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Assessment of body weight and morphological traits of two breed of grower pigs using principal component analysis

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Abstract

The study aimed at explaining objectively the relationship between morphologic traits of two breeds of pigs (Large-white and Duroc) using principal component analysis to determine the body size of grower pigs of two different breeds with a view of identifying components that best define body conformation. Body weight and five biometric variables namely head length, body length, body girth, ham length and ear length. The descriptive statistics showed that the mean body weight of Large-white was 13.14kg while the body measurements were 24.61cm, 71.35cm, 65.12cm, 43.13cm and 21.94cm for head length, body length, body girth, ham length and ear length respectively at 5 – 24 weeks of age. The mean body weight of Duroc was 12.87kg while the body measurements were 23.70cm, 57.93cm, 47.93cm, 22.90cm, 19.26cm for head length, body length, body girth, ham length and ear length respectively. The coefficient of correlation ranges from 0.08-0.424 and 0.01-0.402 for Large-white and Duroc respectively. The association between and were the highest for Duroc, body length r=0.402 and Large-white, body girth 0.424. Two components were identified for Large-white while those of Duroc were three components. The ratios of variance were 53.55 and 71.07% for Large-white and Duroc, respectively. The first factor in each case accounted for the biggest percentage of the total variation, and was designated the general size, the other factors (indices of body shape) offer forms of variation independent of the general size. The principal component based regression models which were chosen for selecting animals for optimal balance accounted for 58 and 76% of the variation in the body weight for Large-white and Duroc respectively. The study concluded that the use of principal component analysis techniques tends to explore the interdependence in the original five parameters measured: head length, body length, body girth, ham length and ear length of Large-white and Duroc

Keywords: Pig, Assessments, Size, Regression, Principal component analysis

Évaluation du poids corporel et des traits morphologiques de deux races de cochons de producteurs utilisant une analyse principale des composants

Résumé

L'étude explique objectivement la relation entre les traits morphologiques de deux races de porcs (gros blanc et de Duroc) à l'aide d'une analyse de composants principaux afin de déterminer la taille du corps des porcs de producteurs de deux races différentes en vue d'identifier les composants qui définissent le mieux la conformation corporelle. Poids corporel et cinq variables biométriques, nommément longueur de la tête, longueur du corps, circonférence du corps, longueur du jambon et longueur de l'oreille. Les statistiques descriptives ont montré que le poids corporel moyen de gros blanc était de 13,14 kg tandis que les mesures du corps étaient de 24,61 cm, 71,35 cm, 65,12 cm, 43,13 cm et 21,94 cm pour la longueur de la tête, la longueur du corps, la circonférence du corps, la longueur du jambon et la longueur de l'oreille respectivement à 5 - 24 semaines. Le poids corporel moyen de Duroc était de 12,87 kg tandis que les mesures du corps étaient de 23,70 cm, 57,93 cm, 47,93 cm, 22,90 cm, 19,26 cm pour la longueur de la tête, la longueur du corps, la circonférence du

corps, la longueur du jambon et la longueur de l'oreille respectivement. Le coefficient de corrélation varie de 0,08 à 0,424 et de 0,01 à 0,402 pour les gros blancs et Duroc respectivement. L'association entre et étaient les plus élevées pour Duroc, la longueur du corps R = 0,402 et de gros blancs, la circonférence du corps 0,424. Deux composants ont été identifiés pour les gros blancs tandis que ceux de Duroc étaient trois composants. Les ratios de variance étaient respectivement de 53,55 et 71,07% pour les gros blancs et Duroc. Le premier facteur de chaque cas représentait le plus gros pourcentage de la variation totale et a été désigné la taille générale, les autres facteurs (indices de la forme du corps) offrent des formes de variation indépendantes de la taille générale. Les principaux modèles de régression basés sur les composants choisis pour sélectionner des animaux pour un solde optimal représentaient 58 et 76% de la variation du poids corporel pour les grands blancs et Duroc respectivement. L'étude a conclu que l'utilisation de techniques d'analyse des composants principaux a tendance à explorer l'interdépendance dans les cinq paramètres d'origines mesurées: longueur de la tête, longueur du corps, circonférence corporelle, longueur du jambon et longueur de l'oreille de grosse blanc et de Duroc

