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Research Article

Descriptive Statistics, Correlation and Regression Coefficient of Growth Traits in the Nigerian Heavy Local Chicken Ecotype

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Abstract: Body weight is a very important characteristic in animal husbandry due to selection criteria and economic profit, and linear body measurement is used as an indirect method of estimating body weight. The aim of the study was to predict body weight from the linear body measurement and establish regression equations for the prediction of body weight and determine the growth trait that most predicts body weight for selection and improvement purposes. A total of 240 grower chicks were used for the study. The birds were generated from the existing 7th Generation of the Nigeria heavy local chicken ecotype (NHLCE) parent stock in the Department of Animal Science, University of Nigeria, Nsukka farm. Ten cocks and sixty hens were selected from the existing flock to establish 10 sire families. Each cock was randomly assigned to 6 hens to form a sire family at a mating ratio of 1:6. Each sire family was housed in a particular pen with a demarcation separating the cock from the hens. Artificial insemination was used as the mating method. Artificial insemination was done at an interval of two days. Fertile eggs produced were marked according to sire families. Fertile eggs were hatched with the aid of an electric automated incubator. The chicks were brooded for eight weeks. At the end of the brooding period, the grower-chicks were randomly chosen for the study and given similar treatments. Body weight and linear body measurements were taken bi-weekly. The results showed that at 20 weeks of age, the birds had an average body weight of 1627.78g and, an average body length, shank length, chest circumference, thigh circumference and thigh length of 24.14cm, 8.32cm, 37.19cm, 11.01cm and 14.50cm, respectively. The correlation coefficients between body weight and linear body measurements were significant ($p<0.01$), strong and positive. Chest circumference had highest coefficient of 0.91, followed by thigh length 0.86 and shank length 0.75, respectively, on the body weight. The regression result showed that chest circumference is the best predictor of body with highest value of R^2 (0.72) and lowest standard error (1.49). It was therefore concluded that linear body measurements can be used to predict body weight and the best predictor of body weight is the chest circumference.
Keywords: Descriptive statistics, correlation, regression, growth traits and NHLCE.

Introduction

The Nigerian heavy local chicken ecotype is a fast growing strain of local chickens developed in the Department of Animal Science, Teaching and Research farm, University of Nigeria, Nsukka. The birds were bred as dual purpose chickens to produce meat and eggs (Udeh *et al*., 2018). Growth is fundamental to all living things and it can be defined as an increase in number of body cells and elongation in size per unit of time (Schulze *et al*., 2001). Indigenous chickens, like improved breeds have a sigmoid growth pattern with differences in growth rate and feed efficiency (Nwosu, 1979). Singh and Singh (1983) had earlier reported that growth is affected by genetic and non-genetic factors. Hence, Cam *et al.*, (2010) affirmed that live weight could be affected by differences in management, environmental and enterprise feeding conditions. Body weight is a very important characteristic in animal husbandry due to selection criteria and economic profit. Body weight is used in determining several other economic traits in farm animals (Pesman and Yardimci, 2008). Due to the fact that body weight forms the basis for assessing growth, feed efficiency and also in making economic and market decisions in farm animals, it is an important attribute (Momoh *et al*., 2010). However, Maciejowski *et al.,* (1982), in agreement, had earlier reported that there is positive correlation between body weight and a number of linear body measurements. Linear body measurements are kind of growth indicators in animal life, and are also helpful in predicting body weight and carcass trait (Atta and El–Khidir, 2004).

Linear body measurement is used as an indirect method of estimating body weight, and it has been reported to be practical, faster, easier, and cheaper approach, especially in the rural areas where the resources are insufficient and the acquisition of expensive sensitive weighing scale is unaffordable (Semakula *et al*., 2011). The shank length and diameter are important indicators of leg development, while body girth and length are good indicators of breast development. Estimates of the relationship between body weight and these linear measurements is not only important in developing predictive equations, it could also be employed in genetic improvement strategies to achieve an optimum combination of body weight and good conformation (Chineke *et al*., 2002). Thus, this study was designed to predict body weight through linear body measurements and also determine the growth trait that most predicts body weight for selection and improvement purposes.

