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Biometrical studies of linear growth traits in five sexed chicken breeds from South-western, Nigeria

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Abstract

Growth is the most important factor considered in determining the productivity of livestock species where breed and sex among others have been implicated to affect this physiological function. It becomes imperative to conduct biometrical studies on these birds to evaluate the effect of breed and sex on their morphometric traits for improved production efficiencies using different functions. 300-day-old chicks comprising 3-indigenous and 2-exotic meat-type chickens used for the study were obtained from reputable hatcheries. Birds were distributed based on their breed and sex into three replicates at 10 birds each. They were fed the experimental diet ad-libitum during the study period. Experimental design was the RCBD and body linear morphometric studies were carried out for 8 weeks period. The birds were managed intensively and measurements were taken from each bird weekly using digital weighing scale and graduated measuring tape. Data generated were analyzed on computer using SAS. Result showed that breed significantly ($p<0.05$) influenced body weights which ranged from 1108.21g(NF) to 1992.55g(MB). Males were heavier (1614gv1439g) in weight and longer in linear body traits (9.33v8.88cmSHL), (14.68v14.39cmDSL), (16.72v16.19cmNTS), (20.32v19.59cmTRL), (22.73v21.80cmSTL), (27.84v26.83cmBRG) and (20.89v20.74cmWGL) than the female chickens. Breast girth contributed highest to body weight and hence the best predictor based on R^2 value. It was recommended that researchers intensify effort at improving the growth performance of the Nigerian indigenous chickens for greater meat production using male breast girth of naked neck chickens with appropriate growth gene. Naked neck chickens should be considered for incorporation as meat producing indigenous chicken breed.

***Keywords:** Avian species, prediction equations, sexual dimorphism, hormonal differences, body morphometry.*

Description of problem

Poultry production is regarded as a means of livelihood and a way of sustaining a reasonable level of economic independence (6). The carcass yield of broiler chickens is of main concern to the producers and consumers of poultry. Based on the foregoing and in an attempt to achieve a greater yield from poultry, farmers have to select broiler breeds and sex that will reach market weight within a minimum rearing period, usually between 5 - 7 weeks of age to maximize profits (27).

Morphometric or conformational traits are common parameters used in determining the efficiency of productivity of different breeds and sexes of livestock species. It is also used in evaluating body weight and this has been observed by commercial breeders and producers over the years (22). Growth is normally attained by a systematic sequence of maturational changes that involves the deposition of protein in tissues leading to increase in length and size of morphometric parts (10). A number of morphological characteristics are known to be the pointers of body growth and market value of chickens apart from body weight (10). Some of these factors are known to affect carcass yield of broiler chickens and they include breed, sex, age, nutrition, management, etcetera. (14; 26; 27).

Apart from body weight, a number of conformation traits are known to be good indicators of growth and market value of broiler (16). Reports have it that most of the linear body measurements reflect primarily the elongation of long bones of the animals (1; 4). Such conformation traits include shank length, breast width, kneel length, wing span, chicken height, body length and head circumference (23). The combination of body weight and conformation could be harnessed for maximum economic returns (2).

Recently, growing consumer interest in eating healthier meat has resulted in increasing interest in indigenous chicken breeds (29). This is because their meat has higher protein and lower fat contents as well as unique flavour when compared with that of broilers (18;19). Indigenous chicken breeds are regarded as a superior source for the production of meat (17) having high nutritional value (19). Also, indigenous chickens are adaptive to tropical environments, survive on little or no input and adjust to fluctuation in feed availability and that these poultry species represent valuable resources for livestock development because of their extensive genetic diversities which allow for their rearing under varied environmental conditions, providing a range of products and functions (3). These merits alongside others are very important in the rearing of indigenous chickens and thus, necessitate researches into their production for greater meat and egg availability at affordable prices to increase the protein intake of the people. Therefore, this study examines the effects of breed and sex on the growth of body morphometric traits of some chicken breeds raised intensively in South-western part of Nigeria.

Materials and methods

Location of Study

The study was carried out at the Poultry Unit of the Teaching and Research Farm of the Federal University of Technology, Akure, Ondo State, Nigeria, located on Latitude 07° 16^1 and 07° 18^1 N and Longitude 05° 09^1 and 05° 11^1 E where there is a bimodal rainfall pattern which starts from March to July and September to October with an average rainfall of 1,556mm per annum each year. The average ambient temperature is between 30 - 32°C while the relative humidity is about 80% (9). Laboratory analysis to determine the proximate composition of the experimental diet was carried out at the Nutrition Laboratory of the Department of Animal Production and Health of the same University.