***Mots-clés**: cochon, Évaluations, Taille, Régression, Analyse des composants principaux.*

Introduction

Pigs generally are foraging animals mainly eating both plants and animals in the wild; in addition, they also consume insects and fish. As livestock, pigs are fed mostly maize, rice bran and soya bean meal including a mixture of vitamins and minerals to their diet. Pig production provides the means by which rapid transformation of animal protein consumption can be achieved in Nigeria. Although pigs are frequently maligned by some social and religious groups in Nigerian (Waiswa, 2005), the animal have good attributes which include: very high in fertility and prolificacy. Generation interval is small. Pigs mature very early and high in feed conversion, and modest in requirement with respect to housing and equipment. The first issue in animals' characterization apart from its production performance is the evaluation of body size and traits (Ibe, 1989). Numerical measure of body conformation will no doubt aid steadfast genetic parameters for the traits to be estimated but also make it possible to include body conformation in breeding program. Body weight has been generally used to quantify body size. The association prevailing among linear body traits offer useful information on performance, productivity and carcass characteristics of farm animals. The numerical dimensions for size and shape are essential for estimating genetic parameters in animal breeding programs (Chineke, 2001 and Riva *et al.,* 2002). Body measurement differs according to many factors which include: breed, yield type and age. The biological relationship prevailing among the linear body traits may be different if the body measurements are salted as multivariate fairly than bivariate, since body dimensions are interconnected phenotypically and genetically (El-mahdy, 1998; Akanno and Ibe, 2005). Growth in pigs like in all livestock's separately from linking to growth in body cells and volume is a complex process; it is controlled by both genetic and non-genetic factors. The mechanisms involved in pig growth are too multifaceted to explain using univariate analysis (Rosario *et al.*, 2003). Hence, multivariate approach is employed to analyze growth data in pigs and other domestic animals. This according to them is because the traits are biologically linked due to linkage of gene loci and the effect of pleiotropy. Principal components analysis (PCA) is a multivariate procedure for

investigating relationships among several numerical variables measured on a number of objects. (Mutsaers *et al.,* 1997). It offers information about the comparative importance of each variable in characterizing the objects. New variables are premeditated which usually involve linear combinations of the old ones. Mutsaers *et al.,* (1997) reported that a small number of these different variables will usually be adequate to define the observational object without losing too much information. The determination of factor analysis therefore, is to discover simple designs of relationships between the variables. To be specific, it seeks to determine if the observed variables can be explained fairly or entirely in terms of a much smaller number of variables which encompass most of the original overall variance called factors. Principle components analysis is a calculated technique that alters a number of probably associated variables into a reduced amount of unassociated variables. PCA has been used by other researchers to assess the relationship between body traits and size in chicken (Yakubu *et al.,* 2009), goat (Moses *et al.,* 2011), turkey (Ogah, *et al.,* 2011) and duck (McCracken *et al*., 2000 and Ogah *et al.,*2009). PCA are weighted linear combination of correlated variables, explaining a maximal amount of variance of the variables. These aid in data reduction, and break multicollinearity which may lead to wrong judgment. Hence the use of principle component analysis to determine the body size and morphological traits of two breed of growing pigs.

Materials and methods

Research site

The study was conducted at the Piggery Unit of the Teaching and Research Farm of the Department of Animal Science, Delta State University, Asaba campus. The University is located between longitude 6° 45' East and latitude 6° 12 North.

Experimental Animals and their management

Eighty (80) pigs comprising of forty Large-white and forty Duroc breeds aged 5 weeks were used for the study. The pigs were maintained at the Piggery Unit of the Faculty of Agriculture Farm, Delta State University. Asaba campus. The animals were fed with cassava peels and palm kernel cake (PKC) as a source of protein. Fresh clean drinking water was available *ad libitum.* The eighty growing pigs were randomly allotted to two treatment groups according to breeds, each treatment group were replicated twice with twenty animals per replicate. Drugs were administered on regular basis to avoid outbreak of diseases. At twenty-four weeks of age. The animals were made to pass through the ethical clearance of the Delta State University, Faculty of Agriculture Animal Ethics Committee on Animals for Research.

