Journal of Agriculture and Environment
Vol. 20 No. 2, 2024: 113-124

Morphometric characterization and prediction of liveweight of swine at pre-weaning and post-weaning

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ABSTRACT

This research was conducted to characterize the body morphometric and predict the liveweight of Swine at pre- and post-weaning. Measured parameters include Head width (HeW), Head length (HL), Hip height (HH), Length of snout (LS), Wither height (WH), Body length (BL), Heart girth (HG), Ear length (EL), Hip width (HW), and Liveweight (LW). This was carried out at University of Benin Research and Teaching Farm. A total of 30 large white x landrace of both sexes were used. Body weight was measured in kilograms (kg) using a digital battery-operated scale and other morphometric measurements were done with a tape rule. Data obtained were subjected to statistical analysis on principal component analysis, regression and descriptive statistics using SPSS software version 19. The highest coefficient of variation was 0.39 for pre-weaned swine and 0.55 for weaned swine (14 weeks). There was also a strong correlation among all the body parts measured with 0.885 being the highest correlation coefficient between pre-weaning head width and weaning hip width while liveweight had a strong correlation with all the measured body parameters. The combination of heart girth, tail length, ear length, hinge length, and wither height were the best model at pre-weaning (R^2 = 93.3%). While that of the weaning liveweight prediction model was found from the combination of wither height and length of snout, ear length, hearth girth, body length, wither height, and tail length (R^2 = 94.2%). The principal component analysis shows that swine can be best described through their hinge length (0.98) and length of the snout (0.97) and they also have a strong linear relationship. In conclusion, the swine weight can therefore be taken under conditions where scales are not readily available and more accurate results can be achieved at weaning. Selection can also be made using this relationship.

Keywords: Morphometric; PCA; liveweight; linear relationship

INTRODUCTION

Swine are one of the most prolific and fast-growing livestock with a high feed conversion ratio and thus, are mostly kept for their meat and pork (fat) with the most important trait of interest being body weight (Oluwole *et al*., 2014). Liveweight has always been measured using weighing scale. Selection in field condition requires some measurement of liveweight using weighing scale. Other body measurements can also be used in the absence of weighing scale. There is difficulty sometimes in measuring the weight of pigs in rural areas due to the unavailability of weighing scales. Therefore, the use of simple linear body measurements to predict liveweight will be necessary to farmers. An investigation by Camp

https://www.ajol.info/index.php/jagrenv
ISSN: 1595-465X (Print) 2695-236X (Online)
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https://dx.doi.org/10.4314/jagrenv.v20i2.11

et al. (2020) on the prediction of liveweight of pigs using birth and weaning weight shows that birth weight was not a good predictor of liveweight as small piglets grow to catch up with bigger piglets. According to Panda *et al*. (2021) at 6 weeks of age, pig liveweights are best predicted from their body length and heart girth while at 8 weeks of age, its best prediction is neck circumference. Knowledge of morphometric characteristics makes the first step in classification of Farm Animal Genetic Resources (Delgado *et al.*, 2001). Afolayan *et al.* (2006) reported that accuracy of functions used to predict body weight from linear body measurements has an immense financial contribution to livestock production enterprises.

In swine breeding, the identification of multivariate relationships among age, body weight, and body measurements is necessary for selecting better animals to gain more genetic progress in reproductive traits (Mwacharo *et al.,* 2006; Tarig *et al.,* 2012). Liveweight differs according to factors such as sex, yield type, and age (Ameha, 2006). Estimating the liveweight using body measurements is practical, faster, simpler, easier, and cheaper to adopt in rural areas and in field conditions where weighing scales are not available. Yakubu *et al.* (2022) reported that wither height, ear length and body weight contributed the greatest variability in the description of pig morphometric.

This research is aimed at morphometric Characterization and prediction of the liveweight of swine at pre-weaning and post-weaning. The objectives of the research include the determination of the swine's body morphometrics, body linear relationship, principal component analysis, relation between pig body morphometrics, and liveweight prediction at 6 and 14 weeks of age.

