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Estimation of Body Weight from Linear Body Measurements in Four-Chicken Genotypes Using Linear and Quadratic Functions

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ABSTRACT: The study was carried out at the Poultry Unit of the Federal University of Technology, Akure, Nigeria to estimate the body weight (BWT) of four-chicken genotypes from their linear body measurements (LBMs) using simple linear and quadratic functions. A total of 180 chicks purchased from a reputable Hatchery in Abeokuta, Ogun State, Nigeria and were divided into four treatments according to their genotype in a completely randomized designed experiment that lasted for 8 weeks. The birds were distributed at 50 birds per genotypes except for Frizzled Feather (FF) chickens that were 30 in number and they were fed the experimental diet ad-libitum for the period of the study. The BWTs and LBMs were taking fortnightly per bird during the period of the study. Results showed that quadratic functions favoured the chicken genotypes at various ages for the different LDMs valued at 477.86(STL), 308.40(NTS),1350.59(NTS) and 2005.38(CHG) for Marshall, Normal feather, Naked neck and FF chickens respectively at weeks 8 except for Marshall at week 6. The coefficient of determination (R^2) showed that the BWTs and LBMs were well described as most of the values obtained were significantly different ($P<0.05$). This suggests that LBMs could be used to predict body weights at specific ages in chickens. Comparison on the basis of R^2 values showed that LBMs were better fitted by quadratic function than linear function among the genotypes. Comparing the two functions, it could be concluded that quadratic had an advantage over the linear.

Key words: Linear body measurements, body weight, indigenous, chicken and genotypes

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INTRODUCTION

Growth is a complex trait in animals that is controlled by genetic and non-genetic factors. The body weight and body conformations are the two important parameters for measuring growth in the domestic chicken (Udeh and Ogbu, 2011). The mechanisms involved in the control of growth in chickens are too complex to be explained only under univariate analysis because all related traits are biologically correlated due to pleiotropic effect of genes and linkage of loci (Rosario *et al.,* 2008). Indigenous chickens play an important role as household food supply in rural areas of developing countries (Kitalyi, 1998 and Zaman *et al.,* 2004) and recently have been raised in intensive system with more efficient output per bird (Saadey *et al.,* 2008). For instance, Ibe (1992) showed that frizzle and naked neck individuals in a tropical environment matured earlier than individual with normal feathering. Nwosu *et al.* (1984) equally reported that normal feathering indigenous chickens of Nigeria reached their point of inflexion earlier than the exotic counterparts. It is therefore possible that these major genes are also associated with earlier sexual maturity, a characteristic which influences

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the growth rate and eventually determine its body size or weight (Nwosu *et al.,* 1984).

Linear body measurements such as shank length, drumstick length, breast girth, wing length and body length is used to relate body dimensions to animal's overall body size or weight. These measurements are frequently used in the studies of chickens' growth. Sulabo *et al.* (2006) concluded that the body weight in commercial broiler chickens could be predicted easily by farmers from any given value of the body linear measurements without the use of sophisticated instrument. Brown *et al.* (1973) observed that linear body measurements could be used in assessing growth rate, body weight, feed utilization and carcass characteristics in poultry. These measurements had been used severally for characterization, evaluation and prediction of breeds' performance in both experimental works and in practice (Lawrence and Fowler, 1997). Changes in linear body measurements are indication of tissue growth evidenced in the muscle and fat tissues (Tegbe and Olorunju, 1998). These parameters tend to increase as the animal grows over the time and reaches a constant value for some indigenous chicken (Oke *et al*., 2006). The knowledge of the growth curve of these chickens may be helpful in their selection and breeding processes. Therefore, this study was designed to estimate the body weights of four Nigerian indigenous chicken genotypes from their linear body measurements using linear and quadratic functions. This could serve as a means of generating a growth curve baseline data for the indigenous chickens in Nigeria to know the body trait with high heritable basis that could be selected for improvement during breeding programmes.

MATERIALS AND METHOD

Study location

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. The University is located in the rain forest zone of South Western part of Nigeria which lies between latitude 7° 16' N and longitude 5° 12' E. The climatic condition typically followed that of South Western Nigeria where it is influenced by a unimodal rainfall pattern which starts from April to October with average of 1556 mm per annum. The average ambient temperature usually ranged between 28 - 31°C while the mean annual relative humidity also ranged between 80 - 88 %.

Source of birds, sample size and experimental layout

A total of 240 day-old chicks were purchased and used for the experiment. Out of this, 165 indigenous chicks were obtained from the Teaching and Research Farm of the Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. This was made up of 50 pure breeds of normal feather, naked neck and Marshall as well as 30 of frizzle feather chickens. The Marshall Broiler chicks were purchased from Fore-Sight Hatchery, Ibadan, Oyo State, Nigeria. The study which lasted for 8 weeks was divided into four treatments based on the genotype of the birds with each bird constituting the experimental units. Completely randomized design was adopted for the experiment.

