$$\text{Incubation weight loss (\%)} = \frac{\text{Egg weight at setting (g) - Egg weight at day 18 (g)}}{\text{Egg weights at setting (g)}} \times 100$$

The weights of the embryos were also monitored throughout the incubation period. Percentage fertility and hatchability were determined as follows:

$$\text{Fertility (\%)} = \frac{\text{Total number of fertile eggs per genotype}}{\text{Total eggs set per genotype}}$$

$$\text{Hatchability (\%)} = \frac{\text{Total number of chicks hatched per genotype}}{\text{Total number of fertile eggs per genotype}}$$

Post-hatch growth: The newly hatched day-old chicks were removed from the hatcher and identified with a numbered wing band corresponding to each egg. The chicks were weighed and reared for four weeks. The hatched chicks from each genotype were reared post hatch for 4 weeks after which the chick weights were measured using the Mettler top-loading weighing balance.

RESULTS

Egg traits during incubation: The effect of chicken genotype on egg quality characteristics is shown in Table 1. There was no significant difference in most of the parameters monitored except yolk weight and shell thickness. FE chickens had a higher yolk weight than the eggs in the other treatment groups whose yolk weights were similar. The shell thickness of the eggs of SE was lower than those of the other genotypes whose thickness was also comparable.

The effect of genotype on relative egg weight loss during incubation is shown in Table 2. There was no significant effect on day 11. However, there was a significant effect on day 7, 15 and 18. NIC, TE and FE had similar but higher relative egg weight than SE. At day 7, egg weight loss of TE, NIC and FE was similar but higher than the eggs in SE. The egg weight loss of NIC was similar to that of TE but higher than those of FE and SE at day 15 of incubation. The loss in TE was also similar to those of FE and SE. Moreover, at day 18, egg weight loss of TE was similar to those of NIC and SE but higher than that of FE. The loss in SE and NIC was intermediate between NIC and FE.

Table 3 shows that there was no significant effect of genotype on relative embryonic weight at incubation day 7,11 and 15. However, at incubation day 18, FE and NIC had similar weights which were higher than that of SE. The weight of the embryos in TE and SE was also similar. Table 4 shows the effect of genotype on albumen weight during embryonic development. There was no significant effect on days 7, 11 and 18. However, there was a significant effect on day 15 as FE eggs had higher weight than SE and TE but similar to NIC. The albumen weight in TE was similar to that of SE but lower than albumen weights of the other genotypes.

The effect of genotype on shell weight during embryonic development is given in Table 5. There was no difference in the shell weights at embryonic day 7, 15 and 18. However, at embryonic day 11, the shell weights of eggs of NIC was similar to those of SE and TE but higher than that of FE eggs. The shell

Table 1: Effect of chicken genotype on egg quality characteristics

Characteristics	NIC (g)	TE (g)	FE (g)	SE (g)	SEM	p-values
Egg weight	50.67	46.25	48.95	47.58	1.14	0.59
Albumen weight	31.25	27.40	27.18	28.56	1.03	0.51
Yolk weight	14.48^{b}	14.51^{b}	17.22^{a}	14.36^{b}	0.45	0.051
Albumen height	1.64	1.25	1.69	1.50	0.09	0.31
Shell weight	4.94	4.32	4.55	4.66	0.12	0.30
Shell thickness	0.66^{a}	0.71^{a}	0.69^{a}	0.36^{b}	0.04	0.001

$^{a-c}$Means within rows with different superscript differ significantly (p<0.05), NIC: 100% local+0% exotic broiler chicken (frizzle feather), TE: 75% local+25% exotic broiler chicken (naked neck), FE: 50% local+50% exotic broiler chicken (normal feather), SE: 25% local+75% exotic broiler chicken (broiler)

Table 2: Effect of genotype on relative egg weight loss during incubation of Nigerian local chickens in crosses with exotic broiler breeder

ED (day)	NIC (g)	TE (g)	FE (g)	SE (g)	SEM	p-values
7	7.24[a]	7.68[a]	7.65[a]	5.28[b]	0.30	0.004
11	8.87	8.27	9.35	7.47	0.41	0.432
15	16.15[a]	13.26[ab]	10.95[b]	9.26[b]	0.87	0.020
18	11.63[ab]	13.78[a]	10.62[b]	11.30[ab]	0.51	0.15

