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Breed differences in growth parameters of broiler chickens

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Target Audience: *Livestock Experts, Poultry Farmers, Animal Scientist and Poultry Breeders*

Abstract

Broilers been essentially a meat type of chicken, coupled with its fast growth rate has been evaluated for factors that may affect its growth, which include but not limited to sex, breed and feeding. This study was carried out to evaluate breed differences in growth parameters of four different broiler breeds. The experimental units were derived from four commercial broiler breeds namely Arbor Acre®, Cobb®, Marshall® and Ross®. Each breed had 76 chicks totaling 304 across the four breeds. On arrival, each chick was tagged using a coloured leg tag, by breed and identification number, and the initial weight of the chicks were taken. Each of the breeds were thereafter randomly selected and assigned to four experimental plots as replicates of the same treatment, ensuring that each replicate had exact number of birds per breed. The broiler birds were reared for a period of 10 weeks and their weight taken and recorded at weekly intervals. All statistical analyses were conducted using boxplot, descriptive and general linear models of Minitab® 17. At the end of the experiment and after exploratory analysis to check for normality and outliers, a total of 217 birds were used in the final analyses. Except for the Marshall breed that had a highly significantly (P<0.01) lower initial weight, final weight, total weight gain and average daily gain, the other three breeds had fairly similar weight. However, there was no significant (P>0.05) difference in mean initial weight across the four replicates. While breed alone accounted for 37.81% of the total variation in initial weight, it only accounted for 30.31%, 30.07% and 30.07% respectively for final weight, total weight gain and average daily gain. The effect of breed on initial weight, total weight gain and average daily gain was only significant (P<0.01) in Marshall, while the other three breeds were not statistically different (P>0.05). It can be deduced from this study that performance in terms of growth parameters for most of the commercially available breeds studied are similar with the exception of Marshall breed which had significantly (P<0.05) lowest values.

Keywords: *Broiler Chicken, breed, growth, Meat*

Description of Problem

Human consumption trends have driven unprecedented changes to the earth's biosphere, where populations of wild animal groups have declined in recent decades [1], while human and livestock populations have risen. [2, 3]. This then call for concerted efforts at producing sufficient food to ensure food security for the teeming population of humans, by ensuring that animals with shorter generation interval are reared to meet the daily animal protein intake requirement.

The significance of animal protein remains undisputed whereby animal protein supply man with high quality nourishment which aids growth, development and tissue replacement. The poultry industry has over the years played an important role in meeting the shortage of animal protein demand [4] through the increased availability of eggs and meat in Nigeria, where the highest net protein utilization of 87% has been recorded with poultry eggs globally. Poultry accounted for about 15% of the total annual protein intake

with an estimated average of 1.3kg per head of poultry products consumed annually in Nigeria [5].

Chicken meat consumption is growing faster than any other meat type and is soon to outpace pork. Its expanding consumption in developing and developed countries is driving the trend, as poultry production, particularly broiler production is the quickest way to increase the availability of high quality protein for human consumption [6, 7]. The significance of broiler production in Nigeria cannot be over emphasized, as it plays a very important role in supply of protein for human's consumption. The broiler industry has undergone tremendous development over the years in terms of genetics, breeding and evolution of different breeds for commercial purposes, where they grow within short time to give quality meat [8, 9, 10]. There has been intense genetic selection for economically important traits such as body weight, growth rate, feed efficiency, and ultimately traits associated with carcass-processing characteristics, which have contributed to the increases in productivity and efficiency obtained in the broiler industry [11, 12, 13, 14, 15, 16, 17]. This led to the development of several industry standard breeds which are suited to different parts of the world yielding high quality meat [10]. Some of these breeds include Arbor Acres®, Marshall®, Hubbard®, Anak®, Cobb® and Ross®, among others [18]. Consequently, the body weight gain of the broiler strains has been markedly increased, as a result of improvement in breeding, genetics and nutrition technologies in broiler evolution and development by focusing generally on selection for growth rate, feed efficiency and carcass characteristics, and have been heavily selected for high juvenile growth rate, breast-meat yield and efficiency of feed conversion which consequently impact the final body weight of broilers [17, 19, 20].

Despite the tremendous progress made in broiler improvement with the use of genetics and improved nurturing for maximal expression of the potentials in advanced countries, the development of suitable strains of broiler chickens for the tropical environment is a research interest which has engaged the attention of a number of poultry geneticists and breeders for the past decades [21]. The genetic selection of broiler chicken breeds for superior growth rate has arguably been primary method for increasing productivity [22]. This study seek to evaluate the performance of the Marshall breed developed in India specifically for tropical environment along with other successfully established breeds of temperate origin in the Nigerian broiler market.

