TROPICAL AGRICULTURAL SCIENCE

Growth Trajectory of the Nigerian Indigenous and Exotic Strains of Chicken Embryos during Incubation under Nigerian Condition

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ABSTRACT

This study investigated embryonic growth and early growth rate in three strains of chicken. A total of nine hundred hatching eggs, 300 each from 3 strains of chicken, were used for this study. The strains of chicken used were Nigerian indigenous chicken (NIC), Isa Brown (IB) and Nera Black (NB) strains. Twenty eggs per strain were randomly selected for breakout at Embryonic Days (ED) 7, 11, 15, and 18 of incubation to determine embryonic weight, egg weight, egg weight loss and shell weight loss during incubation. Embryonic weight was monitored on ED 7, 11, 15, and 18. The results showed that the NIC had greater (P < 0.05) Haugh unit (71.78) than those of NB (53.23) and IB (52.36). Also, percentage egg yolk weight in NIC (28.74) was higher than that of NB (25.87) but similar to that of IB (26.55). Strain significantly (P < 0.05) affected the percentage shell weight from ED 0 until ED15, except at ED18, where they were similar. At ED7, the NB(6.12) showed significant weight loss compared to that of the IB (4.16) but the weight loss was similar to that ofthe NIC chickens. At ED7 and 18, there were significant differences (P < 0.05) in the embryo weight as percentage of egg weight between the strains. NIC showed a higher embryo weight as percentage of egg weight than the two other strains which were similar in value. It was concluded that the present incubation protocol is adequate for NIC as the embryo weight (expressed as percentage of egg weight) was superior to those of the exotic strains.

Keywords: Nigerian indigenous chicken, Isa Brown, Nera Black, incubation, embryonic development, egg traits

INTRODUCTION

The native chicken constitutes about 80 percent of the 120 million poultry birds found in Nigeria. These birds are also known for their adaptation superiority in terms of their resistance to endemic diseases

and other harsh environmental conditions (Nwakpu *et al.,* 1999). Adedeji *et al.* (2006) reported that these chickens adapt very well to the traditional small scale system of production that is prevalent in most areas of Nigeria. However, their characteristics of poor growth, small body size and small egg size have made them to be non-attractive and undesirable in a competitive economic situation (Ibe, 1990).

Studies have shown that the indigenous fowl possesses great potentials for improvement (Peters, 2000; Adedeji *et al.,* 2008, Adebambo *et al.*, 2009). This is due to the fact that they have some inherent advantages which include good fertility and hatchability, better flavour of meat and egg, high degree of adaptability to prevailing condition, high genetic variance in their performance, hardiness, disease tolerance, ease of rearing and ability to breed naturally (Adedeji *et al*., 2008).

The Nigerian local chickens have often been adjudged to be poor in performance with respect to egg laying, body weight, chick production and growth rate (IBe, 1990). Thus , most of the commercial layer chickens used for table egg and chick production are imported strains that have gone through several generations of selection and improvement. The Nigerian local chickens have not gone through such stringent improvement programmes. A direction of improvement is not even clear, that is, whether to improve for layer production or for broiler production. This requires a comparative study of the local chicken strain with the imported strains.

This study therefore attempted a comparison of the Nigerian local chicken (NIC) strain with two commercial strains of layer chickens (NB and *IB*) of high performance. The study evaluated hatching egg quality, incubation performance and hatchability in order to provide physiological basis for any production and economic differences between the indigenous and exotic strains in an effort to improve the performance of the native chicken breed.

MATERIALS AND METHODS

The experiment was conducted at the Teaching and Research Farm, Federal University of Agriculture Abeokuta (FUNAAB), Alabata, Ogun State, which is located within the rain forest zone of South Western Nigeria. The climate is humid with a mean annual rainfall of 1037 mm. The annual mean temperature and relative humidity are 34°C and 82%, respectively (Amujoyegbe *et al.,* 2008).

Egg collection and management

Hatching eggs (300 per strain) from two strains of exotic chickens (*IB* and NB) were collected from CHI, Ajanla Farm, Ibadan, and 300 hatching eggs from the Nigeria indigenous (NIC) normal feather chicken were collected from the Animal Breeding and Genetics Unit of the Federal University of Agriculture, Abeokuta, Nigeria. The eggs were stored for three days in the cold room at the temperature of 18°C prior to setting in the incubator. Before setting, the eggs were fumigated in the fumigation chamber for five (5) minutes using formaldehyde (40%)

and potassium permanganate crystals at a ratio of 2:1.

