

Growth rate, phenotypic correlation and repeatability estimates of body weight and linear body traits of Cobb and Arbor Acre broiler strains

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Abstract

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Correlation coefficients are useful tool in animal breeding as a means of predicting potential response. In this study, body weight (BW) and linear body traits records of Arbor Acre and Cobb broiler strains obtained at 3 – 8 weeks were used to compare the growth performance of the strains as well as estimate the phenotypic correlations (r_p) among BW and the linear body traits. Repeatability (R) values of BW and the linear body traits were estimated at weeks 3, 5 and 7. A total of 200 day old chicks, 100 each of Arbor Acre and Cobb were used for the study. The linear body traits considered were body length (BL), shank length (SL), chest circumference (CC), keel length (KL), wing length (WL) and drum stick length (DSL). Significant differences ($P < 0.05$) were observed between the strains for BW and the linear body traits at the various weeks. BW differed significantly at weeks 5, 6 and 7, which ranged from $1036.67 \pm 36.93 - 1736.67 \pm 46.41$ for Arbor Acre and $930.00 \pm 20.59 - 1563.33 \pm 33.26$ for Cobb. Arbor Acre showed significant ($P < 0.05$) superiority to Cobb in their linear body traits in most of the weeks. BW had high significant ($P < 0.05$; $P < 0.01$) positive r_p with the linear body traits, which ranged from 0.535 (KL) – 0.842 (BL) for Arbor Acre and 0.523 (SL) – 0.834 (BL) for Cobb. The r_p among the linear body traits in both Arbor Acre and Cobb were positive but ranged from moderate to high. The R estimate of BW of Arbor Acre and Cobb were all very highly repeatable at weeks 3, 5 and 7 ranging from 0.90 – 0.99. R values for the linear body traits ranged majorly from moderate $\{(0.31 - 0.67 \text{ and } 0.37 - 0.69)\}$ to high $\{(0.78 - 0.97) \text{ and } 0.97 \text{ and } (0.71 - 0.92)\}$ for Arbor Acre and Cobb, respectively across the weeks evaluated. The result of this study indicates that Arbor Acre could be a strain of choice for rearing in our study area owing to its superiority over Cobb in terms of growth performance. All the linear body traits measure were good estimators of BW in both strains as well as each other, implying that any phenotypic selection on one trait will lead to improvement of others. The high repeatability estimates of body weight and some of the linear traits indicate that fewer records would be required to adequately characterize the inherent growing ability of the birds at the various stages of growth.

Keywords: Growth rate, phenotypic correlation, repeatability, body weight, broiler, strain

Introduction

Recently, Nigeria has witnessed an upsurge in the population of meat type chickens arising from increased numbers of poultry farmers now owing broiler parent and grandparent stocks. These broiler strains are sold using various brand names. The parent stocks are imported strains from the

temperate regions of the world. The performance of these birds is thus, influenced by genotype x environment interactions. The implication is that farmers need to select the strains that are adaptable to the Nigeria environment with good performance (Udeh *et al.*, 2011). Yalcin *et al.* (1997) reported that the use of unsuitable

genotypes in hot regions resulted in decreased growth rate, reduced protein gain and high mortality.

In the poultry industry, growth has been marked as a priority and it is defined as a systematic increase in body mass during definite intervals of time according to the character of species (Chapman and Shaffer, 1996). Lilja *et al.* (1985) and Carborg *et al.* (2003) reported that differences in growth pattern are under genetic control and that variations exist among species. In poultry and livestock species, assessment of performance is usually done using various indices, most especially on development as well as body conformational traits. These traits provide evidences for growth, reflecting the breed standards (Riva *et al.*, 2004). Correlation coefficients are useful in animal breeding as a means of predicting potential response to, or progress from selection (Ige, 2013). According to Assan (2015), positive genetic and phenotypic correlations indicate that improvement in body measurements both at the genetic and phenotypic levels is expected through selection. Repeatability is a measure of an individual's ability to repeat its performance and maintain its ranking in a population of successive records (Ibe, 1995). High repeatability estimates indicate that body measurements can be the basis for selection within populations and that fewer records are needed to ascertain the potential of animals and to realize a high expected response from selection. Therefore, these indices are indispensable in the selection of animals for genetic improvement.