Therefore, the objective of this study was to assess differences in the growth performance of four commercial broiler breeds (Arbor Acre, Cobb, Marshal and Ross), bred under similar conditions, with intent to recommend the best breed(s) for productivity and maximal profitability to the farmers.

Materials and Methods

Experimental Site: The experiment was carried out at the Poultry Research Farm of the Lagos State University, Ojo, Lagos, Nigeria, situated at latitude 6° 27' 59.99" N and longitude 3° 10' 60.00" E in the humid tropics of south west Nigeria.

The Farm consists of a deep litter open floor plan with dimension of 15m x 15m where the animals were kept throughout the study, with an adjoining 3m x 3m space for brooding. Management practices on the farm is intensive with the birds given feed and water *ad libitum* throughout the period of the study. Management practices followed standard procedures for broiler breeding and management in line with breeders' recommendations, where birds were fed commercially compounded broiler feed with 3050 Kcal/Kg Metabolizable energy and 23%

Crude protein using the Hybrid Special Chicken Formula (3 in 1) Feeds. Routine medication and vaccination schedules were strictly adhered to. A deep litter housing system with wood shavings 2-3 inches high from the floor was used during brooding and entire rearing period. The litters were replaced with clean aseptic litter every 2 weeks to keep the birds free from microbial invasion and infections. Feeders and drinkers were provided at spatial interval to avoid crowding, thereby minimizing mortality due to stampeding and overcrowding. Mortality and other sundry records were kept on the farm.

Experimental Units: Four breeds of day old commercial broiler birds were obtained from Zartech Farms in Ibadan, Oyo State. On arrival, there were 76 chicks each for the Arbor Acres, Cobb, Marshall and Ross, all totalling 304 birds. The birds were all tagged using numbered coloured leg tags with identification number indicating their breed and serial number within the breed (A01 – A76, C01-C76, M01-M76 and R01-R76 respectively). The birds were subsequently weighed as soon as they are tagged and the initial weight at day old recorded immediately.

Experimental design: The birds were randomly assigned to each of the four replicates and were all subjected to the same environmental conditions. The floor was demarcated into four equal parts as replicates, with each part comprising randomly assigned 19 birds from each of the four breeds making a total of 76 birds in each replicate. A check on the average weight and variability within each replicate at the commencement of experiment indicated that there was no significant difference ($P>0.05$) in the initial weights across the four replicates to ensure that all four replicates are of comparable weight prior to experiment.

Data Collection: Body weight of the birds were taken on a weekly basis using a 0.00g Camry sensitive digital scale with a maximum weight of 10kg and recorded by their identification number over a period of 10 weeks. All the weekly weights along with the final weight of the birds were consistently recorded using the same digital scale with 0.00g sensitivity.

Data Handling and Statistical Analyses: All recorded data were entered in Microsoft Excel® worksheet. Aside from the weekly body weight measurements taken, other variables and indices such as final weight gain and average daily gain were computed from measured variables.

Final Weigh (FW) was computed as $FW = (Wt_f - Wt_0)$ and average weight gain (AWG) was derived as $AWG = \frac{(Wt_f - Wt_0)}{Length\ (Days)}$ where Wt_f is final weight and Wt_0 is initial weight.

All statistical analyses were done using the exploratory modules (boxplots, descriptive), analysis of variance and post-hoc tests of Minitab 17® statistical software [23].

Aside from birds lost due to mortality across the four breeds, some were also eliminated as outliers from the final analysis. and eventually the final sample size per breed included in the final analyses was Arbor Acre (48), Cobb (52), Marshall (61) and Ross (56), all totalling 217.

The statistical model describing the final analysis of variance is given as:

$$Y_{ijk} = \mu + \alpha_i + \beta_j + e_{ijk}$$

Where Y_{ijk} is the recorded measure or index on each bird

μ is the overall mean

α_i is the i^{th} effect of the breed (i = 4, Arbor acre, Cobb, Marshall, Ross),

β_j is the initial weight of the bird used as covariate

e_{ijk} is the residual error assumed to be normal, independent and random

Further post hoc test were done using the Tukey's Honestly Significant Difference (HSD) for multiple comparison procedure, after a significant ANOVA.