Materials and Methods

Study Location

The study was carried out at the Local Chicken Breeding section of the Poultry Unit, Department of Animal Science Teaching and Research Farm, University of Nigeria, Nsukka. Nsukka. Nsukka is in Enugu state, Nigeria and lies between latitude 06^o 52' 24"N, Longitude 07^o 39' 23" E and 550 meter elevation above the sea level. Nsukka covered land area of 17.52 sq mi (45.38 km^2) with a population of 309,633 people (Federal Republic of Nigeria Official Gazette, 2007). The climate in Nsukka is humid tropical with average annual rainfall of 1680–1700mm. The mean ambient temperature is 26.6^oC (Breinholt *et al.*, 1981).

Experimental Animals and Management

A total of 240 grower chicks were used for the study. The birds were generated from the existing 7^{th} Generation of the Nigeria heavy local chicken ecotype (NHLCE) parent stock in the Departmental farm. Ten cocks and sixty hens were selected from the existing flock to establish 10 sire families. Each cock was randomly assigned 6 hens to form a family at a mating ratio of 1:6. Each sire family was assigned to a particular pen with a demarcation separating the cock from the hens. Artificial insemination was used as the mating method. Artificial insemination was done on interval of two days. Fertile eggs produced were marked according to sire families. Fertile eggs were hatched with the aid of an electric automated incubator. The chicks were brooded for eight weeks. At the end of the brooding period, 240 grower-chicks were randomly chosen for the study. The birds were given feed and water *ad libitum* throughout the experimental period. Vaccinations and medications were provided as at when due and other routine management practices were provided accordingly. Body weight and other linear body measurements were taken bi-weekly throughout the experimental period.

Experimental design and models

The experimental design used for this study was the complete randomized design (CRD) with model

$$X_{ij} = \mu + T_i + \Sigma_{ij}$$

Where

X_{ij} = Individual observation; μ = Overall population mean; Ti = Hatch effect; Σ_{ij} = Experimental random error

Correlation: The correlation model is given as: r sire =

$$\frac{Covs}{\sqrt{\sigma^2 s(x).\sigma^2(y)}}$$

Regression: The regression models are given as:
$Y = B + BX$ -- simple regression model
$Y = B + B_1X_1 + B_2X_2$ +--------+ BX_ZX_Z----------------------- multiple regression model

Standard Partial Regression Coefficient
$Y = \mu + b_1x_1 + b_2x_2 + --- + b_nx_n + \Sigma_{ijklm}$

Where
Y= Body weight; μ= population mean; b_1= Regression coefficient; x_1= Individual trait; Σ_{ijklm} =Error term

Data analysis
Data generated were subjected to descriptive statistics to obtain the means and standard errors of the mean. Correlation and the linear regression coefficients were obtained using SPSS (2013) version 19.

Results and Discussions
Descriptive statistics
The result of the descriptive statistics of the body weight and linear body measurements of the Nigerian heavy local chicken ecotype are presented in table 1.

Table 1. Descriptive statistics of the body weight and linear body measurements of the Nigerian heavy local chicken ecotype