The objectives of this study were to compare the growth traits of Cobb and Arbor Acre broiler strains reared in humid tropics and to estimate phenotypic correlations and repeatability coefficients of the growth traits in the two strains.

Materials and methods

Experimental location

The research was conducted at the Poultry Unit of the Teaching and Research farm of the Michael Okpara University of Agriculture, Umudike located within latitude 05°29' North and longitude 07°33' East of the rain forest zone. The site is about 122 meters above sea level and characterized by annual rainfall of about 2177mm, over a period of 8 to 9 months and short period of dry season. Depending on the season of the year, relative humidity ranges from 50 to 90 %. The ambient temperature of the zone ranges from 18°C-26°C during the rainy season (April – November) and 26°C - 38°C in the dry season (December – March). The meteorological data were gotten from the Meteorological Station of the National Root Crops Research Institute, Umudike, Abia State.

Brooding and stock management

A total of 200 day old chicks, consisting of 100 each of Cobb and Arbor Acre were purchased from a reputable farm in Ibadan. The birds were brooded in an environmentally controlled brooder house for two weeks, after which they were transferred to deep litter pens, each strain having five replicates with 20 birds per replicate. The floor of the pens were covered with wood shaving and kept dry by replacing any wet litter when necessary. The birds were routinely vaccinated and other medications carried out as at when due. The birds were fed starter and finisher diets comprising 22.95 %CP, 2945.00 Kcal/kgME and 20.80 %CP, 3050.00 Kcal/kgME, respectively. Feed and water were given *ad libitum*. The experiment lasted for 8 weeks (56 days).

Data collection and statistical analysis

Body weight and the following linear body

traits were measured on each strain from 3 to 8 weeks of age. Body weight (g) was taken using a weighing balance to the nearest 0.01 gram at weekly intervals. Body length (cm) was measured as the length of the body from the bill to the tail near the uropygial oil gland. Chest circumference (cm) was measured as the circumference of the body under the wing through the anterior border of the breast crest and central thoracic vertebrae. Wing length (cm) was measured as the distance from the shoulder joint to the extremity of the terminal phalange. Shank length (cm) was measured as the distance from the hock joint to the extremity of the metatarsal pad. Drum stick length (cm) was measured as length of the femur bone while Keel length (cm) was measured as the length of the cartilaginous keel bone, from the v-joint to the end of the sternum. Data collected were analyzed using independent student's t-test of SAS (2004) analytical package and significant differences were determined at $p = 0.05$.

Phenotypic correlations among body weight and linear body parameters for each broiler strain at the different weeks were ascertained with Pearson's Product Moment Correlation Coefficients (r) using same SAS (2004) software. The model for the correlation is as shown:

$$r = \frac{\sum X_i Y_i}{\sqrt{\sum X_i^2 \sum Y_i^2}}$$

where,

r = Pearson's correlation

X_i = first random variable of the i^{th} body weight or linear body trait.

Y_i = second random variable of the i^{th} body weight or linear body trait.

Data collected were also subjected to a one way analysis of variance procedure. The model of analysis was of the form:

$$Y_{ij} = \mu + P_i + I_j + e_{ij}$$

where,

Y_{ij} = record of the j^{th} individual in the i^{th} measurement period.

P_i = fixed effect of the i^{th} period of measurement.

I_j = random effect of the j^{th} individual.

e_{ij} = random effect.

The variance components were determined from the mean square expectation of the ANOVA Repeatability (R) was estimated from the variances for weeks 3, 5 and 7 using the method of Becker (1984).

$$R = \frac{\delta_B^2}{\delta_B^2 + \delta_W^2}$$

where,

δ_B^2 = Individual birds' variance component.

δ_W^2 = Variance due to error.