Pre-experimental management

On arrival at the farm, all the chicks used for the study were tagged individually on the wings for ease of identification, weighing and recording. So the initial weights of the chicks were generated and the birds were distributed into four treatments according to their genotypes. There were 50 birds in each genotype except frizzle feather birds that were 30 in number.

Experimental diet

The chick's mash used for the study was formulated at the Teaching and Research Farm Feedmill of the Federal University of Technology, Akure, Nigeria. The diet was formulated to meet the NRC (1994) requirements. The birds were fed the experimental diet *ad-libitum*. The gross and proximate compositions of the diet are shown in Tables 1 and 2 respectively.

Table 1: Percentage composition of experimental diets (g/100g)

Ingredients	Quantity
Maize	45
Wheat offal	12
Brewery dried grain	7
Groundnut cake	15
Fish meal	2
Soya bean meal	12
Bone meal	2
Oyster shell	0.5
Lysine	0.15
Methionine	0.1
Salt	0.4
Premix	0.35
Total	**100**
Calculated Analysis	
Crude protein (%)	23.2
ME (kcal/kg)	2685.49

ME = Metabolizable Energy

Table 2: Proximate composition of experimental diets (g/100g)

Parameters	% Composition
Dry matter (%)	80.85
Moisture content (%)	7.23
Digestible energy (Kcal/kg)	2900
Crude protein (%)	22.8
Crude fibre (%)	4.11
Ash (%)	7.89

Data Collection

During the experimental period, birds were individually weighed fortnightly and their weights were recorded accordingly. The linear body dimensions measured was: shank length (SHL), drumstick length (DSL), nose-to-shoulder length (NTS), trunk length (TRL), shoulder-to-tail length (STL), chest girth (CHG) and wing length (WGL). The descriptions of the linear body dimensions measured are given below:

- Shank length (SHL): This is the distance from the hock joint to the foot.
- Drum stick length (DSL): This is the distance between the hinge and hock joints.
- Nose-to-shoulder (NTS): This is the distance from the nose to the point of the shoulder.
- Trunk length (TRL): This is the longitudinal distance from the point of the shoulder to the tuberosity of the ischium.
- Shoulder-to-tail length (STL): This is the distance from the point of the shoulder to pin bone or to the end of coccygeal vertebrae.

- Chest girth (CHG): This is measured as the body circumference just behind the wings.
- Wing length (WGL): This is measured on the dorsal midline to the highest point of the wing.

All measurements were made in the morning before feeding the birds. Each bird was gently restrained in an unforced position before taking any measurement. Body weights were measured using (5kg max.) sensitive weighing scale (g) while the linear body measurements were done with metric measuring tape (cm).

Statistical analysis

One-way analysis of variance (ANOVA) was used to analyze data generated from the field trial. The regression analysis for body weights and body linear dimensions of the four-chicken genotypes using linear and quadratic functions were carried out using the ANOVA option of SAS version 13.0 statistical package (SAS, 2008). Separation of significant means was carried out using Duncan Multiple Range Test (DMRT) as outlined in the same statistical package at PÂ0.05 probability level.

RESULTS

Tables 3 - 6 showed the estimation of body weight in simple linear and quadratic functions fitted for weight-linear body measurements for the chicken genotypes (i.e. normal feather, naked neck, Frizzle feather and Marshall) used for the study at different ages for each genotype. The tables showed the ages, function, standard error (SE), coefficient of determination (R^2) and level of significance (LS) where R^2 was used to determine the goodness of fit and accuracy of prediction of each function. The contributions of each of the body linear measurements to live weight gain of the birds at specific ages were as shown in the Tables and were explained using the two functions.

For the normal feather chicken at week 2, shoulder-to-tail length (X_5) and trunk length (X_4) had the highest contributions to body weight in quadratic and linear functions respectively. The highest contributions to body weights in linear and quadratic functions at week 4, 6 and 8 were shank length (X_1) and drumstick length (X_2), shank length (X_1) for both functions and drumstick length (X_2) and wing length (X_7) respectively. All functions were significantly different ($P < 0.05$) across ages except for linear function at week 2 while standard error were generally observed to be very low across ages in this genotypes, the highest of 16.89 value being recorded in linear function for nose-to-shoulder (X_3) at week 8. Coefficients of determination (R^2) were generally seen to be high across ages in this genotypes and this showed a better goodness of fit and accuracy of prediction for the two functions. However, quadratic function had an advantage over the linear function for this chicken genotype. Week 6 appeared to be the best age at which prediction could be carried out in chickens because the highest R2 value of 81% was recorded at this age for drumstick length (X_2) and quadratic function.

