

## Effect of different body measurements on body weight of pre-weaning Duroc pigs using Principal Analysis Component Approach

Amao, S. R.

Department of Agricultural Education, (Animal Science Division, Animal Breeding and Genetics Unit), School of Secondary Education (Vocational and Technical Programmes), P.M.B.1010, Emmanuel Alayande University of Education, Oyo, Oyo State, Nigeria.

sholaamao@gmail.com; amaosr@eacoed.edu.ng **Phone Number:** +2348035312418

**Target audience:** Researchers, Animal Breeders, Pig farmers

### Abstract

The body measurements of pigs are the important part of precision *in* livestock farming that closely related to the growth characteristics and traits. It is significant for monitoring and understanding the pig growth at different stages effectively for better selection with the procedure of Principal Component Analysis (PCA) to identify and visualize better traits among the measured parameters. The records of 50 piglets comprising of 20 male and 30 female pigs were used with weekly measurement on body weight (BW), body length (BL), heart girth (HG), heart at withers HW, ear length (EL), pelvic width (PW), tail length (TL) and hock circumference (HC). The obtained data was subjected to PCA and the results observed were highly correlated *s* among most of the morphometric and growth traits. Kaiser-Meyer-Olkin measure of sampling adequacy, Bartlett's Test of Sphericity and communality were calculated. Two PCs were extracted while these PCs accounted for 88.48% and PC1 had 74.21% and PC2 amounted to 14.28% variance, respectively of total variance. PC1 was represented by high loading of BW, BL, HG, HW, EL, PW, TL and HC. PC2 had medium to high loading for PW, TL and HC. PC1 seemed to explain the body of pig whereas PC2 seemed to represent just the few variables of the pig. It can be concluded that traits described by PC1 can be based line for pig improvement. The accounted PCs at different stage may be exploited in breeding and selection programmes to acquire highly coordinated animal bodies using fewer measurements.

**Keywords:** Duroc pig; Morphometric traits; Body measurement; Principal component analysis

### Description of Problem

The knowledge related to the variation of morphometric traits in the existing genetic resources is most significant for the characterization of livestock including non-ruminant animals such as poultry, pigs and rabbits (1). Body weight and body conformation are significant factors for assessing growth in animal husbandry since they have been proven to be useful in comparing the shape and size of livestock animals (2). Body weight has been generally used to quantify body size and the association prevailing among linear body traits to 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 (3, 4). 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 sorted as

multivariate fairly than bivariate, since body dimensions are interconnected phenotypically and genetically (5, 6).

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 pig's live weight and body dimensions are the key indicators of economic implications and production performance that closely related to the health of pigs (7) which provide referential criteria for breeding programs and carcass quality (8). Although, individual difference is natural and inevitable, it can likely result in pigs with different sizes and growth processes when it was not managed properly (9). In pig production, within-batch variation in bodyweight gain of piglets during the nursery period (up to 10 weeks of age) can be high and is of high economic importance (10). The mechanisms involved in pig growth are too multifaceted to explain using univariate analysis (11). 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.

A principal component analysis (PCA) is a multivariate method that converts correlated variables into uncorrelated variables, which are then arranged so that the first few retain the majority of the original variables' variance (12, 13, 14, 15). The PCA has been used by other researchers to assess the relationship between body traits and size in pig (16,17,18,19), chicken (2, 14, 15), goat (20), cattle (21), turkey (22) and duck (23, 24). PCA are weighted linear combination of correlated variables, explaining a maximal amount of variance of the variables. It also aids in data reduction, and break multicollinearity which may lead to wrong judgment. Hence, the study adopted the use of principal component analysis to determine the body size and morphological traits of pre-weaned duroc pigs.

### Materials and Methods

The study was carried out at the Piggery Unit of Teaching and Research Farm, Emmanuel Alayande University of Education, Oyo, Oyo State, Nigeria and Oyo lies on the longitude  $3^{\circ}51'$  east of the green which meridian and latitude  $7^{\circ}51'$  North eastwards from Ibadan, the capital of Oyo State. The latitude is between 300 and 600 meter above sea level. The latitude is between 300 and 600 meter above sea level. The mean annual temperature and rainfall are  $27^{\circ}\text{C}$  and 1,165mm respectively. The vegetation of the area is Southern guinea savannah zone of Nigeria (25).

### Experimental Animals and Management

The using pigs of Duroc as sire and Duroc as dam with the objective to develop a suitable variety adapted to local climatic condition with better productive and reproductive performance. The developed progenies pigs were evaluated for their performance both at organized farm as well as subsistence low-input production system as farmers' field. Piglets produced were housed with their dam in indoor pens (12.0 ft x 10.0 ft with concrete flooring) varying from 6 to 10 piglets per pen. Daily routine

care including deworming and vaccination against swine fever and FMD was routinely offered. The piglets were individually marked by tag for identification. The records of 50 piglets comprising of 20 male and 30 female, maintained at the farm.