Experimental Birds and Layout

A total of 300 birds at 1:1 male to female ratios, comprising of five indigenously improved breeds namely: normal feather, frizzle feather and naked neck; and exotic Hubbard and Marshall broilers were used for the experiment. The indigenous birds were obtained from FUNNAB hatchery in Abeokuta, Ogun State, Nigeria while the Hubbard and Marshall broilers were procured from Foresight hatchery in Ibadan Oyo state, Nigeria. The study which spanned through eight weeks had the birds distributed based on their breeds and sexes into five treatments while the sex was used as block. Each treatment was divided into 3 replicates of 60 birds at 30 male to 30 female at 10 birds per replicate making a total of 60 birds per treatment. The experimental design used was Randomize Complete Block Design (RCBD) in Completely Randomized Design arrangement. The breed was the main source of variation while the block will be showing the effect of the sex.

Experimental Management

The pens were washed and disinfected prior to the chicks' arrival and all necessary brooding facilities were provided. On arrival, all the chicks were tagged at the wings for ease of identification and measurement using a pre-numbered improvised rubber-tags. The initial weights of the chicks were taken individually and recorded appropriately using a sensitive weighing scale based on the breed and sex. The chicks were then distributed into the pens according to the experimental design. The birds used for this study were raised under similar intensive conditions at the Livestock (Poultry Unit) experimentation farm of the University from day old to eight weeks of age. The birds were raised on deep litter system.

Experimental Diet and Feeding

The birds were fed formulated experimental diet ad-libitum for the period of the experiment. The gross and proximate composition of the experimental diet is shown in Table 1 below.

Table 1: Gross and proximate composition of experimental diet

Ingredients	Quantity (g/100g)
Maize	50.0
Wheat Offal	14.0
Soya Bean Meal	14.0
Palm Kernel Cake	5.9
Groundnut Cake	10.6
Fish Meal	1.5
Bone Meal	1.5
Limestone	1.0
Methionine	0.4
Lysine	0.1
Premix	0.5
Salt	0.5
Total	100
Nutrients	Composition (%)
Moisture content	7.98
Dry matter content	92.02
Crude protein	22.88
Ash content	2.87
Fat content	6.13
Crude fibre	6.33
Metabolizable energy (KCal/Kg)	2800

Data Collection

The body weights of each bird and linear body measurements were taken weekly. The weights were collected using a sensitive weighing scale (5kg Max) while the linear body measurements were done using a graduated measuring tape (centimeters). The body morphometric traits measured include: Body weight (BWT), Shank Length (SHL), Shoulder to tail length (STL), Drumstick length (DSL), Nose to Shoulder length (NTS), Wing length (WGL), Trunk length (TRL). All the linear body measurements data obtained were done according to the description reported publication (11). The following defines how the data were obtained during experiment:

- Body weight (BWT): This was measured in grams using a sensitive weighing scale.
- Shank length (SHL): It was measured as the distance from the hock to the extremity of the digitus pedis.
- Drumstick length (DSL): This was measured as the distance from the knee joint to the hock.
- Nose-to-Shoulder length (NTS): Measured as the distance from the nose to the point of the shoulder after it had been carefully stretched.
- Trunk length (TRL): It was measured as the distance from the point of the shoulder to the tuberosity of the ischium.
- Shoulder-to-tail length (STL): It was measured as the linear distance between the neck joint and the tail using a carefully stretched measuring tape positioned along the midline of the bird's back.
- Wing length (WGL): It was measured by stretching the wing and taken as the measurement from humerus–coracoids junctions to the tip of the wing's digit.
- Breast girth length (BRG): This is measured as the body circumference under the wing.

