



## Principal Component and Correlation Analyses of Body Weight and Biometric Traits of Noiler Chickens

Faith, E.A.<sup>1\*</sup>, Negedu, E.O.<sup>2</sup> and Osu, A.D.<sup>1</sup>

<sup>1</sup>Department of Animal Science, College of Agriculture, Science and Technology, Lafia, P.M.B. 33, Nasarawa State, Nigeria

<sup>2</sup>Department of Animal Science, Faculty of Agriculture, Nasarawa State University Keffi, Nasarawa State, Nigeria.

\*[faithelijah2013@gmail.com](mailto:faithelijah2013@gmail.com); [feakumbugu@coastlafia.edu.ng](mailto:feakumbugu@coastlafia.edu.ng)

### Abstract

*This study was designed to evaluate principal components and phenotypic correlations between body weight and biometric traits of Noiler chickens on deep litter system of management. The study was conducted at the Poultry Unit of the Teaching and Research Farm of the Livestock Complex of College of Agriculture, Science and Technology Lafia, Nasarawa State. A total of one hundred and forty (140), six (6) weeks old Noiler chickens comprising of sixty cocks (60) and eighty hens (80) were procured from various brood and sell farmers in Lafia. Traits measured were Body weight (BW), body length (BL), breast circumference (BC), thigh circumference (TC), foot length (FL), total leg length (TLL) and wing length (WL) on bi-weekly basis for two months. Pearson's correlation coefficient was employed to determine the relationships between body weight and biometric traits. Mean values of all the traits for male Noiler chickens were higher compared to their female counterparts. The value for Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy obtained for the male (0.85), female (0.83) and Bartlett test of Sphericity (0.00) were significant at chi-square of 1362.34 (male) and 1548.17 (female). Two principal components PC1 and PC2 were extracted for male and female. PC1 (Eigenvalue male and female = 4.87 and 4.30) accounted for 69.4% and 61.9% and PC2 (Eigenvalue male and female = 0.72 and 1.08) accounted for 10.33% and 15.42% of total variance. In males, foot length (0.87) and body length (0.89) had larger proportion of variance for PC1 and PC2 while in females, thigh circumference (0.90) and body length (0.93) had larger proportion of variance for PC1 and PC2 and these traits could be of importance and useful for selection in genetic improvement programmes. There was positive correlation between body length and thigh circumference (male) and body length and foot length (female). Correlation may be useful as selection criterion because correlated variables are more likely to be governed by the action of the same gene.*

**Keywords:** Biometrics, deep litter, communality, correlation, principal components

### Introduction

Multiple regression models are commonly used to predict body weight of the birds in the future using their body measurements at early ages and to interpret the complex relationships between body weight and body measurements (Mendes and Akkartal, 2007). Latshaw and Bishop (2001) used multiple linear regression models to estimate body weight of chickens based on body measurements. Multiple regression models are useful for predicting body weight of the animals but its biological

interpretation may be misleading because of the number of predicted variables included in the model. At the same time, the existence of a high correlation (multicollinearity problem) between the predictors, yields a deficiency in the regression model formed (Çamdeviren, *et al.*, 2005). Multicollinearity problem can seriously affect least-squares parameter estimates. Especially extreme cases of this problem can cause the least-squares parameter estimates to be far from the true values of the parameters. This will result in incorrect

conclusions about relationships between dependent and predictor variables. One of the approaches to avoid this problem is the use of the principal component analysis (Sousa *et al.*, 2007).

Principal component analysis (PCA) is a mathematical model/procedure that transforms a number of uncorrelated variables into a smaller number of uncorrelated variables called principal components which are ordered so that the first few retain most of the variation present in the original variables (Salako, 2006). PCA has been used as a tool in the assessment of the body shapes which could be of evolutionary significance as well as permit an understanding of the complex growth process going on in the body dimensions of an animal during growth period (Yakubu *et al.*, 2009b). Noiler chicken was developed and introduced to the Nigerian Poultry industry by Amo Farm Sieberer hatchery limited. Smallholder farmers are the major beneficiaries of the introduction of this breed of chicken as it helps to address the difficulties of food and financial insecurities rampant among the Nigerian rural population, especially women (Dudusola *et al.*, 2020). The study was designed to apply principal component analysis and correlation on body weight and biometric traits of Noiler chickens managed on deep litter intensive.