Results

Initial Weight: The initial weight amongst the four breeds were fairly consistent except for the Marshall breed that had significantly ($P<0.05$) lower weight at hatch (Table 1). Chick hatch weight ranged from 27.0g to 46.0g among the four breeds with mean initial weight as presented in Table 1. The coefficient of variation (CV) in weight at hatch was consistent among the four breeds with the Arbor Acre, Cobb, Marshall and Ross having CV of 8.36%, 8.10%, 8.53% and 8.41% respectively. The spread of the initial weight across the breeds were fairly normal for all breeds, except that the normal fit for the Marshall breed was distinctly lower than those of other breeds (Figure 1). Despite the breed differences in initial weight, randomization in selection of birds and assignment into different plots / replicates resulted in a fairly equal initial weight across the four replicates (Table 1).

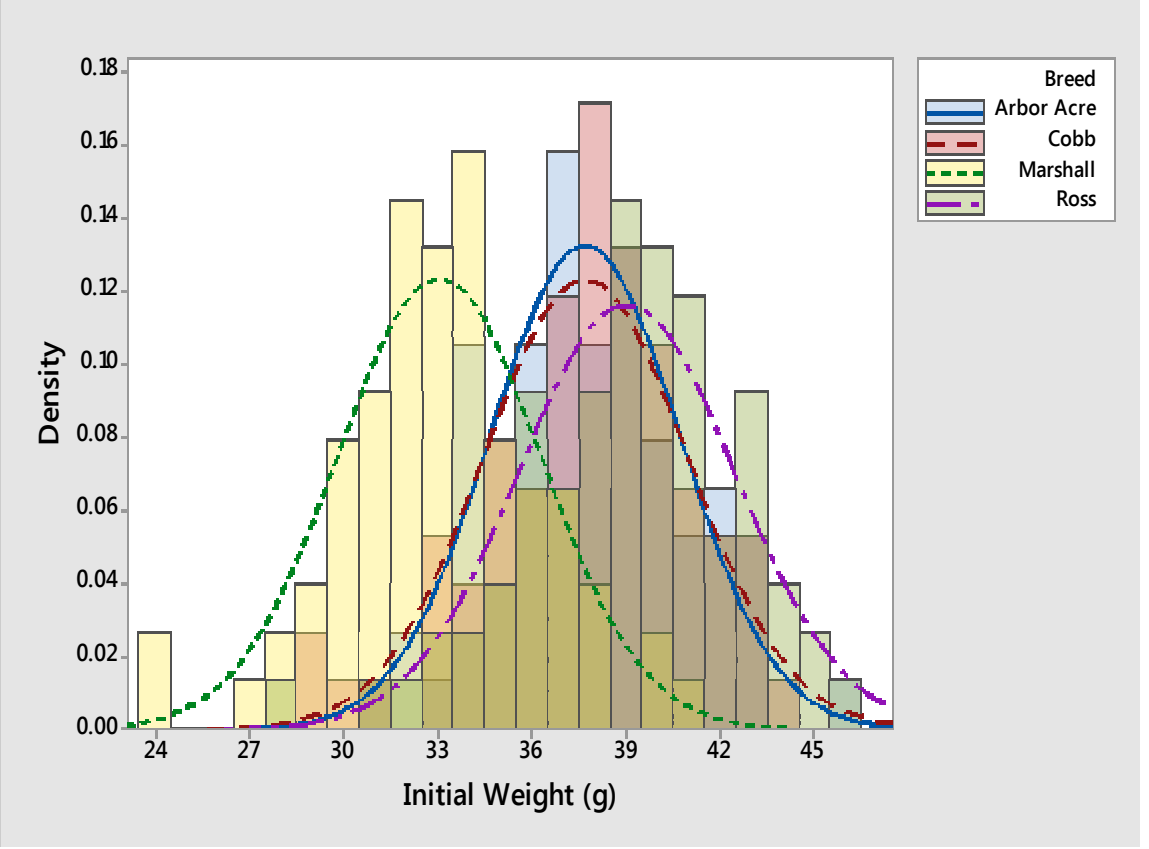

Figure 1: Histogram (with normal curve fit) of Initial Weight of Broiler chickens by Breed

