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Comparative Characteristics on Morphology of Three Strains of Commercial Meat-type Chickens.

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Abstract. *In this study, comparative characteristics on morphology of three strains of commercial meat-type chickens(Arbor Acre, Cobb and Marshall) was carried out.A total of two hundred and eighty-eight (288) day old broiler chicks which comprised ninety six (96) per strain of Arbor Acre, Marshall and Cobb were procured from reputable hatcheries. Each strain represented a treatment and they were randomly assigned to replicates. The parameters examined were weekly body weight and linear body measurements at week 3, 4, 5 and 6 of the experiment. The body weight were determined using scout II electronic sensitive scale of 20 kilogram capacity while the linear body measurements was taken by the use of tailor's measuring tape graduated in centimeters. The data collected were analyzed using correlation and regression procedures.The correlation coefficients among the three strains for body weight and body linear parameters at week 6 revealed positive, negative and low to high significant associations.Arbor Acre and Marshall body weight shown pleiotropic effect with their linear body measurements while the Cobb displayed negative correlation in wing length. The prediction functions (linear, quadratic, allometry and exponential) revealed coefficients of determination (R^2) ranged from 0 to 90%, 1 to 88% and 0 to 38% for Arbor Acre, Cobb and Marshall respectively.The result showed that accuracy was obtained with Linear and quadratic models. The quadratic model had theoretical advantage over linear model with consideration to its goodness of fit to the data. It was observed that the best relationship between body weight and linear body measurements were recorded in Marshall Strain at six weeks of the production cycle.*

Key Words:*Poultry, Arbor Acre, Cobb and Marshall, Correlation, Regression*

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I. Introduction

Poultry keeping is an important means of rapidly increasing the availability of animal protein in the developing countries where malnutrition is a great issue (Amao *et al*., 2010). In Nigeria, poultry consists of chickens, turkeys, duck, geese, quails and guinea fowls. In some part of the world, ostrich and some game birds like quails and pheasant are included. Broiler chickens provide a rapid means of producing animal protein to meet the nutritional requirements of teeming population (Taiwo *et al*., 2005). An improvement have been made towards the potential of broiler strains to provide high quality meat at lower cost (Kemp and Kenny, 2003). In the last 50 years, the amount of time required to reach market weight and the quantity of feed needed to produce a kilogram of meat have been reduced by 50% (Chukwuka *et al*., 2010).

A range of techniques are available to obtain information about broiler weight and body conformation. Some of these techniques used simple and inexpensive equipment, while others required sophisticated and expensive equipment (Kabir *et al*., 2010a). In addition, some authors reported that correlations and equations of prediction are very specific to strain, age of bird and stage at which carcasses were processed for analysis (Ojedapo *et al*., 2008). It is important to have knowledge of the variation of morphometric traits in local genetic resources as such measurements have been discovered to be very useful in comparing body size and by implication, shape of animals (Ogunshola *et al*., 2017). This present study is on comparative characteristics on morphology of Arbor Acre, Cobb and Marshall Broiler strains.

II. Methods

The experiment was carried out at the Poultry Unit of the Livestock Section, Teaching and Research Farm, Federal University of Technology, Akure (FUTA). FUTA is geographically located between latitude 7°5'N and longitude 5°15'E at an altitude of 370m above sea level. The University is located in the humid rain forest zone of Western Nigeria, with tropical climate of broadly two seasons: rainy season (April-October) and dry season (November – March) with a mean annual rainfall of 829 mm, an average annual temperature of 12 °C and an average relative humidity of 86% which characterize the climatic area (Google Earth, 2018).

Two hundred and eighty eight (288) day old broiler chicks comprising of ninety six (96) per strain of Arbor Acre, Marshall and Cobb were used in this research. Each strain represented atreatment and they were randomly assigned into thirty six (36) replicates with eight (8) birds per replicate. The birds were housed on deep litter with the floor covered with wood shavings as litter material. The pen was cleaned to ensure adequate biosecurity in order to prevent disease outbreak and for better growth and development. Broiler starter and broiler finisher diets containing 23% crude protein (CP), 2700kca/kg metabolizable energy and 21%CP, 2800kca/kg metabolizable energy respectively and water were provided *ad-libitum* throughout the experimental period (NRC,1994). All the necessary vaccinations and medications were administered to the birds accordingly.