The standard errors of the estimates were calculated using the formula described by Becker (1984).

$$SE = \sqrt{2(1 - R^2)(1 + (K - 1)R)^2 / K(K - 1)(n - 1)}$$

where,

K = number of measurement,

n = number of birds,

r = repeatability

Results and discussion

The mean and standard errors of body weight and linear body traits of Cobb and Arbor Acre broiler strains are presented in Table 1. Significant ($p < 0.05$) differences were observed between the strains for the parameters measured at the various weeks. Body weight differed significantly in weeks 5, 6 and 7. BL varied significantly at 5 and 8 weeks, SL at 5 and 6 weeks, CC at 3, 5 and 8 weeks, KL at 3, 4, 6, 7 and 8 weeks, WL at 3, 4 and 5 weeks and DSL at 7 and 8 weeks. In all these, Arbor Acre strain was significantly ($p < 0.05$) superior to the Cobb strain. The result of this study agrees with the report of earlier researchers who observed significant strain differences in body weight and linear body traits of broiler chickens (Olawumi *et al.*, 2012; Yahaya *et*

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Table 1: Mean±SE of body weight and linear body traits of Cobb and Arbor Acre strains from 3 – 8 weeks of age

Week	Strain	Trait	3	4	5	6	7	8
Cobb	BW (g)		266.67 ±5.99	666.67 ±5.99	930.00 ±20.59 ^b	1310.00 ±24.98 ^b	1563.33 ±33.26 ^b	1920.00 ±60.32
		BL (cm)	13.15±0.25	14.79±0.10	16.65±0.17 ^b	19.60±0.33	20.53±0.32 ^b	21.57±0.25
		SL (cm)	4.17±0.07	4.91±0.08	5.55±0.12 ^b	6.81±0.14 ^b	8.21±0.15	8.99±0.15
		CC (cm)	15.00±0.29 ^b	19.47±0.29	22.56±0.36 ^b	27.00±0.38	28.13±0.38	30.02±0.19 ^b
		KL (cm)	8.00±0.15 ^b	9.69±0.12 ^b	12.77±0.27	14.67±0.39 ^b	15.37±0.32 ^b	16.37±0.29 ^b
		WL (cm)	10.13±0.09 ^b	13.19±0.11 ^b	15.96±0.16 ^b	17.77±0.21	19.23±0.41	20.40±0.38
		DSL (cm)	5.89±0.07	7.31±0.05	8.98±0.10	12.71±0.23	13.44±0.18 ^b	13.94±0.15 ^b
		Arbor Acre	BW (g)	276.33 ±4.64	676.33 ±4.64	1036.67 ±36.93 ^a	1442.00 ±39.64 ^a	1736.67 ±46.41 ^a
BL (cm)	12.58±0.28	14.86±0.19	17.17±0.18 ^a	20.20±0.34	23.41±0.48 ^a	25.85±0.45		
SL (cm)	4.17±0.07	4.89±0.07	5.85±0.05 ^a	7.43±0.16 ^a	8.32±0.13	9.17±0.07		
CC (cm)	16.07±0.35 ^a	19.30±0.15	24.72±0.30 ^a	27.20±0.28	28.20±0.50	43.27±13.27 ^a		
KL (cm)	8.67±0.23 ^a	10.84±0.17 ^a	12.73±0.27	15.78±0.28 ^a	18.57±0.36 ^a	20.75±0.37 ^a		
WL (cm)	11.36±0.24 ^a	13.91±0.12 ^a	16.39±0.11 ^a	18.50±0.33	19.25±0.14	20.16±0.11		
DSL (cm)	6.13±0.20	7.59±0.14	8.80±0.12	13.04±0.21	14.10±0.24 ^a	14.80±0.21 ^a		

BW=body weight, BL=body length, SL=shank length, CC=chest circumference, KL=keel length, WL=wing length, DSL=drum stick length, SE=standard error.

al., 2012; Udeh *et al.*, 2015). Olawumi *et al.* (2012) opined that Arbor Acre appeared superior to Marshall in body weight. Udeh *et al.* (2015) also noted that Arbor Acre was most superior in body weight compared to Marshall and Ross broilers. However, Yahaya *et al.* (2012) found that Hubbard broiler strain showed superiority over Arbor Acre strain in growth assessment of body weight and linear body measurements from 0 – 56 days study period. The significant differences observed in growth rate of Cobb and Arbor Acre in this study implied that the strains have different genetic potentials for growth. Body weight ranged from 266.67 – 1920 g and 276.33 – 1973 g for Cobb and Arbor Acer, respectively. This affirms the report of Turner (2005) that broiler chickens attain market weight of 1300 to 2000 g at 8 weeks of age. In line with the present finding, Zhao *et al.* (2009) and Taha *et al.* (2010) reported that broiler strains differed in growth rate and weight gain at different ages.