Table 1: Mean ± Standard Error (SE) of Initial weight by breed and replicates

Variables	N	Initial Weight (g)
Breeds		
Arbor Acre	76	37.74±0.35[a]
Cobb	76	37.75±0.37[a]
Marshall	76	33.09±0.37[b]
Ross	76	39.05±0.39[a]
Overall	304	36.91±0.23
Replicates / plots		
A	76	36.54±4.19[a]
B	76	37.26±4.24[a]
C	76	37.20±3.30[a]
D	76	36.66±4.22[a]
Overall	304	36.91±0.23

Means with the same superscript within each column are not statistically different (P>0.05)

Final Weight: The weight of birds at tenth week is as presented in Table 2. The values ranged from 1239.0g to 4443.0g across the four breeds, with CV of 20.87%, 17.82%, 15.08% and 16.72% for Arbor Acre, Cobb, Marshall and Ross respectively. The overall mean weight at tenth week was 2852.9g, while the Marshall breed had the least recorded weight of 2325.7 which was significantly (P<0.05) lower than recorded values for the other breeds that had weight which were not statistically different (Table 2). The effect of breed on the final weight at 10 weeks was highly significant (P<0.01) as recorded in the one-way analysis of variance (Table 3). Breed alone accounted for 30.31% of the total variation observed on the measured trait and initial weight was not significant (P>0.05) on final weight.

Total Weight Gain: Breed of bird accounted for 30.07% of the variation in the total weight gain in birds (Table 3). Marshall breed had the least recorded value of 2935.8g total weight gain in the 10-week period under review (Table 2) which was significantly (P<0.05) than what was recorded for the other three breeds. The overall mean total weight gain across the four breeds 2815.9g and ranged from 1197.0g to 4408.0g in the four breeds. The least value of 2292.4g was obtained in the Marshall breed, reflective of the trend in the final weight analysis. The CV in total weight gain among the four breeds were 21.14%, 18.08%, 15.28% and 16.92% respectively for Arbor Acre, Cobb, Marshall and Ross.

Average Daily Gain: The effect of breed on average daily gain accounted for 30.07% of the total variation (Table 3). Marshall breed had significantly (P<0.05) lower average daily gain compared to other breeds, with a value of 32.75g (Table 2). The overall mean average daily gain was 40.23g, ranging between 17.10g and 62.97g among the four breeds. The coefficient of variation in average daily gain was similar to the values recorded in total weight gain. Marshall had the least average daily gain of 32.75g which was statistically (P<0.05) different from the recorded values of the other three breeds.

Discussion

Initial Weight: The distribution of initial weight at hatching was fairly uniform among three breeds (Arbor Acre, Cobb and Ross) with initial weight means not significantly (P>0.05) different, but that of Marshall was statistically

(P<0.05) different (Figure 1). This lack of difference in the initial weight of the three breeds may be due to the fact that the genetic base of most commercial breeds is the same and therefore the performance traits seldom differs among commercial breeds [24, 25]. The markedly different weight recorded in the Marshall breed can be attributed to the evolution of the breed, which is an admixture of genes of well-known high performing broiler breeds, with some indigenous Indian breeds well adapted to the harsh rearing conditions of developing tropical economies. This explains why the Marshall breed was 3.82g lower than the overall average of 36.91g recorded in initial weight across the four breeds and the only value below the overall mean. Breed effect alone accounted for almost one third (33.23%) of the total variation observed in initial weight. Although, there was no statistical difference in the initial weight of the other three breeds, the marginal superiority of the Ross is in agreement with reports of earlier researchers [26, 27, 28, 29, 30]. It is worthy of note that despite the lower initial weight of the Marshall breed, they were best suited to the humid tropical environment where the research was conducted and recorded the least mortalities throughout the period of the study.

Table 2: Mean ± Standard Error (SE) of final weight, total weight gain and average daily gain by breed

Breeds	N	Final Weight (g)	Total Weight Gain (g)	Average Daily Gain (g)
Arbor Acre	48	3103.4±93.5^{a}	3065.7±93.6^{a}	43.80±1.34^{a}
Cobb	52	3108.5±76.8^{a}	3070.3±77.0^{a}	43.86±1.10^{a}
Marshall	61	2325.7±44.9^{b}	2292.4±44.9^{b}	32.75±0.64^{b}
Ross	56	2975.2±66.5^{a}	2935.8±66.4^{a}	41.94±0.95^{a}
Overall	217	2852.9±41.5	2815.9±41.4	40.23±0.59

Means with different superscripts within each column are statistically different (P<0.05)

Table 3: Analysis of Variance of breed effect on Final weight, Total weight gain and Average daily gain

