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# Estimate of Parameters in Allometry Function Fitted for Body Weight and Linear Body Measurements of Frizzle Feathered, Naked Neck, Noiler and Normal Feathered Chickens

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**Abstract:- This study was carried out with 240 indigenous day-old chickens comprising of mixed sex frizzle feathered, naked neck, normal feathered and Noiler raised to 16 weeks of age to predict the body weight of 4 stains of Nigerian local and improved chickens using multiple linear regression and allometry function/model fitted for body weight and linear body measurements of the 4 stains of chicken. Data generated was subjected to multiple linear regression, allometry analysis and prediction using SAS 9.2 (Version 2008). Result of Prediction using multiple linear regression and allometry functions fitted into body weight and linear body measurements of the four breeds of local chickens in this study from 4 to 16 weeks revealed that wing length, shank length, shank circumference, drumstick length, drumstick circumference, nose to shoulder length, shoulder to tail length, body length, height at withers and breast girth could be the best variables used to predict body weight of frizzle feathered, naked neck, normal feathered and noiler chickens.**

***Keywords***:- *Prediction, Allometry, Fitted, Function, Multiple, Regression, Strain.*

## I. INTRODUCTION

The live body weight of any animal is an important variable that determines the market value of the animal (Kabir *et al*., 2006). Reports on body weight and linear body measurements have been documented and found useful in qualifying body size and shape (Ibe, 1989; Ibe and Ezekwe, 1994). Linear measurements are less subjected to short term changes as in body weight and allow comparisons of growth in different part of the body. Linear body measurements have been used to predict live weights in poultry (Okon *et al*., 1997, Gueye *et al*., 1998), rabbits (Chineke, 2005), goat (Hassan and Ciroma, 1992) and sheep (Chineke, 1996). The use of shank length to predict live body weight in poultry is particularly important where scales are not readily available as in the case in most African rural farming communities and meat markets (Nesamvumi *et al*., 2000). Linear body measurement has also been used to study the effect of crossbreeding and a medium for selecting replacement animals and evaluating breed controlled environments (Shrestha *et al*., 1984).

## II. METHOD AND MATERIALS

This research was carried out at the Poultry Unit of the Research and Teaching Farm of the Faculty of Agriculture, University of Port Harcourt, Rivers State, Nigeria. Two and forty indigenous day old chickens comprising of frizzle feather (60), naked neck (60), normal feather (60) and Noiler (60) were housed on deep litter in four replicated pens, sixty birds per strain and twenty birds per pen selected from each strain and raised for sixteen weeks. All the experimental birds were fed at ad-libitum with the best commercial feeds from day old to 16 weeks old, the birds were fed with chick starter mash with 21% crude protein from day old to 8 weeks and growers mash with 16% crude protein from 8 weeks to 16 weeks. Also fresh water was provided at all time. Data were collected on the linear body parameters that defined growth parameters on weekly basis from day old to 16 weeks of age. These include body weight, body length, breast girth, shank length, shank circumference, drumstick length, drumstick circumference, shoulder to tail length, height at withers, nose to shoulder length and wing length. The body weight was measured in gram using Scout II electronic sensitive scale and top loading Balance (20 kg capacity) while the morphometric traits were measured using a measuring tape graduated in centimeters. Data generated was subjected to multiple linear regression and allometric analyses and prediction using the Statistical Analysis System (SAS, 2008) Version 9.2 software package.

## III. RESULTS

Table 1 shows the multiple regressions coefficients of the body weight (dependent variable) and linear body measurements (predictors) of the four breeds of chickens used in this study at 8 weeks.Results of the multiple linear regression analysis of the body weight and linear body measurement in the four breeds of chickens at 8 weeks were highly significant ($p<0.001$) with coefficients of determination ($R^2$) for Frizzle feather (0.60 +7.41), Normal feather (0.877 + 19.94), Naked neck ( 0.919 + 7.29) and Noiler (0.812 + 9.06). The regression model explains 66% of the dependent variable variation in Frizzle feathered, 88% in Normal feathered, 92% in Naked neck, and 81% in Noiler chickens respectively. The least variability revealed from the regression model was seen in Frizzle feathered chickens. The

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predictors were WGL, SL, SC, DSL, DSC, NTSL, STTL, BL, HAW and BG.The multiple correlation coefficients were very high for the four breeds (82% in Frizzle feathered, 94% in Normal feathered, 96% in named neck and 90% in Noiler chickens) which indicate strong relationship between the dependent and independent variables. Naked neck had the highest coefficient of determination (0.919) which indicated that the body weight of Naked neck can be best predicted with the regression model at 8 weeks.

