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Growth Performance and Weight Estimation of Large White Piglets Weaned at Different Ages

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Abstract

The study was carried out on 24 neonatal large white piglets at the National Livestock Breeding Station, Pong-Tamale to assess their performance when weaned at different ages and to determine the relationship between linear body measurements and the body weight of piglets in weight prediction. The piglets were randomly weaned at three selected weaning ages (4, 6 and 8 weeks) but reared under uniform conditions. Initial body weight (BW), initial body length (BL), initial chest girth (CG) and initial height at withers (HW); were measured. Weekly measurements of the parameters were taken for 20 weeks. By the 20th week, piglets weaned at 8 weeks were superior (P<0.05) by chest girth (58.14 cm) and body weight (18.43 kg) than those weaned at 6 weeks (50.50 cm and 12.79 kg) and 4 weeks (52.61 cm and 14.56 kg). No significant differences (P>0.05) were recorded in the body length and the height at withers of the selected weaned ages. The chest girth was the best predictor of body weight, yielding highest prediction accuracies of 92.3% (at 5 weeks), 76.9% (at 10 weeks), 86.1% (at 15 weeks) and 87.5% (at 20 weeks). Conclusively, large white piglets grew better when weaned at 8 weeks, and chest girth could be reliably used to predict body weight in large white grower pigs.

Keywords*: Swine, body measurements, linear, livestock, prediction*

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INTTRODUCTION

Pig keeping is of great value to most Ghanaian households because of the reasons that pigs are highly prolific and also grow faster than most other animals [1]. In Ghana, swine production is mainly subsistence with a few commercial pig farms, and housing systems are mainly intensive although the free range system is common in most rural communities. In 2012, the total swine population was about 602000 (0.87% of the total livestock population) while domestic pork production was 20224 MT (15.92% of domestic meat production in Ghana) [2], an indication that pig was a major contributor to domestic meat production. The increasing demand for pork requires the production of fast growing pigs as well as management systems that facilitate fast growth.

Growth is a fundamental property of all living organisms and can be defined as the increase in the number of cells and body size over a period of time [3]. In studies of animal growth, linear body measurements (LBM) such as chest girth, height at withers and body length are used to relate dimensions to an animal's overall body size [4]. This is because linear dimensions are directly related to bone development and so any physical growth in LBM is easily noticed. LBM can be taken on many species and are useful in comparing individual animals, breeds of animals, farm performance and even geographical distribution of a species. The need to estimate live weight from simple and more easily measurable variables such as LBM is increasingly being explored in sheep [5], goats [6], cattle [7], and pigs [8–11]. Since changes in body measurements reflect growth in livestock, it is necessary to consider how body measurements are affected by weaning age in piglets in northern Ghana. Weaning is the process of gradually introducing the piglet to different sources of feed and withdrawing the supply of milk by the sow. It may be a stressful period for piglets as they are separated from the sow (mother) into a new environment where they may be mixed with piglets from other litters and presented with different source of feed and water. Piglets weaned early (3 to 4 weeks) have a higher mortality rate and require more attention [12–13], while late weaning (8 weeks and beyond) increases post-partum anoestrus which eventually affects the number of piglets born per sow per year. The variations in the growth performance of piglets weaned at different ages create uncertainties among farmers as to the appropriate age at which piglets should be weaned to ensure optimum growth performance. This experiment was therefore conducted to assess the growth performance of large white piglets weaned at different ages and to develop models for estimating live body weight from LBM.

MATERIALS AND METHODS

Study Area

The study was conducted at the National Livestock Breeding Station, Pong-Tamale, which is located on latitude 9°40′N and longitude 0°49′W [14]. The annual rainfall pattern is erratic at the beginning of the rainy season (in April), and intensifying as the season advances, raising the average from 600 to 1000 mm. Temperatures ranged from 16°C (December–February) to 42°C (March–April) with a usually high average of about 34°C. Average humidity is about 42% between November and March and 80% between June and October. The north-east trade wind (Harmattan) is experienced between November and March [15].

Management of Experimental Animals and Experimental Design

A total of 27 piglets comprising of 14 males and 13 females all furrowed within 42 h by three different breeding sows were identified by ID numbers, given iron injection and their teeth clipped within 72 h after birth. The breeding sows together with their piglets were managed under intensive management system of production. Neonatal piglets were allowed to stay with their dams in the breeding block until weaning. The sty floor was made of concrete and wallows provided. Conventional feeding and medication regimes were followed. Completely randomized design was used where three sets of three piglets (both sexes) each per sow were selected at random from three different sows and subjected to three different weaning ages (4, 6 and 8 weeks) with weaning at 6 weeks as control. Each set of piglets weaned at a given age were housed together but as they were approaching puberty, they were separated according to sex into different stays in order to prevent them from mating.

