# Linear models for Predicting body weight in crossbred chickens

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**Abstract:** Prediction of body weight with linear body measurements of 531day-old crossbred chickens was determined by stepwise regression analysis for mixed sexes at 4 and 8 weeks and separate sexes at 12, 16 and 20 weeks. Shank length was the best single predictor of body weight in Isa Brown x naked neck (IBxNa) at 4 weeks (coefficient of determination, $R^2$ = 65%) and in feathered x Isa Brown (FxIB) at 8 weeks ($R^2$ = 96%). In males, body weight was best predicted by drumstick length (DL) in IBxNa ($R^2$ = 90%) at 12 weeks and in Isa Brown x frizzle feathered (IBxF) at 16 ($R^2$ = 85%) and 20 ($R^2$ = 81%) weeks. The best single predictors of body weight in females were body length (BL) ($R^2$ = 91%), body girth (BG) ($R^2$ = 90%) and body width (BW) ($R^2$ = 90%) in naked neck x Isa Brown (NaxIB) at 12, 16 and 20 weeks, respectively. The best partial predictors of body weight were BG and wing length at 4 weeks ($R^2$ =97%) and BG, BL and keel length (KL) at 8 weeks ($R^2$ =97%) in IBxF; BW and DL ($R^2$ =76%) in normal feathered x Isa Brown (NxIB) males at 16 weeks and BW and DL ($R^2$ =97%) in NxIB females at 20 weeks. The higher $R^2$ values obtained in the models for females made prediction of their body weight more accurate than that of the males. In general, the $R^2$ of mixed sexes ranged from 50-97% and 62-97% at 4 and 8 weeks and for males and females, it ranged from 50-90% and 57-91%; 51-85% and 53-90%; 49-81% and 51-90% at 12, 16 and 20 weeks, respectively. Body weight was best predicted at 8 weeks, and irrespective of genotype, sex and age, the best predictors in single or partial state were BG, BL, KL, BW and DL.

**Key words:** Linear models, body weight, predictors, sex, crossbred chickens.

## I. Introduction

Stepwise regression is a method of multiple linear regression used to analyse the relationship between a set of independent variables or predictors and a dependent variable in linear models. The independent variables produce partial regression coefficients that specify the amount of change in the dependent variable as a result of a unit change in each of the independent variables. Stepwise regression, however, differs from entry procedure of multiple linear regression by employing forward and backward steps to exclude some variables, leaving only those that fit the model (Agostinelli 2002). By so doing, it reduces the interdependency or multicollinearity among independent variables which has been shown to be associated with unstable estimates of regression coefficients (Keskin *et al*. 2007; Yakubu *et al*. 2009) that reduces the accuracy of prediction (Chatterjee *et al*. 2000). The reliability of prediction is reported to depend on positive or negative linear relationship between the dependent variable and the predictors (Semakula *et al*., 2011; Ojedapo, 2012; Sanda *et al.* 2014) as well as the magnitude of the coefficient of determination. The coefficient of determination explains the total variation in a dependent variable that is accounted for by the explanatory variables or predictors in a linear regression model (Agomy *et al.* 2015).

Knowledge of animal weight is important in determining breed characterization (FAO, 2012). It is also useful in management decision (Dingwell, 2006) and in determination of the market price of animals (Semakula *et al*. 2011). The linear body measurements are important estimators of body weight and have been used extensively in prediction analyses (Gunawan and Jakaria, 2010; Birteed and Ozoje, 2012). Predicting body weight using linear body measurements is more reliable than the conventional method of weighing by scale (Lukuyu *et al.* 2016). This is because weight measurement by scale is often biased by gut fill. Moreover, measurements of linear body traits involve the use of simple measuring tape that is cost effective (Heinrichs *et al*. 2007). Prediction of body weight with linear body measurements has been reported in cattle (Lukuyu *et al*. 2016), sheep (Birteeb and Ozoje 2012), goats (Sam *et al.* 2016) and various species of poultry. Most reports on chicken mainly focused on either pure breeds, crossbreds or mixed sexes (Gambo *et al*. 2012; Ajayi *et al*.  2008; Dzungwe *et al*. 2018; Adenaike *et al*. 2015) and not on combinations of genotypes, sexes and ages in chicken. Moreover, many authors who predicted body weight from linear body measurements of chickens used the entry method of multiple linear regression analysis (Ukwu *et al*. 2014; Nosike *et at*. 2017; Ashwini *et al*. 2019), which includes all predictors in a model, thereby increasing interdependency that reduces accuracy of prediction. The chickens used in this study were egg-type crosses, and have been reported to have relatively high egg production performance (Isaac *et al.* 2020). Their egg production is also known to have high correlation with body weight (Isaac and Obike, 2020). Thus, predicting their body weight will aid in selecting egg-type chickens with high egg production potential. Furthermore, body weight varies with sex (Shafey *et al*. 2013) and age (Petrus *et al*. 2019), hence its accurate prediction must consider the two factors. The objective of this study was to use linear models to predict body weight from linear body measurements of crossbred chickens.