For the naked neck chicken at week 2, drumstick length (X_2) had the highest contributions to body weight in linear function while the quadratic function recorded negative (-3.94) value in shoulder-to-tail length (X_5). The highest contributions to body weights in linear and quadratic functions at week 4, 6 and 8 were drumstick length (X_2) for both functions, shank length (X_1) for both functions and wing length (X_7) and nose-to-shoulder (X_3) respectively. All functions were not significantly different ($P>0.05$) across ages except in drumstick length (X_2) and chest girth (X_6) for both functions at week 2, wing length (X_7) at week 4, and trunk length (X_4) for linear function at week 8. However, the two functions and all the linear body dimensions were significantly different ($P<0.05$) at week 6 in trunk length (X_4) and nose-to-shoulder (X_3) for both linear and quadratic functions respectively. The standard error (SE) were generally observed to be low across ages in this genotypes but were better than that of Normal feather chicken. The highest SE value of 63.79 was recorded in linear function for nose-to-shoulder (X_3) at week 8. Coefficients of determination (R^2) were generally seen to be lower compared to normal feather chickens across ages in this study and this showed a better goodness of fit and accuracy of prediction for the two functions are better in normal feather chickens than the naked neck. However, quadratic function generally had an advantage over the linear function for this chicken genotype. Week 6 appeared to be the best age at which prediction could be carried out in naked neck chickens because the highest R^2 value of 55% was recorded at this age for shank length (X_1) with quadratic function. However, nose-to-shoulder (X_3) had the highest contribution to body weight at week 8.

For frizzle feather chicken at week 2, shank length (X_1) had the highest contributions to body weight for both functions. The highest contributions to body weights in linear and quadratic functions at week 4, 6 and 8 were shank length (X_1) and nose-to-shoulder (X_3), drumstick length (X_2) and trunk length (X_4) and nose-to-shoulder (X_3) for both functions respectively. All functions were significantly different ($P<0.05$) across ages except at week 8 in drumstick length (X_2) for both functions. The standard errors were generally observed to be low across ages in this genotype. The lowest and highest values of 25.72 and 180.90 were recorded in quadratic function for chest girth (X_6) and drumstick length (X_2) at week 8 respectively. Coefficients of determination (R^2) were generally seen to be high across ages in this genotypes and this showed a better goodness of fit and accuracy of prediction for the two functions. However, quadratic function had an advantage over the linear function for this chicken genotype. Week 4 appeared to be the best age at which prediction could be carried out in frizzle feather chickens because of the highest R^2 value of 92% recorded at this age in shank length (X_1) and chest girth (X_6) for linear quadratic functions respectively.

For Marshall Chicken at week 2, shank length (X_1) had the highest contributions to body weight for both functions. The highest contributions to body weights in linear and quadratic functions at week 4, 6 and 8 were drumstick length (X_2) and shank length (X_1), shank length (X_1) for both functions and drumstick length (X_2) and wing length (X_7) respectively. All functions were not significantly different ($P>0.05$) across ages except at week 4 where a few parameters for both functions were significantly different ($P<0.05$). The standard errors were generally observed to be low across ages in this genotype. The highest value of 61.53 was recorded in quadratic function for drumstick length (X_2) at week 6. Coefficients of determination (R^2) were generally seen to be relatively low across all ages in this genotypes and this showed a poor goodness of fit and accuracy of prediction for the two functions. However, quadratic function still had an advantage over the linear function for this chicken genotype. Week 6 appeared to be the best age at which prediction could be carried out in Marshall Chickens because the highest R^2 value of 18% was recorded at this age in shank length (X_1) for the two functions.

DISCUSSION

The results on body weights showed an increase in the linear body measurements as the birds matured, indicating a direct positive relationship between body weight and age. The results of growth in linear body dimensions showed an increase in all body measurements of each strain as growth advances in this study. This result was in agreement with the reports of Sonaiya *et al*., (1986) that age is a major determinant of growth and physiological development.

Table 3: Estimate of body weight in simple linear and quadratic functions fitted for weight-linear body measurements for Normal Feather chicken genotype at different ages