[a-c]Means within rows with different superscript differ significantly (p<0.05), ED: Embryonic day, NIC: 100% local+0% exotic broiler chicken (frizzle feather), TE: 75% local+25% exotic broiler chicken (naked neck), FE: 50% local+50% exotic broiler chicken (normal feather), SE: 25% local+75% exotic broiler chicken (broiler)

Table 3: Effect of genotype on relative embryonic weight during incubation of Nigerian local chickens in crosses with exotic broiler breeder

ED (days)	NIC (g)	TE (g)	FE (g)	SE (g)	SEM	p-values
7	4.00	1.88	1.55	1.44	0.44	0.120
11	10.38	10.79	11.97	12.32	0.43	0.354
15	27.75	27.72	26.34	23.93	0.69	0.17
18	45.76[a]	42.99[ab]	48.30[a]	38.57[b]	1.21	0.02

[a-c]Means within rows with different superscript differ significantly (p<0.05), ED: Embryonic day, NIC: 100% local+0% exotic broiler chicken (frizzle feather), TE: 75% local+25% exotic broiler chicken (naked neck), FE: 50% local+50% exotic broiler chicken (normal feather), SE: 25% local+75% exotic broiler chicken (broiler)

Table 4: Effect of genotype on albumen weight during incubation of Nigerian local chickens in crosses with exotic broiler breeder

ED	NIC (g)	TE (g)	FE (g)	SE (g)	SEM	p-values
7	10.34	11.74	11.58	11.76	0.38	0.526
11	10.40	8.34	9.40	6.28	0.49	0.85
15	8.00[ab]	6.76[c]	9.00[a]	7.14[bc]	0.25	0.001
18	0.00	0.00	0.00	0.00	0.00	0.00

[a-c]Means within rows with different superscript differ significantly (p<0.05), ED: Embryonic day, NIC: 100% local+0% exotic broiler chicken (frizzle feather), TE: 75% local+25% exotic broiler chicken (naked neck), FE: 50% local+50% exotic broiler chicken (normal feather), SE: 25% local+75% exotic broiler chicken (broiler)

Table 5: Effect of genotype on shell weight during incubation of Nigerian local chickens in crosses with exotic broiler breeder

ED	NIC (g)	TE (g)	FE (g)	SE (g)	SEM	p-values
7	6.40	5.62	6.60	5.52	0.20	0.14
11	4.78[a]	4.64[ab]	4.24[b]	4.98[a]	0.10	0.039
15	4.60	5.48	5.04	5.16	0.15	0.256
18	5.40	4.74	4.64	5.12	0.12	0.06

[a-c]Means within rows with different superscript differ significantly (p<0.05), ED: Embryonic day, NIC: 100% local+0% exotic broiler chicken (frizzle feather), TE: 75% local+25% exotic broiler chicken (naked neck), FE: 50% local+50% exotic broiler chicken (normal feather), SE: 25% local+75% exotic broiler chicken

Table 6: Effect of genotype on fertility and hatchability of Nigerian local chickens in crosses with exotic broiler breeder

Parameters	NIC	TE	FE	SE	SEM	p-values
Fertility	81.48[c]	86.40[b]	90.85[a]	81.25[c]	1.074	0.0001
Hatchability	82.90[b]	84.57[b]	91.02[a]	85.63[b]	0.89	0.0003

[a-b]Means within rows with different superscript differ significantly (p<0.05), ED: Embryonic day, NIC: 100% local+0% exotic broiler chicken (frizzle feather), TE: 75% local+25% exotic broiler chicken (naked neck), FE: 50% local+50% exotic broiler chicken (normal feather), SE: 25% local+75% exotic broiler chicken

Table 7: Effect of genotype on the chick weights of Nigerian local chickens in crosses with exotic broiler breeder

Age	NIC (g)	TE (g)	FE (g)	SE (g)	SEM	p-values
Day old	32.167	33.333	32.500	36.000	0.805	0.338
Week 1	62.833	65.833	64.333	68.000	1.999	0.843
Week 2	116.50	122.33	137.67	141.67	5.131	0.256
Week 3	177.67[c]	184.50[bc]	224.50[ab]	233.00[a]	8.387	0.027

[a-c]Means within rows with different superscript differ significantly (p<0.05), NIC: 100% local+0% exotic broiler chicken (frizzle feather), TE: 75% local+25% exotic broiler chicken (naked neck), FE: 50% local+50% exotic broiler chicken (normal feather), SE: 25% local+75% exotic broiler chicken

weights in TE was also similar to that of FE. Table 6 shows the effect of genotype on fertility and hatchability of Nigerian local chickens in crosses, exotic broiler breeders. The percentage fertility of FE eggs was significantly higher than those of the other treatment groups, while TE eggs were also higher than NIC and SE whose values were comparable. Moreover, the hatchability of NIC, TE and SE was similar but lower than that of FE.

