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Determination of best fitted regression model for estimation of body weight in Nigerian indigenous chickens

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***Target Audience:** Poultry breeders and scientists*

Abstract

Farmers rearing indigenous chickens in the villages or peri-urban settlements often have problems of accurately estimating body weight of their chicken. Therefore, the study was conducted to determine the best-fitted regression model for estimating body weight of Nigerian indigenous chickens using different linear body measurement. Data on body weight and body measurements recorded on 137 Nigeria indigenous chickens consisting of 57cocks and 80 hens were used for the study. Parameters measured were Body weight (BW), Body length (BL), Wing length (WL), Wing span (WS), Drum stick (DS) Shank length (SL), Body length (BL), Breast girth (BG) and Keel length (KL). Body weight was regressed on body measurements by forward, backward, stepwise and full model regression analysis, to determine the combination of body dimension for each sex that explains variation in the dependent variable for male and female chickens at 20th week of age. The outcome of the study showed that BW= -2223.73 +33.67SL +11.62DS +17.83BG +56.87BL +79.13KL and BW= -1608.61 +13.21WL +20.51BG +69.57BL are the best fitted regression model for predicting body weights of Nigerian indigenous cock and hen, respectively at 20 weeks of age.

***Key words** Regression; indigenous; chicken; forward; backward; stepwise*

Description of Problem

The Nigerian indigenous chicken is one of the major sources of protein for the Nigerian people (1). Indigenous chickens make substantial contributions to household food security in Nigeria. Indigenous chicken serves as source of security and investment in Nigeria, most especially the rural poor. They are majorly used as sources of meat and eggs for consumption. They are a source of income (2). All other forms of livestock in Nigeria are outnumbered by poultry; it is obvious as it is found throughout the country wherever there is human settlement. Out of the total estimated population of 82.4 million local chickens, 11% or 10 million was accounted for commercial holdings (3).

Growth is an essential and intrinsic property of biological systems which can be defined as an increase in the number of cells in the body per unit of time (4). Growth of fowl is analogous to growth of mammalian; consisting of three or four cycles, which occur after hatching. Growth is affected by genetic and non-genetic factors. Growth in Animals involves increase in body size and changes in functional capabilities of the various tissues and organs of animals that begins from conception through maturity. The process of growth includes increase in cell numbers (hyperplasia) and increase in cell size (hypertrophy) (5). Growth performance of an animal is a phenotypic expression which is the outward expression of the animal genetic make-up (4). Body weight is usually used as a measure of

growth in farm animals; however numerous studies have shown that other growth traits relating to body morphometric measurements such as body length, shank length and chest girth can serve as good indicators of growth (6; 7).

Body weight is an important economic trait in the selection of animals. The main purposes of animal breeding practices are to improve traits of economic values (8). In livestock breeding and production, it is very essential to have an accurate method for the estimation of body weight. Knowledge of animal′s live weight is important in the determination of its food requirements for growth, maintenance and production, and drug administration (8). Estimation of live weight directly, involves the use of weighing scales. However, accurate estimation of body weight is difficult under field condition due to certain reasons which include unwillingness by some rural farmers to procure a weighing scale, impatience in weighing the birds and sometimes unavailability of weighing scale. Therefore, there is need to estimate live weight of chickens using simple and easily measurable morphological variables such as linear body measurements become more evident. Linear body measurements can be used to predict live weight in poultry (9; 10). In multiple regression, several quantitative variables are used in combination rather than just one such variable to predict the value of a quantitatively measured criterion variable. It also shows the weight each variable in the combination has contributed to the model. According to (11), R^2, Adjusted R^2, mean squared error (MSE), root mean squared error (RMSE), Akaike's Information Criterion (AIC), are among common criteria that are used to measure model performance and select the relatively best model from a set of potential models. Hence, this study is aimed at estimating the live weight of Nigerian indigenous chicken using different regression models and to determine which of the models is best fitted by giving attention to the model selection criteria by (11).