Age (wk)	Function	SE	R^2 (%)	LS
2	$Y = 103.73 + 0.10x_1$	1.15	0.02	NS
	$Y_1 = -106.44 + 67.92x_1 - 2.51\ x_1^2$	0.25	0.65	*
	$Y = -20.29 + 26.91x_2$	4.48	0.38	*
	$Y_1 = -417.33 + 194.40x_2 - 17.42\ x_2^2$	4.96	0.49	*
	$Y = -57.54 + 17.85x_3$	2.9	0.40	*
	$Y_1 = -200.55 + 49.89x_3 - 1.78\ x_3^2$	1.81	0.41	*
	$Y = -108.57 + 28.95x_4$	3.09	0.60	*
	$Y_1 = -674.02 + 179.75x_4 - 9.98\ x_4^2$	2.94	0.67	*
	$Y = -107.35 + 26.92x_5$	3.12	0.56	*
	$Y_1 = -868.41 + 216.31x_5 - 11.70\ x_5^2$	2.39	0.69	*
	$Y = -78.66 + 16.17x_6$	1.73	0.60	*
	$Y_1 = -147.73 + 28.91x_6 - 0.58\ x_6^2$	0.75	0.60	*
	$Y = -35.72 + 16.42x_7$	2.56	0.41	*
	$Y_1 = -567.07 + 137.35x_7 - 6.80\ x_7^2$	1.19	0.62	*
4	$Y = -102.53+59.09x_1$	9.74	0.38	*
	$Y_1 = -119.28+66.07x_1-0.72\ x_1^2$	7.63	0.38	*
	$Y = -160.52+57.84x_2$	6.91	0.54	*
	$Y_1 = -413.58+138.66x_2-6.41\ x_2^2$	7.12	0.55	*
	$Y = 21.48+15.47x_3$	3.68	0.23	*
	$Y_1 = 419.08-60.11x_3+3.52\ x_3^2$	1.28	0.32	*
	$Y = 32.72+16.91x_4$`	4.07	0.23	*
	$Y_1 = -287.26+83.01x_4-3.37\ x_4^2$	2.22	0.26	*
	$Y = -18.06+20.33x_5$	3.68	0.34	*
	$Y_1 = -152.24+46.24x_5-1.23\ x_5^2$	1.79	0.35	*
	$Y = -150.41+25.40x_6$	2.84	0.58	*
	$Y_1 = -258.79+41.30x_6-0.58\ x_6^2$	1.46	0.58	*
	$Y = -178.33+32.43x_7$	3.32	0.62	*
	$Y_1 = -160.10+29.30x_7+0.13\ x_7^2$	2.28	0.62	*
6	$Y = -229.78+91.98x_1$	12.1	0.50	*
	$Y_1 = -1694.04+541.67x_1-34.25\ x_1^2$	8.71	0.61	*
	$Y = -380.10+91.18x_2$	6.2	0.79	**
	$Y_1 = 59.99-23.09x_2+7.33\ x_2^2$	3.71	0.81	**
	$Y = -299.49+47.90x_3$	10.9	0.25	*
	$Y_1 = -2516.73+372.73x_3-11.85\ x_3^2$	7.82	0.28	*
	$Y = -315.05+48.57x_4$	6.39	0.50	*
	$Y_1 = -973.06+143.04x_4-3.37\ x_4^2$	4.56	0.50	*
	$Y = -167.54+35.38x_5$	6.48	0.34	*
	$Y_1 = -3541.63+477.86x_5-14.41\ x_5^2$	3.39	0.50	*
	$Y = -249.90+37.34x_6$	3.85	0.62	*
	$Y_1 = -367.42+57.90x_6-0.45\ x_6^2$	1.68	0.62	*
	$Y = -36.99+27.74x_7$	7.3	0.20	*
	$Y_1 = -1580.60+243.19x_7-7.46\ x_7^2$	3.15	0.27	*
8	$Y = -220.12+100.29x_1$	9.1	0.68	*
	$Y_1 = 135.74+11.13x_1+5.49\ x_1^2$	6.19	0.68	*
	$Y = -429.80+104.72x_2$	8.23	0.74	**
	$Y_1 = -91.10+32.85x_2+3.77\ x_2^2$	4.57	0.74	**
	$Y = -639.00+81.73x_3$	16.89	0.29	*
	$Y_1 = -2319.91+308.40x_3-7.62\ x_3^2$	10.31	0.29	*
	$Y = -242.51+50.44x_4$	8.39	0.38	*
	$Y_1 = -2390.13+311.08x_4-7.83\ x_4^2$	3.97	0.42	*
	$Y = -354.08+53.59x_5$	7.65	0.46	*
	$Y_1 = -2545.23+304.28x_5-7.11\ x_5^2$	3.67	0.49	*
	$Y = -535.76+55.68x_6$	5.09	0.67	*
	$Y_1 = -199.89+22.08x_6+0.83\ x_6^2$	1.8	0.67	*
	$Y = -463.96+63.16x_7$	11.9	0.33	*
	$Y_1 = -2677.79+331.70x_7-8.10\ x_7^2$	4.65	0.36	*

*Wk = week, Y = body weight (linear function), Y_1 = body weight (quadratic function), SE = standard error, R^2 = coefficient of determination, LS = level of significance, NS = not significant ($P > 0.05$), * = significantly different ($P < 0.05$), ** = highly significant ($P < 0.01$), X_1 = shank length (SHL), X_2 = drumstick length (DSL), X_3 = nose-to-shoulder (NTS), X_4 = trunk length (TRL), X_5 = shoulder-to-tail length (STL), X_6 = chest girth (CHG) and X_7 = wing length (WGL).*