### Feed and Feeding

Starter ration (maize 55.0%, deoiled ground nut cake 21.0%, soybean meal 17.0%, wheat bran 5.5%, mineral mixture 1.0% and salt 0.5%; Metabolizable Energy 13.78 MJ/kg diet and Crude Protein 24%) of 20g per animal were offered from third week onward till weaning as per NRC recommendation (26). The amount of ration was gradually increased by 20 g/week till it reached 80g/piglet/d at the time of weaning (week 6). Water was made available *ad libitum* at all times.

### Collection of Data

Data were collected on the body weight and body conformation of the pigs for both male and female pigs on weekly bases on heart girth, height at wither, ear length, Pelvic width, hock circumference, tail length and body length according to procedures described by (27).

### Statistical analysis

Mean, standard errors, minimum and maximum of body weight and linear body measurement of each pig were obtained using the descriptive statistic of SPSS 22 (28) while the correlation matrix which was the primary information required for PCA generated was done using the factor program of SPSS 22 (28) Statistical package.

### Results

Table 1 depicted the means, standard deviations, and coefficients of variation of morphological traits of duroc pigs at pre-weaning stage. Body measurements viz., body weight, body length, heart girth, heart at withers, ear length, pelvic width, tail length and hock circumference were measured and descriptive statistics revealed the means for corresponding traits as 14.38 kg, 62.84 cm, 57.92 cm, 43.04 cm, 17.38 cm, 45.38 cm, 23.46 cm and 13.58 cm respectively while the coefficient of variation ranges from 5.90 to 34.90.

**Table 1: Descriptive analysis of body morphometric traits of pre-weaning Duroc pigs**

| Traits  | NO  | Minimum | Maximum | Mean  | Std. Deviation | C.V%  |
|---------|-----|---------|---------|-------|----------------|-------|
| BW (Kg) | 150 | 11      | 18      | 14.38 | 2.022          | 5.90  |
| BL (cm) | 150 | 54      | 72      | 62.84 | 6.003          | 6.78  |
| HG (cm) | 150 | 52      | 67      | 57.92 | 4.573          | 12.89 |
| HW (cm) | 150 | 38      | 50      | 43.04 | 4.115          | 23.23 |
| EL (cm) | 150 | 14      | 22      | 17.38 | 2.837          | 13.56 |
| PW (cm) | 150 | 40      | 56      | 45.38 | 4.610          | 34.90 |
| TL (cm) | 150 | 20      | 30      | 23.46 | 3.573          | 31.88 |
| HC (cm) | 150 | 11      | 18      | 13.58 | 2.139          | 21.56 |

BW=Body weight (kg), BL = Body length (cm), HG = Heart girth (cm), HW = Heart at withers, EL = Ear length (cm), Pelvic width (cm), TL = Tail length, HC = Hock circumference, No = Number of Observation, Std. Dev = Standard deviation, C.V = Coefficient of variation

The phenotypic correlations among different body measurements of Duroc pigs are presented in Table 2. The results showed that all the correlations were found to be significantly affected ( $p < 0.01$ ) and positive and varied from 0.314 (body length and ear length) to 0.938 (tail length and hock circumference). Significant ( $p < 0.01$ ) and positive correlations between morphometric characteristics in Duroc pig showed good predictability among the variables, which might be beneficial as selection criteria. All body measurements had a high correlation

with body weight in Duroc pigs. In the present study, the Kaiser-Meyer Olkin (KMO) measure of sample adequacy was 0.878, and the result of the Bartlett test of Sphericity was significant ( $\chi^2=137.922$ ;  $p = 0.000$ ). (29) considered a sample adequacy score of more than 0.80 to be commendable. The significance of the correlation matrices for the body measures of Duroc pigs assessed with Bartlett’s test of Sphericity gave enough evidence for the validity of employing factor analysis for the data set.