MATERIALS AND METHODS

Study Area

This research was conducted at the piggery unit of the Teaching and Research Farm of the University of Benin, Benin City, Nigeria. Benin City is located between latitudes 6° and 6°30'N of the equator and longitudes 5°40' and 6°E. It has a mean annual temperature range of between 24.5 ˚C and 32.7 ˚C. The area has an annual rainfall of 2162 mm and mean relative humidity of 72.5%. (Nigeria Airports Authority, 2022).

Animals and Management

The experimental animals consist of 30 crossbred Large white X landrace. The animals were allowed two weeks for adaptation. All management requirements were adhered to such as proper health management, feeding, maintenance of clean environment, provision of clean drinking water and shower.

Data Collection

A total number of 30 crossbred animals (weaners) were obtained from some private farms in Benin City with average weight of 7kg. Data were obtained on linear body measurements, which include Head width (HeW), Head length (HL), Hip height (HH), Length of snout (LS), Wither height (WH), Body length (BL), Heart girth (HG), Ear length (EL), Hip width (HW), and Liveweight (LW). They were taken following procedure of Oluwole *et al*. (2014).

The height measurement (cm) was done using a graduated measuring stick. The length and circumference measurements (cm) were taken using a tape rule while the width measurement was done using a calibrated wooden caliper. This was done from February to June, 2022.

Data Analysis

Data collected were subjected to statistical analysis using SPSS to describe the data. Pearson correlations was used to determine the relationship between the various body measurements at pre-weaning and weaning. The correlation between the body morphometric at pre-weaning (6weeks) and weaning (15 weeks) were also established.

Linear regression analysis was also carried out to determine the regression coefficients for predicting liveweight of the animals using the linear body measurements (independent variables) for both pre-weaning and weaning. The model is specified as follows:

$LW = a + b_1x_1 + b_2x_2 + b_2x_2$-------------------$+ b_nx_n$..(i)

Where LW is liveweight, a = intercept, b = regression coefficient of the linear body measurement, x = the various linear body measurement ranging from head width, wither height to hip width

Principal Component Analysis (PCA)

Before carrying out the PCA, Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was carried out to determine the adequacy of the data for analysis. Commonalities were also determined to find out the level of variance distribution among the variables and thus decide on whether to use PCA for the variable classification. This was followed by a scree plot to know the component at which the classification of variables will stop based on the cumulative variance. Then PCA was used to determine the classes of the animal from the measured parameters into size or volume. It was further carried out to determine whether the correlation was a true identity matrix or a matrix full of zeros, Bartlett's test of sphericity was carried out. The PCA was summarized to find out the variance and thus the most significant component.

RESULTS

It can be seen from Table 1 that there is a moderate coefficient of variation of less than 20% except for LW and HW which had 34% and 39% at pre-weaning and HW and TL with less than 40% and LW with over 50% variation at weaning.

Table 1: Morphometric of pre-weaning and weaning of pigs

Variable	Pre-weaning			Weaning		
	Mean	SD	CV	Mean	SD	CV
LW	5.54$\pm$0.20	2.18	0.39	7.47$\pm$0.41	1.64	0.55
HeW	6.86$\pm$0.11	1.24	0.18	7.43$\pm$0.17	4.08	0.22
HL	12.78$\pm$0.21	2.32	0.18	13.49$\pm$0.30	2.92	0.22
LS	7.23$\pm$0.16	1.72	0.24	7.85$\pm$0.21	2.11	0.27
WH	25.82$\pm$0.36	3.99	0.15	28.19$\pm$0.58	5.76	0.20
BL	52.33$\pm$1.05	11.64	0.22	57.23$\pm$1.48	14.66	0.26
HG	40.14$\pm$0.72	7.98	0.20	43.10$\pm$0.94	9.29	0.22
EL	5.88$\pm$0.13	1.43	0.24	6.35$\pm$0.18	1.75	0.28
HW	4.66$\pm$0.14	1.58	0.34	5.00$\pm$0.18	1.81	0.36
TL	9.39$\pm$0.22	2.41	0.26	10.56$\pm$0.33	3.22	0.30

Head width (HeW), Head length (HL), Hip height (HH), Length of snout (LS), Wither height (WH), Body length (BL), Heart girth (HG), Ear length (EL), Hip width (HW), and Liveweight (LW).