Incubation

The hatching eggs from each strain were replicated twice at 150 eggs per replicate. The eggs were numbered for identification and set within the same incubator. The eggs were positioned in the setting crates with broad end up to ensure ease of gas exchange (CO_2 and O_2) between the eggs and the environment.

Incubation Protocol

Single Stage Western® Incubator (Shandong, China) was used for setting of the eggs at a temperature of $37.8^{\circ}C$ and 60% relative humidity (R.H) with oxygen concentration of 20%. At Day 19, R.H. was increased to 70%, and towards day 21 or when the chicks were likely to be hatched, R.H. was reduced to 60%. This was to allow the chicks to dry off before being taken out of the hatcher.

Turning of eggs was automatically done by the incubator at an angle of 90^{0} hourly until embryonic day (ED) 18. Turning ensures even distribution of nutrients and prevents adherent of embryo to eggshell. At ED 18, the eggs were candled in the dark room to remove unfertile eggs and the fertile eggs were transferred from setting crates to partitioned hatching trays.

Determination of Egg Quality Parameters

On the day of egg collection, the eggs from each strain were identified and weighed to ascertain the weight of the individual eggs. Ten eggs from each strain were randomly selected for breakout to take these measurements:

Egg weight, yolk weight and shell weight using Mettler top-loading weighing balance. The yolk and shell weights were subtracted from the corresponding egg weight to determine the albumen weight. Shell from the egg's equatorial region was used to measure shell thickness to 0.01 mm with the aid of micrometer screw gauge. Albumen height was measured using a spherometer to determine the Haugh unit of the individual eggs.

Haugh Units: Individual Haugh Unit (HU) score was calculated using the egg weight and albumen height (Haugh, 1937). The Haugh Unit value was calculated for individual eggs using the following formula:

$$HU = 100 \log_{10} (H + 7.5 - 1.7W^{0.37})$$

where:, H = Observed height of the albumen in mm, W = Weight of egg in grams

Determination of Incubation Phase Parameters

Twenty eggs per strain were randomly selected for breakout at ED7, 11, 15, and 18 of incubation to collect data on the following: Egg weight (to determine egg weight loss during incubation) and eggshell weight to determine the shell weight loss. The same weighing balance used in egg quality parameters was also used.

Determination of Unfertile Eggs, Embryo Weight and Embryo Mortality

At the egg breakout, the developing embryo was carefully separated from the thick

albumen and yolk. The embryo was weighed using a Mettler top-loading weighing. Unfertile egg, dead-in-germ (DIG) and dead-in-shell (DIS) embryos were examined on the days of breakout. After candling, the eggs that were not transferred to the hatcher at Day 18 of incubation and unhatched eggs were also broken to examine the unfertile eggs, DIG and DIS embryos.

Experimental Design

The experiment was a Completely Randomized Design (CRD). The model is shown below:

Model:
$Y_{ij} = \mu + T_i + \Sigma_{ij}$
Y_{ij} = Observed value of dependent variable
μ = Population mean
T_i = Effect of Ith strains of chicken
Σ_{ij} = Residual error

Statistical Analysis

All the data collected were analysed using the General Linear Model procedure of SAS (1999). Significantly different means were compared using Duncan Multiple Range Test (DMRT) (Duncan, 1955).

RESULTS

Comparison of the Egg Quality Parameters among Three Strains of Chicken

Effects of strains on egg parameters are shown in Table 1. Strain had significant effects (P < 0.05) on egg weight, shell weight, yolk weight, albumen weight and

Haugh unit. Eggshell thickness and albumen height were not significantly affected by strain. NB and IB were found to be similar in egg weight, yolk weight, albumen weight and percentage albumen weight, but greater compared to NIC. The shell weight of the *IB* was heavier compared to NIC, while NIC and IB showed greater values than NB strain for % shell weight. Whereas the NIC showed greater Haugh unit and percentage yolk weight compared to the other strains, *IB, which* showed intermediate value for percentage yolk weight.

The eggshell weight during incubation as affected by strain is presented in Table 2. Strain did not significantly (P>0.05) affect shell weight at ED (Embryonic Day) 7, 11, and 18. At ED15, shell weights differed significantly among the strains. At ED15, the *IB* egg shell weight was significantly higher than that of NIC, but similar to that of NB. However, the NIC egg shared similar eggshell weight with NB at ED15 of incubation. Strain significantly affected (P < 0.05) the shell weight as the percentage of egg weight from Day 0 to ED15, with the exception at ED18 where they were similar. Shell weight loss was higher in the eggs of the IB strain chicken compared to the egg of NB and NIC, while the eggs of NB had the lowest shell weight loss.