Table 4: Estimate of body weight in simple linear and quadratic functions fitted for weight-linear body measurements for naked neck genotype at different ages

Age (wk)	Function	SE	R^2 (%)	LS
2	$Y = 47.34+5.36x_1$	3.26	0.04	NS
	$Y_1 = 155.02-51.18x_1+7.34\ x_1^2$	7.24	0.06	NS
	$Y = 14.58+10.82x_2$	2.70	0.21	*
	$Y_1 = 284.67-103.30x_2+11.94\ x_2^2$	4.86	0.29	*
	$Y = 31.21+4.10x_3$	1.83	0.08	NS
	$Y_1= 193.55-30.85x_3+1.87\ x_3^2$	1.73	0.10	NS
	$Y = 48.47+2.29x_4$	1.93	0.02	NS
	$Y_1= 154.51-23.38x_4+1.54\ x_4^2$	2.47	0.03	NS
	$Y = 50.58+1.91x_5$	1.67	0.02	NS
	$Y_1= 76.61-3.94x_5+0.33\ x_5^2$	1.65	0.02	NS
	$Y = 0.93+5.62x_6$	1.50	0.19	*
	$Y_1=121.66-14.09x_6+0.80\ x_6^2$	1.39	0.20	*
	$Y = 90.81-2.71x_7$	1.58	0.05	NS
	$Y_1= 227.10-36.02x_7+2.00\ x_7^2$	12.48	0.08	NS
4	$Y=109.72+6.25x_1$	7.58	0.01	NS
	$Y_1= 122.25+1.51x_1+0.44\ x_1^2$	9.54	0.01	NS
	$Y= 86.77+8.69x_2$	6.71	0.03	NS
	$Y_1 = -460.62+179.60x_2-13.24\ x_2^2$	14.53	0.04	NS
	$Y =85.00+5.15x_3$	2.81	0.05	NS
	$Y_1= 199.32-16.88x_3+1.04\ x_3^2$	1.24	0.07	NS
	$Y = 105.50+3.28x_4$	4.34	0.01	NS
	$Y_1= -154.95+48.42x_4-1.95\ x_4^2$	3.93	0.01	NS
	$Y = 96.91+3.76x_5$	4.12	0.01	NS
	$Y_1= -448.50+92.95x5-3.63\ x_5^2$	3.71	0.03	NS
	$Y = 99.97+3.13x_6$	2.88	0.02	NS
	$Y_1 = -41.91+23.47x_6-0.72\ x_6^2$	1.46	0.02	NS
	$Y = 232.91-7.36x_7$	3.17	0.08	NS
	$Y_1= 597.23-65.51x_7+2.30\ x_7^2$	1.83	0.11	NS
6	$Y=-13.64+63.28x_1$	15.37	0.24	*
	$Y_1= -699.26+261.99x_1-14.29\ x_1^2$	20.34	0.26	*
	$Y= -44.47+54.67x_2$	12.23	0.28	*
	$Y_1 = 1178.72-229.95x_2+16.43\ x_2^2$	15.08	0.29	*
	$Y = -46.39+33.93x_3$	7.07	0.36	*
	$Y_1= 1518.14-193.64x_3+8.21\ x_3^2$	3.19	0.05	NS
	$Y = 273.16+10.77x_4$	6.50	0.07	NS
	$Y_1= -973.06+143.04x_4-3.37\ x_4^2$	4.93	0.22	*
	$Y = -97.65+34.42x_5$	8.50	0.25	*
	$Y_1= -351.63+47.86x_5-10.41\ x_5^2$	7.99	0.47	*
	$Y = -31.67+25.60x_6$	3.57	0.50	*
	$Y_1=-37.42+57.90x_6-0.45\ x_6^2$	2.08	0.50	*
	$Y = -487.94+62.62x_7$	8.26	0.50	*
	$Y_1= -1680.60+245.19x_7-7.46\ x_7^2$	7.12	0.55	*
8	$Y=435.60+50.21x_1$	11.13	0.01	NS
	$Y_1=-1516.36+460.73x_1-21.32\ x_1^2$	61.33	0.01	NS
	$Y= -272.61+107.28x_2$	10.69	0.02	NS
	$Y_1 = -3378.07+682.20x_2-26.32\ x_2^2$	50.10	0.02	NS
	$Y = -291.52+75.52x_3$	10.19	0.01	NS
	$Y_1= -10492.00+1350.59x_3-39.64\ x_3^2$	63.79	0.02	NS
	$Y = -1278.22+117.33x_4$	58.81	0.06	NS
	$Y_1= -80.96-12.16x_4+3.46\ x_4^2$	22.52	0.06	NS
	$Y = -1026.61+98.01x_5$	53.58	0.05	NS
	$Y_1= -3156.99+313.03x_5-5.36\ x_5^2$	19.38	0.06	NS
	$Y = -1240.11+93.64x_6$	61.10	0.04	NS
	$Y_1=-3552.92+299.15x_6-4.53\ x_6^2$	16.75	0.04	NS
	$Y = -1342.78+124.85x_7$	10.20	0.02	NS
	$Y_1= -2179.82+221.00x_7-2.75\ x_7^2$	46.96	0.02	NS