Data Collection

The birth weight and chest girth were measured within 24 h of birth. Subsequently, growth parameters (body weight, chest girth, height at withers and body length) were measured weekly in the morning before feeding. The LBM were taken using measuring tape. The experiment lasted for twenty weeks after birth. The parameters are described as follows:

Bodyweight (BW): It was the mass of the live body, and measured using an electronic weighing bridge.

Chest Girth (CG): This was measured as the distance around the circumference of the chest just behind the forelimbs.

Body Length (BL): This was measured from the base of the tail to the base of the neck right above the shoulder.

Height at Withers (HW): This was measured as the distance from the ground to the top of the shoulder of the animal in standing position, with the aid of a metal rule.

Statistical Analysis

The data was subjected to analysis of variance (ANOVA) using Genstat (4th Edition) to obtain the effect of weaning age on weight gain and linear measurements. A 2D line graph was employed to obtain the growth pattern of all body parameters measured at the various weaned ages. Phenotypic correlations among body traits were generated using Pearson's correlation coefficients in SPSS (version 17). Simple and multiple regression models were used to regress body weight on the LBM to determine the best models for prediction of body weight. The respective simple and multiple regression models were defined as:

$$BW_i = \beta_0 + \beta_1 X_i + \varepsilon_i \quad (1)$$

$$BW_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \varepsilon_i \quad (2)$$

Where; BW_i= dependent variable (body weight) of *i*th animal; β_0, β_1, β_2, and β_3= regression parameter(s); X_i = independent variables (BL, CG, HW); ε_i = random error.

RESULTS

Growth Performance of Piglets Weaned at Three Different Ages

The results showed that initial measurements of all traits were generally similar, hence no significant differences (P>.05) were detected among them (Table 1). The initial measurements of the live weight and all traits on neonates were done at birth, and so being similar was an indication that maternal effects of sows did not affect body measurements of the piglets. Clearly, the weaning age had a significant (P<.05) effect on the growth performance of the piglets in the final chest girth and the final body weight measured at the twentieth week, as well as the respective weekly gains (Table 1). However, weaning age had no significant (P>.05) effect on the body length and height at withers of all the piglets throughout the 20 weeks of growth.

***Table 1:** Effects of Weaning Age on Weight Gain and Linear Body Measurements.*

Body Trait	Overall Mean	Weaning Ages (Weeks)			SED	*P*value
		4	6	8		
Initial Body Length (cm)	24.83	25.17	23.71	25.44	1.035	0.25
Final Body Length	62.5	62	59.3	66	3.17	0.14
Weekly Gain in Body Length	2.111	2.087	2.011	2.224	0.186	0.53
Initial Chest Girth (cm)	28.83	30.28	27.86	28.06	1.526	0.22
Final Chest Girth	53.84	52.61^a	50.50^a	58.14^b	2.467	0.02
Weekly Gain in Chest Girth	1.427	1.266^a	1.279^a	1.737^b	0.126	0.001
Initial Withers Height (cm)	21.02	21.94	20.07	20.81	0.753	0.06
Final Withers Height	38.89	38.94	37.21	40.29	1.590	0.20
Weekly Gain in Withers Height	1.003	0.943	0.969	1.101	0.072	0.08
Initial Body Weight (kg)	2.30	2.52	2.09	2.24	0.261	0.25
Final Body Weight	15.33	14.56^{ab}	12.79^a	18.43^b	1.875	0.02
Weekly Gain in Weight	0.727	0.669^a	0.589^a	0.913^b	0.098	0.01

[ab] Within a row, means with different superscripts differ significantly (P<0.05).
SED= Standard Error of Difference.

From the graphs (Figures 1–4), the body measurements seem to increase in a curvilinear pattern over age in all the weaned ages. At the start of the experiment, there were virtually no variations for all body traits among the three selected weaning ages. The growth in body length (Figure 1) was very similar for all piglets, with marginal difference appearing only after the 14th week. In Figure 2, the lines got wider apart after the 18th week, indicating clear difference in the growth of chest girth between piglets weaned at 8 and those weaned at 6 weeks. The pattern of increase in the height at withers of piglets was inconsistent, appearing to be undulating even though it increased in a curvilinear pattern (Figure 3). As the piglets grew, the differences in all the body measurements became obvious with piglets weaned at 8 weeks appearing superior, especially for live body weight (Figure 4).