Statistical Analysis

One-way analysis of variance (ANOVA) was used to analyze all data obtained separately for the effect of breed and sex. Where there are significant differences, the means were separated using Duncan's Multiple Range Test of SAS (28) Version 13 Statistical Package at the probability level of 0.05. The statistical model for the experimental is stated below:

$Y_{ij} = \mu + B_i + S_j + e_{ij}$

Where:

Y_{ij} = Individual observation i.e observation of i^{th} breed (treatment) in the j^{th} sex (block)

μ = General mean

B_i = Effect of i^{th} breed (i = 1-5)

S_j = Effects of j^{th} sex (j = 1-2)

e_{ij} = Experimental errors

Simple linear, Quadratic, Allometric and Multiple linear regression analyses were done using SAS 2008. The mathematical model used during the analysis are given below:

$Y_1 = a + bX$ ……… (i)
(Simple linear function)

$Y_2 = a + bX + cX^2$ ……………… (ii)
(Quadratic function)

$Y_3 = a + bX$ ……………… (iii)
(Allometric function)

$Y = a + b_iX_i + ...+b_nX_n$ ………. (iv)
(Multiple linear function)

Where: Y, Y_1, Y_2, and Y_3 = Dependent variables (Body weights)

X = Independent variables (Shank length (SHL), Drumstick length (DSL), Nose-to-shoulder length (NTS), Trunk length (TRL), Shoulder-to-tail length (STL), Breast girth (BRG) and Wing length (WGL) are equivalent to n and n=i while i= 1, 2, 3, 4, 5, 6, and 7);

b, c, d = Regression coefficients associated with independent variables

a = Intercept at Y-axis which represents the estimate of dependent variable when the independent variable is zero.

Results and discussion

Effect of breed on body weight and linear morphometric traits of experimental birds

The result presented in Table 2 showed that the naked neck weighed heaviest among the indigenous chicken breeds with body weight value of 1308.28g. The breed equally had the longest body morphometry in drumstick length (14.37cm) and breast girth (25.95cm). Normal feather breed recorded the lowest values in all body morphometric traits except drumstick length (13.86cm) and nose-to-shoulder length (15.72cm). The frizzle feather had the highest values in trunk length (19.50cm), shoulder-to-tail length (21.66cm) and nose-to-shoulder length (16.50cm).

Expectedly, the exotic meat-type chickens (Marshall and Hubbard) had the highest average body weights than all the indigenous breeds. The result obtained in this study indicated that Marshall with 1992.55g weighed heaviest among all breeds and even more than Hubbard (1954.73g) broiler chickens. Marshall broilers also had higher values for all morphometric traits except the breast girth (31.23cm) where Hubbard broilers were found better. The result also showed that all the five chicken breeds used for this study were significantly different ($p<0.01$) and variations in their performances were attributed to differences in their breeds. Comparing all the strains, Marshall broiler performed best based on body weight determination using morphometric traits while normal feather indigenous chickens performed lowest.

The highest body weight was recorded for Marshall Broilers in this experimental. Likewise, the highest final body weight among the improved indigenous chickens was recorded for naked neck while the lowest value was recorded for normal feather. These results were in tandem with the findings of many researchers and the resemblance of results obtained were due to similarity in management system (12; 33; 7). Significant differences ($p<0.05$) were recorded in body linear growth parameters of the experimental birds where breast girth generally had the highest mean value contribution to body weights across the genotype used which are in agreement with the reports of other researchers (4; 7). The result for Normal feather body weight which is 1.11kg is lower than the values of 1.32kg and 1.19kg reported by (31) and (32) respectively slightly higher than the value (1.06kg) obtained by (21). Normal feather has the least mean body weight value while the naked necks were the heaviest (1.31kg). This shows that there is a significant difference between the three breeds in terms of body weight. The shank length obtained for the three indigenous chickens has the mean value of 8.89cm which is higher than the values 6.60cm and 8.58cm recorded by (21) and (30) respectively. This could be that the birds used in this study were managed under intensive care. The mean values for wing length in Nigerian local chickens are 17.50cm, 17.80cm, 17.70cm for naked neck, frizzled feather and normal feather respectively (12) which is lower than what was obtained in this study. The average wing length value of 20.74cm in this study was higher than theirs (12) and this could be attributable to the management systems as (12) could have taken their data from local chickens raised on free range as the case with (21). The values for the wing length obtained in this study for normal feather, frizzled feather, naked neck chicken breeds were 19.70cm, 20.03cm, 19.61cm respectively.

The breast girth mean value of 26.83cm for the indigenous breeds obtained in this study is slightly higher and comparable to the value of 26.75cm obtained by (30). this is clearly due to the similarity in the management system adopted these researchers.