## Materials and Methods

### Study area and birds management

The study was carried out at the Poultry Unit of the Teaching and Research Farm of the Livestock Complex of College of Agriculture, Science and Technology Lafia, Nasarawa State. Nasarawa State lies within the Guinea savanna zone of Nigeria at Latitude 8.33°N and Longitude 8.33°E. It is positioned at altitude 181.35m above sea level with an average rainfall of 1182mm annually (NIMET, 2023).

A total of one hundred and forty (140), six (6) weeks old Noiler chickens comprising of sixty cocks (60) and eighty hens (80) were procured from various brood and sales farmers in Lafia. The birds were managed on a deep litter intensive system for the duration of two months. The birds were fed on commercial concentrate finisher feeds and birds were dewormed/vaccinated following the standard protocol.

### Body weight and biometric data

Traits measured were Body weight (BW), body length (BL), breast circumference (BC), thigh circumference (TC), foot length (FL), total leg length (TLL) and wing length (WL). The traits were measured or determined on each Noiler chickens on a bi-weekly basis (twice a month) for two months, following the standard anatomical description adopted by FAO (2012) and AUIBAR (2015). Bodyweights was taken using 10kg digital hanging scale (sensitivity of 0.1gram) while body measurements were taken using flexible tape rule.

### Statistical analysis

SPSS 22 was used to analyze the correlation of body weight with biometric traits of the Noiler chickens. The Principal Component Analysis (PCA) was employed to explain interrelatedness/relationship among the body weight and morphological indices.

Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was estimated to determine the appropriateness of the factor model and value below five was rejected while Bartlett's test of Sphericity test ( $\chi^2$ ) was performed to test if the correlation matrix is an identity matrix (i.e. each variable correlated with itself) used to test the validity of principal component analysis of the data set. Factor loading was based on Eigen value of 1.00 and above, and the best descriptors were identified based on communality extraction factors

closest to 1.00. The varimax criterion of the orthogonal rotation was employed in the rotation to enhance the interpretability of the principal components.

Everitt *et al.*, (2001) defined principal component analysis as a method of transforming variables in a multivariate data set,  $x_1, x_2, \dots, x_p$  into new uncorrelated variables  $y_1, y_2, \dots, y_p$  which account for decreasing proportions of the total variance in the original variables defined as

$$y_1 = a_{11}x_1 + a_{12}x_2 + \dots + a_{1p}x_p.$$

$$y_2 = a_{21}x_1 + a_{22}x_2 + \dots + a_{2p}x_p.$$

$$y_p = a_{p1}x_1 + a_{p2}x_2 + \dots + a_{pp}x_p.$$

The principal components  $y_1, y_2, \dots, y_p$  account for decreasing proportions of the total variance in the original variables  $x_1,$

$x_2, \dots, x_p$ . Variance maximizing orthogonal rotation was used in the linear transformation of the factor pattern matrix in order to make the interpretation of the extracted principal components easier.

## Results and Discussion

### Results

Descriptive analysis (mean and standard deviation) of body weight (kg) and biometric traits (cm) of Noiler chickens was presented in table 1. The result showed that the mean values of all the traits of the male Noiler chickens were higher compared to their female counterparts. This implies that male Noiler chickens were superior to their female counterparts.

**Table 1. Descriptive analysis of body weight (kg) and biometric traits (cm) of Noiler chickens**

Traits	Male		Female	
	Mean	SD	Mean	SD
Body weight (BW)	1.20	0.38	0.97	0.24
Body length (BL)	33.77	2.46	32.65	3.34
Breast circumference (BC)	25.63	3.29	23.45	3.41
Thigh circumference (TC)	11.54	1.77	11.30	1.82
Foot length (FL)	7.15	1.57	6.64	1.76
Total leg length (TLL)	21.53	2.38	20.19	2.43
Wing length (WL)	23.38	1.69	21.99	2.19

SD-Standard deviation

Eigenvalues and share of total variance along with factor loadings after rotation and communalities of the body weight and biometric traits of male Noiler chickens were presented in table 2. The value for Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy obtained for the male Noiler chickens was 0.85 and Bartlett test of Sphericity (0.00) was significant at chi-square of 1362.34. The result indicated that two principal components PC1 and PC2 were extracted. PC1 (Eigenvalue= 4.87) accounted for 69.4% and PC2 (Eigenvalue= 0.72) accounted for 10.33% of total variance.

The varimax rotation method of principal component analysis indicated that body weight and biometric traits that contributed significantly to PC1 were body weight, breast circumference, foot length, wing length and total leg length while for PC2 only body length and thigh circumference contributed to the total variance. Eigenvalues and share of total variance along with factor loadings after rotation and communalities of the body weight and biometric traits of female male Noiler chickens were presented in Table 3.