Age	Parameters	Mean	Std. Dev.	Std. error of mean	Variance	Coefficient of variation	No of Animal
8 weeks	BWT (g)	400.21	149.91	15.59	22472.36	37.48	180
	BL (cm)	17.08	3.23	0.32	10.40	18.89	
	SL (cm)	5.54	0.97	0.10	0.95	17.55	
	CC (cm)	21.82	3.29	0.35	10.80	15.06	
	TC (cm)	5.81	0.99	0.10	0.98	17.02	
	TL (cm)	8.48	1.22	0.13	1.49	14.39	
14 weeks	BWT (g)	1186.14	193.01	20.58	37253.87	24.55	175
	BL (cm)	21.86	1.77	0.19	3.14	8.10	
	SL (cm)	6.22	0.61	0.06	0.37	9.74	
	CC (cm)	30.29	3.24	0.35	10.52	10.71	
	TC (cm)	9.53	1.23	0.13	1.50	14.37	
	TL (cm)	11.93	1.36	0.14	1.84	11.37	
20 weeks	BWT (g)	1627.78	354.88	39.43	125937.50	24.85	173
	BL (cm)	24.14	1.84	0.21	3.41	8.34	
	SL (cm)	8.32	0.83	0.09	0.68	11.28	
	CC (cm)	37.19	4.01	0.45	16.11	11.41	
	TC (cm)	11.01	2.14	0.24	4.56	12.33	
	TL (cm)	14.50	1.37	0.15	1.88	9.47	

BWT = Body weight, B.L = Body length, S.L = Shank length, C.C = Chest circumference, T.C = Thigh circumference, T.L = Thigh length.

The shank length, chest circumference, body length and wing length increased with age. The body length varied from 17.08 to 24.14 with a mean of (17.08, 21.86 and 24.14) at week eight, fourteen and week twenty, respectively. The shank length varied from 5.54 to 8.32 with a mean of (5.54, 6.22, and 8.32) at week eight, fourteen and twenty, respectively. The chest circumference had similar trend and varied from 21.82 to 37.19 with a mean of (21.82, 30.29, and 37.19) for weeks eight, fourteen and twenty, respectively. The thigh circumference and thigh length followed the same pattern of increment. Body weight increased from 400.21g at week eight to 1.6kg at week twenty.

Ojo *et al.*, (2014) who agreed with this pattern of growth had reported that there is a gradual increase of body weight with age. The observed mean body weight in this study 1.627kg at week twenty was slightly higher than 1.45kg reported by Ukwu *et al.*, (2014). Similarly, it is higher than the values (1.19kg) and (1.06kg) reported by Yakubu (2009) and Momoh and Karishima (2008), respectively. These differences could be attributed to the different breeds/strains of chicken used and different management practices employed. Semakula *et al.*, (2011) on another study, reported that all linear body measurements increased with increasing age and stagnated above eight months of age. He noted that linear measurements reflect structural growth, thus, are not expected to change much after maturity is attained but, however, that body weight and other linear measurements such as girth depend on changes in muscle and fat deposition. The coefficient of variation (CV) is a measure of dispersion of the variable or the degree of variation to the population mean. It is important as an indicator of how well you have taken representative samples and how your analytical method performs. It is a ratio of standard deviation to the mean. A lower C.V implies low degree of variation while a higher C.V connotes a higher variation. The CVs were higher at week 8 than weeks 14 and 20. This is in agreement with the findings of Semakula *et al.,* (2011) who reported that all linear body measurements increased with increasing age and stagnated above eight weeks of age. He noted that linear measurements reflect structural growth, thus are not expected to change much after maturity is attained. At week eight, B.L had the highest coefficient of variation (18.89%) whereas TC was highest in week 14 and twenty, respectively. This agreed with the result obtained by Momoh and Karishima (2008) who reported that reported body length and chest circumference were the traits with highest variation when he utilized standard error of the mean to estimate variation. On the other hand, Gambo *et al.*, (2014) in their work observed the shank length to be the trait with the highest variability occurring highest in week 2 but gradually decreasing towards week six. Egene *et al.*, (2014) observed that highest coefficient of variation was found in body length, shank length, and shank thickness. Above all, Daikwo (2011) and Gambo *et al.*, (2014) asserted that age has highly significant effect on all the linear body parameters.

Correlation Coefficient

The results of the correlation coefficients between body weight and linear body measurements of the Nigerian heavy local chicken ecotype are presented in table 2. It could be observed from the table that the correlations were significant (p<0.01) and positive. At week 8, the correlation between body weight and linear body measurements were low to moderate except shank length.

