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Influence of Sexual Dimorphism on Genetic Parameters of Arbor Acre Chicken

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Abstract

The study was conducted to determine the extent of the effect of sexual dimorphism on the body weight and linear traits of Arbor Acre chickens. Hundred-day-old Arbor Acre broiler chicks comprising fifty-two males and forty-eight females were used in this study. Day-old birds were winged tagged and were given feed and water *ad libitum*. Bi-weekly body weight and linear body measurements, namely, wing length, shank length, thigh length, comb length, back length, breast girth and keel length were measured. In addition, the heritability and repeatability of the measured traits were estimated. The results showed that body weight increased as age increased with male chickens having the superior final weight at 8 weeks over their female counterpart. Among the linear body measurement, shank length increased at a rapid rate more than other linear body traits followed by the back length and keel length. The heritability and repeatability estimates ranged from moderate during the early growth phase to high during the later growth phase of 5 and 8 weeks. The study concludes that male Arbor Acre male chickens attained higher weight than the females after eight weeks of growth. Similarly, shank length and back length were good linear body measurements for predicting body weight for selection purposes.

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Introduction

In poultry production, like other animals, sexual dimorphism is a likely occurrence that creates a difference in the growth and development of male and female chickens of the same breeds [1]. Intensive research in the area of breeding and nutrition had a great impact on poultry production in recent times in the area of dimorphism through targeted traits of interest concerning variance components. In the domesticated chicken-like broiler, sexual dimorphism is seen in weight gain and some linear measurement traits, which can produce vast differences in body weight with great economic impact. The effect of sexual dimorphism on weight gain and other body traits has been reported in quail and rabbits [2]. The response to this phenotypic action of dimorphism is an important factor in animal improvement. The selection of better breeds or strains has gone a long way in producing a rapid transformation in animal protein supply using some genetic parameters like breeding value, repeatability, heritability, and genetic and phenotypic correlations. Chen et al. [3] reported a positive genetic correlation between body weight at different ages, sex, and carcass traits, and suggested that direct selection for body weight at 38 and 42 days of age could produce an indirect genetic gain for breast muscle, leg and eviscerated body weight in both male and female chickens. They also reported that heritability estimates for body weight at different ages for the evaluation of genetic variability and considerable direct additive genetic effect seemed to exist in the expression of body composition traits.

Kabir et al. [4] reported that heritability and repeatability are very crucial for artificial selection which culminates in genetic improvement using appropriate breeding plans. In other words, the concept of heritability can alternately be expressed in terms of the proportion of the variation in given traits within a population that is not explained by the environment or random factors [5]. Heritability is an important concept in quantitative genetics, particularly in selective breeding and behavior genetics [6]. In the same vein, the concept of repeatability is key as it relates to the proportion of the total variance in multiple measurements of traits that are due to differences among individuals. Repeatability estimates are important tools for quantifying the transmitting ability of an animal to maintain its performance and ranking within a test group in subsequent generations [7, 8]. Adejoh-Ubani et al. [9] also stated that repeatability is the proportion of the phenotypic variance that is due to both the permanent genetic and environmental effects. This study was carried out to describe the weekly weight gain and linear traits of male and female chickens and to measure both the heritability and the repeatability of those traits using individual measurements.

Materials and Methods

Experimental site

The study was carried out at the Poultry Unit of the Teaching and Research farm of the Aquatech College of Agriculture and Technology, Ibadan. The area lies within the rain forest ecological zone and falls within longitude 7˚27` and latitude 3˚25` in the Ibadan, Southwest area of Oyo State, Southwest Nigeria. The farm is at an altitude of 200-300m above sea level with an annual rainfall of about 1250 mm. The temperature and relative humidity range from 30-35˚C and 76-84%, respectively.

Experimental birds and management

A total of one hundred (100) day-old Arbor Acre broiler chicks comprising fifty-two males and forty-eight females were used in this study. They were brooded with the aid of a guard to limit their movement and conserve heat. Charcoal was used as a source of heat for brooding. All vaccination schedules and management procedures were followed accordingly. The birds were vent-sex and winged tagged at day old for easy identification of males and females. The chicks were reared on deep litter pens with wood shavings as litter material. The chicks were fed broiler starter mash containing 24% crude protein from the day-old till 4 weeks of age and later changed to broiler finisher containing 20% crude protein till the end of the experiment. The chicks were fed *ad libitum* while water was provided freely. The experiment lasted for 56 days.