## II. Materials and Methods

### Study Location

The experiment was conducted at the Poultry Unit of the Teaching and Research Farm of Michael Okpara University of Agriculture, Umudike. The University is located on Latitude $05^0 29'$ North and Longitude $07^0$ $33'$ East. It is approximately 122 m above sea level. The area is characterized by maximum and minimum daily temperature ranges of $27\text{-}36^0$ C and $20\text{-}26^0$ C, respectively, average annual rainfall of 2177 mm, monthly ambient temperature range of 22-33°C and relative humidity of 50- 95 % (NRCRI, 2008). It is located within the tropical rainforest zone of Nigeria.

### Experimental Chickens and Their Management

The parent stock used consisted of 36 exotic Isa Brown (9 cocks and 27 hens), 11 frizzle feathered (3 cocks and 8 hens), 10 naked neck (3 cocks and 7 hens) and 12 normal feathered (3 cocks and 9 hens) chickens. These were managed intensively on deep litter and fed layer mash containing 2650 metabolisable energy per kilogram weight (ME/kg) and 16.5 % crude protein (CP) *ad libitum* and mated in main and reciprocal order to produce fertile eggs. The eggs were set in locally constructed incubator at weekly intervals and hatched in twelve consecutive hatches. The genotypes of the $F_1$ chickens produced were Isa Brown x frizzle feathered (IBxF), Isa Brown x naked neck (IBxNa), Isa Brown x normal feathered (IBxN), frizzle feathered x Isa Brown (FxIB), naked neck x Isa Brown (NaxIB) and normal feathered x Isa Brown (NxIB). The numbers of chickens for the respective genotypes were 123, 49, 116, 137, 42 and 64. The chicks were identified on their bodies with different patterns and colours using permanent markers at day-old. With the identification, chicks of different genotypes but the same hatch were brooded together in cages measuring 79 x 67 x 61 $cm^3$ constructed on deep litter pens, with 2.65 x 1.67 $m^2$ dimension each. Brooding was achieved using electricity and kerosene lanterns and lasted for 4 weeks for each hatch. The birds remained in these pens after brooding according to their hatches. With time, the identifications were fortified by renewing the permanent markers and adding wing bangs of different colours for the various genotypes.

The $F_1$ chickens were fed during starting and growing stages with recommended diets containing 2800 kcal ME/kg and 20% CP, 2550 kcal ME/kg and 15% CP, respectively. Newcastle Disease Vaccine and Gumboro Vaccine were given to the $F_1$ chickens as prophalytics at appropriate ages while broad spectrum antibiotics and other drugs were administered on curative approach.

### Measured Traits

The traits measured were body weight and linear measurements namely shank length, drumstick length, body width, body girth, body length, keel length, and wing length. The descriptions of these traits are reported by Isaac (2020). The traits were measured on individual chickens at 4 and 8 weeks for combined sexes and at 12, 16 and 20 weeks for males and females separately.