The value for Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy obtained for

the female Noiler chickens was 0.83 and Bartlett test of Sphericity was significant at chi-square of 1548.17

The result indicated that two principal components PC1 and PC2 were extracted. PC1 (Eigenvalue= 4.30) accounted for 61.9% and PC2 (Eigenvalue= 1.08) accounted for 15.42% of total variance. The varimax rotation method of principal component analysis indicated that body

weight and biometric traits that contributed significantly to PC1 were thigh circumference, foot length, wing length, body weight, total leg length and breast circumference while for PC2, body length contributed positively and thigh circumference negatively to the total variance. The highest (0.88) communalities obtained for the traits were however recorded for foot length while the least (0.65) was recorded for breast circumference.

**Table 2. Eigenvalues and share of total variance along with factor loadings after rotation and communalities of the body weight and biometric traits of male Noiler chickens.**

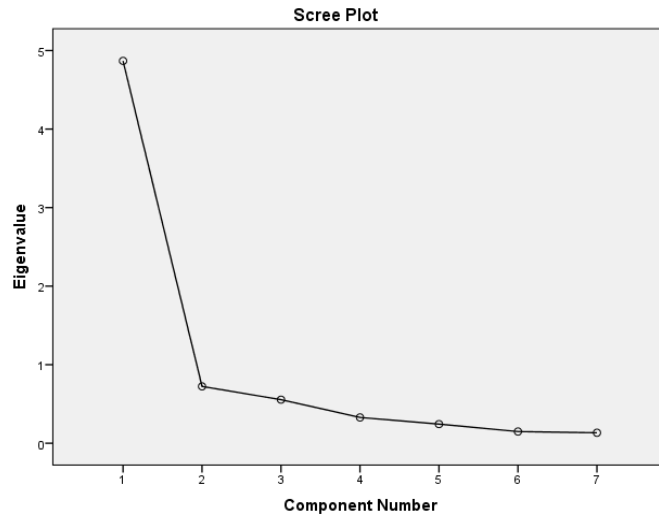
Traits	PC1	PC2	Communality
Body weight (BW)	0.81	0.42	0.83
Body length (BL)	0.32	0.89	0.90
Breast circumference (BC)	0.84	0.29	0.80
Thigh circumference (TC)	0.37	0.86	0.88
Foot length (FL)	0.87	0.26	0.82
Total leg length (TLL)	0.67	0.36	0.57
Wing length (WL)	0.81	0.39	0.80
Eigenvalue	4.87	0.72	
% of total variance	69.54	10.33	

Kaiser-Meyer–Olkin Measure of Sampling Adequacy (0.85), Bartlett’s Test of Sphericity 0.00 (Chi-Square=1362.34)  $P<0.01$ ,

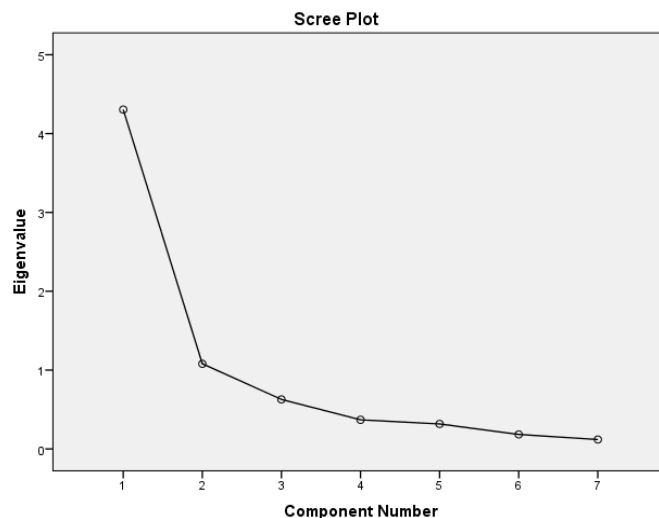
**Table 3. Eigenvalues and share of total variance along with factor loadings after rotation and communalities of the body weight and biometric traits of female Noiler chickens.**

Traits	PC1	PC2	Communality
Body weight (BW)	0.70	0.59	0.82
Body length (BL)	-0.01	0.93	0.87
Breast circumference (BC)	0.52	0.62	0.65
Thigh circumference (TC)	0.90	-0.72	0.81
Foot length (FL)	0.87	0.35	0.88
Total leg length (TLL)	0.61	0.56	0.67
Wing length (WL)	0.77	0.26	0.66
Eigen value	4.30	1.08	
% of total variance	61.49	15.42	