At their day old stage, the body weights (in gram) of the birds was determined before feeding and thereafter the measurement of their body weight was done on weekly basis using Scout II electronic sensitive scale and top loading balance (20kg capacity).The linear body measurement (cm) was recorded using measuring tape graduated in centimeters at week 3, 4, 5 and 6 after acclimation. The body parameters considered for the measurements were Shank Length (SHLT), Shank Circumference (SHCR), Drumstick Length (DRLT), Drumstick Circumference (DRCR), Body Length (BDLT), Wing Length (WGLT), Breast Girth (BRGT) and Height at Withers (WHT).

The estimate of Pearson's correlation of phenotypic components is mathematically represented as follows:

$$r_P = \frac{\delta p\,(\delta x, y)}{\delta p\,(x).\delta p\,(y)}$$

Where

$\delta p(\delta x, y)$= standard deviation due to phenotype for trait x and y

$\delta p(x)$= standard deviation due to phenotype for trait x

$\delta p(y)$= standard deviation due to phenotype for trait y.

Regression model: The linear body measurements were regressed against body weight using simple linear, quadratic,allometry and Exponential models of the statistical analysis system (SAS 2008) version 9.2 software package..

Model functions:

- Linear $Y_1 = a + bx$
- Quadratic $Y_2 = a + bx + cx^2$
- Allometry$Y_a = ax^b$
- Exponential $Y_{e=} e^{bx}$

Y_1 and Y_2 are dependent variables (body weights) while x represents the independent variables (linear body parameters, carcass and organ traits) b and c are the regression coefficients associated with independent variables and a is the intercept represents the estimate of the dependent variable when the independent variable is zero.

For $Y_a$and Y_e which are allometry and exponential body weight functions respectively, a is the allometry coefficient, b is the exponential or growth factor while x is the independent variables

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

III. Results and Discussion

The phenotypic correlation estimates between body weight and linear body measurements as reported in this study for Arbor Acre, Cobb and Marshall at 6 weeks were strong, positive and highly significant ($p<0.001$) (Table 1, 2, & 3). The relationship between body weight and most of the linear body measurements (breast girth, shank length, shank circumference, drumstick length, drumstick circumference, body length and withers height) were in consonance with the findings of Yahaya *et al*.(2012), who reported strong and positive correlation coefficients between body weight and linear measurements in Hubbard and Arbor Acre strains. Similarly, the result also corroborate the findings of Ogunsholа*et al*. (2017).

In a related study, Oleforun-Okeleh *et al*. (2017) reported correlation coefficients that were positive, high and very highly significant in normal feather chickens. Furthermore, Wolanski *et al*. (2006) suggested that body weight could be estimated from body measurements and this is because growth in animals could be evaluated from component parts of the animal. The positive and strong nature of the correlation between body weight and body measurements in Arbor Acre, Cobb and Marshall meat-type chickens indicated that an improvement in the body measurements would invariably lead to a corresponding improvement in the body weight of the chickens because it is an implication of pleiotropic effect.

Table 4, 5 & 6 show the relationship between body weight and the linear body parameters. They were best described by quadratic function using drumstick length and drumstick circumference. Comparing the strains, linear and quadratic model of Arbor Acre and Cobb were excellently predicted using these traits (Drumstick length and drumstick circumference). This report agreed with findings of Sanda *et al.* (2014) that relationship between body weight and linear body measurement were best predicted by the quadratic function with drumstick having the best accuracy of prediction. Raji *et al.* (2009) and Wawro (1990) proposed that more accurate results in predicting body weight can be obtained when several parameters are used as independent variables in predicting and improving carcass performance. The best equation for predicting body weight of Arbor Acre was attained from carcass trait in dressed weight with coefficient of determination (R^2) being 95% for linear function and 96% for quadratic function. This was in-line with the findings of Ogunshola *et al.*(2017) who reported that accuracy of prediction was attained with linear and quadratic functions.