### Statistical Analysis

Models for predicting body weight with linear body measurements in the different genotypes were established using the Stepwise Multiple Linear Regression procedure of IBM SPSS (2011). The general linear model used was of the form in expression (1).

$$Y_i = a + b_1X_1 + b_2X_2 + \ldots + b_kX_k \qquad \ldots (1)$$

This was summed in terms of k in (2)

$$Y_i \quad = \quad a + \sum_{i=k}^{k} b_kX_k \qquad \ldots \ (2)$$

where

$Y_i$ = Body weight of different genotypes ($i = 1, \ldots, 6$)
a = Intercept
$b_i - b_k$ = Partial regression coefficients
$X_i - X_k$ = Linear measurement traits

## III. Results and Discussion

### Prediction of Body Weight of Male and Female Chickens (Mixed Sexes) of Different Genotypes at 4 and 8 weeks of age

Stepwise regression models for prediction of body weight of male and female chickens (mixed sexed) of different genotypes at 4 and 8 weeks are presented in Table 1. At 4 weeks, body weight of IBxF was predicted singly by body girth in model

1 and partially by body girth and wing length in model 2. The regression coefficient (b) in model 1 and the partial regression coefficients ($b_1$ and $b_2$) in model 2 were all positive. Their corresponding coefficients of determination ($R^2$) ranged from 96 to 97%. At 8 weeks, body weight of IBxF chickens was predicted by three models. The predictors were body girth in model 1, body girth and body length in model 2 and body girth, body length and keel length in model 3. Their regression coefficients were positive and coefficients of determination were high, ranging from 85 to 97%. In IBxNa chickens at 4 weeks (Table 1), shank length singly predicted body weight (b =51.54, $R^2$ = 65 %). At 8 weeks, drumstick length in model 1 (b = 47.23, $R^2$ = 84 %) and in combination with body length in model 2 ($b_1$ = 38.74, $b_2$ = 5.96, $R^2$ = 92%), predicted body weight in IBxNa chickens. Body weight of IBxN chickens was predicted by body girth alone in model 1 (b =14.80, $R^2$ =74%) and partially by body girth and body length in model 2 ($b_1$ = 14.01, $b_2$ = 5.77, $R^2$ =87%) at 4 weeks. At 8 weeks, drumstick length singly and partially with wing length and body girth predicted body weight of IBxN chickens in models 1 (b = 71.30, $R^2$ = 90%), 2 ($b_1$ =, b = -18.76, $R^2$ = 95%) and 3 ($b_1$ = 70.47, $b_2$ = -17.75, b3 = 20, $R^2$ = 65%).

At 4 weeks, body weight of FxIB chickens was predicted singly by wing length in model 1 (b = 26.79, $R^2$ = 87%) and partially by wing length and body girth in model 2 ($b_1$ = 17.73, $b_2$ =14.94, $R^2$ = 87%) while at 8 weeks, it was predicted singly by shank length (b = 108.22, $R^2$ = 96). In NaxIB chickens, body weight was predicted singly by shank length at 4 weeks (b = 83.28, $R^2$ =50%) and keel length at 8 weeks (b =112.50, $R^2$ = 62%). In NxIB chickens at 4 weeks, body weight was predicted singly by body girth in model 1(b = 25.37, $R^2$ = 71%), partially by body girth and keel length in model 2 ($b_1$ = 18.15, $b_2$ = 19.50, $R^2$ = 75%) and partially by body girth, keel length and drumstick length in model 3 ($b_1$ = 18.15, $b_2$ = 19.50, $b_3$ =9.17, $R^2$ = 80%). At 8 weeks, the body weight was predicted by body width in model 1 (b = 35.57, $R^2$ = 63%) and body width and body girth in model 2 ($b_1$ = 78.11 $b_2$ = -56.52, $R^2$ = 76%). In every genotype, the standard errors associated with the predictive models were smaller at 4 than at 8 weeks except in FxIB chickens where they were larger at 8 weeks. The intercepts are the first numbers in every model which represent the value of body weight when linear measurement traits are zero.

