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Application of Principal Component Analysis on the Body Morphometric of Nigerian Indigenous Chickens reared intensively under Southern Guinea Savanna Condition of Nigeria

S. R. Amao

ABSTRACT

The experiment employs the principal components analysis (PCA) on the body morphometric of three genetic stocks of Nigerian indigenous chickens reared intensively under southern guinea savanna condition of Nigeria. A total number of 300 birds comprises of 100 each of normal feathered, frizzled feathered and naked neck chickens are randomly selected from the pre-existing reared intensively birds in the farm. Data are collated on body weight (BDW), head length (HL), beak length (BKL), comb length (CL), neck length (NL), body length (BDL), wing length (WG), keel length (KL), thigh length (TL) and shank length (SL). The results from the morphometric measurements indicate that frizzled feather birds displayed superiority in terms of BDW, HL, BKL, CL, NL, TL and SL than naked neck and normal feathered chickens expect for BDL and KL which are favoured by normal feather birds. The pooled correlation matrix reveals that the values obtained highly positive significant correlation is noted between the BDW and HL, BLK, TL, WG, SL, CL and NL. For PCA, two principal components are extracted (PC1 and PC2). PC1 and PC2 contribute 83.14% of the total variance while PC1 account for 65.44% of the total variance. The screen plot indicates that only the first two components have eigenvalues greater than 1. This implies that only the first two components should be retained. The CL, SL, TL, BKL, HL and BDL contribute to the total variability of PC1 and these traits could use for selection in breeding programme to improve the body weight of the genetics stocks of Nigerian local birds.

Keywords: *Morphometric, genetic stocks, principal component analysis, Nigerian local chicken, indigenous chicken*

INTRODUCTION

Indigenous or native poultry plays very important role in the strengthening of economy of backyard peoples, it is source of food and employment for small poultry keepers without investing a penny on the management, disease control

***S. R. Amao** is a Lecturer in the School of Vocational and Technical Education, Emmanuel Alayande College of Education, Oyo, Oyo State. Nigeria.* E-mail: *sholaamao@eacoed.edu.ng.*

and nourishment (Ekue, Pone, Mafeni, Nfi and Njoya 2002). Native poultry survives well in their local environment and can be reared on kitchen waste and may be as free range on open lands. Although, commercial poultry has taken its place but native poultry is still playing very crucial role in the economy of developing countries like Nigeria. Extensive work is required to improve the economic traits of native chicken through modern techniques that helps in selection (Iqbal *et al.,* 2012). However, the indigenous fowl population is considered as gene reservoir particularly for gene that has adaptive value for the local environment. Therefore, the local chicken genetics resource needs to be kept from erosion and dilution to maintain genetic variations within and between groups of animals (Osaiyuwu, Salako and Adurogbangba, 2010).

Growth in the indigenous chicken is 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, Baspinar, Karaca and Keskin, 2006). Rosario, Silva, Coelho, Savino and Dias (2008) opine 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 way out in 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. Udeh and Ogbu (2011) state 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.

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) use 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 (multicolinearity problem) between the predictors, yields a deficiency in the regression model formed (Sharma, 1996; Çamdeviren, Demir, Kanik and Keskin, 2005). Multicolinearity 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 principal component analysis (PCA) (Sousa, Martins, Alvim-Ferraz and Pereira, 2007). The PCA is a multivariate technique to help us to understand the underlying data structure and to form a smaller number of uncorrelated new variables.

Report of Morrison (1976) indicates that the principal components analysis is a multivariate methodology that can be used with success when characteristics are correlated. This analysis transforms an original group of variables into another group, principal components, which are linear combinations of the original variables. The main advantage is the independence of these components. This merit contribute to animal genetics and improvement, principal components simultaneously consider a group of attributes which may be interesting for selection purposes. Another important aspect is that each of the principal components explains a percentage of the total variance. The first principal component explains the highest percentage of this variance which was considered most valuable column by many breeders.