**Table 1 Multiple linear regression of the body weight (dependent variables) on linear parameters (predictors) of the four strains of chicken in Nigeria at 8 weeks**

| Predictors | Regression co efficient ± SEM | | | |
|---|---|---|---|---|
| | Frizzle feathered | Normal feathered | Naked neck | Noiler |
| (Constant) | -682.80± 196.98 | -581.14 ±931.05 | -1102.79 ± 196.98 | -1274.96 ± 339.43 |
| WGL | 9.06 ± 0.98 | 14.963±2.78 | 11.01 ± 9.98 | 10.26 ± 14.85 |
| SL | -16.23± 3.01 | 0.94 ±10..62 | -18.49 ± 3.01 | 0.59 ± 26.09 |
| SC | 58.45 ± 3.72 | 262.44±2.48 | 143.13 ± 3.72 | 61.68 ± 46.79 |
| DSL | 20.87± 2.01 | -50.24±9.88 | 16.79 ± 2.01 | 12.63 ± 31.33 |
| DSC | 16.37± 1.92 | -28.20±5.25 | 45.63 ± 1.92 | 13.89 ± 21.99 |
| NTSL | 11.23 ± 10.60 | 77.46±6.20 | 13.21 ± 1.06 | 8.34 ± 23.47 |
| STTL | 1.49 ± 10.20 | 75.61±3.59 | 21.43 ± 1.02 | 27.44 ± 19.43 |
| BL | 5.91± 5.45 | -130.29±4.89 | 6.64 ± 5.46 | -8.10 ± 9.99 |
| HAW | 19.29 ± 0.16 | 40.92±2.36 | -0.95 ± 0.16 | 2.02 ± 14.36 |
| BG | -682.80 ±15.77 | 11.99±2.43 | 7.36 ± 2.24 | 41.30 ± 17.92 |
| $R^2$ | 0.660 ±7.14 | 0.877 ± 19.41 | 0.919± 7.29 | 0.812 ± 9.07 |
| R | 0.82 0± 7.15 | 0. 937± 19.94 | 0.959± 7.29 | 0.901± 9.17 |

WGL= Wing length, SL= Shank length, DSL= Drumstick length, DSC= Drumstick circumference, NTSL= Nose to shoulder length, STTL= Shoulder to tail length, BL= Body length, BG= Breast girth, HAW= Height at withers, $R^{2=}$ coefficient of determination, R= Multiple correlation coefficient.

**FRIZZLE FEATHERED**= -682.80 + 9.06WGL - 16.23SL+ 58.45 SC +20.87 DSL + 16.37DSC + 11.23 NTSL + 1.49 STTL – 5.91BL+ 19.29 HAW - 682.80 BG **
**NORMAL FEATHERED** -581.136 + 24.92WGL + 0.94SL + 262.44SC -50.24DSL –28.20DSC + 77.46NTSL + 75.61STTL – 130.29BL + 40.92HAW + 11.99BG **

**NAKED NECK** =-1102.79 + 11.01WGL-18.49 SL + 143.13 SC + 16.79 DSL + 45.63DSC +13.21 NTSL - 21.43STTL + 6.64 BL -0.95 HAW + 7.36 BG **

**NOILER**= -1274.96 + 10.26 WGL + 0.59 SL 61.68 SC + 12.63DSL + 13.89 DSC + 8.34 NTSL + 27.44STTL-8.10BL + 2.02 HAW + 41.30 BG **
** *Highly significant difference (P<0.001)*

Table 2 present the coefficients of determination ($R^2$) which showed the strength of body measurements in live weight determination based on multiple linear regression function at 12 weeks of age.Results of the multiple linear regression analysis of body weight ( dependent variable) and linear body measurements ( predictors) of the four breeds of chickens at 12 weeks was significantly very high ($p<0.001$) with the coefficients of determination ($R^2$) for Frizzle feathered (0.877+13.28), Normal feathered (0.821+6.46), Naked neck ( 0.851+4.01), and Noiler (0.795 + 16.71).The regression model accounted for 88%, 82%, 85%, and 80% of total variability of the variables in Frizzle feathered, Normal feathered, Naked neck, and Noiler respectively. Noiler chickens had the least variability (80%) revealed from the regression model. Multiple correlation coefficients for the four breeds of chickens were 94% in Frizzle feathered, 91% in Normal feathered, 93% in Naked neck and 89% in Noiler. Naked neck had the least multiple correlation coefficients. Frizzle feathered chickens had the highest coefficient of determination and their body weight can be best predicted with the multiple regression model at 12 weeks. The predictors of body weight were WGL, SL, SC, DSL, DSC, NTSL, STTL, BL, HAW and BG.