The phenotypic correlations between BW and the linear body traits of Cobb and Arbor Acer broiler strains are shown in Table 2. In both strain, BW had high significant ($P <$

0.05; $P < 0.01$) positive correlations with the linear traits. The correlations ranged from $r_p = 0.524$ (KL) – 0.834 (BL) for Cobb and 0.535 (KL) – 0.842 (BL) for Arbor Acre. This simply implies that all the linear traits measured are good indicators of BW. However, WL ($r_p = 0.740, 0.832$) and BL ($r_p = 0.834, 0.842$) had stronger significant associations with BW in both Cobb and Arbor Acer compared to other traits, which means that both traits are best estimators of BW.

Obike *et al.* (2016b) reported significant ($P < 0.05$; $P < 0.01$) and positive phenotypic correlations of body weight and linear traits which ranged from 0.515 – 0.778 (week 6) and 0.770 – 0.981 (week 8) for Anak broiler strain. Debbi *et al.* (2014) reported a stronger range of phenotypic correlations between body weight and linear body traits in Marshal (0.760 – 0.932) broiler strain and turkey (0.760 – 0.987). In Chinchilla rabbits, phenotypic correlations between body weight and linear body measurements ranged from 0.36 – 0.91, 0.47 – 0.82 and 0.34 – 0.71 in weeks 3, 6 and 8 (Okoro *et al.* 2010). According to Assan (2015), the positive and high correlations between

Table 2: Phenotypic correlations among body weight and linear body parameters of Cobb and Arbor Acre broiler strains

	BW	BL	SL	CC	KL	WL	DSL
BW	1	0.842**	0.627*	0.654*	0.535*	0.740**	0.505*
BL	0.834**	1	0.423	0.555*	0.876**	0.390	0.699**
SL	0.666*	0.112	1	0.574*	0.393	0.423	0.552*
CC	0.604*	0.994**	0.801**	1	0.404	0.544*	0.403
KL	0.524*	0.793**	0.523*	0.355	1	0.892**	0.511*
WL	0.832**	0.931**	0.391	0.823**	0.540*	1	0.377
DSL	0.530*	0.448	0.567*	0.574*	0.401	0.417	1

BW=body weight, BL=body length, SL=shank length, CC=chest circumference, KL=keel length, WL=wing length, DSL=drum stick length, **Correlation significant at 0.01 level, *Correlation significant at 0.05 level. Upper diagonal = Arbor Acre, Lower diagonal = Cobb

body weight and the various linear body measurements were consistent owing to the fact that body weight indicate the overall body growth, which itself, is a measure of the sum total of increases in size of the different structural body components. Kerketta *et al.* (2015) measuring linear traits in goats reported that body weight had positive and significant correlation with all body measurements (chest circumference, height at withers, body length and pelvic girth) and scrotal biometry (testicular circumference, testicular length, testicular width, testicular thickness and testicular volume). The correlations obtained indicated that as the birds grew, there was a positive relationship between their body weight and the linear body traits. Therefore, improvement in body traits at the phenotypic level is expected through selection on body weight and vice versa.