Table 1: The correlation coefficients between body weight and linear body measurements of Arbor Acre at six weeks of age

	BW	BRGT	WGLT	SHLT	SHCR	DRLT	DRCR	BDLT	WHT
BW	1.00								
BRGT	0.92***	1.00							
WGLT	0.17*	0.20**	1.00						
SHLT	0.93***	0.92***	0.17*	1.00					
SHCR	0.93***	0.89***	0.12	0.93***	1.00				
DRLT	0.92***	0.91***	0.19**	0.95***	0.91***	1.00			
DRCR	0.94***	0.90***	0.20**	0.95***	0.91***	0.94***	1.00		
BDLT	0.92***	0.90***	0.18*	0.93***	0.89***	0.93***	0.90***	1.00	
WHT	0.93***	0.91***	0.17*	0.98***	0.93***	0.95***	0.95***	0.94***	1.00

***= Very highly significant ($p<0.001$),** = Highlysignificant ($p<0.01$) and * = Significant ($p<0.05$)
BDWT= Body weight, BRGT= Breast girth, WGLT= Wing length, SHLT= Shank length, SHCR= Shank circumference, DRLT= Drumstick length, DRCR= Drumstick circumference, BDLT= Body length, WHT= Withers height.

Table 2: The correlation coefficients between body weight and linear body measurements of Cobb at six weeks of age

	BW	BRGT	WGLT	SHLT	SHCR	DRLT	DRCR	BDLT	WHT
BW	1.00								
BRGT33	0.93***	1.00							
WGLT	-0.04	-0.05	1.00						
SHLT	0.89***	0.94***	-0.05	1.00					
SHCR	0.06	0.09	-0.02	0.08	1.00				
DRLT	0.90***	0.92***	-0.04	0.96***	0.10	1.00			
DRCR	0.93***	0.93***	-0.04	0.93***	0.09	0.95***	1.00		
BDLT	0.89***	0.90***	-0.06	0.93***	0.07	0.95***	0.92***	1.00	
WHT	0.84***	0.87***	-0.05	0.90***	0.05	0.89***	0.87***	0.88***	1.00

***= Very highly significant ($p<0.001$)
BDWT= Body weight, BRGT= Breast girth, WGLT= Wing length, SHLT= Shank length, SHCR= Shank circumference, DRLT= Drumstick length, DRCR= Drumstick circumference, BDLT= Body length, WHT= Withers height

Table 3: The correlation coefficients between body weight and linear body measurements of Marshal at six weeks of age.

	BW	BRGT	WGLT	SHLT	SHCR	DRLT	DRCR	BDLT	WHT
BW	1.00								
BRGT	0.61***	1.00							
WGLT	0.53***	0.93***	1.00						
SHLT	0.60***	0.92***	0.95***	1.00					
SHCR	0.54***	0.91***	0.91***	0.88***	1.00				
DRLT	0.57***	0.96***	0.95***	0.94***	0.92***	1.00			
DRCR	0.44***	0.76***	0.71***	0.69***	0.71***	0.77***	1.00		
BDLT	0.51***	0.94***	0.95***	0.92***	0.91***	0.95***	0.71***	1.00	
WHT	0.54***	0.95***	0.95***	0.95***	0.92***	0.97***	0.75***	0.96***	1.00

***= Very highly significant ($p<0.001$)

BDWT= Body weight, BRGT= Breast girth, WGLT= Wing length, SHLT= Shank length, SHCR= Shank circumference, DRLT= Drumstick length, DRCR= Drumstick circumference, BDLT= Body length, WHT= Withers height.