Measured traits

Body weight and five (5) biometric traits were measured on each animal, the body reference point by standard zoometric process of Gueye *et al.* (1998) and Tegula *et al.* (2008). The part measured were head length, (HL), body length (BL), body girth (BG), ham length (HML) and ear length (EL). The parameters were measured in centimeter (cm). All measurements were taken by the researcher to avoid between-individual's variations.

Statistical analysis

The means and standard errors of body weight and morphological traits were calculated using the descriptive statistic of SPSS Version 16 (SPSS, 2007). Body weight and morphological traits quantities of relationships were also calculated. Bartletts test of sphericity were used to test if the correlation matrix is a uniqueness matrix (each variable correlated with itself) or a correlation matrix full of zero. The

fittingness of the data set to PCA was further verified by Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (KMO=0.650), to test whether the partial correlations among variables are small. The varimax criterion of the orthogonal rotation was employed in the rotation of the factor matrix to enhance the interpretability of the principal component. The stepwise multiple regression procedure was used to obtain models for determine body size from body measurements (a) and from factor (b)

BWT = a +B1X1 +, +BkXk (a)

BS=a+B1FS1 +.....BkFSk..... (b)

Where body size is the B,

regression intercept is the a,

B1 is the i-th partial regression coefficient of the i-th linear body measurement XI or the i-th factor scores (FS).

Aggregate percentage of variance principle was engaged in determining the number of principal component extract. The factor program of SPSS 2007 statistical package was used for the principal component analysis.

Results and discussion

Table 1 shows the descriptive statistic outlining mean ± standard error, minimum, maximum and coefficient of variation estimate of body weight and body measurement of the two breeds of pigs (Large-white and Duroc). From the morphometric character of the two breeds of pigs that was investigated, the Large-white had higher significant values of body weight and body measurements estimated. The average body weight of Large-white and Duroc were 13.4 and 12.87 kg respectively. The mean body length of Large-white (71.35) is significantly ($P<0.05$) higher than that of Duroc (57.93). The head length, body girth, ham length and ear length of Large-white show more variation than that of Duroc. These recent mean values are similar to those reported by Fayeye *et al.* (2006). In another study by Ogah *et al.* (2009), females had higher mean values than male except for rump height. The coefficient of variation (c v) for body weight and body trait measurements range from 3.13 – 10.92 except for body weight in Duroc pigs, thus showing evidence that body characteristics and body weights are good reliable indices of body size.

Table 1: Descriptive Statistic of the body weight and linear body measurements of two breeds of pigs, (Large-white and Duroc)

Variable	Breeds	Mean±standard error	Minimum	Maximum	C V%
Body weight(kg)	Largewhite	13.14±0.23	10.80	16.40	10.92
	Duroc	12.88±0.34	8.80	20.00	16.85
Head length (cm)	Largewhite	24.61±0.19	22.00	27.00	4.91
	Duroc	23.71±0.20	21.00	26.00	5.24
Body length (cm)	Largewhite	71.35±0.82	58.00	81.00	7.23
	Duroc	57.93±0.78	51.00	68.00	8.46
Body girth (cm)	Largewhite	65.13±0.45	60.00	75.50	4.36
	Duroc	47.93±0.51	43.00	55.00	6.74
Ham length (cm)	Largewhite	43.14±0.21	40.50	46.00	3.13
	Duroc	22.88±0.20	19.00	25.00	5.55
Ear length (cm)	Largewhite	21.94±0.23	19.00	26.00	6.71
	Duroc	19.26±0.13	18.00	21.00	4.36

c v: coefficient of variation

Phenotypic correlations

Quantities of relationship between body weight and body measurement of the two genetic groups are shown in Table 2. Highly significant ($p<0.01$) association exist among body weight and morphometric