Data collection procedure

Bi-weekly body weight (g) of individual birds was measured using a weighing balance with an accuracy of 0.5g so also the linear body measurements (cm) were taken with the aid of a measuring tape. All measurements were carried out early in the morning before feeding. The following linear body measurements were taken:

wing length (WL), which was measured as the distance between the shoulder joint and the extremity of the terminal phalange; shank length (SL), which was measured from the tarsometatarsus from the hock joint to the metatarsal pad; thigh length (TL), which was taken as the length between the hock joint and the pelvic joint; comb length (CL), which was measured from one end to another at the joining site to the head; back length (BL), which was measured from the back of the neck region to the end of the tail region; breast girth (BG), which was measured as the circumference of the breast region; and keel length (KL), which was measured from the chest bone to the end of the abdomen region.

Data analysis

Data collected were subjected to one-way analysis of variance (ANOVA) using the general linear model (GLM) of SAS [10] to estimate variance components, which was later utilized in the estimation of heritability and repeatability of growth traits.

Results and Discussion

Body weight and linear body measurements at 2 weeks of age

Table 1 shows the mean body weight and linear body measurement of Arbor Acre chickens at 2 weeks. The results showed that male chickens have higher body weight at two weeks when compared to their female counterpart. The superiority of body weight recorded for male chickens in this study could be attributed partly to shank length because the female chicken had a higher length for most of the linear traits. The body weight obtained in this study for both male and female chickens was higher when compared to the report of Kabir et al. [4] using Anak broiler (191.63) and Ojo et al. [11] using Hubbard broiler chickens (204.40) at 2 weeks but it was lower in comparison to the report of Ojedapo [12] in Marshall broilers (374.78). The heritability was moderate for body weight and linear body traits. The results of the heritability gave an indication that these traits are slightly influenced by environmental factors. The highest repeatability was recorded in male chickens for body weight and comb length. The moderate repeatability value recorded in body traits of both male and female chickens in this study shows that Arbor Acre chickens can be effectively selected at 2 weeks and the selection can be based on keel length. However, high repeatability estimates of between 0.90 and 0.99 have been reported for body weight in broiler chickens reared in the tropics (4) at 2 weeks of age [11].

Body weight and linear body measurements at 4 weeks of age

Table 2 presents the mean body weight and linear body measurements for male and female Arbor Acre strains at 4 weeks. The results showed that female chickens had higher body weight and longer linear body measurements than their male counterpart. The body weight of Arbor Acre chickens increased exponentially with age given an average of 42% increase at 4 weeks when compared to weight recorded in 2 weeks. Ojo et al. [11] reported in their study that age is an indicator of growth and physiological development in Hubbard broiler chickens. The numerical advantage the female chicken had on the male chicken in weight and linear measurements is an indication that female chickens performed well during the early growth phase. Malik et al. [13] in their study reported higher estimates in male chickens for shank length than in female. The heritability estimates were higher in breast girth and keel length for female chickens while the shank length presented the highest the lowest value in male and female chickens, respectively.

Table 1 Body weight and linear body measurement of Arbor Acre chickens at 2 weeks of age.

Traits	Male	Heritability	Repeatability	Female	Heritability	Repeatability
Body weight	237.10 ±10.50	0.45 ±0.01	0.61 ±0.05	231.55 ±7.74	0.40 ±0.10	0.57 ±0.02
Wing length	10.20 ±0.17	0.48 ±0.03	0.48 ±0.00	10.28 ±0.17	0.41 ±0.07	0.48 ±0.02
Shank length	6.86 ±0.22	0.44 ±0.01	0.55 ±0.01	6.79 ±0.15	0.46 ±0.06	0.51 ±0.03
Thigh length	9.00 ±0.15	0.51 ±0.00	0.48 ±0.00	9.24 ±0.16	0.45 ±0.08	0.49 ±0.02
Comb length	1.28 ±0.04	0.50 ±0.07	0.56 ±0.01	1.31 ±0.03	0.47 ±0.11	0.52 ±0.04
Back length	9.80 ±0.24	0.56 ±0.10	0.51 ±0.01	9.93 ±0.16	0.47 ±0.05	0.48 ±0.02
Breast girth	1.84 ±0.44	0.49 ±0.11	0.43 ±0.00	1.80 ±0.34	0.44 ±0.09	0.57 ±0.10
Keel length	5.13 ±0.13	0.57 ±0.06	0.51 ±0.01	5.08 ±0.12	0.54 ±0.05	0.53 ±0.04

Note: value ± standard deviation

Table 2 Body weight and linear body measurement of Arbor Acre chickens at 4 weeks of age.