There are only a few reports about the use of principal components analysis in chicken data especially in Nigeria contents. Ibe (1989) analyzes the body weight of *Gallus gallus* at different ages, together with four body linear measurements: breast and thigh widths, and shank and keel lengths. In all ages the first two principal components explained at least 85% of the total variation. According to Mendes (2009), the principal components could be used in the selection index to simplify them, because such an index would have few principal components in the place of all the original traits.

Recently, the use of PCA to reduce number of predictors, to avoid multicolinearity problem and to predict dependent variable values have begun to increase with the availability of related statistical package programs such as SAS, STATISTICA, SPSS and NCSS (Raick, Beckers, Soetaert and Gregoire, 2006; Sousa, Martins, Alvim-Ferraz and Pereira, 2007). Therefore, the main aim of this study is to describe the body morphometric of normal feathered, frizzled feathered and naked neck Nigerian local chickens using the Principal Components Analysis (PCA) approach in the southern guinea environment of Nigeria.

MATERIALS AND METHOD

This experiment was carried out at the Poultry Unit of Teaching and Research Farm, Emmanuel Alayande College of Education, Oyo, Oyo State, Nigeria. Oyo lies on the longitude 3°5' east of the green witch meridian and latitudes 7°5'

North eastwards from Ibadan, the capital of Oyo State. The altitude is between 300 and 600 meter above sea level. The mean annual temperature and rainfall are 27^{o}C and 1,165mm respectively. The vegetation of the area is Southern guinea savanna zone of Nigeria (Amao, 2017). A total of 300 day-old chicks comprising 100 each of normal, naked neck and frizzled birds were sourced from pre-existed screened birds in the farm and used for the study. Each of the bird was tagged using wing band according to their strains and their age was between 6 to 7 months.

The body weights (BDW) of the birds were obtained on weekly basis with aids of sensitive scale. The body conformation measurements includes head length (HL), beak length (BK), comb length (CL), neck length (NL), body length (BL), keel length (KL), thigh length (TH), and wing length (WL) and shank length (SL) were measured on a weekly bases on each of the strain by tailor measuring tape as described by Egena, Ijaiya, Ogah and Aya (2014); Ikpeme *et al*. (2016).

Head length (HL): The distance between the occipital bone to the insertion of the beak into the skull.

Comb length (CL): Horizontal distance from the beginning to the end of the comb;

Beak length (BKL)*:* Measured as distance from the rectal apterium to the maxillary nail.

Body length (BL): Length between the tip of the Rostrum maxillare (beak) and that of the cauda (tail, without feathers).

Neck length (NL): Distance between the occipital condyle and the cephalic borders of the coracoids;

Shank length (SL): Distance from the shank joint to the extremity of the digitus pedis;

Wing length: Length of the wing from the scapula joint to the last digit of the wing.

Thigh length (TL): Length of the femur through the fibula and the tibia to the hock joint.

Keel length (KL)*:* The circumference of the breast region.

Principal component analysis procedures

Principal component analysis is a method for transforming the variables in a multivariable data set X_1, X_2……….. X_n into new variables Y_1, Y_2………Y_n, which are unrelated with each other and account for decreasing proportions of the total variance of the original variables, defined as:

$$Y1 = P_{11}X_1 + P_{12}X_2 + \ldots\ldots\ldots\ldots + P_{1n}X_n$$

$$Y2 = P_{21}X_1 + P_{22}X_2 + \ldots\ldots\ldots\ldots + P_{2n}X_n$$

$$Y3 = P_{n1}X_1 + P_{n2}X_2 + \ldots\ldots\ldots\ldots + P_{nn}X_n$$

With the coefficient being chosen so that Y1, Y2 …… Yn account for decreasing proportion of the total variance of the original variables, X_1, X_2 ……..X_n (Everitt, Laudau and Leese, (2001). Eyduran, Topal and Sonmez (2010) note that Bartletts test of sphericity was used to test if the correlation matrix was an identity matrix (each variable correlated with itself) or a correlation matrix full of zero. The suitability of the data set to PCA was further tested by Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (Kaiser, 1960). This tested whether the partial correlations among variables were small. A KMO measure of 0.60 and above is considered adequate and acceptable while 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.