characters. The coefficient ranges from 0.08 - 0.424 and 0.01 - 0.402 respectively for Large-white and Duroc. Among the body shape characters, the highest correlation was found between body length and body girth for Duroc (r= 0.402) and Large-white (0.424). The coefficient of correlations in this study are comparable to those reported earlier by Yakubu and Ayoade (2009); Yakubu (2010). The good correlation between body size and linear measurements in this study shows that an increase in one body measurements will result in a corresponding increase in body size. Consequently, the relationship existing between body size and morphometric characters implied that the combination of these morphometric characters can be used to estimate live weight of pigs in places where weighing scales are not available. This therefore, produces a basis for the genetic manipulation and improvement of the two breeds of pigs in Nigeria.

Table 2: Phenotypic correlations of body weight and linear body measurements for Large-white (above diagonal) and Duroc (below diagonal)

Traits	BW	HL	BL	BG	HML	EL
BW		0.203	0.370*	0.296	0.375*	-0.177
HL	-0.183		0.147	0.080	0.187	-0.206
BL	0.402*	-0.274		0.424**	0.217	-0.070
BG	0.010	-0.100	0.186		0.238	-0.270
HML	0.337	-0.166	0.341*	0.389*		-0.196
EL	-0.047	0.092	0.190	0.150	0.066	

Correlation is * significant (P<0.05) * and **(P<0.01), BW: Body weight, HL: Head length, BL: Body length, BG: Body girth, HML: Ham length and EL: Ear length.

Principal component matrix

The anti-image correlations calculated revealed that partial correlation was low, signifying that true factors occurred in the data of the two genotypes of pigs, and this was maintained by kaiser-meyer-olkin degree of sampling capability calculated from the diagonal of partial correlation, revealing the proportion of the variance in the body measurements caused the underlying factor, and this was revealed to be very high for all the morphometric characters in both breeds (0.62 and 0.59). The overall significance of correlation matrix as tested with Barlett's test of sphericity for body dimension of Large-white (chi square = 24.67) and Duroc (chi square= 28.97), respectively provide plenty of support for the validity of factor analysis of the data set. Large-white pigs, four variables were loaded on PC1. They are body weight, head length, body length and ham length. The other two variables – body girth and ear length were loaded on PC2. For Duroc, three variables were loaded on PC1. They are body weight, body length and body girth. Ham length and ear length contributed more to PC2. PC3 however had only head length as its variable. Figures 1and 2 presents the scree plot showing the point of cut – off at PC3 for Duroc and PC2 for Large-white the point at which the curve flattens out. The principal components collected in the present study can be used with other economic indices in evaluating adaptability of pigs for management purpose. Similar reports have been studied and reported by Putra and Ilham (2019) and Akinsola *et al.* (2014).

Table 3: Communalities of body measurements, eigenvalues and s hare of total variance along with factor loadings of two breeds of pigs (Large-White and Duroc)

Traits	P C1	P C2	P C3	Communalities
Large-white				
Body Weight	0.74	-0.04		0.54
Head Length	-0.59	0.10		0.36
Body Length	0.73	0.19		0.57
Body Girth	0.17	0.77		0.62
Ham Length	0.57	0.54		0.61
Ear Length	-0.26	0.67		0.51
Eigen values	2.00	1.22		
% of total variance	33.29	20.26		
Duroc				
Body Weight	0.63	0.43	-0.04	0.58
Head Length	0.21	0.29	0.85	0.84
Body Length	0.80		0.08	0.65
Body Girth	0.79	-0.08	-0.04	0.63
Ham Length	0.37	0.46	-0.67	0.80
Ear Length	0.06	-0.89	-0.11	0.80
Eigen values	2.05	1.20	1.05	
% of total variance	34.20	20.03	17.47	

PC1,2 and 3: principal component 1, 2 and 3, %: percentages, HL: head length, BL: body length, BG : body girth, HML: ham length and EL: ear length.