Traits	Male	Heritability	Repeatability	Female	Heritability	Repeatability
Body weight	545.23 ±26.93	0.55 ±0.01	0.74 ±0.08	569.92 ±26.41	0.58 ±0.03	0.74 ±0.10
Wing length	13.21 ±0.28	0.57 ±0.02	0.60 ±0.02	13.41 ±0.40	0.66 ±0.03	0.65 ±0.05
Shank length	12.43 ±0.97	0.50 ±0.02	0.68 ±0.05	13.67 ±0.25	0.71 ±0.03	0.50 ±0.09
Thigh length	14.20 ±0.15	0.52 ±0.02	0.60 ±0.07	14.96 ±0.99	0.53 ±0.02	0.52 ±0.01
Comb length	1.82 ±0.05	0.60 ±0.03	0.64 ±0.08	1.92 ±0.06	0.57 ±0.03	0.66 ±0.10
Back length	12.63 ±0.23	0.59 ±0.02	0.68 ±0.04	12.90 ±0.23	0.61 ±0.03	0.58 ±0.03
Breast girth	2.13 ±0.04	0.61 ±0.03	0.60 ±0.02	2.15 ±0.06	0.53 ±0.02	0.64 ±0.03
Keel length	9.33 ±1.11	0.61 ±0.03	0.62 ±0.03	9.49 ±1.10	0.49 ±0.02	0.62 ±0.03

Note: value ± standard deviation

Table 3 Body weight and linear body measurement of Arbor Acre chickens at 6 weeks of age.

Traits	Male	Heritability	Repeatability	Female	Heritability	Repeatability
Body weight	903.61 ±56.42	0.66 ±0.05	0.90 ±0.10	927.67 ±33.27	0.77 ±0.08	0.79 ±0.05
Wing length	16.33 ±1.14	0.68 ±0.08	0.67 ±0.07	16.36 ±0.21	0.75 ±0.08	0.67 ±0.06
Shank length	17.67 ±0.22	0.70 ±0.07	0.69 ±0.05	17.81 ±0.15	0.72 ±0.05	0.66 ±0.05
Thigh length	15.28 ±0.25	0.77 ±0.06	0.68 ±0.08	15.76 ±0.24	0.81 ±0.08	0.68 ±0.06
Comb length	2.4 ±0.10	0.59 ±0.04	0.80 ±0.10	2.25 ±0.06	0.64 ±0.04	0.74 ±0.06
Back length	14.66 ±0.63	0.55 ±0.07	0.81 ±0.07	15.48 ±0.18	0.59 ±0.04	0.66 ±0.05
Breast girth	3.77 ±0.08	0.67 ±0.01	0.74 ±0.07	3.44 ±0.07	0.57 ±0.04	0.66 ±0.05
Keel length	11.85 ±0.28	0.80 ±0.08	0.75 ±0.07	11.80 ±0.22	0.44 ±0.02	0.75 ±0.06

Note: value ± standard deviation

The repeatability estimates were moderate to fairly high in both female and male chickens. Amongst the linear body measurement, shank length and back length had the highest repeatability value in male chickens while the repeatability value was higher in comb length among the linear measurements in male chickens. The moderate to fairly high heritability and repeatability estimates obtained at 4 weeks for both sexes showed that environmental influence on these traits was reduced compared to the results obtained at 2 weeks of age. The heritability estimates obtained in this study were higher than what Sanda et al. [14] reported in their study. Kabir et al. [4] and Ubani et al. [15] reported moderate to high estimates of repeatability in linear body measurements in broiler chickens.