Table 2: Correlation coefficient between morphometric measurement at pre-weaning (6 weeks) and weaning (15 weeks) age in swine.

Weaning (15wks) Pre-weaning (6wks)	LW	HeW	HL	LS	WH	BL	HG	EL	HW	TL
LW	0.832**	0.839**	0.876**	0.848**	0.803**	0.851**	0.717**	0.865**	0.870**	0.812**
HeW	0.805**	0.841**	0.880**	0.862**	0.810**	0.843**	0.710**	0.838**	0.885**	0.806**
HL	0.793**	0.831**	0.879**	0.860**	0.777**	0.838**	0.698**	0.840**	0.878**	0.782**
LS	0.750**	0.808**	0.859**	0.826**	0.754**	0.801**	0.664**	0.835**	0.861**	0.765**
WH	0.580**	0.634**	0.656**	0.625**	0.606**	0.633**	0.528**	0.667**	0.681**	0.614**
BL	0.764**	0.801**	0.828**	0.822**	0.754**	0.817**	0.685**	0.818**	0.844**	0.739**
HG	0.585**	0.605**	0.636**	0.626**	0.591**	0.610**	0.497**	0.616**	0.624**	0.562**
EL	0.821**	0.852**	0.879**	0.859**	0.786**	0.846**	0.727**	0.839**	0.876**	0.800**
HW	0.789**	0.820**	0.855**	0.856**	0.773**	0.841**	0.705**	0.843**	0.883**	0.769**
TL	0.582**	0.613**	0.648**	0.634**	0.510**	0.611**	0.585**	0.597**	0.640**	0.571**

HeW = head width, HL = hinge length, LS = length of snout, WH = wither height, BL = body length, LW = liveweight, HG = hinge girth, EL = ear length, HW = hip width, TL= tail length

The variables at the vertical axis are the body measurement at pre-weaning (6 weeks) while those at the horizontal axis are for weaning (15 weeks)

The correlation coefficients at pre-weaning and weaning were moderate to high, positive and significant ($p<0.05$) (Table 2). They range between 0.479 and 0.885. The only relatively weak and positive correlation is between heart girth at pre-weaning and weaning heart girth (0.479). This means that selection for increased heart girth at pre-weaning will result to small increase in heart girth at 15 weeks old.

The predictive equations for liveweight (LW) in kilogram (kg) through linear body measurements in Pigs using stepwise multiple regression analysis are shown in Table 3. Liveweight can be better predicted for both pre-weaning and weaning from the linear body measured parameters shown with respect to their high level of coefficient of determination with the highest being 93.3% in a combination of HG, TL, EL, HL, and WH. The prediction equations for swine of 15 weeks' age have the highest coefficient of determination of 94.2% and thus animal weight determination using linear body measurement should be best carried out at weaning.

Table 3: Stepwise regression for liveweight and morphometric at pre-weaning and weaning