Juvenile growth: Table 7 shows the effect of genotype on chicks' juvenile growth. There was no significant difference in the post-hatch juvenile growth of the birds at day old, week 1 and 2 However, at week 3, the weights of the birds in SE was higher than those of TE and NIC but similar to FE. The weights of the chicks in NIC were lower than those FE and SE but comparable to that of TE.

DISCUSSION

The number and size of pores in hatching eggs can influence the rate of moisture loss and heat conductance across the eggshell[17]. Generally, there was no consistency in the egg weight loss across different genotypes at different incubation periods in the present study. The similarity recorded at ED 11 suggested that the eggs of the different genotypes in this study had a similar proportion of pore number areas and diameter[16]. The losses recorded were within the normal range of 10 and 20% of the initial egg weight needed for optimal hatchability[18,19] among the different crosses.

Chicken performance is known to be related to embryonic developmental parameters[20]. Overall, there was no significant difference in the embryonic weight up to day 15. This observation is in agreement with earlier studies on different strains of exotic chickens in comparison with Nigerian indigenous chickens[21]. The similarity in the embryonic weight up to this stage may be explained by the resemblance in most of the hatching egg quality characteristics in the present study which indicate that the eggs had similar gas diffusion, nutrient availability and embryonic growth[22]. The variation in the embryonic weight across the treatment groups at ED18 may be ascribed to genetic differences. This corroborates the report of Wolanski *et al.*[23] also indicated that a great deal of variation exists in the conversion of egg contents into chick body mass among strains. The lower weights of the FE embryos than those of FE and NIC at ED18 indicates a poorer growth trajectory at this stage of incubation. The similarity in the albumen reduction rate in the hatching eggs at most of the incubation periods in the present study suggests that the embryos had a similar conversion rate of albumen to body tissues.

The eggshell weight is important to the developing embryo[16]. Shell quality determines gas exchange and moisture loss during incubation and poor shell quality has been related to a higher egg moisture loss during incubation[24]. Egg calcium components are synthesized to provide skeletal development in the developing embryos[25] during incubation. In the present study, there was a similarity in the eggshell weights for the most part of the incubation stage. The lower value of the FE eggs than those of SE and NIC at ED 11 reflects a genetic variation in the recruitment of shell calcium for the skeletal development of embryos

Fertility and hatchability are the major determinants of profitability in the hatchery enterprise[26]. Variations infertility in chicken crossbreeding have been attributed to the dissimilarity in their fecundity with respect to their genetic type[27]. The results of the present study therefore indicate that FE chickens were more fecund than those of the other crosses while TE birds were intermediate. An increase in hatchability is advantageous[28] and crossbreeding has been reported to influence the hatchability of chicken eggs[29]. The higher hatchability recorded in FE chickens suggests the combination of NIC and exotic broiler at this level is optimum. The similarity in the hatching weight of the chicks in the present study is at variance with the observation of Ifeanyichukwu[30] who stated that the hatch weights of the crossbred groups were influenced. At week 3 post-hatch growth, FE and SE chicks were bigger than NIC and TE. This observation is in agreement with the findings of Adeleke *et al.*[13] who reported that improvement in the growth performance of Nigerian local chickens could be achieved through crossbreeding with exotic types. The variation in post-hatch growth with respect to the genetic constitution in the present study favors FE and SE chickens at week 3 post-hatch. The early juvenile growth of the birds in the present study was used in estimating the performance as chick body weight at an early age has been found to be linearly related to body weight at slaughter age[31]. Contrary to the trend of the results obtained in the current study, Peters *et al.*[32] reported that indigenous chicken genotypes had higher maturing rate than their exotic birds.

CONCLUSION

Improvement in embryonic development and post-hatch growth of the local chicken could be obtained by crossing with the exotic strains and that chickens with the genotype of 50% exotic and 50% indigenous (FE) combining ratio is recommended.

SIGNIFICANCE STATEMENT

This study discovered that crosses involving broiler chickens with Nigerian indigenous chickens at 50% had the highest performance under the tropical environment.

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