Table 1: Stepwise regression models for predicting body weight from linear measurement traits of male and female chickens (mixed sexes) of different genotypes at 4 and 8weeks of age

| **Genotype** | **S/N.** | **Week 4** | | | **Week 8** | | |
|---|---|---|---|---|---|---|---|
| | | **Prediction Model** | **$R^2$ (%)** | **SE** | **Prediction Model** | **$R^2$ (%)** | **SE** |
| IBxF | 1 | Y= -173.33+28.16BG | 96 | 6.20 | Y= -213.75+33.99BG | 85 | 29.41 |
| | 2 | Y= -181.88 +23.74BG+ 6.07WL | 97 | 5.46 | Y= -280.64+21.89BG+11.63BL | 91 | 23.93 |
| | 3 | | | | Y= -339.75+16.86BG+11.20BL +24.34KL | 97 | 21.09 |
| IBxNa | 1 | Y= -68.97+51.54SL | 65 | 9.86 | Y= -91.46+47.23DL | 84 | 20.94 |
| | 2 | | | | Y= -123.31+38.74DL+5.96BL | 92 | 16.09 |
| IBxN | 1 | Y= -32.17+14.80BG | 74 | 5.95 | Y= -326.58+71.30DL | 90 | 22.20 |
| | 2 | Y= -111.71+14.01BG+5.77BL | 87 | 4.20 | Y= -262.04+91.39DL-18.76WL | 95 | 22.20 |
| | 3 | | | | Y=-394.79+70.47DL-17.75WL +20.57BG | 65 | 19.86 |
| FxIB | 1 | Y=-215.74+26.79WL | 87 | 13.42 | Y= -159.27+108.22SL | 96 | 12.43 |
| | 2 | Y=-259.07+17.73WL+14.94BG | 92 | 11.24 | | | |
| NaxIB | 1 | Y=-153.62+83.28SL | 50 | 3.96 | Y= -294.89+112.50KL | 62 | 53.29 |
| NxIB | 1 | Y= -143.09+25.37BG | 71 | 14.05 | Y= -296.64+35.57BW | 63 | 44.86 |
| | 2 | Y=-140.90+18.15BG+19.50KL | 75 | 12.73 | Y= -198.08+78.11BW-56.52BG | 76 | 37.22 |
| | 3 | Y=-154.56+14.13BG +19.38KL +9.17DL | 80 | 12.10 | | | |

IBxF = Isa Brown x frizzle feathered main cross, IBxNa =Isa Brown x naked neck main cross, IBxN = Isa Brown x normal feathered main cross, FxIB = Frizzle feathered x Isa Brown reciprocal cross, NaxIB = Naked neck x Isa Brown reciprocal cross and NxIB = Normal feathered x Isa Brown reciprocal cross, $R^2$ = Coefficient of determination, SE = standard error, Y= Body weight, SL = Shank length, DL = Drumstick length, BW = Body width, BG =Body girth, BL = Body length, KL=Keel length and WL= Wing length

**Prediction of Body Weight of Male Chickens of Different Genotypes At 12, 16 and 20 Weeks of Age**

Stepwise regression models for prediction of body weight of male chickens of different genotypes at 12, 16 and 20 weeks of age are presented in Table 2. At 12 weeks, body weight of IBxF male chickens was predicted singly by drumstick length in model 1(b =59.53, $R^2$ = 90%) and partially by drumstick length and shank length ($b_1$ = 32.04, $b_2$ =45.88, $R^2$ = 56%) in model 2. At 16 and 20 weeks, drumstick length singly predicted 85% and 81% of body weight of IBxF males in models 1 and 2, respectively. The regression coefficients in each case were positive. Body weight of male IBxNa chickens was predicted singly by drumstick length ($R^2$ =90), keel length ($R^2$ =73%) and drumstick length ($R^2$ = 63%) at 12, 16 and 20 weeks of age, respectively. The regression coefficients of the models were all positive. In IBxN male chickens, body length singly (b= 27.92, $R^2$ = 67%) and in partial combination with wing length ($b_1$= 19.46, $b_2$= 17.77, $R^2$ = 73%) predicted body weight at 12 weeks while body width single predicted the body weight at 16 (b= 44.07, $R^2$ = 59%) and 20 (b= 56.99, $R^2$ = 61%) weeks. At 12 weeks, body weight of FxIB male chickens were predicted singly by shank length in model 1 (b= 111.46, $R^2$ = 50%) and partially by shank length band drumstick length ($b_1$= 74.23, $b_2$= 27.08, $R^2$ 53%). At 16 weeks, drumstick length singly and in combination with keel length predicted body weight in FxIB male chickens while at 20 weeks the body weight was predicted by drumstick length and body width both singly and in combination. The regression coefficients were positive and coefficients of determination ranged from 50 to 55% at both ages.