	Model (LW)	R^2(%)
	-5.55+1.62HeW	85
	-4.71+0.90HeW+0.56LS	88
	-5.08+0.63HeW+0.58LS+0.05HG	89.6
	-4.61+0.60HeW+0.74LS+0.05HG-0.13TL	90.6
6 weeks	-3.77+0.26HeW+0.26HeW+0.63LS+0.03HG-0.16TL+0.56EL	92
	-4.42-0.12HeW+0.20LS+0.02HG-0.23TL+0.71EL+0.50HL	93.1
	-4.51+0.21LS+0.02HG-0.22TL+0.66EL+0.45HL	93
	-4.82+0.02HG-0.23TL+0.72EL+0.58HL	92.9
	-5.38+0.22HG-0.21TL+0.69EL+0.51HL+0.57WH	93.3
	-7.66+0.26BL	90.1
	-7.64+0.15BL+0.83LS	91.6
	-8.77+0.11BL+0.75LS+0.98HG	92.8
	-8.78+0.10BL+0.53LS+0.10HG+0.21TL	93.6
15 weeks	-9.56+0.09BL+0.40LS+0.10HG+0.20TL+0.10WH	93.9
	-9.68+0.11BL+0.43LS+0.11HG+0.23TL+0.10WH-0.37EL	94.2

R^2 = Coefficient of determination

The results from Table 4 show a high adequacy of data for principal component analysis with weaning data being the most adequate with 95.3% adequacy.

Table 4: KMO and Bartlett's Test of the swine body morphometric

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	Approx. Chi-Square	Bartlett's Test of Sphericity	
		df.	Sig.
0.894			
weaning	1711.257	36	0.000
0.953	1695.711	36	0.000

The scree plot shows eigen value and component number to determine one-dimensionality of linear measurement as shown in Figure1. It also shows that components 1 and 2 are the best for the morphological description of the pig.

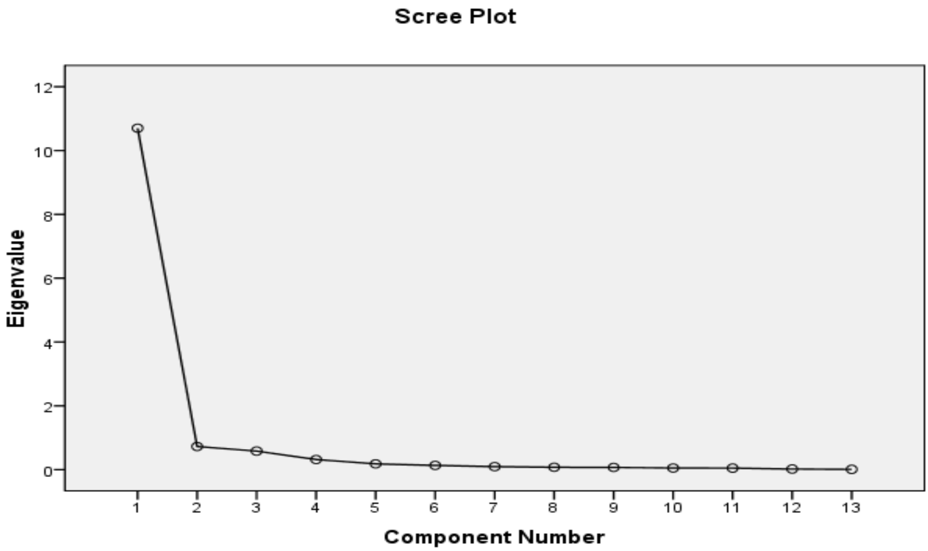

Figure 1: Screen plot showing eigen values and the component number of swine at pre-weaning

It can be seen from Table 5 that component 1 can effectively describe the data for weaning with the majority of this being length (HL, LS, BL, EL, HeW). This means that better morphology and categorization of swine at pre-weaning may be done through length of their body, snout, ear and hinge. The total Eigenvalue and percentage variance are 10.7 and 82.32% respectively for component 1 while that for component 2 are 0.72 and 5.58 respectively. This implies that component 1 will offer the best description with respect to significance of the data followed by component 2.