Table 2. Correlation coefficients between body weight and linear body measurements of the Nigerian heavy local chicken ecotype (NHLCE)

Age	Parameters	BWT	BL	SL	CC	TC	TL
8 Weeks	BWT	1	0.54**	0.72**	0.45**	0.35**	0.38**
	BL	0.54**	1	0.66**	0.63**	0.41**	0.37**
	SL	0.72**	0.66**	1	0.66**	0.53**	0.48**
	CC	0.45**	0.63**	0.66**	1	0.47**	0.52**
	TC	0.35**	0.41**	0.53**	0.47**	1	0.43**
	TL	0.38**	0.37**	0.48**	0.52**	0.431**	1
14 Weeks	BWT	1	0.75**	0.59**	0.91**	0.58**	0.86**
	BL	0.75**	1	0.58**	0.77**	0.50**	0.71**
	SL	0.59**	0.58**	1	0.49**	0.47**	0.51**
	CC	0.91**	0.77**	0.49**	1	0.50**	0.83**
	TC	0.58**	0.50**	0.47**	0.50**	1	0.52**
	TL	0.64**	0.71**	0.58**	0.75**	0.48**	1
20 Weeks	BWT	1	0.57**	0.69**	0.69**	0.54**	0.64**
	BL	0.57**	1	0.57**	0.48**	0.46**	0.52**
	SL	0.69**	0.57**	1	0.57**	0.52**	0.65**
	CC	0.69**	0.48**	0.57**	1	0.49**	0.64**
	TC	0.54**	0.46**	0.52**	0.49**	1	0.45**
	TL	0.64**	0.52**	0.65**	0.64**	0.45**	1

BWT = Body weight, B.L = Body length, S.L = Shank length, C.C = Chest circumference, T.C = Thigh circumference, T.L = Thigh length

At week 14, the correlation between body weight and chest circumference became highest with coefficient of 0.91, followed by thigh length 0.86 and shank length 0.75, respectively. However, at week 20, the correlation coefficient between body weight and linear body measurements decreased with highest value 0.69 on shank length and chest circumference, and 0.64 on thigh length. The decrease in correlation coefficient is a proof that linear body measurements are not expected to change much when maturity is attained (Semakula *et al.,* 2011). The results in this study corroborate the report of Ukwu and Okoro, (2014) who reported significant high and positive correlation between body weight and the linear body traits. It also conforms to the findings of Yahaya *et al.,* (2012).

All the correlations were high, positive and significant ($p<0.01$). This implies that there exist a strong linear relationship between body weight and linear body parameters. This result also suggests that an improvement in linear body parameters would lead to a corresponding improvement in the body weight also, it implies that for every change in the linear body trait, there is a change in the body weight measurements of the animal that shows growth is taking place. The values obtained in week 8 agreed with the values reported by Okon *et al.,* (1996), where moderate to high correlation coefficient on body weight and body linear measurement were observed. The result corroborates the findings of Ige *et al.,* (2013) who reported low correlation coefficients between body weight and chest circumference at week 18 and 20.

Semankula *et al.,* (2011) findings strongly agreed with the results of this study. He reported that the highest correlation coefficient was C.C (0.88) closely followed by B.L (0.81) and thigh length (0.80). It also corroborates the findings of Vincent *et al.,* (2015) who recorded highest correlation (r= 0.88 and 0.79 for males and female) between B.W and C.C. Ojo *et al.,* (2014) also reported that the best correlation was obtained between body weight and chest girth at the 2nd week of age with r =0.70. This could mean that chest circumference has the highest relationship with body weight while the thigh circumference has the least relationship.