The data collected were subjected to one-way analysis of variance using the general linear model of (SAS, 2009) and Duncan multiple range of the same software were used to separate the means. The below model was adopted:

$$Y_{ij} = ì + S_i + e_{ij}$$

Where

Y_{ij} = The individual measurement on each bird
ì = The overall mean
S_i = Effect of the i^{th} strain (1, 2, 3)
e_{ij} = The random errors

The correlation matrix which was the primary data required for PCA generated. The principal components analyses were performed using the factor program of SPSS 22 (2013) statistical package.

RESULTS AND DISCUSSION

Table 1 reveals the pattern of phenotypic variables of the three genetic stocks of Nigerian local chickens. The results reveal significant effects between the variables measured and among the genetics group of Nigerian local birds. The frizzled feather birds displayed superiority in terms of body weight, head length, beak length, comb length, neck length, thigh length and shank length than naked neck and normal feathered chickens except for body length and keel length which were favoured by normal feather birds.

The pooled correlation coefficient matrix of morphometric variables of the three genetic stocks of Nigerian local birds is presented in table 2. The results reveal that the observed values varied between r = -0.90 and r = 0.88 and there are very highly positive significant correlations between the body weight and head length, beak length, thigh length, wing length, shank length, comb length and neck length. However, almost all the measured variables were very highly significant correlated except for body length and keel length relationship with other variables that had negative correlations. The value for Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (Kaiser, 1960) obtained was 0.782 which Bartlett test of sphericity was significant at chi-square of 5528.115 while the determinant value was 7.19E-009.

Table 3 shows the eigenvalues and shares of total variance along with factor loading after varimax rotation communalities of pooled morphometric traits of three genetic stocks of Nigerian local chickens. The result indicated that only two principal components PC1 and PC2 were extracted. PC1 and PC2 contributed 83.14% of the total variance while PC1 accounted for 65.44% of the total variance. Furthermore, the varimax rotation method of principal component analysis indicated that conformation traits that contributed significantly to PC1 were comb length, shank length, thigh length, beak length, head length and body weight while PC2 displayed that beak length, wing length, head length and body weight contributed to the total variance. The communalities obtained for all the traits were at highest range to close to unit. The highest was from Shank while the least was from Keel length.

The Figure 1 reveals the screen plot. Only the first two components have eigenvalues greater than 1. There is small drop between components 2 and components 3. On a screen plot, components 4 through 10 appeared as screen at the base of the cliff composed of components 1 and 2. Together components 1 and 2 account for 83.14 % of the total variance. This implies that the only the first two components should be retained.

The morphometric variables of normal feather, frizzled feather and naked neck genetic stocks of Nigerian local chicken reveal that these morphometric variables are genotypes dependents. These are earlier reported by Egena *et al*. (2016) in the middle belt of Nigeria, Yakubu, Kuje and Okpeku (2009) in Northern part of Nigeria and Ikpeme *et al.* (2016) in Eastern part of Nigeria. These authors attribute the variations that existed in the body conformation measurements of Nigerian local birds were due to differences in the genetic makeup of the birds, environmental factors and availability of feeds to the birds. The current observation that favoured frizzle feathered birds than its counterparts naked neck and normal feather chickens in respect to body weight, head length, beak length, comb length, neck length, thigh and shank length were in line with documentations of Egena, Ijaiya, Ogah and Aya (2014) and Ajayi *et al.* (2012) who report that both frizzled and naked neck genetic stocks were groups of genes that should be preserved and not yet fully exploited because of the potentials. However, the current findings were not agreed with the values reported by Yakubu, Kuje and Okpeku, (2009) who note higher values for the variables measured than the current values.