Table 5: Principal component analysis of the morphometric of swine at pre-weaning (6 weeks)

	Component				
Morphometric (cm)	1	2	3	4	5
HeW	0.965	-0.057	0.051	-0.117	-0.061
HL	0.974	0.105	-0.033	-0.027	0.011
LS	0.969	0.071	-0.064	-0.024	-0.017
WH	0.822	-0.200	-0.218	0.479	0.006
BL	0.946	-0.038	0.005	-0.125	-0.046
LW	0.943	-0.069	-0.170	-0.148	0.105
HG	0.746	-0.237	0.577	0.061	0.224
EL	0.946	0.052	0.162	-0.024	-0.170
HW	0.962	0.095	-0.065	-0.045	-0.018
TL	0.659	0.727	0.021	0.100	0.137

Hew = head width, HL = hinge length, LS = length of snout, WH = wither height, BL = body length, LW = liveweight, HG = hinge girth, EL = ear length, HW = hip width, TL= tail length

Table 6: Eigenvalues of pre-weaning performance

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	10.701	82.318	82.318	10.701	82.318	82.318
2	.726	5.582	87.901			
3	.581	4.469	92.369			
4	.317	2.442	94.811			
5	.180	1.383	96.195			
6	.133	1.021	97.216			
7	.094	.721	97.937			
8	.074	.573	98.509			
9	.068	.523	99.033			
10	.051	.395	99.428			
11	.047	.362	99.790			
12	.018	.140	99.929			
13	.009	.071	100.000			

Table 7: Communalities for pre-weaning morphometric

Variable	Initial	Extraction
HeW	1.000	.954
HL	1.000	.962
RH	1.000	.955
LS	1.000	.949
WH	1.000	.993
BL	1.000	.915
HG	1.000	.999
EL	1.000	.952
HW	1.000	.941
TL	1.000	0.993

Hew = head width, HL = hinge length, LS = length of snout, WH = wither height, BL = body length, LW = liveweight, HG = hinge girth, EL = ear length, HW = hip width, TL= tail length

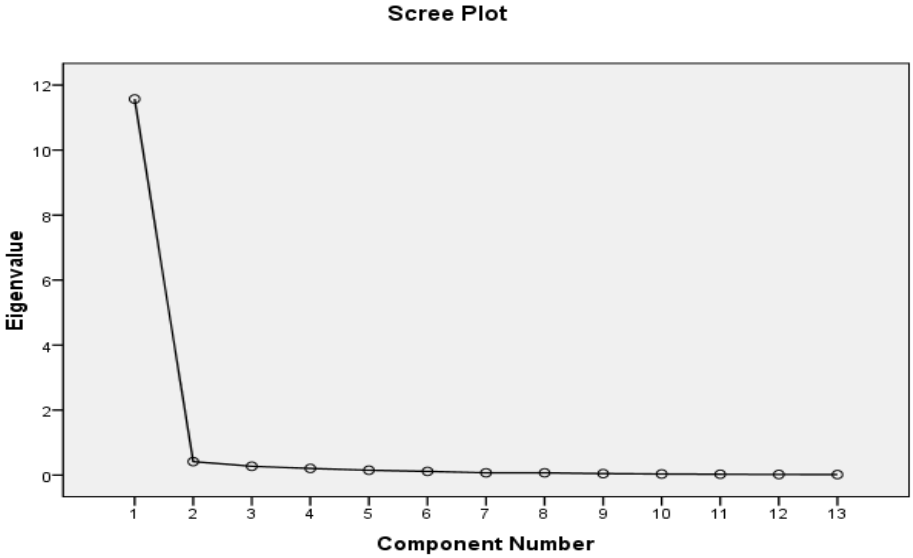

Figure 2: Scree plot for the swine body morphometric at weaning.

There is a high eigen variance of approximately 89% for component 1. The communalities' value ranges from 0.79 to 0.96. Table 8 shows the PCA of the swine morphometric at weaning component 1 provides the best description with HeW, HL, RH, and LS being the best morphometric for describing this data. The total Eigenvalue and percentage variance are 11.57 and 89% respectively for component 1 while that for component 2 are 0.41 and 3.19 respectively.