Comparison of Egg Weight Loss during Incubation

Table 3 shows the comparison of egg weight loss (%) during incubation. Strain showed significant (P <0.05) effect on weight loss at ED7 of incubation but not on other days

of measurements. At ED7, the NB showed a significant higher weight loss compared to that of the *IB* but the weight loss was similar to that of the eggs of the NIC. Weight loss by the NIC eggs was also similar (P>0.05) to that of the *IB* eggs during incubation. In effect, weight loss by the NIC eggs was intermediate between the NB and *IB* eggs. At ED18, egg weight loss was similar among the three strains.

Comparison of Egg Weight at Setting, Egg Weight and Embryo Weight during Incubation

Egg weight at setting, egg weight and embryo weight at different incubation periods for each of the three strains are shown in Table 4. At ED 7 and 15 of incubation, egg weights of NB and IB were significantly (P< 0.05) higher compared to NIC. The NB strain had greater (P< 0.05) egg weight than IB and NIC at ED11 and 18. NIC had similar weight with IB. As incubation days advanced, strain did not show significant (P>0.05) effect on embryo weights except on ED 18 of the embryo development, where NB had significantly (P< 0.05) higher embryo weight than the two other strains.

Comparison of Embryo Weight as the Percentage of Egg Weight (%) during Incubation

The embryo weight as the percentage of egg weight affected by strain is shown in Table 5. At ED7 and 18, there were significant differences (P < 0.05) in the embryo weight relative to the egg weight

between the strains. At ED 7, this observation was higher in NIC than those of IB and NB, while IB and NB were similar. Moreover, at ED18, the embryo weight as the percentage of egg weight was significantly higher in NIC than that of IB but similar to that of NB. However, there were no significant effects (P>0.05) of strain on the embryo weight as the percentage of egg weight at ED11 and 15.

DISCUSSION

In this study, strain was found to have significant effects on the absolute shell weight, percentage shell weight, absolute yolk weight, percentage yolk weight, absolute albumen weight, percentage albumen weight and the Haugh unit values. There were no significant effects of strain on the eggshell thickness and albumen height. Absolute yolk and albumen weights, with the exception of the absolute shell weight of these different strains of chicken, were directly proportional to the egg weights. This has previously been observed by Marion *et al*. (1964) who reported significant differences in egg weights among the lines of White Leghorns and that both egg yolk and shell weights were directly proportional to egg weight. The higher egg weights in the NB and IB strains of chicken when compared to that of NIC could be attributed to strain effects. The similarity in the eggshell thickness of these strains showed their similar ability to withstand losses due to cracks. In a corresponding study, smaller eggs had stronger shells than larger ones, as hens have a finite capacity to

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TABLE 1
Comparison of the egg quality parameters among the three strains of chicken

Strain	N	Egg weight (g)	Eggshell thickness (mm)	Shell weight (g)	%Shell weight □	Yolk weight (g)	%Yolk weight □	Albumen weight (g)	%Albumen weight □	Albumen height (mm)	Haugh unit
NIC	10	48.82±3.54[b]	0.43±0.09	5.05±0.53[b]	10.37±1.03[a]	14.00±1.21[b]	28.74±2.31[a]	29.69±2.80[b]	60.74±1.77[b]	5.14±0.52	71.78±3.06[a]
NB	10	63.98±8.66[a]	0.36±0.03	5.09±0.63[b]	8.04±1.12[b]	16.41±1.59[a]	25.87±2.48[b]	42.48±7.40[a]	66.09±3.26[a]	4.50±1.30	53.23±4.41[b]
IB	10	63.47±6.07[a]	0.42±0.06	6.02±0.90[a]	9.55±1.55[a]	16.78±1.58[a]	26.55±2.42[ab]	40.67±5.30[a]	63.91±3.27[a]	4.59±1.08	52.36±5.73[b]

[a,b] Means(±SD) within a column with different superscripts differ significantly (P < 0.05).
N=Number of observations; □=As percentage of egg weight

TABLE 2
Comparison of the eggshell weight, %shell weight and shell weight loss during incubation

Strain	N	(ED0) Sw	(ED0) %sw □	(ED7) Sw	(ED7) %sw □	(ED11) Sw	(ED11) %sw □	(ED15) Sw	(ED15) %sw □	(ED18) Sw	(ED18) %sw □	(ED0-ED18) Swl(%)
NIC	10	5.05±0.53[b]	10.37±1.03[a]	5.24±0.59	11.00±0.7[a]	5.58±0.98	11.55±1.58[a]	5.04±0.52[b]	10.69±1.17[a]	4.54±0.73[a]	10.84±2.02	10.09±0.03[b]
NB	10	5.09±0.63[b]	9.55±1.12[a]	4.96±0.57	8.75±0.60[c]	5.04±0.69	8.78±0.93[b]	5.30±0.63[ab]	9.49±0.75[b]	4.95±0.67	9.48±0.81	2.75±0.04[c]
IB	10	6.02±0.90[a]	8.04±1.55[b]	5.64±0.94	9.95±1.25[b]	5.86±0.62	10.92±1.08[a]	5.68±0.52[a]	10.70±0.6[a]	5.19±0.71	10.54±1.11	15.99±0.14[a]