The phenotypic associations among the linear body traits in both Cobb and Arbor Acre were positive and ranged from moderate to high. The BL of the Cobb strain had moderate to high significant ($P < 0.05$; $P < 0.01$) association with CC (0.554), DSL (0.699) and KL (0.876). SL recorded significant moderate correlations with CC (0.574) and DSL (0.552). The correlations between KL and WL and DSL were 0.892 and 0.511, respectively. CC and WL were moderately associated (0.544). The Arbor

Acre strain showed strong correlations ($P < 0.01$) between BL and CC (0.994), KL (0.793) and WL (0.931). SL had high association with CC (0.801) but moderate values with KL and DSL. CC was also highly associated with WL. Significant moderate association was observed between CC and DSL as well as between KL and WL. Olawumi (2014) noted moderate to high significant associations (0.48 – 0.95) among BL, SL and thigh length in commercial pullets. Obike *et al.* (2016a) also reported a moderately to high significant correlations among BL, breast girth, SL, thigh length, WL and wing span of Anak broiler strain. In Makoei sheep, Abbasi and Ghafouri-Kesbi (2011) noted positive phenotypic correlations which ranged from moderate – 0.32 (height at wither/scrotal circumference) to high – 0.94 (height at withers/height at back). The positive correlations recorded among the linear traits measured in both Cobb and Arbor Acre suggests linkage by genes responsible for growth. It, therefore, implies that any phenotypic selection for one trait will lead to improvement of others. The variance components and repeatability (R) estimates of body weight and linear body traits of Arbor Acre and Cobb broiler strains in weeks 3, 5 and 7 are presented in Tables 3 and 4, respectively. The R estimates of body weight of Arbor Acre and

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Cobb were all very highly repeatable in all the weeks ranging from 0.90 – 0.99. This is similar to the result of Sola-Oyo and Ayorinde (2011) who reported a high R estimate of 0.99 for body weight in four broiler strains (Arbor Acre, Anak 2000,

Ross and Shavers) in weeks 2, 4 and 6. Sanda *et al.* (2014) also observed high estimates for body weight in three broiler strains – Arbor Acre (0.74 – 0.86), Marshall (0.72 – 0.84) and Ross (0.70 – 0.88) in weeks 4, 8 and 10.

Table 3: Repeatability estimates of body weight and linear body traits of Arbor Acre strain at weeks 3, 5 and 7

Trait	3			Week					
	σ_i^2	σ_w^2	R±SE	5			7		
	σ_i^2	σ_w^2	R±SE	σ_i^2	σ_w^2	R±SE	σ_i^2	σ_w^2	R±SE
BW	332.76	0.90	0.99±0.02	2052	0.99	0.99±0.02	32309	0.99	0.99±0.00
BL	0.92	1.19	0.44±0.12	0.97	0.49	0.67±0.11	0.77	3.41	0.19±0.07
SL	1.00	0.07	0.94±0.09	1.00	0.03	0.97±0.02	0.98	0.24	0.80±0.13
CC	0.87	1.88	0.32±0.14	0.87	1.96	0.31±0.15	0.75	3.74	0.17±0.08
KL	0.95	0.77	0.55±0.17	0.93	1.10	0.46±0.12	0.87	1.91	0.31±0.14
WL	0.94	0.90	0.51±0.13	0.99	0.19	0.84±0.12	0.98	0.27	0.78±0.13
DSL	0.96	0.63	0.61±0.12	0.98	0.23	0.81±0.14	0.96	0.47	0.67±0.11

BW=body weight, BL=body length, SL=shank length, CC=chest circumference, KL=keel length, WL=wing length, DSL=drum stick length, σ_i^2 =individual variance, σ_w^2 =error variance, S.E=standard error.

Table 4: Repeatability estimates of body weight and linear body traits of Cobb strain at weeks 3, 5 and 7

Trait	3			Week					
	σ_i^2	σ_w^2	R±SE	5			7		
	σ_i^2	σ_w^2	R±SE	σ_i^2	σ_w^2	R±SE	σ_i^2	σ_w^2	R±SE
BW	537.76	0.99	0.90±0.14	6356.81	0.99	0.99±0.06	16594.90	0.99	0.99±0.01
BL	0.94	0.96	0.49±0.13	0.97	0.45	0.69±0.12	0.90	1.52	0.37±0.15
SL	0.99	0.07	0.92±0.09	0.99	0.23	0.81±0.17	0.90	0.35	0.73±0.14
CC	0.92	0.13	0.42±0.26	0.91	1.32	0.41±0.11	0.86	2.12	0.29±0.01
KL	0.98	0.36	0.73±0.14	0.93	1.11	0.46±0.11	0.90	1.55	0.37±0.14
WL	0.99	0.11	0.89±0.11	0.97	0.40	0.71±0.14	0.83	2.50	0.25±0.06
DSL	1.00	0.11	0.90±0.11	0.99	0.15	0.87±0.12	0.94	0.90	0.51±0.17