Effects of sex on body weight and morphometric traits in different chicken breeds

The results of effects of sex on body weight and morphometric traits in different chicken breeds presented in Table 3 indicated that; among the female indigenous chicken breeds, naked neck had the highest value for body weight (1236.10g), drumstick length (14.05cm) and breast girth (25.56cm) with least values in shank length (8.50cm), nose-to-shoulder length (14.89cm) and wing length (19.23cm). The frizzled feather had the highest values in shank length (8.62cm), nose-to-shoulder length (16.28cm), trunk length (19.32cm), shoulder-to-tail length (21.19cm) and wing length (20.44cm) and lowest value in breast girth (23.96cm). Normal feather breed had the least values in body weight, drumstick length, trunk length and shoulder-to-tail length with values 1122.08g, 13.55cm, 18.33cm and 20.47cm respectively. While for their male counterparts, naked neck had the highest value for body weight (1380.46g), drumstick length (14.70cm), shoulder-to-tail length (22.28cm), breast girth (26.33cm) and wing length (19.99cm) but had least value in nose-to-shoulder length (15.88cm). Frizzled feather had the highest value in shank length (9.20cm), Nose-to-shoulder length (16.71cm) and trunk length (19.86cm) with least value in drumstick length (13.19cm). while the normal feather breed had the least values in body weight, shank length, trunk length, shoulder-to-tail length, breast girth length and wing length with the values 1094.33g, 8.47cm, 18.10cm, 20.47cm, 24.62cm and 19.44cm respectively.

Table 2: Effect of breed on linear body morphometric traits of experimental birds

Breed	BWT (g)	SHL (cm)	DSL (cm)	NTS (cm)	TRL (cm)	STL (cm)	BRG (cm)	WGL (cm)
NF	1108.21^{c}	8.50^{b}	13.86^{d}	15.72^{c}	18.21^{c}	20.47^{c}	24.66^{c}	19.70^{c}
FF	1270.96^{bc}	8.91^{b}	13.38^{d}	16.50^{b}	19.50^{b}	21.66^{b}	24.73^{c}	20.03^{c}
NN	1308.28^{b}	8.58^{b}	14.37^{c}	15.39^{c}	19.23^{b}	21.46^{b}	25.95^{b}	19.61^{c}
MB	1992.55^{a}	9.94^{a}	15.91^{a}	17.50^{a}	21.50^{a}	24.04^{a}	30.12^{a}	22.86^{a}
HB	1954.73^{a}	9.62^{a}	15.15^{b}	17.17^{a}	21.25^{a}	23.69^{a}	31.23^{a}	21.89^{b}
±SEM	43.82	0.12	0.22	0.23	0.34	0.31	0.37	0.29
P-value	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
LS	***	***	***	***	***	***	***	***

Means with different superscripts a, b, c and d within the same column are significantly different ($p<0.001$), NF = Normal feather, FF = Frizzled feather, NN = Naked neck, MB = Marshal broiler, HB = Hubbard broiler, ±SEM = Standard error of mean, BWT = Body weight, SHL = Shank length, DSL = Drumstick length, NTS = Nose-to-Shoulder length, TRL = Trunk length, STL = Shoulder-to-tail length, BRG = Breast girth and WGL = Wing length, LS = Level of significance

For the exotic breeds, Marshall broiler male had higher values in body weight, shank length, drumstick length, nose-to-shoulder length and wing length while Hubbard broiler male had higher values in the trunk length, shoulder-to-tail length, and breast girth. Similar observations were noticed for the exotic female breeds. The Table indicated that sex has no significant (p>005) effect on all the body morphometric traits of the experimental chickens.

The pooled value results obtained in Table 3 showed that the body weights and linear body morphometry have no significant effect ($p>0.05$) on the sexes of the experimental birds. The values of body weight (1614.74g) and breast girth (27.84cm) were observed higher in males than in females with 1439.15 and 26.83cm respectively.