[a,b] Means(±SD) within a column with different superscripts differ significantly (P < 0.05).
N=Number of observations; ED0= day0; Sw= Shell weight; Swl%=Shell weight loss %; □= As the percentage of egg weight; ED= Embryonic day

TABLE 3
Comparison of egg weight loss (%) during incubation

Strain	N	ED 7	ED 11	ED 15	ED 18
NIC	10	4.69±1.36[ab]	7.76±2.57	10.89±5.90	12.15±2.72
NB	10	6.12±2.29[a]	9.26±1.72	13.71±3.62	16.09±5.10
IB	10	4.16±1.21[b]	8.57±2.73	11.26±2.47	15.64±4.44

[a,b] Means(±SD) within a column with different superscripts differ significantly (P < 0.05).
ED=Embryonic day; N=Number of observations

TABLE 4
Comparison of egg weight at setting, egg weight and embryo weight during incubation

Strain	ED7			ED11		ED15		ED18	
	Ews	Ew	Emw	Ew	Emw	Ew	Emw	Ew	Emw
NIC	48.82±3.54[b]	47.56±0.12[b]	0.77±0.12	48.27±4.27[b]	3.52±0.25	47.35±4.02[b]	11.41±1.45	42.71±7.25[b]	21.07±3.30[ab]
NB	63.98±8.66[a]	56.67±0.09[a]	0.67±0.10	57.62±7.95[a]	3.82±0.45	55.96±6.24[a]	11.76±2.54	52.24±5.99[a]	23.94±2.16[a]
IB	63.47±6.07[a]	56.63±0.27[a]	0.63±0.27	53.93±5.58[ab]	3.60±0.38	53.04±2.42[a]	11.57±0.59	49.28±5.20[ab]	20.27±2.76[b]

[a,b] Means(±SD) within a column with different superscripts differ significantly ($P < 0.05$).

N=Number of observations; Ews=Egg weight at setting; Ew=Egg weight; Emw=Embryo weight

TABLE 5
Comparison of embryo weight as the percentage of egg weight (%) during incubation

Strain	N	ED7	ED11	ED15	ED18
NIC	10	1.63±0.25[a]	7.36±0.96	24.18±3.17	49.93±7.66[a]
NB	10	1.18±0.10[b]	6.75±1.22	21.00±4.07	46.18±5.01[ab]
IB	10	1.10±0.43[b]	6.78±1.24	21.87±1.69	41.71±8.21[b]

[a,b] Means(±SD) within a column with different superscripts differ significantly ($P < 0.05$).

N=Number of observations

deposit calcium in the shell, and as a result, the same amount of calcium is spread over a larger area (Butcher & Miles, 2003).

In the present study, the local strain of chicken (NIC) had the lowest egg weight compared to NB and IB , but had similar eggshell weight with the NB strain, with the exception of the IB strains. Contrary to this finding, a report by Silversides *et al.* (2006) described the effect of strain on shell quality of layer chickens, with the largest strains producing the heaviest eggshells and the lightest strains producing the smallest eggs with lighter eggshell weights. Although the mean shell weights obtained in this study were slightly higher than that by Oguike and Onykweodiri (1999) for Yaffa and Issa Brown layers, those of NIC and NB were similar to what Fayeye *et al.* (2005) had observed in the egg traits of the Fulani-ecotype chickens, but lower than that of the egg of the IB strain. The higher percentage in the shell weight of the eggs of the NIC and IB strains chicken than that of the NB strain chicken suggested that they had more mineralization (calcium,Ca and P, phosphorus) deposit that could be ushered into skeletal development than that of NB strain. Pageze *et al.* (1996) reported that chicken embryos source Ca in the shell for mineralization during skeletal development. Calcium so recovered not only mineralize a developing skeleton previously cartilaginous, it also calcifies yolk sac spheres (Roufosse, 1979).

