ISSN 1819-1878

Asian Journal of Animal Sciences

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Asian Journal of Animal Sciences 6 (1): 13-22, 2012
ISSN 1819-1878 / DOI: 10.3923/ajas.2012.13.22

Prediction of Body Weight and other Linear Body Measurement of Two Commercial Layer Strain Chickens

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ABSTRACT

A total of 509 birds comprising 249 Nera Black (NB) and 260 Brown Shaver (BR) were used for this study. Data were collected on the birds from week one to twenty. Prediction of Body Weight (BW), Chest Girth (CG), Keel Length (KL), Body Length (BL) and Shank Length (SL) were highly significant ($p<0.001$). The coefficient of determination (R^2) varied from 85 to 99% for CG and KL. In both genotypes, the relationship between BW and other body measurements were higher in CG and KL traits and best described by cubic model. Cubic function ($R^2 = 99\%$) predicted BW more accurately than quadratic and linear functions. The phenotypic correlation coefficients at day old in NB between BW and BL were positive, medium and highly significant ($p<0.01$), the phenotypic correlation coefficients for BW and BL in BR was low, negative and highly significant ($p<0.01$). Lower correlation values were obtained between BW and BL and significant ($p<0.05$) in NB strain at 4 weeks old. Also, negative highly significant was achieved between BW and SL. At 8 weeks old, low to medium correlation coefficients were observed between BW and SL, BW and KL, BW and CG in NB strain. Significant correlations were achieved between BW and SL, BW and CG traits in BR strain. At 12 weeks old, high, positive and significant ($p<0.01$) values were observed between BW and other traits in NB. The phenotypic correlation coefficients were of medium to high in NB between BW and KL, BW and BL at 16 weeks old. There were highly significant differences ($p<0.01$) between BW and other traits measured in BR strain. At 20 weeks old, the correlation values obtained were low to high in NB, lower values were also obtained for BR at the same age. As a result of these observations, it was considered possible to use the body weight in determining BL, SL, KL and CG.

Key words: Prediction, body weight, layer chicken, strains

INTRODUCTION

Poultry population was put at 114.3 million comprising of 82.4 million chickens (11% of which was commercially raised) and 31.9 million other poultry which included pigeons, ducks, guinea fowls and turkeys (RIM, 1992). Poultry outnumbers all other forms of livestock in Nigeria and not surprisingly is found throughout the country wherever, there is human settlement. Although, pigeons, ducks, guinea fowl and some turkeys are also widely kept, chickens are by far the most common. Typically, they are maintained under traditional, low input, free range systems of management but substantial numbers are also raised intensively on commercial bases, particularly in the southern states. Commercial holdings account for some 10 million chickens or 11.2% of the total estimated population of 82.4 million (Anaeto and Chioma, 2007).

Protein supply from livestock products was estimated to be only 3.0 g/caput/day in 1993 and a projection of 5.32 g/caput/day has been made for the year 2010 (Shaib *et al.*, 1997). This is dismally short of the 35 g recommended by FAO (1993).

Poultry farming in Nigeria was mostly a backyard venture up to about 1960. Some indigenous poultry used for the production of eggs and meat were hardy but poor in productivity. Lack of interest in poultry was due to low productivity of indigenous birds (poor genetic make up), low prices for eggs and meat, inadequate knowledge of poultry diseases and scientific methods of feeding and management (including housing/nutritional requirements).

Growth is a fundamental property of biological systems and it can be defined as an increase in the number of cells in the body size per unit of time (Schulze *et al.*, 2001; Lawrence and Fowler, 2002). Growth of fowl is analogous to growth of mammalian; consisting of three or four cycles, which however, occurred after hatching. Indigenous chickens, like improved breeds has a sigmoid growth pattern with differences in growth rate and feed efficiency (Nwosu, 1979), although the indigenous fowl seemed to complete the rapid growth phase earlier than improved breeds (Oluyemi, 1980). Growth is affected by genetic and non-genetic factors (Singh and Singh, 1983; Gupta *et al.*, 1988; Pinchasov, 1991). The assessment of a growth model is of particular importance in animal production, because of its practical implications (possibility of verifying the adherence of a feeding schedule or a rearing system to a reference condition, as it is calculated by a regression equation (Sabbioni *et al.*, 1999).