**Table 2: Descriptive analysis of body morphometric traits of pre-weaning Duroc pigs**

| Traits | BW     | BL     | HG     | HW     | EL     | PW     | TL     | HC    |
|--------|--------|--------|--------|--------|--------|--------|--------|-------|
| BW     | 1.000  |        |        |        |        |        |        |       |
| BL     | 0.890* | 1.000  |        |        |        |        |        |       |
| HG     | 0.769* | 0.864* | 1.000  |        |        |        |        |       |
| HW     | 0.644* | 0.638* | 0.826* | 1.000  |        |        |        |       |
| EL     | 0.647* | 0.314* | 0.459* | 0.664* | 1.000  |        |        |       |
| PW     | 0.698* | 0.434* | 0.519* | 0.713* | 0.854* | 1.000  |        |       |
| TL     | 0.711* | 0.544* | 0.574* | 0.852* | 0.803* | 0.843* | 1.000  |       |
| HC     | 0.830* | 0.676* | 0.622* | 0.759* | 0.788* | 0.782* | 0.938* | 1.000 |

\*Significant at the 0.01 level

BW=Body weight (kg), BL = Body length (cm), HG = Heart girth (cm), HW = Heart at withers, EL = Ear length (cm), Pelvic width (cm), TL = Tail length, HC = Hock circumference.

Table 3 indicated the linear type characteristics in pre-weaned Duroc pig, using a Varimax rotational component matrix of different variables. The results revealed that PC1 had the higher values of 0.933, 0.916, 0.897, 0.886, 0.852, 0.812, 0.807 and 0.774 for body weight, body length, heart girth, heart at withers, ear length, pelvic width, tail length and hock circumference respectively than PC2 of values 0.120, 0.279, 0.243, 0.026, 0.385, 0.479, 0.491 and 0.608 for body weight, body length, heart girth, heart at withers, ear length, pelvic width, tail length and hock circumference respectively. The PC1 values

ranges between 0.774 - 0.933 whereas PC2 values varied from 0.026 to 0.608.

The communalities and unique factors for body measurements of pre-weaned duroc pigs are depicted in Table 4. The communalities are the proportions of variance in the original variables that indicate the proportion of variation in the communalities. Communalities varied from 0.786 (heart at wither) to 0.968 (body length), whereas all the traits were found to be strong communalities which close to unit. The unique factor extracted varied from 0.120 (body weight) to 0.348 (Hock circumference).

**Table 3: Linear type characteristics in pre-weaned Duroc pig, using a Varimax rotational component matrix of different variables**

| Traits                  | Components |       |
|-------------------------|------------|-------|
|                         | PC1        | PC2   |
| Body weight (Kg)        | 0.933      | 0.120 |
| Body length (cm)        | 0.916      | 0.279 |
| Heart girth (cm)        | 0.897      | 0.243 |
| Heart at withers (cm)   | 0.886      | 0.026 |
| Ear length (cm)         | 0.852      | 0.385 |
| Pelvic width (cm)       | 0.812      | 0.479 |
| Tail length (cm)        | 0.807      | 0.491 |
| Hock circumference (cm) | 0.774      | 0.608 |

PC1 = Principal component 1, PC2 = Principal component 2

**Table 4: Pre-weaned Duroc pigs communalities and unique factors influence various morphometric traits**

| Traits                  | Communalities | Unique factor |
|-------------------------|---------------|---------------|
| Body weight (Kg)        | 0.864         | 0.120         |
| Body length (cm)        | 0.968         | 0.234         |
| Heart girth (cm)        | 0.889         | 0.342         |
| Heart at withers (cm)   | 0.786         | 0.213         |
| Ear length (cm)         | 0.892         | 0.123         |
| Pelvic width (cm)       | 0.875         | 0.223         |
| Tail length (cm)        | 0.917         | 0.342         |
| Hock circumference (cm) | 0.888         | 0.348         |

The eigenvalue represents the variability accounted by each factor out of total variability and two components having eigenvalue greater than one as shown in Table 5. The results were extracted based on Kaiser rule criterion as suggested by (30). These extracted two factors collectively

accounted for 88.481% of the total variability present in the parameters measured. The first principal component accounted for the greatest proportion of the total variance (74.205%) was found to be highly correlated with while PC2 explained only 14.276% of the total variance.

**Table 5: Different components in Duroc pig explaining the total variance**

| Component | Initial Eigenvalue |               |              | Extraction sums of |               |              | Square loading |               |              | Rotation sum of Squared loading |               |              |
|-----------|--------------------|---------------|--------------|--------------------|---------------|--------------|----------------|---------------|--------------|---------------------------------|---------------|--------------|
|           | Total              | % of Variance | Cumulative % | Total              | % of Variance | Cumulative % | Total          | % of Variance | Cumulative % | Total                           | % of Variance | Cumulative % |
| 1         | 5.936              | 74.205        | 74.205       | 5.956              | 74.205        | 74.205       | 3.863          | 48.288        | 74.205       |                                 |               |              |
| 2         | 1.142              | 14.276        | 88.481       | 1.142              | 14.276        | 88.481       | 3.215          | 40.192        | 88.481       |                                 |               |              |
| 3         | 0.447              | 5.584         | 94.065       |                    |               |              |                |               |              |                                 |               |              |
| 4         | 0.273              | 3.408         | 97.473       |                    |               |              |                |               |              |                                 |               |              |
| 5         | 0.153              | 1.915         | 99.388       |                    |               |              |                |               |              |                                 |               |              |
| 6         | 0.037              | 0.457         | 99.845       |                    |               |              |                |               |              |                                 |               |              |
| 7         | 0.011              | 0.132         | 99.977       |                    |               |              |                |               |              |                                 |               |              |
| 8         | 0.002              | 0.023         | 100.000      |                    |               |              |                |               |              |                                 |               |              |

