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PRINCIPAL COMPONENT ANALYSIS OF BODY MEASUREMENTS IN A POPULATION OF INDIGENOUS NIGERIAN CHICKENS RAISED UNDER EXTENSIVE MANAGEMENT SYSTEM

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ABSTRACT

This study was carried out to investigate the relationship among body measurements in indigenous Nigerian chickens sampled in Niger state using principal component analysis with the view of identifying components that best define body conformation in them. A total of 750 birds were used for the study. The parameters recorded were: body weight, body length, body girth, wing length, shank length and shank thickness. The descriptive statistics showed that the mean body weight was 1.69 kg while the body measurements were 38.77 cm, 25.30 cm, 22.23 cm, 11.01 cm and 1.10 mm for body length, body girth, wing length, shank length and shank thickness, respectively. The coefficients of correlation obtained were: $r = 0.709$ (between body weight and body length), $r = 0.448$ (between body weight and body girth), $r = 0.667$ (between body weight and wing length), $r = 0.203$ (between body weight and shank length) and, $r = 0.499$ (between body weight and shank thickness) respectively. Principal component analysis with variance maximizing orthogonal rotation was used to extract the components. Two principal components were extracted in the chickens explaining 66.4 % of the total variation in the original variables. Generally, the first principal component had the largest share of the total variance and correlated highly with body weight, body length and wing length while the second principal component had its loadings on shank length. These components could be used as selection criteria for improving body weight of indigenous Nigerian chickens.

Key words: indigenous chicken; body measurements; extensive management; principal component analysis

INTRODUCTION

The Nigerian indigenous chicken represents a large pool of untapped genetic resource. In spite of increase in the growth of the poultry industry in Nigeria (particularly with the introduction of exotic chicken breeds), the indigenous chicken breeds still remain the largest source of poultry meat and eggs. Although they are generally less productive when compared to the exotic species, indigenous chickens play a vital role in the socio-economic life of those keeping them (Alabi e*t al*., 2012). 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 (Latshaw and Bishop, 2001). Such comparison could be used as basis for selection and improvement programmes.

Growth in the indigenous chicken like in all animals apart from relating to increase in body cells and volume is a complex process. It is controlled by both genetic and non-genetic factors (Kor *et al*., 2006).

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Rosario *et al.* (2003) opined that the mechanisms involved in chicken growth are too multifaceted to be explained using univariate analysis. This according to them is because the traits are biologically linked due to linkage of gene loci and the effect of pleiotropy. Principal component analysis (PCA), a multivariate procedure could be a leeway to solving problems associated with univariate analysis of growth and related traits. This is due to its ability to reduce related variables into lesser number of uncorrelated variables called principal components. Jolliffe (2002) stated that the components will be arranged in such a way that the first few components will retain most of the variations existing in the original variables (Udeh and Ogbu, 2011). Multivariate analysis involving the use of principal components has been reported by Yakubu *et al.* (2009). The study was however carried out in a different location. In genetic terms, every ecological niche (i.e. ecological zone or environment) is governed by its own peculiar variability. The present study was carried out therefore to estimate body weight from body measurements of indigenous Nigerian chickens sampled in Niger state using orthogonal conformation traits derived from principal components.

MATERIAL AND METHODS

Study area

The study was carried out in Niger state, Nigeria. Niger state is located in the Southern guinea savannah area on longitude 30˚2′ North and latitude 11˚3′ East. The state has a land area of 80,000 square kilometres with maximum altitude at its highest point of 1475 m above sea level. The state experiences distinct dry and wet seasons with annual rainfall varying from 1100 mm in the north to 1600 mm in the south. The maximum temperature does not exceed 39˚C and is experienced between March and June. The minimal temperature (as low as 21˚C) is usually experienced between December and January.

Data collection

Seven hundred and fifty (750) indigenous chickens (male and female) between the ages of 5 to 6 months and above (i. e. 20 to 24 weeks) were sampled in the three (3) agricultural zones of the state. The birds were randomly sampled at Bida, Lavun and Badeggi (representing zone A), Minna, Paikoro and Gwada (representing Zone B) and at Kontagora, Tegina and Rijau (representing zone C).

Parameters measured

Body weight of individual birds was measured using a mechanical hanging balance of 2.5 kg with a precision of 20 g. The following metric measures were recorded using tape rule (cm): body length (BL), body girth (BG), wing length (WL) and shank length (SL). Shank thickness (ST) was determined using vernier calliper. The metric measurements were as described by Fayeye *et al*. (2006). The reference points were: body length (distance from the tip of the beak, through the body trunk to the tail), body girth (the circumference of the breast region), wing length (length of the wing from the scapula joint to the last digit of the wing), shank length (length of the tarso-metatarsus from the hock joint to the metatarsal pad) and shank thickness (diameter of the tarso-metatarsus just below the spur).