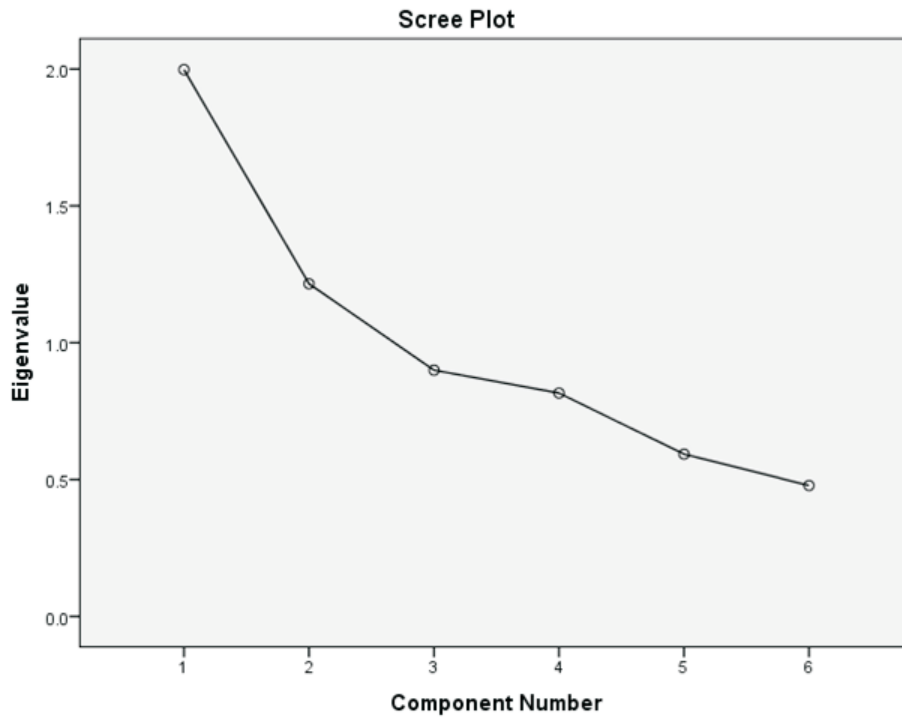

Figure 1: Screen plot for the morphological traits of Duroc grower pigs

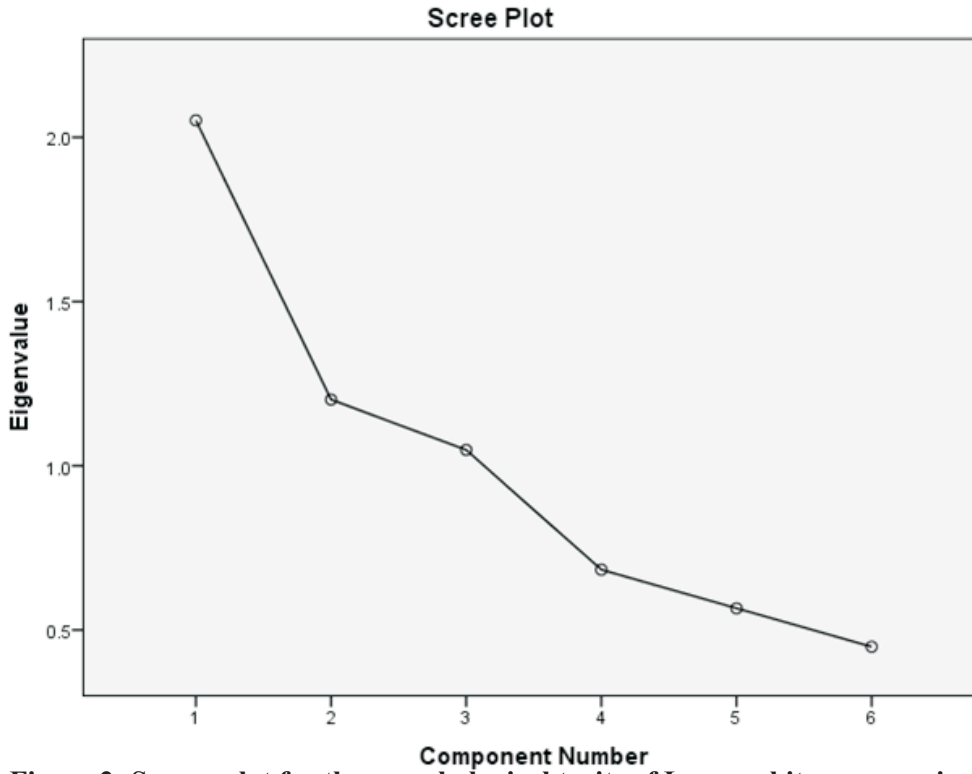

Figure 2: Screen plot for the morphological traits of Large-white grower pigs

Reliant unique body measurements and their reliant principle component factor scores were used to predict body weight of Large-white and Duroc (Table 5). The results of stepwise multiple regression analysis in normal Large-white revealed that head length alone accounted for 37% of the variation in body weight. The inclusion of body length did not increase the variation in body weight, there was no improvement (R^2=37) when body girth, ham length and ear length were included in the equation the variation increase to 48%. Duroc breed, the head length, body length contributed 37% variation to the body weight and when all the traits were included to the prediction equation it accounted for 40% of variation in body weight, the present result are consistent with the submission of peters *et al*. (2006) in chickens and Teguia *et al.,* (2007) in ducks and yakubu (2009) in yankasa sheep. To increase the meat yield of pigs requires the genetic improvement of body weight. Accurate measurement of this variable, which is often hard in local villages due to lack of weighing scales, is a pre-requisite for achieving this aims. That is while, the use of measurable linear body measurements, which are more relevant for on-farm within herd use. Consequently, use of interdependent explanatory variables ought to be treated with carefulness, since multicollinearity has been shown to be associated with unstable estimates of regression coefficient (Ibe, 1989; Malau-Aduli *et al*., 2004 and Peter *et al.,* 2006) interpreting the estimation of original effects to these predicators impossible. This warrants the use of indices of the morphological traits, mentioned as principal components for prediction.