Growth curves are used to describe the regular change generated by the live weight or some part of the animal with the age increasing which commonly is an S-type curve. Animal growth involves increase in size and changes in functional capabilities of the various tissues and organs of animals that occur from conception through maturity. The growth process includes increases in cell numbers (hyperplasia) and increases in cell size (hypertrophy). Growth performance of an animal is a phenotypic expression which is the outward expression of the animal genetic make up. Genetic factors have great influence on the performance of an animal. This explains the situation where within the same breed or strain, individual variations in performance are common observations. Individuals that show superior performance should be identified and used in the genetic improvement programme (Chineke, 2001).

The justification of the study is to characterize the commercial layer strains of chicken with respect to their growth traits.

The objective was to estimate the growth traits of two commercial layer strains Nera black and Black shaver, the correlation coefficients among body weight and other body parameters within each strain at various ages and to compare the growth pattern of Nera black and Black shaver strains using three regression models.

MATERIALS AND METHODS

Experimental site: The research was carried out at the Poultry Unit, Teaching and Research Farm of the Ladoke Akintola University of Technology, Ogbomoso, Oyo state, Nigeria. Ogbomoso lies on the longitude 4° 15' East of the Greenwich Meridian and Latitude 8° 15' North-East of the equator. It is about 145 km North-Eastwards from Ibadan, the capital of Oyo state. The altitude is between 300 and 600 meters above sea level. The mean annual temperature is about 27°C (Oguntoyinbo, 1978) while that of rainfall is 1247 mm. The vegetation of the area is derived savanna.

The experimental birds: Bovan Nera black (NB) and Black Shaver (BL) are egg laying, light strain birds and are tolerant to tropical climate. The population of chickens consisted of 249 Nera black and 254 Black shavers. They were obtained from a reputable poultry farm (Zartech, Ltd), Ibadan, Oyo state at day-old.

Housing and management of chicks: Before the arrival of the chicks, the floor of the house and the surroundings were kept clean of debris and cobwebs. The feeders and drinkers were thoroughly washed and disinfected. Chicks were wing-tagged according to the strain and housed in the brooding pen for five weeks and rearing of chicks continued until 20 weeks. The chicks were fed *ad libitum* with a commercial chicks starter diet that supplied 18.49% crude protein and 2522.9 kcal kg^{-1} metabolizable energy from 0 to 8 weeks. Thereafter, they were fed on a commercial growers ration that supplied 15.85% crude protein and 2400.8 kcal kg^{-1} metabolizable energy to 18 weeks. The birds were fed the same feed throughout the experimental periods. Clean water was supplied *ad libitum* throughout the experimental period.

Growth traits: Two hundred and forty birds randomly selected in all the two strains were individually weighed, to determine the initial body weight (BW) using a sensitive weighing balance of 0.05 g sensitivity. Other body measurements were also taken with the use of a measuring tape calibrated in centimeter which included Body Length (BL), Chest Girth (CG) and Keel Length (KL) from day-old to twenty weeks. The traits measured on weekly basis for 20 weeks include:

Body Weight (BW): Measured with the use of a sensitive weighing balance with a capacity of three decimal digits
Body Length (BL): Measured as the distance between the base of the neck and the cloaca
Chest Girth (CG): Taken as the circumference of the breast around the deepest region of the breast
Keel Length (KL): Taken as the length region of the sternum

Regression model: Traits studied were body weight, chest girth, body length, shank length and keel length from week one to twenty. Measurements of chest girth, keel length, body length and shank length were regressed against body weight using simple linear, Quadratic and Cubic regression analysis (SAS, 2003).

Model function:

- Linear $Y_1 = a + bx$
- Quadratic $Y_2 = a + bx + cx^2$
- Cubic $Y_3 = a + bx + cx^2 + dx^3$

Y_1, Y_2 and Y_3 are dependent variables (body weights) while x represents the independent variables (chest girth, keel length, shank length and body length), b, c, d are the regression coefficients associated with independent variables and a is the intercept represents the estimate of dependent variable when the independent variable is zero.

Regression equations were determined for each strain and tested for parallelism. The relationship between body weight and each of the measurements (chest girth, keel length, shank length and body length) were also assessed and the coefficient of determination (R^2) was used to compare the accuracy of prediction.

Growth traits: Analysis was done using mixed model least square and maximum likelihood computer program (Harvey, 1990). The model was fitted for the effect of strains with age used as covariate

Model 1:

$$Y_{ij} = \mu + S_i + A + e_{ij}$$

Where:

Y_{ij} = The observation of the individual bird.