Table 8: Principal Component Analysis for the swine morphometric at weaning

	Component				
Morphometric(cm)	1	2	3	4	5
HeW	.974	-.014	-.037	-.052	.074
HL	.980	-.015	.064	-.046	.051
LS	.982	.014	.043	-.001	.053
WH	.912	.024	.066	.342	-.208
BL	.979	.008	-.036	-.057	-.038
IW	.928	.250	.002	-.167	-.152
PG	.970	-.098	-.075	.071	.042
HG	.888	-.176	-.394	.057	.062
EL	.949	-.065	-.034	-.168	-.128
HW	.966	.039	.051	-.070	-.052
TL	.876	-.329	.303	-.006	.093

Hew = head width, HL = hinge length, LS = length of snout, WH = wither height, BL = body length, LW = liveweight, HG = hinge girth, EL = ear length, HW = hip width, TL= tail length

Table 9: Eigenvalues for weaning performance of swine

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11.570	89.003	89.003	11.570	89.003	89.003
2	.415	3.192	92.195	.415	3.192	92.195
3	.271	2.085	94.280	.271	2.085	94.280
4	.204	1.570	95.850	.204	1.570	95.850
5	.150	1.152	97.002	.150	1.152	97.002
6	.114	.875	97.877			
7	.070	.538	98.414			
8	.068	.525	98.939			
9	.045	.345	99.284			
10	.034	.261	99.545			
11	.025	.190	99.734			
12	.019	.145	99.879			
13	.016	.121	100.000			

Extraction Method: Principal Component Analysis.

Table10: Communalities for weaning morphometric

Morphometric(cm)	Initial	Extraction
HeW	1.000	.959
HL	1.000	.970
LS	1.000	.970
WH	1.000	.997
BL	1.000	.965
HG	1.000	.981
EL	1.000	.950
HW	1.000	.945
TL	1.000	0.976

Hew = head width, HL = hinge length, LS = length of snout, WH = wither height, BL = body length, LW = liveweight, HG = hinge girth, EL = ear length, HW = hip width, TL= tail length

The communality values for the variables were very high at both pre-weaning and weaning as shown in Tables 7 and 10 with the highest being Heart Girth at pre-weaning (0.999) and Wither Height at weaning (0.997) which implies high level of variance distribution among the variables and thus very good for PCA distribution.

DISCUSSION

A cheaper and alternative means of estimating liveweight of pigs will make management of pig herd easier and better especially where weighing scales are not readily available. The summary statics showed an average pre-weaning weight of 5.54 and weaning weight of 7.47. This shows an improvement in liveweight with age. The same improvement was also seen in other morphometric.

The correlation coefficient which shows the relationship between two variables showed that all the body parameters measured were strongly correlated and highly significantly ($p < 0.01$) with the highest coefficient of correlation being 0.885 (pre-weaning Head width and weaning Hip Width). The pre-weaning and weaning correlation (0.832) show the pre-weaning selection of weight will affect weaning performance with respect to weight. However, liveweight has high correlation coefficient with all the parameters. There was similar observation by Oluwole *et al*. (2014) who reported high correlation coefficient between length of snout and liveweight. Tegbe and Olorunda (1998) and Adeola (2013) reported similar positive correlations between liveweight and body measurements in pigs while Afolayan *et al*. (2006), Salako (2004) observed the same for sheep. However, there was a contrasting report by Bello and Adama (2012) in which they observed a significant negative association between ear length and height at wither (0.774) and highest positive coefficient of correlation between body weight and chest girth (0.677) for goat. This could be as a result of the differences in the animals used. The results of this experiment imply that the selection of any of these body parameters at pre-weaning will translate to near proportionate performance with the strongly associated parameter at weaning. The implication of the positive relationships in the present study is that body weight could be estimated from body measurements, especially under village conditions where scales are not readily available.