Table 2: Stepwise regression models for predicting body weight from linear measurement traits of male chickens of different genotypes at 12, 16 and 20 weeks of age

| Genotype | S/N | Week 12 | | | Week 16 | | | Week 20 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Prediction model | $R^2$ (%) | SE | Prediction model | $R^2$ (%) | SE | Prediction model | $R^2$(%) | SE |
| IBxF | 1 | Y= -59.01+50.35DL | 50 | 53.92 | Y= -397.47+79.74 DL | 85 | 43.58 | Y= -35.25+58.27DL | 81 | 63.40 |
| | 2 | Y= -96.35+32.04DL+45.88SL | 56 | 49.26 | | | | | | |
| IBxNa | 1 | Y= 203.99+59.53DL | 90 | 22.12 | Y= 215.51+77.15KL | 73 | 49.19 | Y= 62.16+58.28DL | 63 | 79.05 |
| IBxN | 1 | Y= -214.54+27.92BL | 67 | 70.79 | Y= -315.41+44.07BW | 59 | 114.46 | Y= -605.23+56.99BW | 61 | 145.51 |
| | 2 | Y= -214.52+19.46BL +17.77WL | 73 | 65.55 | | | | | | |
| FxIB | 1 | Y= -29.08+111.46SL | 50 | 62.15 | Y= -242.76+76.61DL | 51 | 84.32 | Y= -419.49+93.51DL | 50 | 112.64 |
| | 2 | Y= -145.37+74.23SL +27.08DL | 53 | 60.53 | Y= -349.33+66.41DL+27.90KL | 54 | 82.35 | Y= 613.97+61.95DL +21.56BW | 55 | 106.65 |
| NaxIB | 1 | Y= -422.66+91.23 DL | 60 | 94.92 | Y=-544.58+102.69DL | 73 | 80.47 | Y= -483.06+188.64DL | 70 | 86.55 |
| NxIB | 1 | Y= -660.72+72.65 BW | 69 | 114.57 | Y= -471.83+46.84BW | 63 | 121.08 | Y= -413.91+50.85BW | 49 | 176.78 |
| | 2 | | | | Y= -1102.55+32.34BW +74.26DL | 76 | 98.16 | Y= -715.12+36.36BW +71.24KL | 59 | 161.04 |

Genotypes are defined in Table 1. $R^2$= Coefficient of determination, SE = standard error, Y= Body weight, SL= Shank length, DSL =Drum stick length, BG= body girth. BW= Body width, KL= keel length, BL = Body length, WL=Wing length Body weight of male NaxIB chickens was predicted singly by drumstick length at 12 (b= 91.23, $R^2$ = 60%) 16 (b= 102.69, $R^2$ = 73%) and 20 (b= 188=64, $R^2$ = 70%) weeks. Body width at 12 weeks alone and in combination with drumstick length at 16 and keel length at 20 weeks, predicted body weight of male NxIB chickens. Except model 1 at week 12 whose R2 = 49%, the $R^2$ of other models were above 50%. In general, the standard errors increased with age.