The body weights obtained in this study ranged between 1.11 - 1.31kg with average being 1.23kg for the male indigenous chicken breeds (naked neck, normal feather and frizzled feather). The result of this study is higher than the value (1.06kg) reported by (21) for male local chickens; lower than the value (1.45kg) reported by (21). The difference could be attributed to rearing system as (21) measurement were taken from birds on free range while those of (30) were obtained from those managed intensively which is the same as that of the present study. (21) further noted that male usually had higher values in body weights and linear body measurements than female chickens which might be due to the differences in the secretion of sex hormones that are regulated through differential genetic constitution in the sexes. The male chickens in this study were observed heavier and longer than their female counterparts and these findings were corroborated by the works of (32). (20) also reported that male chickens are always found with larger values for wing length and breast girth than the female chicken genotype. The findings of the present study agreed with (20) for naked neck, Hubbard and Marshall broiler chickens but disagrees with the values obtained for normal feather and frizzle feather where the female recorded a higher value for wing length. However, these differences were not statistically significant (p>0.05) due to large variation within groups and fewer observations in certain groups. The variations in linear body measurements between sexes in different studies were attributed to sexual dimorphism occasioned by hormonal secretion (13; 11). This will probably make the naked neck male a better meat producing indigenous specie than the other breeds.

Table 3: Effect of sex on morphometric traits of experimental chicken breeds

Breed	Sex	BWT	SHL	DSL	NTS	TRL	STL	BRG	WGL
NF	M	1094.33	8.47	14.16	16.22	18.10	20.47	24.62	19.44
	F	1122.08	8.52	13.55	15.23	18.33	20.47	24.70	19.96
±SEM		58.35	0.17	0.30	0.31	0.45	0.41	0.50	0.38
FF	M	1376.50	9.20	13.19	16.71	19.86	22.13	25.50	19.61
	F	1165.42	8.62	13.57	16.28	19.32	21.19	23.96	20.44
±SEM		77.79	0.22	0.40	0.41	0.60	0.55	0.67	0.51
NN	M	1380.46	8.66	14.70	15.88	19.75	22.28	26.33	19.99
	F	1236.10	8.50	14.05	14.89	18.70	20.63	25.56	19.23
±SEM		54.38	0.15	0.28	0.28	0.42	0.38	0.47	0.36
HB	M	2102.32	9.92	15.00	17.26	22.05	24.65	32.24	22.13
	F	1807.13	9.32	15.30	17.08	20.45	22.72	30.21	21.65
±SEM		57.47	0.16	0.29	0.30	0.45	0.41	0.49	0.38
MB	M	2120.11	10.42	16.33	17.52	21.82	24.12	30.52	23.30
	F	1865.00	9.46	15.49	17.48	21.17	23.98	29.73	22.43
±SEM		56.66	0.16	0.29	0.30	0.44	0.40	0.49	0.37
Pooled Value	M	1614.74	9.33	14.68	16.72	20.32	22.73	27.84	20.89
	F	1439.15	8.88	14.39	16.19	19.59	21.80	26.83	20.74
±SEM		32.34	0.09	0.17	0.18	0.26	0.23	0.28	0.22
P-value		NS	NS	NS	NS	NS	NS	NS	NS

a and b = Means within column with different superscripts are significantly different (p<0.05), HB = Hubbard broiler, NF = Normal feather, FF = Frizzled feather, NN = Naked neck, MB = Marshal broiler, M = Male, F = Female, SEM = Standard error of mean, BWT = Body weight, SHL = Shank length, DSL = Drumstick length, BRG = Breast girth, NTS = Nose-to-shoulder, TRL = Trunk length, STL = Shoulder-to-tail length and WGL = Wing length

Regression estimates of body weight for both sexes of experimental birds

Table 4 shows body weight prediction equations, standard error of mean and coefficient of determination (R^2) for the fitted linear, quadratic and allometric functions from morphometric traits with their respective level of significance. All morphometric traits were statistically highly significant (p<0.001) for the fitted functions and have strong existing relationship with body weights and this had earlier been reported by some researchers (24; 8). The traits generally had positive values of regression coefficients for all the fitted functions. Coefficient of determination (R^2) had the highest values of 87% using the multiple linear models when all morphometric traits are considered together. Highest coefficient of determination (R^2) always gives the best prediction of accuracy (8). Thus, this will give a best prediction of body weight of the birds when compared to testing of the morphometric traits singly. Breast girth (X_6) had the highest values (0.74 - 0.75) using the linear and non-linear model functions. It also gave the best prediction of accuracy for body weight (BWT) when compared to the other traits. The highest values of breast girth and prediction of accuracy for body weight in this study is agreed with reports of several researches (2; 1; 6; 8; 24).