Principal components are orthogonal to both and are more dependable in weight estimation. In the present study, PCI, PC2 and PC3 as combination, the total variability of body weight improvement in the amount of variance explained 76% in Duroc while Large-white the combination of PCI and PC2 of the total variability of body weight gave a considerable improvement in the amount of variance explained 58 percent. Equally, Shahin and Hassan (2000) resulted in regression equation for estimating body weight in rabbit using independent factors score.

Table 5: Step wise multiple regression of live body weight on original body parameters and on their factor scores of Large-white and Duroc

Variables	Models	R^2	S E
1. Large -white Original body measurement as independent variables			
Head Length	BW=3.40+0.06HL	37	2.04
Head length and body length	BW=3.40+0.06HL+0.15BL	37	2.02
Head length, body length body girth and ham length	BW=3.40+0.06HL+0.15BL+0.12BG+0.53HML	48	1.96
2. Orthogonal traits in independent variables			
PC1 and PC 2	13.14PC1 – 0.04PC2	58	0.98
2. Duroc Original body measurement as explanatory variables.			
Head length	BW=5.16+0.78HL	40	1.33
Head length, and body length	BW=5.16+0.78HL+0.11BL	40	0.04
Head length, body length, body girth and ham length	BW=5.16+0.78HL+0.11BL-0.07BG	40	1.33
Head length, body length, body girth ham length and ear length.	BW5.16+0.78HL+O.11BL-0.07BG+0.23HML-0.06EL	40	1.38
2. Orthogonal traits in independent variables			
PC1,PC2 and PC3	12.88PC1+12.27PC2+0.04PC3	0.76	1.04

In conclusion, the coefficient of determination estimates (R^2) obtained for both breeds indicated that principal component analysis is a robust techniques and more efficient in predicting body weight compared to the traditional regression analysis. The use of principal component analysis techniques tends to explore the interdependence in the original five parameters measured: Head length, Body length, Body girth, Ham length and Ear length of Large-white and Duroc. This is while the objective simultaneous analysis of these body measurements reasonably than on individual basis, the resultant two and three principal components in each genetic group could aid in selection and breeding programs of pigs.

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