The egg of the NIC had higher percent yolk weight than that of the NB and IB chicken. The dissimilarity noticed in the weights of the yolk and percent yolk weight before incubation might be influenced by strain (Wolanski *et al.,* 2007). The dissimilarity in the yolk weights before setting might have been altered at Day 18 (after incubation) by the effect of different egg component reduction causes (evaporation and metabolism) in the incubator. The similar albumen height in these strains suggests that these strains had similar limitation in gas diffusion, nutrient availability, and embryonic growth (Peebles *et al.,* 2000). Peebles *et al.* (2000) reported that thick albumen might slow gas diffusion, limit nutrient availability, and thus decrease embryonic growth. The higher percentage albumen weights of the eggs of NB and IB strains over NIC probably afforded the exotic strains' ability of providing more protein for assimilation into tissue than the NIC during embryonic development. Romanof and Romanof (1949) reported that albumen contains approximately 67% of the protein content of the egg and increased in mass more acutely than the total mass of the egg. It was observed that the eggs from the NIC had higher Haugh unit than the eggs of the NB and IB strains that had similar Haugh unit. It is generally accepted that the higher the Haugh unit value, the better the quality of the egg albumen (Curtis *et al.,* 2005). A negative relationship was reported between egg weight and Haugh unit (Kinney, 1970). In contrast, Emsley *et al.* (1997) demonstrated that heavy eggs had higher Haugh unit. However, the result of this study is in agreement with the report by Kinney *et al.* (1970).

The results of the percent shell weight from Day 0 until ED18 suggested the influence of genetic variation at different phases of embryonic development. During incubation, the reduction in the eggshell weights between ED0 and ED18 indicated that some calcium components might have been synthesised into providing skeletal development in the developing embryos (Pageze *et al*., 1996). This result might suggest that the embryo of the IB strain might have converted more calcium component to skeletal formation than the embryos of the NIC and NB strains, respectively. Although the eggs of the NB and IB strain chickens were heavier than that of the NIC, they did not show any effect on egg weight losses (which were the same for all the strains) except at ED7.. The similarity observed on the overall egg weight losses at Day 18 of incubation might suggest that the three egg categories used for the study had similar proportion of pore area or pore diameter regardless of the egg size (Abiola *et al*., 2008). Deeming (1995) indicated that eggs that lost less than 10% or over 20% of their initial weight were less likely to hatch. The author attributed this to a reflection of functional porosity of the shell and the initial mass of each egg.

Although the embryo weights were similar up to ED15, the embryo's relative weight to the egg weight of the NIC showed superiority in the embryo development compared to the embryos of the NB and IB strains at ED7 and 18.

The disparity in the embryo weights at Day 18 did not agree with the pattern of the differences in the initial egg size and hatch weight. Although the embryo weight of NIC at Day 18 did not agree with its initial egg weight, it had an intermediate value. This could be linked to the finding of Peebles *et al.* (2000) who reported that albumen height may be a factor in determining dry matter (DM) accumulation of chicken embryos. Wolanski *et al.* (2006) also reported that a great deal of variation exists in the conversion of egg contents into chick body mass among strains. This was shown from ED0 to 7 and ED11 to 15 where NIC had lower reduction rate of albumen than the two other strains, but similar embryo weight as other strains. The results of the embryo weight during incubation showed that the embryo of the NIC had higher conversion rate of albumen than those of the IB and NB strains at ED7 and 15. The IB strain had higher conversion rate at ED11 than the two other strains, while NB strain had an intermediate conversion rate at ED7, 11, and 15. Overall, these findings suggested that different strains may have different growth trajectory at different periods during embryonic development.

The difference observed in hatch weight may have been influenced by initial egg weight, as supported by Yannakopoulos and Tserveni-Gousi (1987). The higher hatch (day-old chick) weight observed in NB and IB strains than the NIC at hatch could be attributed to the differences in yolk content retention of different strains at hatch (Wolanski *et al.,* 2006). These authors suggested that some chicken strains utilised yolk reserves more efficiently than

others when incubated with a common incubation profile. However, the NB and IB strain embryos had a better development than that of NIC from Day 18 of embryo development to Day 21 (hatching day). This was observed in the hatch weights recorded. It was therefore suggested that multi-stage incubator be used between days 18 and 21 of incubation to ascertain the cause(s) of this dispersion in growth of the embryos at these stages of incubation.

Arising from the results of this study, using the currently used incubation protocols under a south-western Nigerian condition, it can be concluded that the reduction in the eggshell weights until ED18 suggested that some calcium components had been ushered into providing skeletal development in the developing embryos. The similarity observed on the overall egg weight losses at ED18 of incubation suggests that the three egg categories used for the study had similar proportion of pore area or pore diameter regardless of the egg size. The weight differences of the embryos at ED18 suggest ed the influence of genetic differences. Based on the findings from this study, it can be concluded that the incubation protocol used for the exotic strains of chicken is adequate for the Nigerian indigenous chickens.

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