Table 4: Estimate of parameters in Simple linear, Quadratic, Allometry and Exponential functions fitted for Linearbody measurements in predicting body weight of Arbor Acre meat-type chicken

Traits	Function	Equation	MSE	AR^2(%)	R^2(%)	LS
BRGT	Linear	$Y=-769.48+160BRGT$	199.43	85	85	***
	Quadratic	$Y_1=-1440+272.12BRGT-4.40BRGT^2$	198.32	85	85	NS
	Allometry	$Y_a=149.70BRSG^{0.89}$	224.16	34	35	***
	Exponential	$Y_e=654.60e^{0.06BRSG}$	224.16	34	35	***
WGLT	Linear	$Y=1102.50+5.68WGLT$	503.80	2	3	NS
	Quadratic	$Y_1=-538.56+123.46WGLT-0.68WGLT^2$	383.70	43	44	***
	Allometry	$Y_a=1457.70WGLT^{0.05}$	277.20	-1	0	NS
	Exponential	$Y_e=1688.60e^{-0.01WGLT}$	278.19	-1	0	NS
SHLT	Linear	$Y=-1018.70+347.39SHLT$	191.45	86	86	***
	Quadratic	$Y_1=909.09-281.86SHLT+49.05SHLT^2$	189.28	86	86	*
	Allometry	$Y_a=28.71SHLT^{1.99}$	240.33	24	25	***
	Exponential	$Y_e=253e^{0.25SHLT}$	243.36	23	24	***
SHCR	Linear	$Y=-3217.30+990.69SHCR$	193.07	86	86	***
	Quadratic	$Y_1=-3566.80+1147.10SHCR-17.30SHCR^2$	193.58	86	86	NS
	Allometry	$Y_a=52.94SHCR^{2.17}$	204.55	46	46	***
	Exponential	$Y_e=197.40e^{0.44SHCR}$	200.67	47	48	***
DRLT	Linear	$Y=-1166.60+219.13DRLT$	196.04	85	85	***
	Quadratic	$Y_1=2125.20-415.59DRLT+29.39DRLT^2$	182.45	87	87	***
	Allometry	$Y_a=8.24DRLT^{2.08}$	226.95	32	33	***
	Exponential	$Y_e=207.90e^{0.16DRLT}$	221.45	36	37	***
DRCR	Linear	$Y=-1114.80+205.57DRCR$	177.04	88	88	***
	Quadratic	$Y_1=1075.70-202.57DRCR+18.20DRCR^2$	161.22	90	90	***
	Allometry	$Y_a=9.61DRCR^{1.98}$	206.91	44	44	***
	Exponential	$Y_e=254.20e^{0.14DRCR}$	209.10	43	44	***
BDLT	Linear	$Y=-1438.90+136.89BDLT$	205.22	84	84	***
	Quadratic	$Y_1=-3885.90+393.88BDLT-6.54BDLT^2$	199.05	85	85	**
	Allometry	$Y_a=77.86BDLT^{0.99}$	247.28	20	20	***
	Exponential	$Y_e=685.80e^{0.04BDLT}$	251.83	17	18	***
WHT	Linear	$Y=-742.38+102.07WHT$	193.53	86	86	***
	Quadratic	$Y_1=566.93-43.71WHT+3.83WHT^2$	192.20	86	86	NS
	Allometry	$Y_a=8.21WHT^{1.68}$	248.09	19	20	***
	Exponential	$Y_e=340.30e^{0.07WHT}$	250.41	18	19	***

Y=body weight (linear function), Y_1=body weight (quadratic function), Y_a=body weight (allometry function), Y_e= body weight (exponential function), MSE=mean of standard error, AR^2=Adjusted coefficient of determination, R^2= coefficient of determination, LS= level of significance, ***= very highly significant (P<0.001), **= highly significant (P<0.01), *=significant (P<0.05), NS= not significant.
Breast girth-BRSG, Wing length-WNGL, Shank length -SHNL, Shank circumference-SHNC, Drumstick length-DRML, Drumstick circumference- DRMC, Body length -BDYL, Withers height- WHTH.