Kaiser-Meyer–Olkin Measure of Sampling Adequacy (0.83), Bartlett’s Test of Sphericity 0.00 (Chi-Square=1548.17)  $P<0.01$



**Figure 1.** Scree plot of the male Noiler chickens from the Principal component analysis (PCA)



**Figure 2.** Scree plot of the female Noiler chickens from the Principal component analysis (PCA)

Scree plots of the male and female Noiler chickens from the Principal component analysis (PCA) are presented in Figures 1 and 2. For male Noiler chickens (Figure 1), only the first component have eigenvalues greater than 1 and accounted for 69.54% of the total variance. In the case of the female Noiler chickens (Figure 2), components 1 and 2 have eigenvalues greater than 1 and both accounted for 76.91% of the total variance.

The Pearson's correlations of body weight and biometric traits of male and female Noiler chickens at six, eight, ten and twelve weeks of age were presented in Table 4,5,6 and 7. There were strong and positive significant ( $P < 0.01$ ) phenotypic correlations between body weight and biometric traits. The highest significant positive correlation for male was observed between body weight and breast circumference ( $r = 0.759$ ) while for female, highest coefficient was obtained between body

weight and body length ( $r = 0.611$ ) at six weeks of age (Table 4).

The highest significant positive correlation for male was observed between body weight and breast circumference ( $r = 0.750$ ) and for female was between thigh circumference and foot length ( $r = 0.635$ ). Body length and thigh circumference ( $r = -0.708$ ) as well as body length and foot length ( $r = -0.616$ ) had highest strong significant negative correlation for both female and male birds at eight weeks of age (Table 5).

The highest significant positive correlation for male was observed between body weight and breast circumference ( $r = 0.638$ ) and for female was between body length and thigh circumference ( $r = 0.551$ ) at ten weeks of age (Table 6). The highest significant positive correlation for male was observed body length and thigh circumference ( $r = 0.749$ ) and for female was between body length and foot length ( $r = 0.706$ ) at twelve weeks of age (Table 7).

**Table 4. Pearson's correlation of body weight and biometric traits of male and female Noiler chickens at 6 weeks of age**

Traits	BW	BL	BC	TC	FL	TLL	WL
BW	-	-0.083	0.759**	-0.066	0.438**	-0.044	0.025
BL	0.611**	-	-0.287*	0.726**	-0.363**	0.189	0.210
BC	0.174	0.302**	-	-0.152	0.353**	0.036	0.198
TC	0.399**	0.346**	0.119	-	-0.450**	0.211	0.350**
FL	-0.059	0.195	0.460**	0.030	-	-0.435	-0.443**
TLL	0.206	0.358**	0.231	0.351**	0.157	-	0.379**
WL	0.108	-0.054	-0.048	0.265	0.151	-0.129	-

Estimates for male at upper diagonal and female lower diagonal.

\*\*Significant at  $P < 0.01$ ; \*Significant at  $P < 0.05$

**Table 5. Pearson's correlation of body weight and biometric traits of male and female Noiler chickens at 8 weeks of age**

Traits	BW	BL	BC	TC	FL	TLL	WL
BW	-	0.332**	0.750**	0.123	0.202	-0.240	0.166
BL	0.457**	-	0.387**	0.621**	-0.616**	-0.103	-0.293*
BC	0.225	0.615**	-	0.033	0.291*	-0.179	0.105
TC	-0.281	-0.708**	-0.283	-	-0.435**	-0.157	-0.010
FL	0.091	-0.426**	-0.416**	0.635**	-	-0.263	0.197
TLL	0.109	0.336**	0.087	-0.028	0.336**	-	0.210
WL	0.396**	0.100	0.145	0.256	0.119	-0.031	-

Estimates for male at upper diagonal and female lower diagonal.

\*\*Significant at  $P < 0.01$ ; \*Significant at  $P < 0.05$

**Table 6. Pearson's correlation of body weight and biometric traits of male and female Noiler chickens at 10 weeks of age**

Traits	BW	BL	BC	TC	FL	TLL	WL
BW	-	0.453**	0.638**	0.332*	0.117	-0.376**	0.516**
BL	0.384**	-	0.172	0.286*	0.088	0.140	0.169
BC	0.109	0.264	-	0.049	-0.053	-0.030	0.499**
TC	0.294**	0.551**	-0.013	-	0.046	-0.365**	0.245
FL	0.109	0.367**	-0.155	-0.076	-	0.269	0.059
TLL	0.262	0.413**	-0.398**	0.332**	0.267	-	0.192
WL	-0.204	-0.213	0.111	0.349**	-0.080	-0.467**	-

Estimates for male at upper diagonal and female lower diagonal.