The high association of body weight with chest circumference was possible due to large contribution to body weight by chest circumference consisting of bones, muscles and viscera. The decrease correlation coefficient at week 20 indicates that no reasonable genetic progress can be made as the chicken grow older and also, this could be partly explained from the fact that most of the linear body traits have reached their terminal growing point and could no longer increase proportionately with increase in weight.

Linear regression

The results of the linear regression of body on linear body measurement of the Nigerian heavy local chicken ecotype are presented in table 3.

Table 3. Linear regression of body weight (dependent variable) on body measurement (independent variables) of the Nigerian heavy local chicken ecotype using simple linear regression

Independent variable	Intercept (a)	Std error	Regression coefficient	R^2	Significance
Body length	-909.52	4.33	83.67	0.38	0.000**
Shank length	-1159.38	10.99	316.42	0.58	0.000**
Chest circumference	-904.80	1.49	59.68	0.72	0.000**
Thigh circumference	-317.43	6.26	143.38	0.46	0.000**
Thigh length	-620.55	3.17	125.38	0.71	0.000**

Shank length had the highest regression coefficient (316.42), followed by thigh circumference (143.38), thigh length (125.38), body length (83.67) and chest circumference had the least value (59.68). The coefficient of determination (R^2) is a key output of regression analysis. It is interpreted as the proportion of the variance in the dependent variable that is predictable from the independent variable. It explains the extent to which the dependent variable is predictable. The standard error of the estimate is a measure of the accuracy of prediction made with a regression line. It is simply the difference between what a subjects actual score was (y) and what the predicted score is (y').

All the linear body measurements under study were statistically significant; and they also had high coefficients of determination (R^2) ranging from 0.38 to 0.72. This showed that they were all good predictors of body weight. This result is in agreement with the findings of Adeleke *et al.,* (2004) who reported that body weight can be predicted from linear body measurements for cross bred egg-type chickens and Adeniji and Ayorinde (1990) for Cob broilers strain.

The values of R^2 obtained in this study were lower than the R^2 values (73.91% to 97.91%) and (82% to 92%) reported by Adeleke *et al.,* (2004) and Amao *et al.,* (2011), respectively. The differences in R^2 values obtained in this study and those of earlier researches could be attributed to the difference in chicken strain/breed used. The chest circumference had the lowest standard error (1.49) and the highest value of coefficient of determination of 72.0% and hence, it is adjudged to be the best predictor of body weight. This was also observed by Ojedapo *et al.,* (2012) who reported the chest circumference as the best predictor of weight in two commercial layer strain chicken. Similarly, Ajayi *et al.,* (2008) and Momoh and Karishima (2008), also reported that chest circumference is the best predictor of body weight.

Regression Equation

The linear regression equation that could be used to predict body weight from the body linear measurement of the Nigerian local chicken ecotype is presented in table 4. The result showed that the best linear regression equation is the one of chest circumference (BWT = -904.804 + 5.680CC) because it has the lowest value of standard error and highest value of coefficient of determination.

Table 4. Linear regression equation of body weight on linear body measurement for local chickens

Regression equation	R	R^2	Std. error	Probability
BWT = -909.52 + 83.67BL	0.615	0.37	4.33	0.00
BWT = -1159.37 + 316.42SL	0.758	0.58	10.99	0.00
BWT = -904.80 + 59.68CC	0.849	0.72	1.49	0.00
BWT = -317.43 + 143.38TC	0.679	0.46	6.26	0.00
BWT = -620.55 + 125.38TL	0.847	0.71	3.17	0.00
BWT=Body weight, R^2=coefficient of determination				

The least predictive equation was the body length (BWT = -909.52+83.67BL) because it has the lowest coefficient of determination (37.9%) and standard error (4.33). Vincent *et al.,* (2015) reported that regressing chest circumference on the body weight had the highest coefficient of determination (R^2= 0.65 and 0.78 for females and males).