Body weight and linear body measurements at 6 weeks of age

Means body weight and linear body measurement of Arbor Acre strains at 6 weeks are presented in Table 3. From the results, it can be observed that the body weight of female chickens was higher at 6 weeks when compared with male chickens. Although there was a 30% increase in body weight at 6 weeks when compared to 4 weeks body weight, it was at a reducing rate. The 6 weeks body weight of female chickens was higher with about a 2.6% increase over the male counterpart. Meaning that age and sex is an important factor to be considered in body weight and linear body measurement in chickens. Malik et al. [13] on the contrary, reported higher weight gain in males than females at 6 weeks of age. In linear body measurements, male chickens had higher measurements of comb length, breast girth and keel length. It could be deduced from this study that wing length, shank length, thigh length and back length can be used in the selection for body weight. Ojo et al. [12] in Hubbard chickens concluded that Hubbard broilers could be effectively selected based on the breast girth. The heritability in male chickens ranged from moderate to high with the highest value recorded in keel length. However, in female chickens, keel length recorded the lowest heritability value while the highest value was gotten in thigh length. The repeatability of back length was highest in male chickens while female chickens recorded the highest value of keel length. The heritability value obtained in male chickens was moderate to high with the propensity for female chickens producing a better meat-to-bone ratio. The longer back length obtained in male chickens indicates that they could be selected over female chickens if the total weight is of the essence while female chickens could be the choice in the event of a more flesh-to-bone ratio. The magnitude of the repeatability estimate indicates the extent to which selection can affect

Table 4: Body weight and linear body measurement of Arbor Acre chickens at 8 weeks of age.

Traits	Male	Heritability	Repeatability	Female	Heritability	Repeatability
Body weight	1515.26 ±43.17	0.77 ±0.03	0.84 ±0.05	1441.44 ±65.60	0.89 ±0.08	0.93 ±0.04
Wing length	19.94 ±0.32	0.84 ±0.03	0.78 ±0.06	19.80 ±0.31	0.75 ±0.07	0.78 ±0.02
Shank length	20.22 ±0.37	0.87 ±0.03	0.81 ±0.07	20.52 ±0.19	0.57 ±0.06	0.76 ±0.03
Thigh length	18.64 ±0.29	0.66 ±0.06	0.77 ±0.07	18.08 ±0.20	0.58 ±0.08	0.76 ±0.05
Comb length	2.67 ±0.03	0.87 ±0.07	0.75 ±0.04	2.49 ±0.04	0.69 ±0.05	0.78 ±0.08
Back length	17.56 ±0.27	0.80 ±0.08	0.77 ±0.04	16.98 ±0.18	0.73 ±0.07	0.75 ±0.04
Breast girth	4.70 ±0.03	0.65 ±0.03	0.76 ±0.08	4.59 ±0.02	0.79 ±0.05	0.74 ±0.06
Keel length	13.78 ±0.28	0.69 ±0.03	0.81 ±0.05	12.76 ±0.18	0.79 ±0.07	0.78 ±0.04

Note: value ± standard deviation

subsequent flock performance.

Body weight and linear body measurements at 8 weeks of age

Table 4 presents the means of the mean of body weight and linear body measurements of Arbor Acre strains at 8 weeks of age. The table shows that male chickens had a superior weight at 8 weeks of age compared to their female counterpart, even though heritability for body weight was higher in female chickens than in male chickens. There was an increasing trend in weight gain but at a reducing rate from 2 weeks to 8 weeks. The body weight increased at an exponential rate at the initial stage and later at a reducing rate. The male chicken showed superiority at the 8 weeks by attaining 5.1% weight gain above the female chickens. Among the linear body measurements, male chickens showed the superior numerical values over the female chickens except in shank length. The heritability and repeatability among the linear body measurements were high with all the estimates ranging above 0.57. The highest heritability estimate was recorded in shank length and comb length for male chickens while the breast girth and keel length were highest for female chickens. The repeatability estimates in male chickens were highest in shank length and keel length while the female chickens recorded the highest estimates in wing length, comb length and keel length. The interaction of environment on the performance of both sexes is reduced as revealed by the higher value of repeatability and heritability obtained at this age. The high heritability and repeatability estimates among the linear body measurements recorded in this study at this age were in agreement with Kabir et al. [4] when they reported high repeatability estimates for body weight, neck length, thigh length and back length between 2-8 weeks in Anak broilers. Similar results were obtained by Sola-Ojo et al. [11] in their study when they concluded that moderate to high repeatability estimates were obtained for growth traits in Arbor Acre broiler chickens fed normal broiler diets.

Conclusions

Sexing should be done at the early age of the bird to be able to do specific rearing for specific purposes towards improved profitability. Female chickens should be reared more if 6 weeks of body weight is desired while male chickens should be considered for 8 weeks of rearing. Selection based on shank length and keel length, singly, may be useful in improving the overall body growth of an animal and such selection may be advocated when it is desired to alter the shape of animals and to shift the greater economic value.

Conflict of interest

The authors declare no conflict of interest.

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