\*\*Significant at  $P < 0.01$ ; \*Significant at  $P < 0.05$

**Table 7. Pearson's correlation of body weight and biometric traits of male and female Noiler chickens at 12 weeks of age**

Traits	BW	BL	BC	TC	FL	TLL	WL
BW	-	0.400**	0.474**	0.567**	0.246	-0.179	0.411**
BL	0.306**	-	0.417**	0.749**	0.329	0.280*	0.295*
BC	-0.141	0.198	-	0.507**	0.217	0.090	0.524**
TC	0.220	0.490**	-0.078	-	0.269	0.015	0.378**
FL	0.262	0.706**	-0.008	-0.036	-	-0.136	0.189
TLL	0.110	0.408**	-0.269	0.490**	0.189	-	0.304*
WL	0.276	0.017	0.214	0.512**	-0.144	-0.283	-

Estimates for male at upper diagonal and female lower diagonal.

\*\*Significant at  $P < 0.01$ ; \*Significant at  $P < 0.05$

## Discussion

The average body weight reported in this study ( $1.20 \pm 0.38$ ) for male and ( $0.97 \pm 0.24$ ) was lower than  $1.44 \text{ kg} \pm 0.34$  observed by Ige *et al.* (2012) in Frizzle feathered. Although the values obtained for the body weight in this study for the male Noiler chickens was higher than 1.13 kg reported for normal feathered by Ikpeme *et al.* (2016). Lower value of body weight 0.62kg was however reported by Faith *et al.* (2018) on indigenous normal feathered chickens. The result of this study on body weight and biometric traits was similar to the report of Yakubu *et al.* (2009) in indigenous normal feathered chickens. According to Mendes (2009), the first principal component provides an adequate summary of the data in most cases. The report of this study is similar

to the finding of Ogah *et al.* (2009) who presented data that showed PC1 accounting for the largest variance in the body measurements of ducks with high positive loadings on body width, bill width, shank length, body length, head length and neck length. High values of communalities computed for male and female Noiler chickens imply that principal component analysis of the study was appropriate for the data sets.

The high values of communalities of the female and male Noiler chickens observed in this study (0.88-0.90) were similar to the report of Yakubu *et al.* (2009b) with high range of communalities (0.755-0.987) for body measurements of Arbor Acre broilers. This is in agreement with the report of Mendes (2009) who reported a communality range of

0.785- 0.987 for body measurements of Ross broilers. Lower values of communality implied weakness in explaining variation in body traits.

The highest significant positive correlation observed between body weight vs breast circumference (male) and body weight and body length (female) at six weeks of age, between body weight vs breast circumference (male) and thigh circumference and foot length (female) at eight weeks of age, between body weight and breast circumference (male) and body length and thigh circumference (female) at ten weeks of age and body length and thigh circumference (male) and between body length and foot length (female) at twelve weeks of age of this study are indications that body weight is a valuable trait in assessment of relationship with body parameters (Yakubu *et al.*, 2022; Faith *et al.*, 2020). The strong relationship existing between body weight and biometric traits may be useful as selection criterion, since positive correlations of traits suggest that the traits are under the same gene action (Pleiotropy) (Mallam *et al.*, 2024). This report is in line with the findings of Yakubu *et al.* (2022) who reported varied relationships between body weight, morphometric and thermo-physiological traits of indigenous pigs under tropical conditions. The result of this study also agrees with the submission of Ikpeme *et al.* (2016) in three Nigerian local ducks, Oguntunji and Ayorinde (2014) in Nigerian Muscovy duck who reported strong relationship between body weight and other linear measurements.

### Conclusion

High values of communalities computed for male and female Noiler chickens implies that principal component analysis of the study was appropriate for the data sets. In males, foot length (0.87) and body length (0.89) had larger proportion of variance for PC1 and for PC2 while in females, thigh circumference (0.90)

and body length (0.93) had larger proportion of variance for PC1 and PC2 and these traits could be of utmost importance and useful for selection and genetic improvement programme. There was significant positive correlation between body weight and breast circumference (male) and body weight and body length (female) at six weeks of age. Correlation at week twelve between body length and thigh circumference (male) and body length and foot length (female) were also positive and significant. Correlation may be useful as selection criterion because correlated variables are more likely to be governed by the action of the same gene.

### Conflict Of Interest

The authors declare no conflict of interest exist

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