Materials and methods

A total of 137 birds from the sixth generation (F6) of Nigerian indigenous chickens were used for the study conducted at the Poultry Breeding unit of Federal University of Agriculture, Abeokuta. The study lasted for a period of 20 weeks. The body weights of birds were determined using a sensitive scale. Linear body measurements were taken with the aid of a measuring tape. The body measurements of interest include Wing length (WL), Wing span (WS), Drum stick (DS), Shank Length (SL), Breast Girth (BG), Body Length (BL), Keel Length (KL).

Statistical Analysis

Statistical analysis of data collected from the experiment was performed using Proc. Regression in Statistical Analysis Software (12). Body weight was regressed on body measurements by forward, backward, stepwise and full model regression analysis as described by (13), to determine the combination of body dimension for each sex that explains variation in the dependent variable for male and female chickens at 20^{th} week of age.

Statistical model

$Y = \beta_0 + \beta_1 X + e$ .....(1)
Simple regression model
$Y = \beta + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_k X_k + e$
..... (2) Multiple regression model
Where Y = dependent variable (body weight)
B = the intercept
X = independent variables (WL, BG, DS, SL, BL, WS, KL)
β = the regression coefficient associated with WL, BG, DS, SL, BL, WS, KL.

e = random error term

Evaluation and comparison of different regression model to determine the best fitted regression equation was done using the coefficient of determination (R^2), Residual mean square error, (RMSE), Akaike information criterion (AIC) and significant value were used.

Results

Tables 1 and 2 shows the Forward method of multiple regression equations of Nigerian indigenous chickens (male) using body weight and linear measurements and their coefficient of determinations (R^2), residual mean square errors (RMSE), Akaike information criterion (AIC) and P-values. In Forward method of multiple regression (male), the equation with five variables have the highest coefficient of determination (68.37%) and Residual mean square error of 95981 which makes it the best fit out of all the models. Also, in Forward method of multiple regression (female), the equation with three variables is considered to be the best fit as the residual mean square error (43906) and the Akaike information criterion (349.30) were both at the minimum.

Table1: Forward method of multiple regression equations of Nigerian indigenous chickens (male) using Body weight and linear measurements and their coefficient of determinations R^2, residual mean square errors, Akaike information criterion (AIC) and P-values.

Model	Equation	R^2	RMSE	AIC	P-VALUE
Forward step1	BW= -1225.68 + 99.91BL	53.01%	134683	411.99	***
Forward step2	BW= -2009.72 + 33.07BG + 76.86BL	64.00%	105133	399.25	***
Forward step3	BW= -2314.81 + 24.58BG +64.49BL +90.12KL	67.13%	97843	396.97	***
Forward step4	BW= -2229.73 + 21.26BG +28.25SL +59.97BL +83.00KL	68.37%	95981	397.83	***
Forward step5	BW= -2223.73+33.67SL + 11.62DS +17.83BG +56.87BL +79.13KL	68.82%	96510	400.16	***

***(P<0.001).

Table 2: Forward method of multiple regression equations of NIC (female) using Body weight and linear measurements and their coefficient of determinations R^2, residual mean square errors, Akaike information criterion (AIC) and P-values.

Model	Equation	R^2	RMSE	AIC	P-VALUE
Forward step1	BW= -996.00 +89.98BL	63.49%	55438	359.17	***
Forward step2	BW= -1600.16 +24.49BG +73.53BL	70.28%	45712	349.69	***
Forward step3	BW= -1608.61 +13.21WL +20.51BG 69.57BL	71.82%	43906	349.30	***
Forward step4	BW= -1717.15 +14.24WL +4.58WS +18.87BG +67.96BL	72.08%	44064	351.51	***

***(P<0.001).

Tables 3 and 4 show the backward methods of multiple regression equations for both male and female chickens, respectively. For the males, the equation with four variables is observed to be the best fit with the coefficient of determination of 68.37% and residual mean square error of 95981. The best fit backward regression model for female is the equation with three variables with residual mean square error of 43906 and Akaike information criterion of 349.30.