Table 4: Estimates of body weight for both sexes of experimental birds using different functions

Equation	R^2	±SEM	P-value	LS
$Y_1 = -1565.01 + 342.35X_1$	0.52	19.73	0.001	***
$Y_2 = -5774.16 + 1201.19X_1 - 43.21X_1^2$	0.59	19.73	0.001	***
$Y_3 = 5.27 + 0.22X_1$	0.50	19.71	0.001	***
$Y_1 = -647.03 + 151.327X_2$	0.30	20.81	0.001	***
$Y_2 = 1114.60 - 112.08X_2 + 9.46X_2^2$	0.35	20.78	0.001	***
$Y_3 = 5.64 + 0.11X_2$	0.36	20.80	0.001	***
$Y_1 = -717.11 + 138.40X_3$	0.28	22.39	0.001	***
$Y_2 = 702.03 - 57.23X_3 + 6.48X_3^2$	0.32	22.36	0.001	***
$Y_3 = 5.62 + 0.10X_3$	0.32	22.39	0.001	***
$Y_1 = -558.81 + 105.72X_4$	0.34	18.13	0.001	***
$Y_2 = 2109.46 - 177.53X_4 + 7.32X_4^2$	0.38	18.11	0.001	***
$Y_3 = 5.81 + 0.07X_4$	0.35	18.10	0.001	***
$Y_1 = -1269.11 + 126.38X_5$	0.47	18.67	0.001	***
$Y_2 = -586.34 + 57.07X_5 + 1.68X_5^2$	0.48	18.65	0.001	***
$Y_3 = 5.33 + 0.07X_5$	0.48	18.67	0.001	***
$Y_1 = -1463.63 + 109.31X_6$	0.74	11.31	0.001	***
$Y_2 = -779.20 + 56.99X_6 + 0.97X_6^2$	0.75	11.29	0.001	***
$Y_3 = 5.27 + 0.07X_6$	0.74	11.28	0.001	***
$Y_1 = -1131.55 + 127.97X_7$	0.39	20.24	0.001	***
$Y_2 = 1644.86 - 154.07X_7 + 7.01X_7^2$	0.42	20.23	0.001	***
$Y_3 = 5.41+0.09X_7$	0.41	20.26	0.001	***
$Y = -2914.04 + 86.04X_1 + 14.62X_2 + 12.58X_3 - 11.05X_4 + 50.33X_5 + 68.88X_6 + 21.91X_7$	0.87	13.33	0.001	***

X_1 = Shank length (SHL), X_2 = Drumstick length (DSL), X_3 = Nose-to-shoulder length (NTS), X_4 = Trunk length (TRL), X_5 = Shoulder-to-tail (STL), X_6 = Breast girth (BRG), X_7 = Wing length (WGL), BWG = Body weight, ±SEM = Standard error of mean, R^2 = Coefficient of determination, Y_1 = Simple linear, Y_2 = Quadratic, Y_3 = Allometric, Y = Multiple linear regression, P-value = Probability value and LS = Level of significance

Predictive estimates of body weight determination for male experimental birds

Table 5, shows body weight prediction equations, standard error of mean and coefficient of determination (R^2) for the fitted linear, quadratic and allometric functions from morphometric traits with their respective level of significance. All morphometric traits were statistically highly significant (p<0.01) for the fitted functions and have strong existing relationship with body weights. The morphometric traits generally had positive values for regression coefficients for all the fitted functions. The regression coefficients of the linear, quadratic and allometric functions for all morphometric traits were positive.

Coefficient of determination (R^2) had the highest value (0.88) when all independent traits are combined together in the prediction of body weight. Thus, this will give a best prediction of body weight of the male chicken strains when compared to the morphometric traits singly. Breast girth (X_6), amongst the other independent morphometric traits gave the highest values using both the linear and non-linear functions when they act individually thus will give the highest prediction of accuracy and contribution to body weight. Nose-to-shoulder length (X_3) gave the least value of prediction of body weight (0.22, 0.28 and 0.29) for all functions. High value of breast girth and prediction of accuracy for body weight in this study is in agreement with the reports of several researches (2; 24 and1).