*Wk = week, Y = body weight (linear function), Y_1 = body weight (quadratic function), SE = standard error, R^2 = coefficient of determination, LS = level of significance, NS = not significant ($P > 0.05$), * = significantly different ($P < 0.05$), ** = highly significant ($P < 0.01$), X_1 = shank length (SHL), X_2 = drumstick length (DSL), X_3 = nose-to-shoulder (NTS), X_4 = trunk length (TRL), X_5 = shoulder-to-tail length (STL), X_6 = chest girth (CHG) and X_7 = wing length (WGL).*

Table 5: Estimate of body weight in simple linear and quadratic functions fitted for weight-linear body measurements for frizzle feather genotype at different ages

Age (wk)	Function	SE	R^2 (%)	LS
2	$Y=-116.55+58.35x_1$	16.80	0.52	**
	$Y_1= -725.01+347.88x_1-33.88\ x_1^2$	15.70	0.67	**
	$Y= -103.91+45.58x_2$	10.39	0.64	**
	$Y_1 = -475.28+201.55x_2-15.91\ x_2^2$	13.25	0.68	**
	$Y = -309.89+52.68x_3$	9.42	0.74	**
	$Y_1= -305.81+51.67x_3+0.06\ x_3^2$	14.49	0.74	**
	$Y = -242.66+41.86x_4$	10.24	0.60	**
	$Y_1= -1116.90+242.41x_4-11.40\ x_4^2$	11.65	0.64	**
	$Y = -246.84+39.46x_5$	8.09	0.68	*
	$Y_1= -1009.19+202.85x_5-8.67\ x_5^2$	8.25	0.72	**
	$Y = -133.60+23.94x_6$	3.26	0.83	*
	$Y_1=136.08-29.83x_6+2.60\ x_6^2$	2.78	0.84	*
	$Y = 5.59+16.84x_7$	7.82	0.30	**
	$Y_1= -415.36+137.56x_7-8.31\ x_7^2$	5.68	0.42	*
4	$Y=-405.58+121.32x_1$	11.72	0.91	*
	$Y_1= 239.55-126.02x_1+23.09x_1^2$	16.81	0.92	*
	$Y= -569.79+116.52x_2$	15.18	0.84	*
	$Y_1 = 750.52-271.46x_2+28.02\ x_2^2$	21.56	0.87	*
	$Y = -533.29+74.41x_3$	16.50	0.65	**
	$Y_1= -1621.05+282.24x_3-9.81\ x_3^2$	18.48	0.66	**
	$Y = -493.46+62.96x_4$	13.58	0.66	**
	$Y_1= -1180.11+177.01x_4-4.68\ x_4^2$	12.06	0.67	**
	$Y = -516.81+61.20x_5$	10.88	0.74	**
	$Y_1= -1158.58+162.25x_5-3.93\ x_5^2$	8.21	0.75	**
	$Y = -361.30+47.12x_6$	4.30	0.92	*
	$Y_1=83.47-23.47x_6+2.72\ x_6^2$	2.85	0.92	*
	$Y = -287.48+53.92x_7$	8.64	0.78	*
	$Y_1= 433.97-103.43x_7+8.21\ x_7^2$	6.78	0.81	**
6	$Y=429.57-0.48x_1$	0.59	0.06	NS
	$Y_1= -1131.95+204.26x_1-0.70\ x_1^2$	0.10	0.84	**
	$Y= -649.96+114.11x_2$	31.06	0.55	**
	$Y_1 = 687.19-186.41x_2+16.67\ x_2^2$	31.90	0.56	**
	$Y = -474.65+69.89x_3$	21.71	0.49	**
	$Y_1= 2281.60-407.87x_3+20.25\ x_3^2$	13.80	0.58	**
	$Y = -1181.56+110.98x_4$	30.35	0.55	**
	$Y_1= -54.08.17+709.24x_4-21.06\ x_4^2$	31.63	0.57	**
	$Y = -1321.12+110.41x_5$	28.15	0.58	**
	$Y_1= -2379.57+248.35x_5-4.47\ x_5^2$	25.75	0.58	**
	$Y = -1046.64+83.20x_6$	21.33	0.58	**
	$Y_1=-5145.79+554.10x_6-13.49\ x_6^2$	14.07	0.62	**
	$Y = 272.88+9.69x_7$	39.80	0.01	NS
	$Y_1= -9831.52+1314.64x_7-41.78\ x_7^2$	19.07	0.33	**
8	$Y=-1136.34+192.39\ x_1$	91.49	0.29	*
	$Y_1= -16591.00+3305.85x_1-155.93\ x_1^2$	69.50	0.53	**
	$Y= -329.67+94.80x_2$	110.20	0.06	NS
	$Y_1 = -2988.79+543.32x_2-18.84\ x_2^2$	180.90	0.06	NS
	$Y = -2169.36+207.80x_3$	82.97	0.36	**
	$Y_1= -62227.00+8727.75x_3-301.24\ x_3^2$	105.60	0.65	**
	$Y = -1843.97+163.10x_4$	63.08	0.38	**
	$Y_1= -9183.83+1091.24x_4-29.27\ x_4^2$	63.70	0.39	**
	$Y = -2206.76+172.76x_5$	58.06	0.45	**
	$Y_1= -13808+1540.72x_5-40.16\ x_5^2$	45.74	0.49	**
	$Y = -1564.39+112.27x_6$	44.82	0.36	**
	$Y_1=-21047.00+2005.38x_6-45.76\ x_6^2$	25.72	0.52	**
	$Y = -2286.95+192.16x_7$	62.78	0.46	**
	$Y_1= -21010.00+2582.19x_7-75.98\ x_7^2$	68.63	0.52	**