μ = The overall mean

Si = The fixed effect of strain (i = 1, 2)

A = Age, as covariate

e_{ij} = The uncontrolled environmental and genetic deviation attributable to individual within each strain, assumed to be normally and independently distributed (-NID) with Zero mean and Variance σ^2 with the age in weeks as a covariate

This model was subjected to one-way analysis of variance using the general linear model of SAS (2003). Correlation analysis for the growth traits was done with Pearson moment correlation of SAS (2003).

RESULTS

The least square means of body weight, body length, shank length, keel length and chest girth of two different commercial layer strains at different ages are presented in Table 1-5. Strains had significant ($p<0.05$) effect on body weight, body length, shank length, keel length and chest girth at all ages except at day-old for keel length. Nera black strains had superior BW (30.31±0.02 g) and were significantly different ($p<0.05$) from Brown shaver strain (27.02±0.09 g). At 4 to 20th week, Nera black had the heavier body weight and was significantly ($p<0.05$) different from the Brown shaver strains (Table 2). This trend was consistent from day-old to 20 weeks of age for all the two strains studied. There were significant ($p<0.05$) differences in chest girth between the two strains.

Table 1: Least square means of body weight (g) of two genotypes from day-old to 20 weeks

			Genotypes	
Age (weeks)	N	Overall mean	Nera black	Brown shaver
0	120	28.67±0.06	30.31±0.02[a]	27.02±0.09[b]
4	120	151.61±0.69	185.70±1.08[a]	117.51±0.29[b]
8	120	335.98±0.78	371.53±0.72[a]	300.43±0.83[b]
12	120	554.64±0.20	591.60±0.16[a]	517.67±0.24[b]
16	120	790.32±0.41	828.43±0.37[a]	752.21±0.44[b]
20	120	1132.46±2.56	1236.77±0.65[a]	1028.15±4.46[b]

Means with different superscripts along the same row are significantly ($p<0.05$) different

Table 2: Least square means of body length (cm) of two genotypes from day-old to 20 weeks

			Genotypes	
Age (week)	N	Overall mean	Nera Black	Brown shaver
0	120	4.68±0.03	4.96±0.01[a]	4.40±0.04[b]
4	120	7.79±0.03	8.66±0.03[a]	6.92±0.03[b]
8	120	10.56±0.05	11.45±0.06[a]	9.66±0.03[b]
12	120	14.75±0.01	15.37±0.02[a]	14.12±0.00[b]
16	120	18.49±0.04	19.62±0.03[a]	17.36±0.04[b]
20	120	20.25±0.04	21.31±0.03[a]	19.08±0.04[b]

Means with different superscripts along the same row are significantly ($p<0.05$) different

Table 3: Least square means of shank length (cm) of three genotypes from day-old to 20 weeks

			Genotypes	
Age (weeks)	N	Overall mean	Nera black	Brown shaver
0	120	2.01±0.02	2.27±0.02[a]	1.75±0.02[b]
4	120	3.46±0.03	3.64±0.04[a]	3.27±0.01[b]
8	120	5.75±0.02	6.18±0.02[a]	5.32±0.02[b]
12	120	7.59±0.03	8.71±0.02[a]	6.47±0.03[b]
16	120	8.95±0.02	9.12±0.01[a]	8.78±0.02[b]
20	120	9.44±0.02	10.14±0.02[a]	8.73±0.01[b]

Means with different superscripts along the same row are significantly ($p<0.05$) different

Table 4: Least square means of keel length (cm) of two genotypes from day-old to 20 weeks

			Genotypes	
Age (weeks)	N	Overall mean	Nera black	Brown shaver
0	120	1.52±0.02	1.54±0.01	1.50±0.03
4	120	2.20±0.01	2.72±0.01[a]	1.68±0.01[b]
8	120	3.50±0.03	4.32±0.03[a]	2.67±0.02[b]
12	120	6.85±0.03	7.18±0.01[a]	6.52±0.02[b]
16	120	8.50±0.02	8.84±0.02[a]	8.16±0.01[b]
20	120	10.26±0.01	11.19±0.01[a]	10.32±0.01[b]

Means with different superscripts along the same row are significantly ($p<0.05$) different

Table 5: Least square means of chest girth (cm) of two genotypes from day-old to 20 weeks

			Genotypes	
Age 1(weeks)	N	Overall mean	Nera black	Brown shaver
0	120	4.55±0.02	4.71±0.01[a]	4.39±0.02[b]
4	120	5.84±0.01	6.65±0.02[a]	5.02±0.00[b]
8	120	7.79±0.03	9.04±0.04[a]	6.53±0.02[b]
12	120	13.52±0.02	14.32±0.01[a]	12.72±0.02[b]
16	120	17.09±0.02	17.67±0.02[a]	15.58±0.02[b]
20	120	19.55±0.02	20.34±0.02[a]	18.75±0.01[b]