**Table 2 Multiple linear regression of body weight (dependent variable) on linear parameters (predictors) of the four strains of chicken in Nigeria at 12 weeks**

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| Predictors | Regression co efficient ± SEM | | | |
|---|---|---|---|---|
| | Frizzle feathered | Normal feathered | Naked neck | Noiler |
| (Constant) | -1715.55± 50.11 | -723.43±17.78 | -1887.28 ± 138.92 | -1826.02 ± 45.31 |
| WGL | 36.09± 19.63 | 5.75±9.39 | 76.94 ± 6.74 | -4.57 ± 10.36 |
| SL | -17.31± 4.85 | 1.60±26.71 | 65.23 ± 13.52 | 55.53 ± 3.59 |
| SC | 11.59± 9.29 | 5.28±51.98 | 107.53 ± 2.70 | -50.99 ± 5.58 |
| DSL | 34.57± 3.49 | -29.62±18.04 | -69.89 ± 8.20 | 18.35 ± 2.55 |
| DSC | 7.74 ± 12.16 | 21.61±16.43 | 6.44 ± 8.91 | 34.03 ± 5.56 |
| NTSL | 42.21± 2.37 | 5.65±6.36 | -68.25 ± 12.29 | 51.06 ± 21.38 |
| STTL | -2.36 ± 2.28 | 41.68±10.44 | -92.06 ± 12.40 | 49.26 ± 5.52 |
| BL | 10.77 ± 8.30 | -15.04±8.27 | 98.32 ± 10.45 | -44.81 ± 5.93 |
| HAW | 14.33 ± 7.98 | 4.70±8.58 | -6.08 ± 22.47 | -7.19 ± 5.47 |
| BG | -0.91 ± 0.19 | 39.57±11.24 | 10.01 ± 22.48 | 43.59 ± 9.65 |
| $R^2$ | 0.877 ± 13.76 | 0.821±6.35 | 0.851 ± 3.97 | 0.795 ± 17.21 |
| R | 0.937 ± 13.76 | 0.906 ±6.38 | 0.930 ± 3.67 | 0.892 ±16.21 |

WGL= Wing length, SL= Shank length, DSL= Drumstick length, DSC= Drumstick circumference, NTSL= Nose to shoulder length, STTL= Shoulder to tail length, BL= Body length, BG= Breast girth, HAW= Height at withers, $R^{2=}$ coefficient of determination, R= Multiple correlation coefficient.

**FRIZZLEFEATHERED** = -1715.55 + 36.09WGL -17.31SL+ 11.59SC + 34.57DSL + 7.74DSC + 42.21NTSL – 2.36STTL + 10.77BL+ 14.33HAW – O.91 BG**
**NORMAL FEATHERED** =-723.43 + 5.75WGL + 1.60SL + 5.28SC - 29.62DSL + 21.61DSC + 5.65NTSL + 41.68STTL – 15.04BL + 4.70HAW + 39.57BG **

**NAKED NECK** = -1887.28 + 76.94WGL + 65.23SL + 107.53SC – 69.89DSL + 6.44DSC – 68.89NTSL – 92.06STTL + 98.32BL – 6.08HAW + 10.01BG (SEM ± 399.07) **

**NOILER**= -1826.02 - 4.57 WGL+ 55.53 SL -50.99SC +18.35DSL + 34.03DSC + 51.06TSL+ 49.26STTL + 44.81BL - 7.19HAW + 43.59BG **
** *Highly significant difference (P<0.001)*

Table 3 presents the multiple linear regression of body weight (dependent variable) on linear measurements (predictors) of the four breeds of chickens in Nigeria at 16 weeks of age. The multiple linear regression analysis of body weight and linear body measurements of the four breeds of chickens was significantly very high (p<0.001) with the coefficient of determination ($R^2$) for Frizzle feathered (0.945 + 9.44), Normal feathered (0.93 + 7.81), Naked neck (0.793 + 4.94) and Noiler (0.97 + 7.65) as presented. The coefficient of determination ($R^2$) of 95%, 93%, 79% and 97% observed for frizzle feathered, normal feathered, Naked neck and Noiler chickens respectively represents the proportion of variance for dependent variables that's explained by the independent variable or multiple regression model. The four breeds had very high multiple correlation coefficient value (Frizzle feathered had 97%, Normal feathered 96%, Naked neck 89% and Noiler 99%). Noiler chickens had the highest coefficient of determination ($R^2$) (0.97 + 7.65) and multiple correlation coefficient (R) value (0.986 + 7.65). The body weight predictors were WGL, SL, SC, DSL, DSC, NTSL, STTL, BL, HAW and BG.