Table 3: Backward method of multiple regression equations of NIC (male) using body weight and linear measurements and their coefficient of determinations R^2, residual mean square errors, Akaike information criterion (AIC) and P-values.

Model	Equation	R^2	RMSE	AIC	P-VALUE
Backward step1	BW= -2310.40 +4.79WS +31.31SL +8.89DS +16.85BG +56.95BL +77.86KL	68.92%	98176	403.17	***
Backward step2	BW= -2223.73 +33.67SL +11.62DS +17.83BG +56.87BL +79.13KL	68.82%	96510	597.13	***
Backward step3	BW= -2229.73 +28.25SL +21.26BG +59.97BL 83.00KL	68.37%	95981	397.83	***
Backward step4	BW= -2314.81 +24.58BG +64.49BL +90.12KL	67.13%	97843	396.97	***

***(P<0.001

Table 4: Backward method of multiple regression equations of NIC (female) using Body weight and linear measurements and their coefficient of determinations R^2, residual mean square errors, Akaike information criterion (AIC) and P-values.

Model	Equation	R^2	RMSE	AIC	P-VALUE
Backward step1	BW= -1706.49 +14.42WL +4.49WS -4.78SL +18.56BG +68.09BL +3.72KL	72.21%	45057	356.83	***
Backward step2	BW= -1704.45 +14.10WL +4.00WS +18.41BG +67.73BL +3.63KL	72.19%	44478	354.07	***
Backward step3	BW= -1717.15 +14.24WL +4.58WS +18.87BG +67.96BL	72.08%	44064	351.51	***
Backward step4	BW= -1608.61 +13.21WL +20.51BG +69.57BL	71.82%	43906	349.30	***

***(P<0.001).

Tables 5 and 6 show the stepwise multiple regression models for Nigerian indigenous chickens. The equation with three variables is considered to be the best fit for predicting body weight of male chicken at 20 weeks of age as it meets all the three criteria. Coefficient of determination (67.13%), residual mean square error (97843) and Akaike information criterion (396.392). for the female, the equation with three variables is also considered to be the best fit, as it also meets the three criteria coefficient of determination (71.87%), residual mean square error (43906) and Akaike information criterion (349.30).

Table 5: Stepwise method of multiple regression equations of Nigerian indigenous chickens (male) using Body weight and linear measurements and their coefficient of determinations R^2, residual mean square errors, Akaike information criterion (AIC) and P-values.

Model	Equation	R^2	RMSE	AIC	P-VALUE
Stepwise step1	BW= -1225.68 + 99.91BL	53.01%	134683	410.11	***
Stepwise step2	BW= -2009.72 + 33.07BG + 76.86BL	64.00%	105133	399.24	***
Stepwise step3	BW= -2314.81 + 24.58BG +64.49BL +90.12KL	67.13%	97843	396.92	***

***(P<0.001).

Table 6: Stepwise method of multiple regression equations of Nigerian indigenous chickens (female) using Body weight and linear measurements and their coefficient of determinations R^2, residual mean square errors, Akaike information criterion (AIC) and P-values.

Models	Equation	R^2	RMSE	AIC	P-VALUE
Stepwise step1	BW= -995.896 +89.98BL	63.50%	55438	359.17	***
Stepwise step2	BW=-1600.16 +24.49BG +73.53BG	70.28%	45712	349.69	***
Stepwise step3	BW= -1608.61 +13.21WL +20.51BG +69.57BL	71.82%	43906	349.30	***

***(P<0.001).

Table 7 and 8 show the full model method of multiple regression (male) having seven variables with coefficient of determination (68.92%), residual mean square error (100200) and Akaike information criterion (406.309). while the female having six variables with coefficient of determination of 72.21%, residual mean square error of 45672 and Akaike information criterion of 359.64. the P-value is not suitable for comparing the models as individual model is significant at 0.001(***).