Means with different superscripts along the same row are significantly ($p<0.05$) different

Phenotypic correlations among growth traits: The phenotypic correlation coefficients for body weight and linear measurements for 0, 4 and 8 weeks are presented in Table 6. At day old,

Table 6: Phenotypic correlation coefficients of growth traits at day old, 4 and 8 weeks of age

Traits	NB	BR
Day old		
BL	0.404**	-0.260**
SL	-0.120	0.151
KL	-0.071	0.057
CG	0.114	-0.166
4 weeks old		
BL	0.212*	-0.197*
SL	-0.599**	-0.161
KL	0.435**	-0.024
CG	-0.174	-0.307**
8 weeks old		
BL	-0.168	0.105
SL	-0.255**	0.406*
KL	-0.456**	-0.175
CG	-0.365**	-0.574**

BW = Body weight, BL = Body length, SL = Shank length, KL = Keel length and CG = Chest girth, *p<0.05 and **p<0.01

Table 7: Phenotypic correlation coefficients of growth traits at 12, 16 and 20 weeks of age

Traits	NB	BR
12 weeks old		
BL	0.707**	0.253**
SL	0.755**	0.274**
KL	0.804**	0.121
CG	0.534**	0.181*
16 weeks old		
BL	0.702**	0.749**
SL	0.124	0.822**
KL	0.566**	0.910**
CG	-0.109	0.748**
20 weeks old		
BL	-0.222*	0.431**
SL	0.093	0.101
KL	0.464**	-0.187*
CG	0.608**	-0.311**

BW = Body weight, BL = Body length, SL = Shank length, KL = Keel length and CG = Chest girth **p<0.01 and *p<0.05

result showed that phenotypic correlation coefficients of body weight and body length in Nera black were positive, medium and highly significant (p<0.01, 0.404), the phenotypic correlation coefficients for body weight and boy length in Brown shaver was negative and significant (p<0.01, -0.260). At 4 weeks of age, the phenotypic correlation coefficients for body weight and linear body measurement for each strain for body weight and body length, keel length which was positive and negative as in case of shank length in Nera black strain. They showed significant (p<0.01) differences. The phenotypic correlation coefficient is low-high in BR, low-medium in NB. The phenotypic correlation coefficients for body weight and linear body measurements are very low and negative though significant (p<0.01) in NB, low-high and significant (p<0.01) in BR at 8 weeks of age.

The phenotypic correlation estimates for body weight and linear body measurement at 12, 16 and 20 weeks of age for the strains are shown in Table 7. The phenotypic correlation for body weight and linear body measurement was high and positively significant ($p<0.01$) in NB. BR strains also observed the same trend except against KL. All showed significant differences ($p<0.01$).

At 16 weeks of age, the phenotypic correlation coefficients for body weight and linear body measurement were highly significant for all traits in BR. Lower values were obtained for CG and SL in NB. The values obtained for all the traits were generally low in BR and medium in NB, at 20 weeks of age.

Prediction of growth pattern among the strains: The equation, estimate of parameter and coefficient of determination for the fitted functions are presented in Table 8a, b demonstrated a

Table 8a: Estimation of parameters in simple linear, quadratic and cubic functions fitted for body weights-linear body measurements of two different layer strains

Linear measurement	Functions	S.E.	R^2%	Sig.
Chest girth				
Nera black	$Y = -239.50+64.55x$	0.30	95	**
	$Y_2 = 7.94+15.12x+2.01x^2$	0.07	96	**
	$Y_3 = -965.22+305.52x-23.46x^2+0.68x^3$	0.01	99	**
Brown shaver				
	$Y = -163.30+58.98x$	0.23	96	**
	$Y_2 = -101.79+45.00x+0.63x^2$	0.07	97	**
	$Y_3 = -845.71+287.50x-22.17x^2+0.65x^3$	0.01	99	**
Keel length				
Nera black	$Y = -153.86+113.08x$	0.53	95	**
	$Y_2 = 48.81+24.31x+7.32x^2$	0.16	97	**
	$Y_3 = -184.52+182.51x-21.16x^2+1.50x^3$	0.05	99	**
Brown shaver	$Y = -25.34+95.90x$	0.43	96	**
	$Y_2 = 7.61+77.61x+1.69x^2$	0.21	96	**
	$Y_3 = -255.40+264.12x-35.61x^2+2.14x^3$	0.07	97	**