Data analysis

Means, standard errors and coefficient of variation of body weight and body measurements of the chickens were obtained using Microsoft Excel 2007. The data was pooled for both sexes. Pearson correlation coefficients among the body measurements were calculated and the correlation matrix was the primary data required for principal component analysis (PCA). Bartlett's test of sphericity was used to test if the correlation matrix was an identity matrix or a correlation matrix full of zeros. The suitability of the data set to carry out PCA was further tested using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. This tested whether the partial correlations among variables were small. A KMO measure of 0.60 and above was considered adequate (Eyduran *et al.*, 2010). The stepwise multiple regression procedure was used to obtain models for predicting body weight from body measurements (a) and from factor scores (b).

$$BWT = a + B1X1 + \ldots + BkXk \quad (a)$$
$$BWT = a + B1FS1 + \ldots + BkFSk \quad (b)$$

Where, *BWT* is the body weight, *a* is the regression intercept, *B1* is the i^{th} partial regression coefficient of the i^{th} linear body measurement (*X1*) or the i^{th} factor scores (*FS*). The principal components analyses and multiple regressions were carried out using the SPSS 16 (2007) statistical package.

RESULTS

Table 1 shows the descriptive statistics for body weight and body measurement traits of indigenous Nigerian chickens (pooled data because of non significant effect of sex, P>0.05). The mean body weight was 1.69 kg while the body measurements were 38.77 cm (BL), 25.30 cm (BG), 22.23 cm (WL), 11.01 cm (SL) and 1.10 mm (ST), respectively. Shank thickness varied more (coefficient of variation = 38.53 %) while body girth (coefficient of variation = 5.87 %) varied the least.

Table 1: Mean, standard deviation (SD) and coefficient of variation (CV %) for live body weight and body measurements of indigenous Nigerian chickens

Parameter	Mean	SD	CV
Body weight (kg)	1.69	0.35	20.95
Body length (cm)	38.77	7.14	18.42
Body girth (cm)	25.30	1.49	5.87
Wing length (cm)	22.23	1.56	7.00
Shank length (cm)	11.01	1.34	12.20
Shank thickness (mm)	1.10	0.42	38.53

Table 2: Correlation coefficients between live body weight and body measurements of indigenous Nigerian chicken

	BW	BL	BG	WL	SL	ST
Body weight (BW)	1					
Body length (BL)	0.709**	1				
Body girth (BG)	0.448**	0.351**	1			
Wing length (WL)	0.667**	0.696**	0.516**	1		
Shank length (SL)	0.203**	0.213**	0.212**	0.200**	1	
Shank thickness (ST)	0.499**	0.419**	0.359**	0.406**	0.124**	1

Correlation coefficients were all highly significant (p<0.01)

The skeletal dimensions (BL, SL and ST) were more variable (coefficient of variation ranged from 12.20 to 38.53 %) compared to the flesh dimension (BG).

The coefficient of correlation of body weight and body measurements of indigenous Nigerian chicken is presented in Table 2. The correlation ranged from r = 0.124 to r = 0.709. The relationships between body weight and all the body measurements were positive and highly significant (P<0.01). The highest correlation was obtained between body weight and body length while correlation between shank length and shank thickness was observed to be the least. Kaiser-Meyer Olkin (KMO) measure of sampling adequacy was 0.804 while results of the Bartlett test of sphericity was significant (chi-square 1473.00; P = 0.000).

The Eigen value of the total variance, the rotated component matrix and communalities of body weight and body measurements are presented in Table 3. The communalities ranged from 0.456 (BG) to 0.963 (SL). The Eigen value showed the amount of variance explained by each of the factors out of the total variance. Two common factors were identified with Eigen values of 3.049 (PC1) and 0.936 (PC2). The two factors combined accounted for 66.40 % of the total variability present in the parameters measured. PC1 had high loadings on wing length (0.840), body weight (0.826) and body length (0.814) while PC2 being orthogonal to PC1, loaded heavily on shank length (0.997). Negative loading was observed only for shank thickness (PC2).

The results of regression analysis for predicting live body weight from the five interdependent body measurements of indigenous Nigerian chicken showed that body length alone accounted for 38.3 % of the variability in live body weight. The proportion of explained variation gradually increased from 44.2 % when body girth was added, to 60.2 % when all the five body measurements (BL, BG, WL, SL and ST) were used in the equation. PC1 and PC2 together accounted for 68.4 % of the variation in live body weight of the indigenous Nigerian chickens.

DISCUSSION

The Information on body weight and body measurements of the birds showed that they were

Table 3: Explained variation linked to rotated component matrix, communalities, Eigen values and percentage of total variance of body measurements of indigenous Nigerian chicken

Parameter	PC1	PC2	Communalities	Unique factor
Body weight	0.826	0.049	0.684	0.316
Body length	0.814	0.125	0.678	0.322
Body girth	0.613	0.248	0.456	0.544
Wing length	0.840	0.152	0.728	0.272
Shank length	0.095	0.997	0.963	0.037
Shank thickness	0.689	-0.015	0.475	0.525
Eigen value	3.049	0.936		
% of total variance	50.81	15.59	66.40	
Description	General size	Shank length		