**Prediction of Body Weight of Female Chickens of Different Genotypes At 12, 16 and 20 Weeks of Age**

Stepwise regression models for body weight prediction of female chickens of different genotypes at 12, 16 and 20 weeks of age are presented in Table 3. At 12 weeks, body width singly and in partially with keel length predicted 71 and 74%, respectively of the body weight of female IBxF chickens. At 16 weeks, 77 and 81% of the body weight of IBxF chickens were predicted singly by body width and partially by body width and wing length while at 20 weeks, 60% and 68% of the body weight were predicted singly by drumstick length and partially by drumstick length and keel length, respectively. Shank length ($R^2$ =57%), drumstick length ($R^2$ = 70%) and keel length ($R^2$ = 70%) were single predictors of body weight of female IBxNa chickens at 12, 16 and 20 weeks, respectively. All regression coefficients were positive. Body width singly and partially with drumstick length in models 1 and 2 predicted 70% and 73% of the body weight of female IBxN chickens at 12 weeks, respectively. At 16 weeks in the same genotype, body width singly predicted 63% of the body weight of these chickens. At 20 weeks, however, body weight of the chickens were predicted singly by body width in model 1 (b = 62.22, $R^2$ = 64%), partially by body width and keel length in model 2 ($b_1$ = 55.23, $b_2$ =27.73, $R^2$ = 67%) and partially by body width, keel length and wing length ($b_1$ = 52.26, $b_2$ = 30.09, $b_3$ = -1.84, $R^2$ = 70%) in model 3.

In female FxIB chickens at 12 weeks, body weight was predicted singly by shank length ($b_1$ = 27.72, $R^2$ = 57%) and in partial combination with drumstick length ($b_1$ =78.12, $b_2$ =27.72, $R^2$ =61%). At 16 weeks, the body weight was predicted by drumstick length alone in model 1 (b = 69.79, $R^2$ = 50%) and in partially by drumstick length and keel length ($b_1$ =54, $R^2$ = 83, $b_2$ =29.04, =53%). At 20 weeks, drumstick length singly and in combination with keel length predicted 51% and 55% of body weight of these chickens in models 1 and 2, respectively. The regression coefficients were positive in each case. Body length, body girth and body width singly predicted 91%, 90%and 90% of the body weight of female NaxIB chickens at 12,16 and 20 weeks, respectively. The regression coefficients were positive in each case. Body width singly and in partial combination with shank length predicted 64% and 70% body weight of female NxIB chickens at 12 weeks. At 16 and 20 weeks, body width singly and partially with drumstick length predicted body weight of these chickens with respective coefficients of determination of 63%, 76%, 69% and 75%. Similar to the males, the standard errors associated with the predictive models in females generally increased with age.

Table 3: Stepwise regression models for predicting body weight from linear measurement traits of female chickens of different genotypes at 12, 16 and 20 weeks of age

| Genotype | S/N | **Week 12** | | | **Week 16** | | | **Week 20** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Prediction model** | **$R^2$(%)** | **SE** | **Predictive Equation** | **$R^2$(%)** | **SE** | **Predictive Equation** | $R^2$(%) | SE |
| IBxF | 1 | Y=-246.88+32.92BW | 71 | 49.97 | Y=-483.05+46.09BW | 77 | 54.19 | Y=-203.74+69.88DL | 60 | 85.95 |
| | 2 | Y=-379.3+24.83BW+ 44.89KL | 74 | 48.13 | Y=-661.98+39.26BW +19.18WL | 81 | 49.70 | Y=-390.92+44.74DL+62.20KL | 68 | 78.75 |
| IBxNa | 1 | Y=81.78+70.62SL | 57 | 20.43 | Y=-67.18+54.35 DL | 70 | 22.28 | Y=44.56+47.46KL | 70 | 28.24 |
| IBxN | 1 | Y=-283.07+37.03BW | 70 | 68.63 | Y=-508.80+49.62BW | 63 | 112.61 | Y=-822.36+62.22BW | 64 | 144.85 |
| | 2 | Y=-254.88+26.53BW +17.86DL | 73 | 65.04 | | | | Y=-820.34+53.23 BW + 27.73KL | 67 | 139.00 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | | | | | | | Y=-768.55+52.26BW +30.09KL -1.84WL | 70 | 134.0 |
| FxIB | 1 | Y=-177.67+127.72SL | 57 | 45.01 | Y= -210.47+69.79DL | 50 | 73.29 | Y=-468.15+91.62DL | 51 | 106.96 |
| | 2 | Y=-227.91+78.12SL +27.72DL | 61 | 43.22 | Y= -260.01+54.83DL +29.04KL | 53 | 71.20 | Y= -458.95+65.03DL +41.39KL | 55 | 102.69 |
| NaxIB | 1 | Y=10.73+18.05BL | 91 | 17.12 | Y= 278.03+22.05BG | 90 | 22.64 | Y= 315.77+23.07BW | 90 | 30.37 |
| NxIB | 1 | Y=-261.46+36.56BW | 64 | 95.02 | Y= -471.83+46.84BW | 63 | 121.08 | Y= -725.33+57.56BW | 69 | 31.11 |
| | 2 | Y=-481.80+24.95BW +89.00SL | 70 | 85.75 | Y= -1102.55+32.34BW +74.26DL | 76 | 98.16 | Y=-1271.62+42.68BW +62.59DL | 75 | 118.2 |