Table 5:Estimate of parameters in Simple linear, Quadratic, Allometry and Exponential functions fitted for linear body measurements in predicting body weight of Cobb meat-type chicken

Traits	Function	Equations	MSE	AR^2(%)	R^2(%)	LS
BRSG	Linear	$Y=-744.39+160.01BRSG$	211.28	86	86	***
	Quadratic	$Y_1=-335.03+92.82BRSG+2.59BRSG^2$	211.24	86	86	Ns
	Allometry	$Y_a=340BRSG^{0.10}$	271.85	42	43	***
	Exponential	$Ye=2037.60e^{-0.01BRSG}$	276.09	12	13	NS
WGLT	Linear	$Y=1300.10-0.22WGLT$	560.23	0	1	NS
	Quadratic	$Y_1=-1782.40+199.17WGLT-0.15WGLT^2$	253.26	80	80	***
	Allometry	$Y_a\ 64.23WGLT^{1.15}$	337.93	11	12	***
	Exponential	$Ye=649.50e^{0.06WGLT}$	347.17	10	11	**
SHLT	Linear	$Y=-1012.80+360.18SHLT$	251.84	80	80	***
	Quadratic	$Y_1=-258.12+114.17SHLT+19.12SHLT^2$	252.18	80	80	NS
	Allometry	$Y_a=33.25SHLT^{1.94}$	331.63	14	15	***
	Exponential	$Ye=253.90e^{0.25SHLT}$	339.10	14	15	***
SHCR	Linear	$Y=1233.20+13.16SHCR$	559.63	0	3	NS
	Quadratic	$Y_1=-3855.30+1281.20SHCR-30.79SHCR^2$	225.04	84	84	***
	Allometry	$Y_a=-2086.90SHCR^{-55.03}$	254.84	49	50	***
	Exponential	$Ye=97.69e^{0.58SHCR}$	261.78	49	50	***
DRLT	Linear	$Y=-1281.60+235.34DRLT$	239.54	82	82	***
	Quadratic	$Y_1=943.88-194.27DRLT+19.91DRLT^2$	225.05	84	84	***
	Allometry	$Y_a=-322.90DRLT^{-22.61}$	289.56	35	35	***
	Exponential	$Ye=51.14e^{0.27DRLT}$	290.46	37	38	***
DRCR	Linear	$Y=-1259.20+219.22DRCR$	201.35	87	87	***
	Quadratic	$Y_1=1144.20-208.55DRCR+18.25DRCR^2$	193.18	88	88	***
	Allometry	$Y_a=-245.40DRCR^{-17.68}$	214.30	64	65	***
	Exponential	$Ye=113.4e^{0.20DRCR}$	219.25	64	65	***
BDLT	Linear	$Y=-1483.40+142.66BDLT$	253.21	80	80	***
	Quadratic	$Y_1=-1469.80+141.21BDLT+0.04BDLT^2$	253.92	79	80	NS
	Allometry	$Y_a=46.09BDLT^{1.17}$	323.12	19	19	***
	Exponential	$Ye=113.40e^{0.20BDLT}$	219.25	64	65	***
WHT	Linear	$Y=-450.40+90.89WHT$	307.94	70	70	***
	Quadratic	$Y_1=-2483.80+306.62WHT-5.34WHT^2$	244.56	81	81	***
	Allometry	$Y_a=3.86WHT^{1.94}$	309.76	25	26	***
	Exponential	$Ye=229e^{0.09WHT}$	315.01	26	27	***

Y=body weight (linear function), Y_1=body weight (quadratic function), Y_a=body weight (allometry function), Y_e= body weight (exponential function), MSE=mean of standard error,AR^2=Adjusted coefficient of determination, R^2= coefficient of determination, LS= level of significance,***= very highly significant (P<0.001), **= highly significant (P<0.01), NS= not significant.
Breast girth-BRGT, Wing length-WGLT, Shank length -SHLT, Shank circumference-SHCR, Drumstick length-DRLT, Drumstick circumference- DRCR, Body length -BDLT, Withers height- WHT.