The coefficient of determination ranges between 85 and 93.3% at pre-weaning and 90.1 and 94.2% at weaning. The best prediction for weight using only one parameter was HeW with 85% R^2 at pre-weaning and BL with 90.1% R^2 at weaning. The highest values of coefficient of determination (R^2) are 93.3% and 94.2% at pre-weaning and weaning respectively, when other body linear measurements were included in the models. A combination of heart girth, tail length, ear length, hinge length and wither height will give the best predictive model for liveweight at pre-weaning while wither height, length of snout, ear length, hearth girth, body length, and tail length will give the best prediction for liveweight at weaning. The overall coefficient of determination is high with the least being 85% for swine at pre-weaning. The least for swine at weaning is 90.1%. It can be inferred from the models that swine body weight was better predicted at weaning. Khargharia *et al.* (2015) had similar observation for body weight prediction in goat where he reported 74% R^2 when only body length was included and 87% when other linear body measurements were included. Santanu *et al.* (2021) showed heart girth as a better prediction of liveweight at pre-weaning and also not that such relation was non-linear. Pig producers and researchers could estimate the liveweight of pigs by substituting the values of linear measurements in any of the equations shown. The differences in this equation with others above could be due to the variations in the number and type of morphological measurements used in different studies including climate, nutrition, management and environment as reported by Islam *et al*., (1991) and Benyi, (1997).

Kaiser-Meyer-Olkin Measure of Sampling Adequacy for the principal component analysis showed that the data collected at both pre-weaning (89.4%) and weaning (95.3%) were adequate for the analysis. This is because Kaiser (1974) recommended 0.5 or 50% for sample adequacy and the result of this experiment far outweighs that. The proportion of variance can be used to explain the significance of the principal component of the observed data. The cumulative variance of commonalities ranged between 0.997 to 0.945 for weaning and 0.999 to 0.941 for pre-weaning. Anye *et al.* (2010) reported high commonalities in guinea pigs at weaning and weaning. This means that high variance had been shared among the various variables and could therefore be classified by the PCA. On individual component basis, the principal component variance of 82.318 and 5.58% for component 1 and 2 respectively at pre-weaning (6 weeks) and 89.00% and 3.19% for component 1 and 2 respectively at weaning (14 weeks) are best be used in describing the significance of the component as observed in the scree plot where both curves terminate at component 2 with near strait horizontal line in other components. Most of the data on traits used in the principal component analysis can be used in describing the swine at pre-weaning from component 1 with the best being hinge length (0.974) and length of snout (0.969). Khargharia *et al.* (2015) observed that body length, rump height and heart girth contributed to the high variance in component 1 while Ajayi and Oseni (2012) reported heart girth, hinge leg length, and thigh length as the highest contributors to variance in component one of the PCAs. Therefore, in principle component 1, the hinge length and snout length were the most closely related. All the parameters can be used for the description of the animal with the best being hinge length (0.98) and length of snout (0.982). It can be observed from this finding that the length of the snout and hinge length plays a vital role in pig description as similar effects were found at both pre-weaning and weaning. One can also infer that the two parameters can actually help in swine classification and morphology and this according to Oga et al. (2009) could be due to strong genetic influence. A relationship can thus be said to exist between pre-weaning and weaning morphometric of swine and the regression models shows that these variables can be used in the prediction of the performance of these animals for selective breeding strategy.

CONCLUSION

The study concluded that body linear measurement had a positive correlation with liveweight. The multiple regression model was better in predicting liveweight at weaning than at pre-weaning. The principal component analysis showed that component 1(Head width) has the highest Eigenvalues, which is the best for describing the animals morphologically. The results of this studies showed that relationship exist between the body morphometric of pigs at pre-weaning and weaning and thus can exploited in selective breeding based on phenotypic traits.

It can therefore be recommended that in every swine breeding programme The pre-weaning and weaning performance parameters are very vital; Selection can be done based on the morphometric relationship that exist between pre-weaned and weaned piglets; That nonlinear relationship between these morphometric parameters be estimated and compared with their linear relationship.

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