Table 7: full model method of multiple regression equations of Nigerian indigenous chickens (male) using Body weight and linear measurements and their coefficient of determinations (R^2), residual mean square errors, Akaike information criterion (AIC) and P-values.

Equation	R^2	RMSE	AIC	P-value
BW = -2323.06 +3.61WL +3.34WS +30.99SL +8.59DS +16.89BG +57.13BL +78.07KL	68.92%	100200	406.39	***

***(P<0.001).

Table 8: full model method of multiple regression equations of Nigerian indigenous chickens (female) using Body weight and linear measurements and their coefficient of determinations (R^2), residual mean square errors, Akaike information criterion (AIC) and P-values.

Equation	R^2	RMSE	AIC	P-value
BW=-1707.05+14.45WL+4.49WS - 4.22SL - 0.44DS +18.66BG + 68.02BL	72.21%	45672	359.64	***

***(P<0.001).

Discussion

According to (14), the AIC of a candidate model which is over-specified and has a large number of parameters tends to underestimate the risk function overly. The variance of the AIC may increase as the number of parameters increases. Thus, the model with the most parameters tends to make AIC the smallest, and so the AIC often selects the model with the most parameters as the best model. The equation BW= -2223.73 + 33.67SL + 11.62DS + 17.83BG + 56.87BL + 79.13KL and BW= -1717.15 + 14.24WL + 4.58WS + 18.87BG + 67.96BL were found to be the best for estimating the bodyweight in male and female Nigerian indigenous chicken respectively. For backward method**,** BW= -229.73 +28.25SL +21.26BG +59.97BL +90.12KL and BW= -1608.61 + 13.21WL + 20.51BG + 69.57BL were considered to be the best for estimating the body weight in male and female NIC respectively. The report of (15) and (14) that regression model with lowest AIC and RMSE estimates are considered the most appropriate model corroborates the result obtained for this experiment. For predicting body weight using stepwise method of multiple regression, BW= -2314.81 +24.58BG 64.49BL + 90.12KL for male and BW= -1608.61 +13.21WL +20.51BG +69.57BL for female were considered the best for predicting body weight of Nigerian indigenous chickens. These results are similar to the report of (16) and (17) who reported that the larger the R^2 and smaller the RSME produce better goodness of fit. The full model consists all the linear measurement in predicting body weight of Nigerian Indigenous chicken, BW= -2323.06 +3.61WL +3.34WS +30.99SL +8.59DS +16.89BG +57.73BL + 78.07KL for male and BW= -1707.05 +14.45WL +4.49WS -4.22SL -0.44DS +18.66BG +68.02BL for female.

The forward multiple regression model with the highest R^2, minimum RMSE and AIC (BW= -2223.73 +33.67SL +11.62DS +17.83BG +56.87BL +79.13KL) is considered to be the best fitted regression model for predicting body weight of Nigerian Indigenous cock at 20 weeks of age. This is in consonant with the submission of (15).The best fitted regression model for predicting body weight of Nigerian indigenous hen was observed in both stepwise and backward regression methods (BW= -1608.61 +13.21WL +20.51BG +69.57BL). This selection was based on the model meeting all the criteria or two out of the three criteria (R^2, RMSE, AIC). Since all the models are significant at 0.001 (***).

Conclusion and Application

1. Body weight of Nigerian indigenous (male) at 20 weeks of age may be estimated using BW= -2223.73 +33.67SL +11.62DS +17.83BG +56.87BL +79.13KL as this met the R^2 and AIC criteria
2. BW= -1608.61 +13.21WL

+20.51BG +69.57BL may be used to predict the body weight of Nigerian indigenous (female) at 20 weeks of age. As this met the R^2, RMSE and AIC criteria.

3. These results show that body weight of Nigerian indigenous chicken (male) at 20 weeks of age may be predicted from SL, DS, BG, BL and KL
4. Precisely, WL, BG and BL may be used for predicting the body weight of Nigerian indigenous (female) at 20 weeks of age.