Genotypes are defined in Table 1. $R^2$ = Coefficient of determination, SE = standard error, Y= Body weight, SL= Shank length, DSL =Drum stick length, BG= body girth. BW= Body width, KL= keel length, BL = Body length, WL=Wing length

The negative intercepts in the prediction models meant non-existence of body weight when the values of linear body measurements were zero. This implies that the linear body measurements are important estimators of body weight (Francis *et al*. 2002). The positive regression coefficients obtained in most of the models meant that a unit increase in any of the predictors resulted in increase in body weight, indicating that the chickens gained weight as their linear body traits increased. This suggests that the linear body measurements could serve as indirect selection criteria for body weight improvement (Bene *et al*. 2007; Assan, 2015). The high coefficients of determination observed for both the mixed and separate sexes in different genotypes indicated that the prediction of body weight using these linear measurements was practically reliable. However, the higher range of coefficients of determination at 8 weeks (62-97%) compared to 4 weeks (50-97%) was an indication that body weight should be more accurately predicted at 8 weeks in these chickens. The observed increase in the coefficient of determination with age was similar to the findings of Nwaogwugwu *et al*. (2018) in Cinnamon Brown strain of Japanese quail but disagreed with the higher coefficients obtained at younger age of rabbits and chickens as reported by Akanno *et al*. (2007) and Adedibu and Ayorinde (2011). These differences might come from breeds and species as they are known to affect the performance of animals (Al-Marzooqi *et al*. 2019). Similarly, the higher coefficients of determination obtained in models for females compared to those of males at 12 (females= 57-91%; males = 50-90%), 16 (females = 53-90%; males = 51-85%) and 20 (females = 51-90%; males = 49-81%) weeks confirms the report of Benyi *et al*. (2015) that sex of an animal affects its body weight significantly. It also indicates that prediction of body weight could be more accurate in female than the male chickens. The fewer number of linear body measurements involved in the models for males, especially at 16 and 20 weeks**,** indicated that prediction of body weight was easier in males than females. For this reason, Tahtali (2019) used factor analysis to eliminate multicollinearity among body traits in Lambs in order to improve ease and accuracy of prediction.

Shank length, drumstick length, body girth, body width, keel length and body length obtained as single predictors of body weight in IBxNa and NaxIB at 4 and 8 weeks and IBxF, IBxN, IBxNa and NaxIB chickens at 12, 16 and 20 weeks indicated that body weight could be easily predicted with these traits in their respective genotypes, thus confirming the report of Nwaogwugwu *et al*. (2018) that prediction is easier with single than multiple predictors. Gambo et al. (2014) similarly reported shank length, body girth and body length as predictors in quail. Also the partial predictors which differed with genotype, sex and age indicated that these factors influence body weight and should be considered separately for accurate prediction. This result collaborated with the report of Adedibu and Ayorinde (2011) that sexual dimorphism influenced body weight prediction, resulting in different predictors in males and females of two broiler strains at different ages. The combinations of body girth, body length and keel length in mixed sexes, body width and drumstick length in males and body width and drumstick length in females obtained as the best partial predictors of body weight collaborated with the findings of Adedibu and Ayorinde (2011) and Vincent *et al*. (2015).

## IV. Conclusion

Body girth, body length, body width, drumstick length, keel length and shank length were found as best predictors of body weight either in single or combined state with others. Body weight was best predicted at 8 weeks and was more accurately predicted in females than in males. The predictors and prediction accuracy differed with genotype, sex and age of the chickens. These factors should be considered important during prediction.

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