## Discussion

These recent descriptive statistics of duroc pigs i.e mean values are similar to those reported by (16, 17, 18, 32, 33) and the coefficient of variation (c.v) for body weight and body trait measurements, thus showing evidence that body characteristics and body weights are good reliable indices of body size and falls in the same ranges for this investigation. (16) found similar ranges of values of descriptive statistics for duroc breeds pigs at pre-weaning stage. (17) reported ranges of values for means that was similar to this documentation for Mizo local pigs. (18) documented similar ranges of

descriptive statistics for crossbred (75% Landrace × 25% Bareilly local) that consistent with this current finding.

All body measurements had a high correlation with body weight of the pigs. Similarly, various researchers (17, 18, 32) and (34) observed a highly positive correlation of body weight with body measurements indicating the possible use of body measurements in predicting body weight. (35) reported the highly correlation magnitudes among body weight and other linear measurement in crossbred Nigerian indigenous pigs. (18) observed the highest correlation between body weight and other

body measurements of crossbred pigs. In their study, (17) found a strong association between body weight and linear body measurement in a meta-analysis to understand the relationship between pig body weight and variation from birth to market. (34) reported significant and positive correlations between morphometric characteristics in Ghungroo pigs. Similar KMO values and significant Bartlett test of Sphericity were observed by (19, 35).

The two principal components were extracted in pre-weaning duroc pigs that accounted for the maximum variation in the morphological traits (17, 18, 32, 36). According to (36), the first principal component exhibited strong positive loadings on body weight, body length, ornithological measurement, heart girth, and heart at withers, whereas the second component had significant positive loadings on ear length, pelvic width and tail length. According to (17); PC1 and PC2 accounted for the most value of the overall variance, whereas PC1 accounted for highest of the value. These findings of PC1 having the largest variability out of all the variables were consistent with the findings of the current investigation. According to (18), two variables accounted for most value of the overall variability in the characteristics studied. PC1 loaded strongly accounted for highest of the variation at early stage while PC2 loaded orthogonal on pelvic width, tail length and hock circumference and also, the first principal component (PC1) showed the most variability, which was strongly related to body weight, body length, heart girth, heart at withers and pelvic width. (32) found that two main components explained most of the values of the overall variance in the original variables. They found highest PC1 loadings on pigs body weight, body length, heart girth, heart at withers and pelvic width. (36) discovered four components that explained most values of the total variation in ten variables, with PC1 having the strongest correlations with body weight, body length, heart girth, heart at withers and pelvic width and PC2 having the strongest correlations with tail length and pelvic width. However, the similarities in the authors submission on the PC from the various studies with this current study is an indication that the traits measured were based on the correlation, preventing

overfitting of trait to be selected, removed correlated traits for its usefulness and improved visualization of correlated traits for future selection.

The communalities are the proportions of variance in the original variables that indicated the proportion of variation in the communalities. In the pre-weaning duroc pig, communalities varied, highest and close to unit with the low to high unique factor. Similarly, (19) found strong communalities in pig growth stages and in diverse kinds of pigs (35). (16) found similar ranges of values of medium to high for duroc pigs. (17) found a wide range of communalities closes to unit for pigs body measures. (18) reported strong communalities that close to unit for crossbred pigs. (32) observed strong communalities in body measurements in Ugandan village pigs. Thus, the higher communalities value recorded among the traits in questions, the more and better the extracted factors explain the variance of the traits for overall assessments of the performance of the pigs that assist the breeders in improvement of the traits of these higher values.

### Conclusion and Application

1. In conclusion, all morphometric traits had a high positive and significant correlation with body weight indicating the possible use of morphometric traits in predicting body weight in pigs.
2. The current study revealed that the extracted two PC had the largest share of the total variance and explained 88.481% in pig of the total variability present in the original morphological traits while PC1 contains 74.205% and PC2 amounted to 14.276%.
3. The communality values close to 1 for some traits in the present study gave the better explanation for the reason for selection criteria.
4. However, accounted PCs at different stage may be exploited in breeding and selection programmes to acquire highly coordinated animal bodies using fewer measurements.

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