References

Ogbonna, J. U`., Oredeni, A. O., Rahmon, D. A. and Adedeji, A. (2002). Effect of enzyme supplementation on digestibility and nutrient utilization of cassava peel meal- base layer's diet Proceedings of 7th Annual Conference of Animal Science of Nigerian (ASAN), Sept. 16-19, 2002, University of Agriculture, Abeokuta, Nigeria 134-135

Muchadeyi, F. C., Eding, H., Wollny C. B. A., Groenveld, E., Makusa, S. M., Shamseldin, R., Simianer, H. and Weigend, S, (2007). Absence of population structuring in Zimbambwe chicken ecotype inferred using microsatellite analysis. *Animal Genetic.*, 38: 332-339

Farayola, T. R., Adeymo A. A., Nwachukwu, S. C, and Yusuf, A. (2013). Extension strategy development and training needs for small scale commercial poultry farmers in Nigeria. *International Journal of Poultry Science*, 3(4): 99-105

Ojedapo, L. O., Amao, S. R., Ameen, Adedeji, S. A., Ogundipe, R. I. and Ige, A. O. (2012). Prediction of body weight and other linear body measurement of two commercial layer strain chickens. *Asian Journal of Animal Science*, 6: 13 – 22.

Chineke, C. A. (2001). Interrelationships existing between body weight and egg production traits in Olympia black layers. *Nigerian Journal of Animal Production* 28 (1): 1– 8.

Ige, A. O. (2013). Relationship between bodyweight and growth traits of crossbred Fulani ecotype chicken in derived savannah zone of Nigeria. *International Journal of Applied Agricultural and Agricultural Research*. 9: 157 - 165

Yunusa, A. J. and Adeoti, T. M. (2014). Multivariate analysis for body weight and some linear body measurements of Nigerian indigenous chickens. *Slovak Journal Animal Science*, 47: 142 – 148

Musa, A.M., Idam, N.Z. and Elamin, K.M. (2012). Regression analysis of linear body measurements on live weight in Sudanese Shugor Sheep. *Online Journal of Animal Feed Research*. 2(1): 27-29.

Okon, B., Ogar I. B. and Mgbere, O. (1997). Interrelationship of live body measurements of broiler chicken in the humid tropical environment. *Nigerian Journal of Animal Production*. 24 (1 and 2): 7-12

Akanno, E. C, and Ibe, S. N. (2006). Prediction of body weight of domestic rabbit at different stages of growth using linear body measurement, *Nigerian Journal of Animal Production*, 33(1): 3- 7.

Hoang, P. (2019). A new criterion for model selection. *Mathematics*. 7: 1215

SAS (2002). Statistical analysis software enterprise guide version four, SAS

Institute Inc., Cary NC.

.Pesmen, G and Yardimci, M, (2008), Estimating the live weight using some body measurements in Saamen goats, *Achivazootechnica*. 11: 664-668

Hirokazu, Y., Ken-Ichi, K., Shinpei, I. and Mariko, Y. (2017). A study on the bias-correction effect of the AIC for selecting variables in normal multivariate linear regression models under model misspecification. *REVSTAT Statistical Journal*. 15(3): 299 – 332. `

Ali, A., Javed, K., Zahoor, I; and Anjum, K.M. (2020). Determination of best fit non-linear function to describe the growth of Kajli sheep. *South African journal of Animal Science* 50(3): 452 – 459

Topal, M., Yildiz, N., Esenbuğa, N., Aksakal, V., Macit, M. and Özdemir, M. (2003). Determination of best fitted regression model for estimation of body weight in Awassi sheep. *Journal of Applied Animal Research.* 23: 201–208

Topal, M and Macit, M. (2004). Prediction of body weight from vody measurement in morkaraman sheep. *Journal of Applied Animal Research*. 25: 97 – 100.