*Wk = week, Y = body weight (linear function), Y_1 = body weight (quadratic function), SE = standard error, R^2 = coefficient of determination, LS = level of significance, NS = not significant ($P > 0.05$), * = significantly different ($P < 0.05$), ** = highly significant ($P < 0.01$), X_1 = shank length (SHL), X_2 = drumstick length (DSL), X_3 = nose-to-shoulder (NTS), X_4 = trunk length (TRL), X_5 = shoulder-to-tail length (STL), X_6 = chest girth (CHG) and X_7 = wing length (WGL).*

Table 6: Estimate of body weight in simple linear and quadratic functions fitted for weight-linear body measurements of Marshall chicken genotype at different ages

Age (wk)	Function	SE	R^2 (%)	LS
2	$Y=-41.41+49.58x_1$	10.27	0.29	*
	$Y_1= --163.23+299.20x_1-27.07\ x_1^2$	24.83	0.30	*
	$Y= 170.92+2.72x_2$	2.55	0.02	NS
	$Y_1 = 131.27+13.67x_2-0.70\ x_2^2$	1.65	0.02	NS
	$Y = 125.34+6.17x_3$	2.53	0.09	NS
	$Y_1= 25.16+24.88x_3-0.85\ x_3^2$	1.15	0.10	*
	$Y = 136.83+5.06x_4$	2.58	0.06	NS
	$Y_1= 122.45+7.55x_4-0.10\ x_4^2$	0.99	0.06	NS
	$Y = 136.40+4.58x_5$	2.22	0.07	NS
	$Y_1= 162.79+0.27x_5+0.17\ x_5^2$	0.91	0.07	NS
	$Y = 129.82+4.38x_6$	1.62	0.11	**
	$Y_1=174.55-1.97x_6-0.22\ x_6^2$	0.29	0.12	**
	$Y = 132.62+5.47x_7$	2.50	0.08	NS
	$Y_1= 251.10-15.69x_7+0.90\ x_7^2$	1.02	0.09	NS
4	$Y=396.37+0.48x_1$	0.85	0.01	NS
	$Y_1= -104.18+86.46x_1-0.86\ x_1^2$	0.26	0.16	*
	$Y= -51.30+61.45x_2$	19.63	0.14	*
	$Y_1 = 1342.06-317.54x_2+25.67\ x_2^2$	19.83	0.17	*
	$Y = 292.25+8.15x_3$	7.27	0.02	NS
	$Y_1= 768.71-71.53x_3+3.27\ x_3^2$	2.22	0.06	NS
	$Y = 110.73+21.40x_4$	7.54	0.12	*
	$Y_1= 401.97-23.58x_4+1.72\ x_4^2$	5.13	0.12	*
	$Y = 124.59+19.22x_5$	7.00	0.11	*
	$Y_1= 453.60-28.42x_5+1.71\ x_5^2$	4.39	0.12	*
	$Y = 36.18+21.30x_6$	6.21	0.17	*
	$Y_1=1500.41-157.23x_6+5.40\ x_6^2$	2.53	0.23	*
	$Y = -48.45+33.58x_7$	10.05	0.16	*
	$Y_1= 828.32-99.36x_7+5.02\ x_7^2$	8.84	0.17	*
6	$Y=-229.78+91.98x_1$	38.5	0.04	NS
	$Y_1= -1694.04+541.67x_1-34.25\ x_1^2$	56.00	0.04	NS
	$Y= -380.10+91.18x_2$	37.89	0.01	NS
	$Y_1 = 59.99-23.09x_2+7.33\ x_2^2$	61.53	0.02	NS
	$Y = -299.49+47.90x_3$	20.38	0.07	NS
	$Y_1= -2516.73+372.73x_3-11.85\ x_3^2$	15.28	0.18	*
	$Y = -315.05+48.57x_4$	13.80	0.01	NS
	$Y_1= -973.06+143.04x_4-3.37\ x_4^2$	8.22	0.01	NS
	$Y = -167.54+35.38x_5$	10.72	0.03	NS
	$Y_1= -3541.63+477.86x_5-14.41\ x_5^2$	1.99	0.03	NS
	$Y = -249.90+37.34x_6$	14.23	0.01	NS
	$Y_1=-367.42+57.90x_6-0.45\ x_6^2$	6.60	0.02	NS
	$Y = -36.99+27.74x_7$	25.85	0.01	NS
	$Y_1= -1580.60+243.19x_7-7.46\ x_7^2$	18.12	0.02	NS
8	$Y=-220.12+100.29x_1$	54.69	0.01	NS
	$Y_1= 135.74+11.13x_1+5.49\ x_1^2$	82.92	0.01	NS
	$Y= -429.80+104.72x_2$	34.92	0.01	NS
	$Y_1 = -91.10+32.85x_2+3.77\ x_2^2$	29.67	0.08	NS
	$Y = -639.00+81.73x_3$	22.68	0.03	NS
	$Y_1= -2319.91+308.40x_3-7.62\ x_3^2$	13.18	0.05	NS
	$Y = -242.51+50.44x_4$	16.33	0.02	NS
	$Y_1= -2390.13+311.08x_4-7.83\ x_4^2$	6.61	0.02	NS
	$Y = -354.08+53.59x_5$	16.87	0.02	NS
	$Y_1= -2545.23+304.28x_5-7.11\ x_5^2$	5.63	0.03	NS
	$Y = -535.76+55.68x_6$	13.21	0.04	NS
	$Y_1=-199.89+22.08x_6+0.83\ x_6^2$	2.72	0.04	NS
	$Y = -463.96+63.16x_7$	20.38	0.01	NS
	$Y_1= -2677.79+331.70x_7-8.10\ x_7^2$	9.39	0.01	NS