**Table 3 Multiple linear regression of the body weight (dependent variables) on linear parameters (predictors) in the four strains of chicken in Nigeria at 16 weeks**

| Predictors | Regression co efficient ± SEM | | | |
|---|---|---|---|---|
| | Frizzle feathered | Normal feathered | Naked neck | Noiler |
| (Constant) | -2240.70 ±367.75 | 1906.89±307.72 | -2660.93 ± 439.48 | -2990.31 ± 719.82 |
| WGL | -8.84 ± 14.25 | 66.59 ± 20.49 | 72.41 ± 17.62 | 23.77 ± 25.32 |
| SL | 30.45 ± 19.84 | -26.54 ± 19.59 | -2.27 ± 0.98 | 7.93 ± 3.46 |
| SC | 68.80 ± 4.68 | -38.56 ± 4.23 | 33.34 ± 18.43 | -91.85 ± 8.44 |
| DSL | 82.23 ± 3.32 | 39.09 ±16.33 | 14.25 ± 13.09 | 94.55 ± 33.51 |
| DSC | -2.96 ± 2.5 | 109.18 ± 16.32 | 2.91 ± 15.01 | 40.27 ± 3.91 |
| NTSL | 2.82 ± 2.46 | -121.84 ±3.35 | -58.70 ± 15.74 | 8.55 ± 4.62 |
| STTL | 11.95 ± 2.09 | -39.32 ± 3.65 | -46.32 ± 13.01 | 73.29 ± 19.58 |
| BL | 2.06 ± 2.08 | 68.45 ±3.02 | 2.89 ± 3.79 | -31.28 ± 2.75 |
| HAW | -1.11 ± 6.00 | -3.39 ± 6.53 | 53.80 ± 8.67 | 21.27 ± 1.22 |
| BG | -1.24 ± 6.09 | 20.01 ± 11.29 | 35.53 ± 10.86 | 24.93 ± 15.53 |

| | | | | |
|---|---|---|---|---|
| $R^2$ | 0.946 ± 9.44 | 0.93 ±7.81 | 0.793±4.94 | 0.971 ± 7.65 |
| R | 0.973± 9.44 | 0.96 ±7.62 | 0.891±4.94 | 0.986 ± 7.65 |

WGL= Wing length, SL= Shank length, DSL= Drumstick length, DSC= Drumstick circumference, NTSL= Nose to shoulder length, STTL= Shoulder to tail length, BL= Body length, BG= Breast girth, HAW= Height at withers. $R^{2=}$ coefficient of determination, R= Multiple correlation coefficient.

**FRIZZLE FEATHERED** = -2240.70 - 8.84WGL + 30.45SL+ 68.80SC + 82.23DSL – 2.96DSC +2.82NTSL + 11.95STTL + 2.06BL - 1.11HAW -1.24 BG **

**NORMALFEATHERED** =-1906.89 + 66.59WGL -26.54SC – 38.56SC + 39.09DSL + 109.18DSC -121.84NTSL – 39.32STTL + 68.45BL – 3.39HAW + 20.01BG **

**NAKED NECK** = -2660.93 + 72.41WGL -2.27SL + 33.34SC + 14.25DSL + 2.91DSC – 58.70NTSL – 46.32STTL + 2.89BL + 53.80HAW + 35.53BG **

**NOILER**= -2990.31 + 23.77 WGL + 7.93SL – 91.85SC + 94.55DSL + 40.27DSC + 8.55NTSL + 73.29STTL -31.28BL + 21.27HAW + 24.93BG**
*** Highly significant difference (P<0.001)*

Allometry function can be used for body weight prediction when fitted for body weight and linear body measurements.Table 4 represents the equation, estimate of parameters, coefficient of determination ($R^2$), standard error and significance in allometry function fitted for body weight and linear body measurements of Frizzle, Naked neck, Noiler and Normal feathered chickens from 4 – 16 week. The allometry functions fitted for body weight and linear body measurements of Frizzle feathered, Naked neck, Noiler and Normal feathered was significantly very high (p<0.001) with moderate to high coefficients of determination ($R^2$) for all the parameters (predictors): WGL,SL, SC, DSL, DSC,NTSL, STTL, HAW, BG and BL. Description of the relationship using allometry equation (function) gave the following coefficients of determination ($R^2$) for WGL (89%), SL (81%), SC (76%), DSL (85%), DSC (81%), NTSL (86%), STTL (93%), HAW (87%), BG (61%) and BL(53%). Shoulder to tail length (STTL) had the highest coefficient of determination ($R^2$). The parameters that best predicted body weight using allometry equation is Shoulder to tail length (93%) followed by WGL (89%), HAW (87%), NTSL (86%) and DSL (85%).