Table 5: Estimates of body weight from LBM for male experimental birds using different models

Equation	R^2	±SEM	P-value	LS
$Y_1 = -854.73 + 251.16X_1$	0.47	29.36	0.001	***
$Y_2 = -539.46 + 1156.09X_1 - 42.27X_1^2$	0.58	29.42	0.001	***
$Y_3 = 5.82 + 0.17X_1$	0.44	29.32	0.001	***
$Y_1 = -1192.89 + 178.08X_2$	0.34	27.40	0.001	***
$Y_2 = 5282.36 - 690.23X_2 + 29.68X_2^2$	0.38	27.43	0.001	***
$Y_3 = 5.61 + 0.12X_2$	0.34	27.40	0.001	***
$Y_1 = -1054.07 + 148.61X_3$	0.22	30.87	0.001	***
$Y_2 = 277.52 - 22.33X_3 + 6.24X_3^2$	0.29	31.02	0.001	***
$Y_3 = 5.65 + 0.11X_3$	0.28	30.98	0.001	***
$Y_1 = -731.68 + 107.91X_4$	0.40	14.59	0.001	***
$Y_2 = -589.96 + 85.34X_4 + 1.18X_4^2$	0.43	15.21	0.001	***
$Y_3 = 5.65 + 0.84X_4$	0.45	15.23	0.001	***
$Y_1 = -1141.79 + 114.77X_5$	0.43	14.48	0.001	***
$Y_2 = 473.03 - 37.91X_5 + 3.87X_5^2$	0.48	14.52	0.001	***
$Y_3 = 5.39 + 0.09X_5$	0.48	14.52	0.001	***
$Y_1 = -1712.28 + 119.43X_6$	0.78	7.01	0.001	***
$Y_2 = -1212.86 + 84.01X_6 + 0.62X_6^2$	0.78	7.00	0.001	***
$Y_3 = 5.30 + 0.07X_6$	0.76	7.01	0.001	***
$Y_1 = -1694.79 + 159.01X_7$	0.50	17.48	0.001	***
$Y_2 = -1878.41 + 176.57X_7 - 0.42X_7^2$	0.50	17.49	0.001	***
$Y_3 = 5.30 + 0.10X_7$	0.50	17.49	0.001	***
$Y = 365.87 + 29.34X_1 + 26.13X_2 + 31.17X_3 - 31.68X_4 + 60.13X_5 + 78.68X_6 + 42.26X_7$	0.89	17.22	0.001	***

X_1 = Shank length (SHL), X_2 = Drumstick length (DSL), X_3 = Nose-to-shoulder length (NTS), X_4 = Trunk length (TRL), X_5 = Shoulder-to-tail (STL), X_6 = Breast girth (BRG), X_7 = Wing length (WGL), BWG = Body weight, ±SEM = Standard error of mean, R^2 = Coefficient of determination, Y_1 = Simple linear, Y_2 = Quadratic, Y_3 = Allometric, Y = Multiple linear regression, P-value = Probability value, LS = Level of significance and LBM = Linear body morphometry

Estimates of body weight from linear body morphometry for female experimental birds

The body weight prediction equations, standard error of mean and coefficient of determination (R^2) for the fitted linear, quadratic and allometric functions from morphometric traits with their respective level of significance is shown in Table 6. All morphometric traits were highly statistically significant ($p<0.01$) for the fitted functions and have strong existing relationship with body weights and this had been verified earlier by some researchers (24 and 8). The morphometric traits generally had positive values for regression coefficients for all the fitted functions. The regression coefficients of the linear, quadratic and allometric functions for all morphometric traits were positive (8).

Coefficient of determination (R^2) had the highest values (0.72 - 0.87) when all independent traits are combined together in multiple system to predict body weight. Thus, this will give the best prediction of body weight of the female chicken breed when compared to the morphometric traits singly. Breast girth (X_6) amongst the other independent morphometric traits gave the highest values using the linear and non-linear model functions when they act individually which gave the highest contribution and prediction of accuracy for body weight. The highest contribution value of breast girth to body weight in this study agreed with those of (2; 24 and 1). Nose-to-shoulder length (X_3) gave the least value of prediction of body weight (0.25 - 0.33).