BW=body weight, BL=body length, SL=shank length, CC=chest circumference, KL=keel length, WL=wing length, DSL=drum stick length, σ_i^2 =individual variance, σ_w^2 =error variance, S.E=standard error.

In another investigation with Japanese quail, Obike *et al.* (2016b) reported estimates of 0.93 and 0.99, 0.87 and 0.94 and 0.61 and 0.84 for heavy, medium and low body weight lines at ages 4 and 6, respectively. The result noted in this study is an indication that body weight in both Arbor Acre and Cobb has ability to repeat its outstanding performance and maintain ranking in successive records. The strains

can be selected at any of the stages of growth with high expected genetic response for body weight. The R estimates for the linear body traits ranged majorly from moderate to high across the weeks (3, 5 and 7) evaluated. However, low estimates were noted for CC at week 7 for both Arbor Acre (0.17 ± 0.08) and Cobb (0.29 ± 0.01) as well as BL (0.19 ± 0.07) in Arbor Acre and WL (0.25 ± 0.06) in Cobb. SL had high

repeatability estimates – 0.80 – 0.97 (Arbor Acre) and 0.73 – 0.92 (Cobb), which implies that this trait can be selected at any of the stages of growth for improvement. This is contrary to 0.46 observed for SL at week 4 in Arbor Acre (Sola-Ojo and Ayorinde, 2011). WL also recorded high estimates of 0.84 in week 5 and 0.78 in week 7 (Arbor Acre) and 0.89 in week 3 and 0.71 in week 5 (Cobb). DSL had values of 0.81 in week 5 for Arbor Acre and 0.90 and 0.87 in weeks 5 and 7, respectively for Cobb. KL was only highly repeatable (0.73) at week 3 in Cobb. All other estimates for the traits in the various weeks were moderately repeatable – 0.31 to 0.67 (Arbor Acre) and 0.37 to 0.69 (Cobb). In Shavers broiler strain, medium repeatability estimates (0.58 and 0.55) were reported for KL and shank diameter (Sola-Ojo and Ayorinde, 2011). Obike *et al.* (2016b) noted moderate estimates for linear body traits (SL – 0.49, KL – 0.46 and WL – 0.32) of low body weight line Japanese quail. The high repeatable estimates noted for some of the traits indicate large influence of additive genes (Obike *et al.* 2016b) which would enable a breeder to realize a high expected genetic response from selection (Falconer, 1989). For those traits with low and medium estimates of repeatability, larger numbers of records is needed for any gain in accuracy of selection to be made owing large influence of environmental variables.

Conclusion

Significant differences were observed for body weight and the linear body traits (BL, SL, CC, KL, WL and DSL) between Arbor Acre and Cobb at various weeks of measurement. Arbor Acre was superior to Cobb in all the traits at these weeks where significance was noted for the traits. Thus, Arbor Acre could be a strain of choice for rearing in the study zone. The phenotypic

correlations showed high and positive significant associations of BW with the linear traits in both Arbor Acre and Cobb, which means that a particular body trait or a combination of it can be used to predict BW of the strains and vice versa. The phenotypic associations among the linear body traits measured were moderate to high as well as positive in the strains. Its implication is high predictability among the variables. R estimates of BW in Arbor Acre and Cobb were significantly very high in weeks 3, 5 and 7. This indicates appreciable influence of additive genes and that fewer measurements are required to realize a high expected response from selection of BW. R estimates of the linear body traits were high, moderate and low. Unlike traits with high repeatable estimates, the low and moderate estimates would require higher number of records to predict the inherent transmitting ability of the strains at the various stages of growth.

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