**Table 4 Simple allometric equations fitted for body weight of the four strains of chickens**

| Parameters | Prediction equation | RMSE | $R^2$% | Significance |
|---|---|---|---|---|
| WGL | Log y = 0.43 + 0.85 logWGL | 0.04 | 0.89 | <0.0001*** |
| SL | Log y = 0.96 + 0.64 log SL | 0.05 | 0.81 | <0.0001*** |
| SC | Log y=1.09 + 0.77 logSC | 0.05 | 0.76 | <0.0001*** |
| DSL | Log y = 0.94 + 0.58 logDSL | 0.04 | 0.68 | <0.0001*** |
| DSC | Log y = 1.15 + 0.46 logDSC | 0.05 | 0.81 | <0.0001*** |
| NTSL | Log y = 0.41 + 0.98 logNTSL | 0.04 | 0.86 | <0.0001*** |
| STTL | Log y = 0.36 + 0.90 logSTTL | 0.03 | 0.93 | <0.0001*** |
| HAW | Log y = 0.56 + 0.65 logHAW | 0.04 | 0.87 | <0.0001*** |
| BG | Log y = 0.80 + 0.56 logBG | 0.07 | 0.61 | <0.0001*** |
| BL | Log y = 0.96 + 0.20 logBL | 0.07 | 0.53 | <0.0001*** |

*** Highly significant difference (P<0.0001)*
WGL= Wing length, SL= Shank length, DSL= Drumstick length, DSC= Drumstick circumference, NTSL= Nose to shoulder length, STTL= Shoulder to tail length, BL= Body length, BG= Breast girth, HAW= Height at withers

## IV. DISCUSSION

The various linear body measurements has earlier described as appropriate predictor variables for body, the coefficient of determination obtained by the four strains of chickens from 4-16 weeks were highly significant which indicated that these traits could be used to predict body weight precisely which is in agreement with the report by Musa *et al.* (2011), Chitra *et al*. (2012) and Dahioum *et al.* (2016). The consistent high coefficient of determination ($R^2$) obtained under multiple linear regression fitted for body weight and linear body measurements ofthe four strains of chickens from 4 weeks to 16 week indicated that WGL, SL, SC, DSC, NTSL, STTL, BL, HAW and BG could be the best used to predict body weight of the four strains of chickens which is in agreement with the report of Ige (2014) that easily measurable body parts such as breast girth (chest girth) and body length helped in determination of body weight. Raji *et al.* (2009) reported highest coefficient of determination value for breast girth, body length, wing length using linear regression model.Prediction of body weight using linear body measurement fitted into allometry function was highly significant and had high coefficient of determination. Prediction of body weight using allometry function also

revealed that the best parameters for prediction were shoulder to tail length, wing length, height at withers and nose to shoulder length. Allometry and multiple linear regressions could be used for body weight prediction from 4 to 16 weeks of age. Generally, the result shows that the relationship between body weight and other growth traits varied much with age indicating that a single weight estimation model should not be adopted across age as suggested by Semakula *et al*. (2011). The disparity in the different models for predicting body weight at various age may be attributed to variation in maturity pattern of the different body parts (Chineke, 2005). Judging from significantly positive regression coefficients associated with growth traits indicated that these traits increased with unit change in body weight and vice versa. Similar observation was made by Ajayi *et al*. (2008) in population of two commercial meat type chickens.

## V. CONCLUSION

The consistent high coefficient of determination ($R^2$) obtained in multiple linear regression of body weight and linear body measurements of the 4 strains of chickens from 4 weeks to 16 weeks indicated that WGL,SL, SC, DSC, NTSL, STTL, BL HAW and BG could be the best used to predict body weight of Frizzled, Naked neck, Noiler and Normal feathered in the study. Prediction of body weight using allometry function also revealed that the best parameters for prediction were shoulder to tail length, wing length, height at withers and nose to shoulder length. Allometric and multiple linear regressions could be used for body weight prediction using linear body traits from 4 to 16 weeks of age.

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