*Wk = week, Y = body weight (linear function), Y_1 = body weight (quadratic function), SE = standard error, R^2 = coefficient of determination, LS = level of significance, NS = not significant ($P > 0.05$), * = significantly different ($P < 0.05$), ** = highly significant ($P < 0.01$), X_1 = shank length (SHL), X_2 = drumstick length (DSL), X_3 = nose-to-shoulder (NTS), X_4 = trunk length (TRL), X_5 = shoulder-to-tail length (STL), X_6 = chest girth (CHG) and X_7 = wing length (WGL).*

Genotypes strongly influenced linear body traits at various stages of this experiment. Omeje and Nwosu (1986) opined that relationships between age, body weight and body linear dimensions 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 as observed in this study. Generally, each measurement studied increased with increase in age in each genotype. This result corroborates the work of Alimi (2012) who reported that positive, high and significant relationship existed between body weight and body linear measurements in chickens. In his experiment, the chest girth predicted body weight more appropriately than other linear measurements. This agrees with the findings of Momoh and Kershima (2008) that chest girth can be used to predict body weight. Differences in linear traits reflect useful measures that depict the size and shape of animal (Chineke, 2003). The growth pattern from this study showed that it was in agreement with the findings of Adeniji and Ayorinde (1990) that body weight of birds can easily be predicted from any given value of body measurements such as body length, shank length, drumstick length, chest girth, kneel length and shank thickness in the cob broiler strain using linear and stepwise regression equation.

CONCLUSION AND RECOMMENDATIONS

Comparison on the basis of R^2 values showed that linear body measurements were better fitted by quadratic function than linear function among the genotypes. However, the goodness of fit and accuracy of prediction was best in frizzle feather followed by normal feather, naked neck and least in Marshall Broiler chickens. Generally, week 6 appeared to be the best age at which prediction could be carried out in chickens especially the indigenous strains considering the highest values of R^2 recorded at this age. The chest girth (X_6), nose-to-shoulder (X_3), drumstick length (X_2) and wing length (X_7) had the highest contribution to body weight in frizzle feather, Marshall Broiler, normal feather and naked neck respectively. It could be deduced that for any of the fitted functions, the older the animal, the lower the standard error, the higher the R^2 and the higher the accuracy of prediction. Comparing the two functions, it could be concluded that quadratic function had an advantage over linear function.

It can be recommended that quadratic function should be used over linear function predicting body weight of chicken genotypes at week six with chest girth having the highest contribution to body weights among the linear body dimensions studied. Prediction was best with frizzle feathered Nigerian indigenous chicken genotypes.

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