Table 6: Estimates of body weight-LBM for female experimental birds using different functions

Equation	R^2	±SEM	P-value	LS
$Y_1 = -2320.98 + 411.49X_1$	0.56	29.92	0.001	***
$Y_2 = -1360.41 + 195.35X_1 + 13.38X_1^2$	0.59	29.90	0.001	***
$Y_3 = 4.54 + 0.30X_1$	0.57	29.95	0.001	***
$Y_1 = -703.90 + 136.61X_2$	0.38	14.28	0.001	***
$Y_2 = -248.87 + 88.78X_2 + 1.95X_2^2$	0,34	14.24	0.001	***
$Y_3 = 5.72 + 0.11X_2$	0.36	14.26	0.001	***
$Y_1 = -391.06 + 102.40X_3$	0.25	14.58	0.001	***
$Y_2 = 901.44 - 70.47X_3 + 6.34X_3^2$	0.33	14.62	0.001	***
$Y_3 = 5.73 + 0.09X_3$	0.32	14.60	0.001	***
$Y_1 = -413.01 + 85.96X_4$	0.27	11.36	0.001	***
$Y_2 = 2711.88 - 230.53X_4 + 8.33X_4^2$	0.32	11.40	0.001	***
$Y_3 = 5.97 + 0.06X_4$	0.27	11.25	0.001	***
$Y_1 = -912.85 + 101.43X_5$	0.39	10.21	0.001	***
$Y_2 = -1900.88 + 183.88X_5 - 1.39X_5^2$	0.45	10.27	0.001	***
$Y_3 = 5.36 + 0.09X_5$	0.45	10.27	0.001	***
$Y_1 = -1279.61 + 98.57X_6$	0.70	5.21	0.001	***
$Y_2 = -1129.33 + 87.99X_6 + 0.28X_6^2$	0.73	5.23	0.001	***
$Y_3 = 5.30 + 0.07X_6$	0.72	5.21	0.001	***
$Y_1 = -613.95 + 91.33X_7$	0.34	10.41	0.001	***
$Y_2 = 2083.86 - 189.29X_7 + 7.54X_7^2$	0.37	10.43	0.001	***
$Y_3 = 5.52 + 0.08X_7$	0.37	10.43	0.001	***
$Y = -2994.37 + 151.11X_1 + 9.63X_2 + 8.43X_3 - 18.74X_4 + 61.10X_5 + 59.19X_6 + 12.58X_7$	0.87	11.23	0.001	***

X_1 = Shank length (SHL), X_2 = Drumstick length (DSL), X_3 = Nose-to-shoulder length (NTS), X_4 = Trunk length (TRL), X_5 = Shoulder-to-tail (STL), X_6 = Breast girth (BRG), X_7 = Wing length (WGL), BWG = Body weight, ±SEM = Standard error of mean, R^2 = Coefficient of determination, Y_1 = Simple linear, Y_2 = Quadratic, Y_{43} = Allometric, Y = Multiple linear regression, P-value = Probability value, LS = Level of significance and LBM = Linear body morphometry

Conclusion and Applications

1. This study showed that the body weights and morphometric traits of normal feather, frizzle feather and naked neck indigenous chickens are lesser than that of the exotic Marshall and Hubbard meat-type chickens.
2. The Nigerian indigenous chickens can perform better under intensive management system than the existing extensive one.
3. In this study, the breed influenced the growth of the experimental birds and the male chickens generally recorded higher values than their female counterparts. Of the linear body measurements, the breast girth gave the highest contribution to body weight while quadratic function gave the best prediction model.
4. This research has shown that selection of breast girth would help to improve

the growth and body weight performance as well as muscular accretion of indigenous poultry birds. In view of the current global warming, researchers in the poultry industry in Nigeria should be encouraged to direct their research efforts towards the improvement of indigenous chicken, which generally have better adaptability to tropical climate than the exotic ones, through purposive breeding strategies and better management practices.

5. Regression estimates in this study also showed corresponding increase in body linear morphometric traits leads to corresponding increment in body weight where breast girth was found to be the best predictor of body weight based on the values of coefficient of determination (R^2).
6. The male chickens appeared better than the female ones in their predictive values while quadratic function was best among the three functions used. However, the multiple linear function gave the best prediction of body weight when all morphometric traits are considered together than when considered singly.
7. It could be recommended that researchers and farmers should intensify effort at improving the growth performance of the Nigerian indigenous chickens for greater meat production using male breast girth with appropriate growth gene from naked neck chickens. Naked neck chickens can be considered by Nigerian Livestock Breeders Association and government for incorporation as meat producing indigenous chicken breed.
8. Quadratic function or multiple linear regression estimates are recommended for estimating the body weight from linear body morphometry of poultry species especially in rural areas where digital weighing scales are readily inaccessible.

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