PC = principal component

Table 4: Multiple regression (stepwise) of live body weight (kg) on original body measurements and their orthogonal traits of indigenous Nigerian chicken

Step	Predictor	Intercept	Regression coefficient	SE	R^2
Original body measurements as independent variables					
1	Body length	- 1.555	0.074	0.46	0.383
2	Body length	- 2.419	0.065	0.45	0.442
	Body girth		0.048		
3	Body length	- 2.641	0.046	0.43	0.454
	Body girth		0.029		
	Wing length		0.066		
4	Body length	- 2.181	0.050	0.33	0.577
	Body girth		0.028		
	Wing length		0.054		
	Shank length		0.003		
5	Body length	- 2.082	0.044	0.32	0.602
	Body girth		0.021		
	Wing length		0.050		
	Shank length		0.003		
	Shank thickness		0.351		
Orthogonal traits as independent variables					
1	FC1	1.327	0.484	0.33	0.682
2	FC1	1.327	0.484	0.33	0.684
	FC2		0.029		

SE: standard error of estimate; FC = factor; R^2 = coefficient of determination heavier than those reported by Yakubu *et al.* (2009) in normal feathered, naked neck and frizzled indigenous Nigerian chickens. The values for body length, body girth and shank length were also superior to the values reported by Peters *et al.* (2010) in Nigerian native chickens. These differences could be due to environmental factors, differences in the genetic makeup of the birds and feed availability in the ecological niches where the birds are reared.

Body weight related highly and positively with all the original body measurements of the chickens. This is suggestive of their possible usage (i. e. the body measurements) in the prediction of body weight in the indigenous chickens. This is because an increase in any of the body measurement will invariably lead to a corresponding increase in the body weight of the chickens (Ajayi *et al*., 2008). Shank length had the lowest correlation coefficient with body weight. Shank length is a non economic part of the chicken; so even if it does not grow proportionately as the chicken grows, it might not necessarily be a bother to farmers. The strong relationship existing between body weight and body measurements may be useful as a selection criterion. This is because correlated traits are more likely to be governed by the same gene action. Yakubu *et al*. (2009) reported that this could be the basis for genetic manipulation and upgrading of the native chicken stock.

The observed high value of Kaiser-Meyer-Olkin measure of sampling adequacy (0.804) means that correlations between the variables were not unique, that is not related to the remaining variables outside each sample correlation. Kaiser (1960) reported a measure of sampling adequacy above 0.80 to be meritorious. The significance of the correlation matrices tested with Bartlett's Test of Sphericity for the body measurements of indigenous chicken provided ample support for the authenticity of using factor analysis for the data set.

The high communalities gave further credence to the appropriateness of the principal component analysis. According to Wuensch (2012), communalities represents the amount of the variable that is accounted for by the components (since the loadings are correlations between variables and components and the components are orthogonal, a variable's communality is the coefficient of determination of the variable predicted from the components). Similarly high communalities have been reported in Nigerian indigenous chicken by Yakubu *et al*. (2009), in different breeds of broiler chickens (Mendes, 2011; Udeh and Ogbu, 2011; Ajayi *et al*., 2012) and in indigenous turkey (Ogah, 2011a). The low contribution of shank length to PC1 was not too surprising as the trait equally had the lowest correlation with body weight. This is a clear indication of its weakness in explaining the total variation in the body measurement of the indigenous chickens. Body girth had the lowest communality with about 45.6 % of the variation accounted for by common factors and 54.4 % of the variation accounted for by unique factors related to it alone. The communalities for the skeletal dimensions (body length, wing length and shank length) were higher than for the flesh dimension (body girth). Ogah (2011b) reported similar findings working with adult Muscovy ducks.

The first principal component (PC1) had the highest variability correlating very much with body weight, body length and wing length. This has been the trend in most studies (Kashimawura *et al*., 2001; Salako, 2006; Sadek *et al*., 2006). Body length alone accounted for 38.3 % of the variation in body weight of the indigenous Nigerian chickens. This is much lower than the 83.0 % reported by Yakubu *et al.* (2009) for Nigerian indigenous chickens managed extensively. The amount of variation was however enhanced with the inclusion of more independent variables in the equation similar to the findings of Ajayi *et al*. (2012). The use of PC1 as a single predictor in the present study explained 68.2 % of the total variability in the body weight of indigenous Nigerian chickens. Combination of PC1 and PC2 only led to a 0.29 % improvement in the amount of variance explained in the chickens. Orthogonal variables gave a better and more dependable estimation of body weight than the use of the original independent variables. This is because of the problem of multicollinearity commonly connected with the use of interdependent original body dimensions. According to Malau-Aduli *et al.* (2004), multicollinearity is associated with unstable estimates of regression coefficients.

CONCLUSION

This study revealed the interdependency of the five original body measurement characters on each other. This interdependency was explored by analysing them at the same time using principal component analysis rather than by analysing them separately. Also, orthogonal body measurements obtained from the analysis was discovered to be a more appropriate means of predicting live body weight in indigenous Nigerian chickens than the use of the original interrelated traits measured.

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