Table 6: Estimate of parameters in Simple linear, Quadratic, Allometry and Exponential functions fitted for linear body measurements in predicting body weight of Marshall meat-type chicken

Trait	Function	Equation	MSE	AR^2(%)	R^2(%)	LS
BRSG	Linear	$Y=-765.1+157.98BRSG$	652.56	37	37	***
	Quadratic	$Y_1=-2012.5+377.27BRSG-8.99BRSG^2$	652.45	37	38	NS
	Allometry	$Y_a\ 178.50BRSG^{0.82}$	865.46	3	5	NS
	Exponential	$Ye=797.70e^{0.05BRSG}$	922.40	1	2	NS
WGLT	Linear	$Y=-1165.60+151.69WGLT$	699.04	27	28	***
	Quadratic	$Y_1=-512.75+62.59WNGL-2.93WGLT^2$	701.35	27	28	NS
	Allometry	$Y_a=1511.6WGLT^{-1.00}$	885.46	-1	0	NS
	Exponential	$Ye=1973.60e^{-0.01WGLT}$	932.88	-1	0	NS
SHLT	Linear	$Y=-1047.80+347.10SHLT$	658.74	36	36	***

	Quadratic	Y_1=-3556.50+1119.90SHLT-61.40SHLT^2	658.29	36	37	NS
	Allometry	Y_a =293.50SHLT$^{0.84}$	878.02	1	2	NS
	Exponential	Ye=799.20e$^{0.10SHLT}$	927.51	-1	1	NS
SHCR	Linear	Y=-2485.5+823.99SHCR	693.66	29	29	***
	Quadratic	Y_1=-1614.10+422.40SHCR+45.59SHCR^2	696.02	28	29	NS
	Allometry	Y_a =545.10SHCR$^{-1.00}$	880.54	-1	1	NS
	Exponential	Ye=1132.80e$^{0.08SHCR}$	932.12	-1	0	NS
DRLT	Linear	Y=-1199.60+217.92DRLT	674.30	32	33	***
	Quadratic	Y_1=-3849+731.33DRLT-23.87DRLT^2	674.38	32	33	NS
	Allometry	Y_a 540.80DRLT$^{0.43}$	883.00	-1	1	NS
	Exponential	Ye=1371.50e$^{0.02DRLT}$	933.04	-1	1	NS
DRCR	Linear	Y=-463.22+139.61DRCR	741.15	18	19	***
	Quadratic	Y_1=-6016.20+1147.30DRCR-43.50DRCR^2	702.55	27	28	***
	Allometry	Y_a =527.00DRCR$^{-1.00}$	882.23	-1	1	NS
	Exponential	Ye=1493.00e$^{0.01DRCR}$	933.41	-2	0	NS
BDLT	Linear	Y=-1233.10+127.23BDLT	707.83	26	26	***
	Quadratic	Y_1=-177.93-29.91BDLT+4.24BDLT^2	709.40	25	26	NS
	Allometry	Y_a 4223.00BDLT$^{-1.00}$	883.99	-1	1	NS
	Exponential	Ye=3281.60e$^{-0,03BDLT}$	926.36	1	2	NS
WHT	Linear	Y=-423.71+84.89WHT	694.10	28	29	***
	Quadratic	Y_1=-83.438+44.83WHT+1.09WHT^2	696.37	28	28	NS
	Allometry	Y_a =6826.60WHT$^{-0.46}$	883.56	-1	1	NS
	Exponential	Ye=3967.70e$^{-0.04WHT}$	925.03	1	2	NS

Y=body weight (linear function), Y_1=body weight (quadratic function), Y_a=body weight (allometry function), Y_e= body weight (exponential function), MSE=mean of standard error, AR^2=Adjusted coefficient of determination, R^2= coefficient of determination, LS= level of significance,***= very highly significant (P<0.001), NS= not significant, Breast girth-BRGT, Wing length-WGLT, Shank length -SHLT, Shank circumference-SHCR, Drumstick length-DRLT, Drumstick circumference- DRCR, Body length -BDLT, Withers height- WHT.

IV. Conclusion

The linear body measurement shows pleotropic effect with body weight except wing length in Cobb strain that had negative relationship. This means that an increment in linear body measurement leads to corresponding increment in body weight of the bird. Prediction of body weight of the three broiler strains can be accurately evaluated using linear and quadratic models when considering their goodness of fit to data.

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