Source	df	Final Weight Mean Squares	Total Weight Gain Mean Squares	Average Daily Gain Mean Squares
Initial Weight	1	214532^{ns}	258465^{ns}	52.75^{ns}
Breed	3	6196547**	6196547**	1264.60**
Error	212	264845	264845	54.05
Eta Squared (%)		30.31	30.07	30.07

* = P < 0.05; ** = P < 0.01; *** = P < 0.001; ^{ns} = P > 0.05

Final Weight:

The Marshall breed had significantly (P<0.05) lower final weight in this study as reported in Table 2. The very similar values recorded in both the Arbor Acre and Cobb breeds in their initial weight also played out in the very close values recorded in their final weight. However, both breeds surpassed the Ross that had the highest initial weight at the beginning of the experiment. This marginal superiority of Cobb breed over other breeds is in consonance with earlier reports [20, 27, 28, 29] who indicated that Cobb broiler strain achieved heavier body weight and higher weight gain than the other strains. The Marshall breed was 527.2g, which is almost 18.5% lower than the overall average final weight across the four breeds. It is well

established in literature that the initial weight of broiler birds directly impacts their final weight. Having corrected for differences in initial weight of the breeds, which was not statistically significant (P>0.05) in the model for the analysis of final weight at the end of the research, it was observed that breed largely accounted for differences in total variation of final weight, with the Marshall breed having significantly (P<0.05) lower values than the other three breeds (Table 3). This corroborates earlier reports that the strain of the chicken affects its feed intake, digestibility, feed conversion ratio and growth rate at different ages [14, 19, 30, 31].

Total Weight Gain

The mean total weight gain recorded among the four breeds were consistent with the trend observed in the Final Weight analysis (Table 3). The Marshall breed gained 523.5g (18.60%) less than the overall average across the four breeds. Despite the fact that there was no statistical difference (P>0.05) in the total weight gain recorded for the Arbor Acre, Cobb and Ross, the Marshall breed evidently had the least recorded value on the same parameter and this difference due to breed accounted for 30.07% of the total variation observed (Table 3). This difference in performance of Marshall breed can be explained by the evolution of the breed compared to other popular commercial lines, which were selected from high producing lines. This observation is in consonance with reports that most of the commercial strains of broilers evolved from the same origin and as such effects of the different breeds due to their genetic make-up alone could not solely be advanced for differences in their performances. It has been reported that studies on genetic improvement brought expressive impacts on the production systems for development of breeds compatible to the highly competitive requirements in the productive, industrial and consumer markets [26]. However other researchers reported that there was no significant difference due to breed or strain in average daily feed intake, average daily weight gain and efficiency of feed utilization [15, 17]. However, the marginal superiority of the Cobb breed confirms earlier reports of those who worked on different breeds and indicated that Cobb broiler strain achieved heavier body weight and higher weight gain than the other strains [20, 27, 28, 29, 30].

Average Daily Gain

Average daily gain in this study was very similar to the total weight gain, where breed accounted for 30.07% of total variation observed (Table 3). Although the Marshall breed recorded the least average daily gain (Table 2) throughout the period of study, 7.48g lower than the overall mean among the four breeds. It is however noteworthy that Marshall had the least variation (CV = 15.28%) within breed when compared to other breeds. The other three breeds (Arbor Acre, Cobb and Ross) all had mean average daily gain greater than the overall mean value. This invariably classified the breeds into two broad clusters where Arbor Acre, Cobb and Ross are in one cluster and Marshall consistently was in the other cluster, considering all the growth parameters studied. The observation in this study confirmed earlier reports [15, 17, 20].

Conclusion and Applications

The following conclusions can be deduced from this study and recommendations based on the observations:

1. The business of broiler production promises to be lucrative if it is properly managed due to the fact that net return on investment in this project was profitable.
2. Most commercial breeds of broilers currently available in the country have very similar productivity potentials but

only differs in their adaptation to the prevailing tropical environment as recorded by differences in mortality where the Marshall breed had the least.

3. Arbor Acre, Cobb and Ross breeds outperform Marshall breed on all productivity parameters studied.
4. The Marshall breed recorded better flock uniformity in all parameters investigated, compared to the other three breeds.
5. The Marshall breed stabilized within the first three weeks, without recording any mortality thereafter.
6. Despite the lower performance of the Marshall breed in the parameters studied, it has potential for better profit yield considering its livability advantage over the other three breeds.

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