Meanwhile, the pooled correlation matrix indicates that very high, positive significant correlation among the traits under consideration were in accordance with the claim of Ikpeme *et al.* (2016) in three Nigerian local, Oguntunji and Ayorinde (2014) in Nigerian Muscovy duck and Apuno, Mbap and Ibrahim (2011) local chickens in Nigeria. These researchers note that strong relationship existed between body weight and other linear measurement and this information may be used as selection criterion because correlated variables are more likely to be governed by the same gene action. However, the obtained high value of Kaiser-Meyer-Olkin measure of sampling adequacy was described by Kaiser (1960) as midding and acceptable value. Thus, implies that relationships between the variables were not related to the rest of the traits outside each sample correlation.

The principal component analysis presently indicated that two components were extracted and such results were similar to the reports of Udeh and Ogbu (2011) in broiler chickens and Ikpeme *et al.* (2016) for three Nigerian local birds. These authors extracted two principal components that accounted for 65% and 73.96% of the total variability respectively while the two principal components extracted in this study amounted to 84.56%. The higher communalities observed presently were in accordance with the works of Yakubu, Kuje and Okpeku (2009) in indigenous Nigerian chickens, Egena, Ijaiya, Ogah and Aya (2014) in Nigerian indigenous chickens, Ikpeme *et al.* (2016) in three Nigerian local chickens and Amao (2017) in two commercial meat-type chickens. This represents the amount of the variable that is accounted for by the components.

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Table 1: Patterns of phenotypic variables of three genetic stocks of Nigerian local chickens

Traits	Normal feather	Frizzled feather	Naked neck
Body weight (kg)	1.19 ± 0.02^{c}	1.43 ± 0.01^{a}	1.39 ± 0.02
Head length (cm)	6.43 ± 0.01^{c}	7.06 ± 0.01^{a}	6.93 ± 0.01^{b}
Beak length (cm)	2.83 ± 0.01^{c}	3.43 ± 0.02^{a}	2.96 ± 0.0^{b}
Comb length (cm)	3.62 ± 0.02^{c}	5.10 ± 0.01^{a}	3.73 ± 0.01^{b}
Neck length (cm)	11.97 ± 0.01^{b}	13.06 ± 0.20^{a}	12.09 ± 0.24^{b}
Body length (cm)	24.82 ± 0.88^{a}	22.77 ± 0.67^{c}	24.18 ± 0.89^{b}
Wing length (cm)	18.23 ± 0.45^{c}	18.84 ± 0.02^{b}	19.18 ± 0.88^{a}
Keel length (cm)	9.99 ± 0.24^{a}	9.58 ± 0.40^{b}	9.31 ± 0.04^{c}
Thigh length (cm)	9.42 ± 0.03^{c}	12.31 ± 0.56^{a}	10.60 ± 0.90^{b}
Shank length	10.05 ± 0.05^{c}	10.74 ± 0.67^{a}	10.16 ± 0.05^{b}

^{abc} *Means along the same row with different superscripts are significantly different (P<0.05)*

Table 2: Pooled correlation matrix of morphometric variables of the three genetic stocks of Nigerian local chickens

Traits	BDW	HL	BKL	CL	NL	BDL	WG	KL	TL	SL
BDW	1.00									
HL	0.78***	1.00								
BKL	0.75***	0.93***	1.00							
CL	0.54***	0.68***	0.86***	1.00						
NL	0.24***	0.28***	0.19***	0.31***	1.00					
BDL	-0.59***	-0.77***	-0.90***	-0.91***	-0.25***	1.00				
WG	0.63***	0.80***	0.63***	0.18**	0.07	-0.35**	1.00			
KL	-0.54***	-0.75***	-0.55***	-0.16	-0.11	-0.39***	-0.85**	1.00		
TL	0.68***	0.87***	0.97***	0.93***	0.28***	-0.94**	0.49**	-0.44***	1.00	
SL	0.61***	0.68***	0.82***	0.88***	0.44***	-0.82***	0.25***	-0.13***	0.88***	1.00

***P < 0.001

BDW= Body Weight, HL = Head Length, BKL = Beak Length, CL = Comb Length, NL = Neck Length, BDL = Body Length, WL = Wing Length, KL = Keel Length, TL = Thigh Length, SL = Shank Length.