Sig. = Significant, **$p<0.01$

Table 8b: Estimation of parameters in simple linear, quadratic and cubic functions fitted for body weights-linear body measurements of two different layer strains

Linear measurement	Functions	S.E.	R^2%	Sig.
Body length				
Nera black	$Y = -399.20+67.11x$	0.31	95	**
	$Y_2 = -28.19+4.23x+2.30x^2$	0.05	97	**
	$Y_3 = -393.06+106.98x-6.24x^2+0.21x^3$	0.01	98	**
Brown shaver	$Y = -309.43+63.27x$	0.25	96	**
	$Y_2 = -102.43+22.85x+1.67x^2$	0.05	98	**
	$Y_3 = -181.94+48.32x-0.73x^2+0.07x^3$	0.01	98	**
Shank length				
Nera black	$Y = -329.20+127.97x$	1.12	85	**
	$Y_2 = 120.61-45.25x+13.74x^2$	0.55	88	**
	$Y_3 = -701.13+461.20x-77.56x^2+4.99x^3$	0.23	90	**
Brown shaver	$Y = -276.77+124.12x$	0.74	92	**
	$Y_2 = -35.57+22.00x+8.93x^2$	0.36	94	**
	$Y_3 = -212.27+147.94x-16.99x^2+1.59x^3$	0.20	94	**

SE = Standard error, R = coefficient of determination and Sig. = Significant strong inter-relationship ($p<0.001$) between body weight and linear body measurements. The coefficient of determination varied from 85 to 99% and the magnitude of these coefficients of determination for each parameter in the regression equation shows the relative contribution of each body measurement to the body weight of bird for that particular genotype.

In the two genotypes, the relationship between body weights and other body measurements, chest girth and keel length were best described by cubic model. The coefficient of determination (R^2) varied from 98 to 99% and 97 to 99% for chest girth and keel length respectively. Body weight and keel length, chest girth and keel length only in Nera black, chest girth and keel length in Brown shaver. Linear function predicted the body weight in the same way as quadratic function. The regression coefficient associated with independent variables X and partially representing any amount of change in Y for each unit change in X had a positive value in the relationships between body weight and chest girth; body weight and keel length. The observation, therefore, of the positive value for the regression coefficient is an indication that body weight would increase with linear body dimensions (chest girth and keel length).

DISCUSSION

The results of growth traits showed increase in all body measurements of each strain as growth advances in this study. This result is in line with reports of Sonaiya *et al.* (1986) that age is a major determinant of growth and physiological development. Omeje and Nwosu (1986) opined that these relationships could be utilized in the genetic improvement of growth through selection. Giordani *et al.* (1993) also reported significant difference in the growth performance of different strains of birds.

The result of body weight and linear body measurements as affected by chick genotype suggests that the NB was superior to BR considered in body weight and linear body measurement. NB therefore possesses gene for faster growth than the BR strains used in this study, although they are also light strains and were bred specifically for increased egg production.

The phenotypic correlation estimates between body weight and linear body measurements as reported in this study agreed with the findings of Ezzeldin *et al.* (1994) who reported medium to high phenotypic correlation coefficients in body weight and body measurements in pure breed chickens and their crosses.

The growth pattern result from this study showed that it was in agreement with the conclusion of Adeniji and Ayorinde (1990) that body weight of birds can easily be predicted from any given value of six body measurements (body length, body girth, keel length, shank length, drumstick length and shank thickness) in the Cobb broiler strain using linear and stepwise regression equation. For the two genotypes, the relationship between body weight, chest girth, keel length, body length and shank length were best described by cubic function. This is in line with the findings of Adeniji and Ayorinde (1990), Monsi (1992) and Adeleke *et al.* (2004) who reported that increasing chest girth or keel length through selection will result in corresponding increase in body weight.

CONCLUSION

The growth traits increased with age in the two strains and NB strain was found more favoured in almost all the ages. The relationship that existed among the traits was of low-medium and negative in NB but of positive value in BR strain. Higher correlated values were obtained in BR strains at 16th week of age.

The results from the study demonstrated a positive relationship between body weight and body measurement components (chest girth and keel length) showing that increase in the growth rate of any of the components will correspondingly increase live weight gain. The study also indicated that with these strains of chicken, body weight of birds could easily be predicted from any given value of the two body measurements. Cubic growth model produced the best fit from chest girth in all the strains and age data.

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