The regression coefficient associated with the independent variable X and partially representing the amount of change in Y for each unit change in X had a positive value in the relationship between body weight and the linear body parameters under study. The implication of the positive value for the regression coefficient is that body weight gain increases directly with linear body dimensions. This was also observed by Ajayi *et al.,* (2008) for Ross and Anak titan broiler strains.

Multiple Regressions

The results of the multiple regression of body weight on linear body measurement of the Nigerian heavy local chicken ecotype are presented in table 5. The results showed that not all the linear measurements were strong predictors when multiple regressions were applied.

Table 5. Multiple regression of body weight (dependent variable) on body measurements (independent variable) of the Nigerian heavy local chicken ecotype

Independent Variable	Intercept (a)	Std error	Regression coefficients	Sig
Body length	-1076.398	3.652	-5.78	0.102
Shank length		12.220	84.970	0.000
Chest circumference		3.076	21.662	0.000
Thigh circumference		5.592	24.098	0.000
Thigh length		5.443	57.587	0.000

The body length was found not significant ($p > 0.01$) with negative coefficient of regression. This shows that it was not really a strong predictor as the linear regression showed. It had a non-linear increase with body weight. However, other linear body measurements were highly significant ($p < 0.01$), and thus, showed that they are strong predictors.

Yakubu *et al.*, (2009) earlier reported that a good prediction equation with $R^{2\,=}$ 0.87 was obtained when chest circumference, thigh length and shank length were combined. The positive value of regression coefficient in the linear traits shows a direct linear relationship with body weight meaning that an increase in the linear body measurement will bring about a proportionate increase in the body weight.

Multiple Regression Equation

The multiple regression equation of body weight on linear body measurements of the Nigerian heavy local chicken ecotype is presented in table 6.

Table 6. Multiple regression equation of body weight on linear body measurements for local chicken

Independent variable	Regression equation	Std. error	R	R^2
	BWT = -1076.39			
Body length	-5.98	3.65	0.89	0.79
Shank length	84.97	12.22		
Chest circumference	21.66	3.08		
Thigh circumference	24.09	5.59		
Thigh length	57.98	5.44		
BWT = Body weight, R^2 = coefficient of determination				

Multiple linear regression equation can be said to be a better regression equation for prediction of body weight considering its low standard error compared to linear regression equations. Multiple regression equation also, had higher value of coefficient of determination R^2 (0.79).

The regression equation is given as:

BWT = -1076.39 -5.98BL + 84.97SL + 21.66CC + 24.09TC + 57.98TL.

The coefficient of determination was observed to have increased when B.L, S.H, C.C, T.C and T.L were combined in a multiple regression equation compared to the values obtained when the linear body parameters were used singly in a linear regression equation. Similar result was also observed by Momoh and Karishima (2008) who reported coefficient of determination (R^2) of B.L (0.47 and 0.13) and C.C (0.52 and 0.62) for male and female but when B.L, and C.C were combined in a multiple linear regression, R^2 in both male and female increased to 0.67 and 0.68 respectively. Ojo *et al.*, (2014) reported an increment in R^2 value when all linear body measurements were combined in a multiple regression model, in Japanese quail. The result also, corroborate with the findings of Raji *et al.*, (2009). This is also in agreement with the findings of Adeniji and Ayorinde (1990), who reported high coefficient of determination when two body linear measurements were combined. The very high R^2 value obtained when the linear body measurements were combined in a multiple regression suggest that the combination of two or more linear body measurement will be more appropriate since there is existence of variation in the maturing pattern of the various body parts in chicken. Multiple linear regression equation also gave better results i.e. precise value of body weight than the simple linear regression equation. Gueye *et al.,* (1998) stated in his work that when chest circumference and body length were put together in a multiple regression for body weight, they gave better results than when used singly.

Conclusion

From the findings in this study, it could therefore, be concluded that chest circumference had the lowest standard error (1.49) and the highest value of coefficient of determination of 72.0% and hence, it is adjudged to be the best predictor of body weight.

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Conflicts of interest

The authors declare no conflicts of interest.

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