Table 3: Eigen values and shares of total variance along with factor loading after varimax rotation communalities of pooled morphometric traits of three genetic stocks of Nigerian local chickens

Traits	PC1	PC2	Communalities
CL	0.963	0.138	0.98
SL	0.944	0.151	0.99
TL	0.874	0.447	0.98
BDL	-0.874	-0.342	0.96
BKL	0.778	0.596	0.91
NL	0.440	-0.019	0.91
WL	0.071	0.958	0.90
KL	-0.250	-0.938	0.90
HL	0.595	0.784	0.90
BDW	0.510	0.649	0.90
Initial eigenvalues	6.544	1.770	
% of total variance	65.440	17.690	83.14

BDW = Body Weight, HL = Head Length, BKL = Beak Length, CL = Comb Length, NL = Neck Length, BDL = Body Length, WL = Wing Length, Keel Length, TL = Thigh Length, SL = Shank Length.

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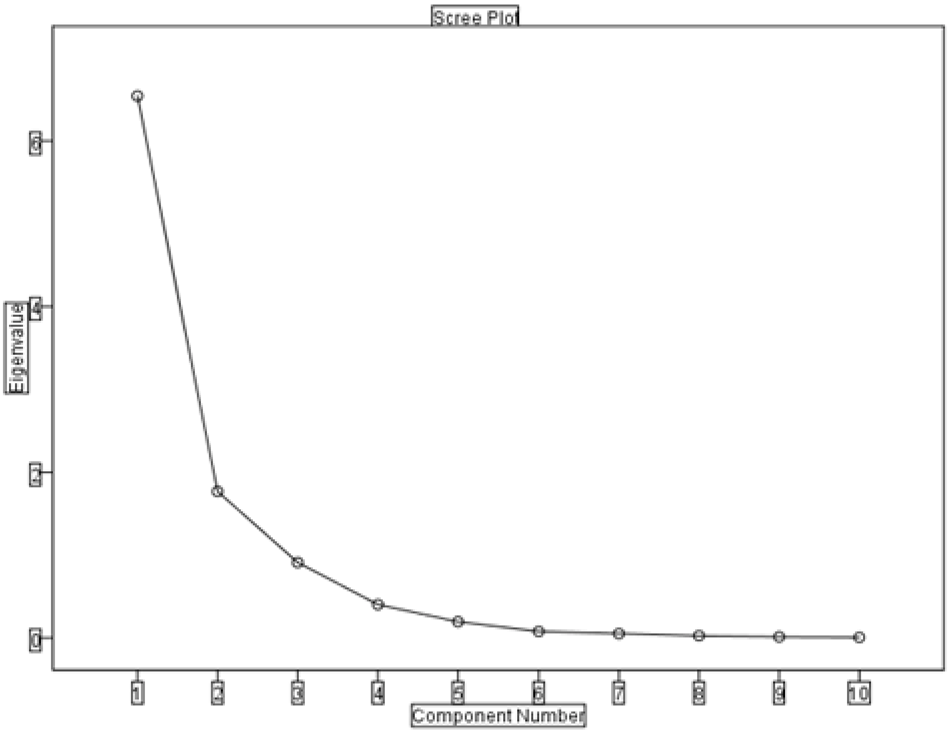

Fig 1: Screen plot for pooled values of indigenous chickens

CONCLUDING REMARKS

The principal components analysis (PCA) on the body morphometric of three genetic stocks of Nigerian indigenous chickens reared intensively under southern guinea savanna condition of Nigeria was conducted at the Poultry Unit of Teaching and Research Farm, Emmanuel Alayande College of Education, Oyo, Oyo State, Nigeria. Based on the results of the experiment, it may be concluded that the superiority displayed by frizzled feather chickens over the naked neck and normal feather for measured morphometric traits was an indication for the breeders that these genes should be preserved from moving to extinction in the environment. The traits accounted for PC1 are comb length, shank length, thigh length, beak length, head length and body length could be used for selection in breeding programme to improve the body weight of the genetics stocks of Nigerian local birds.

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