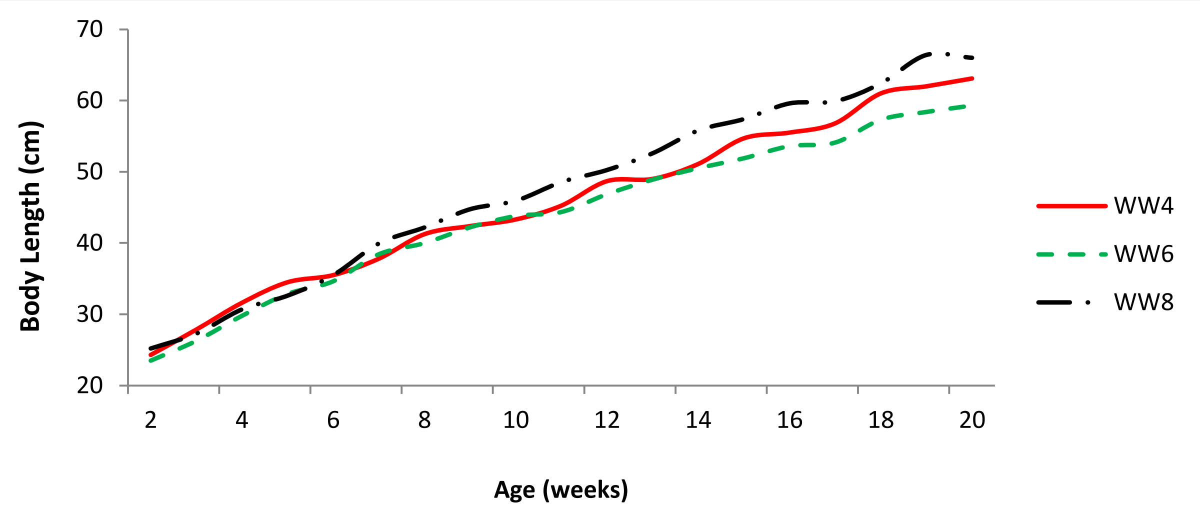

Fig. 1: *Growth Pattern of Body Length as Influenced by Weaning Age.WW4= Weaned at Week 4, WW6= Weaned at Week 6, WW8= Weaned at Week 8.*

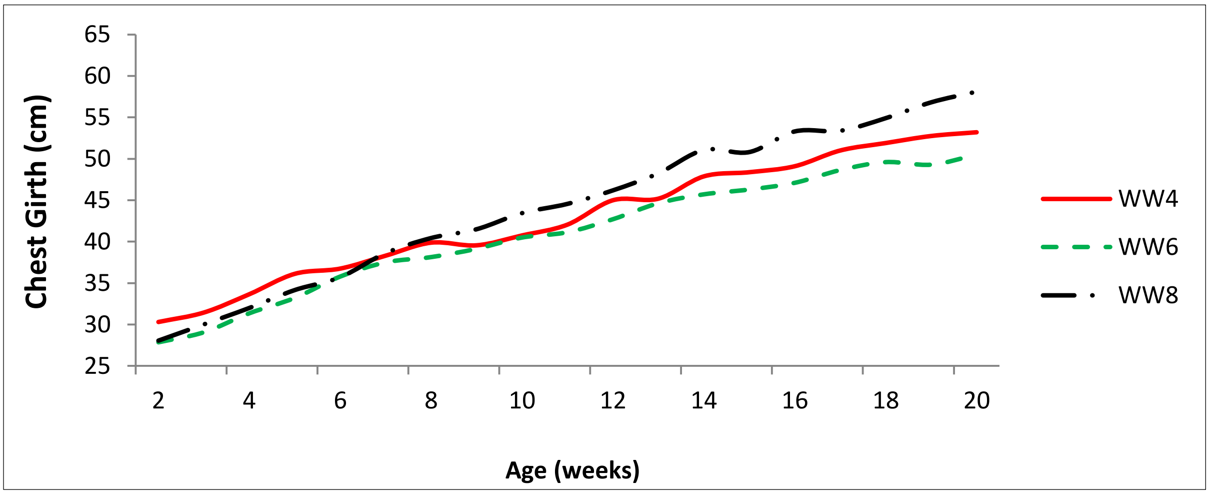

Fig. 2: *Growth Pattern of Chest Girth as Influenced by Weaning Age. WW4= Weaned at Week 4, WW6= Weaned at Week 6, WW8= Weaned at Week 8.*

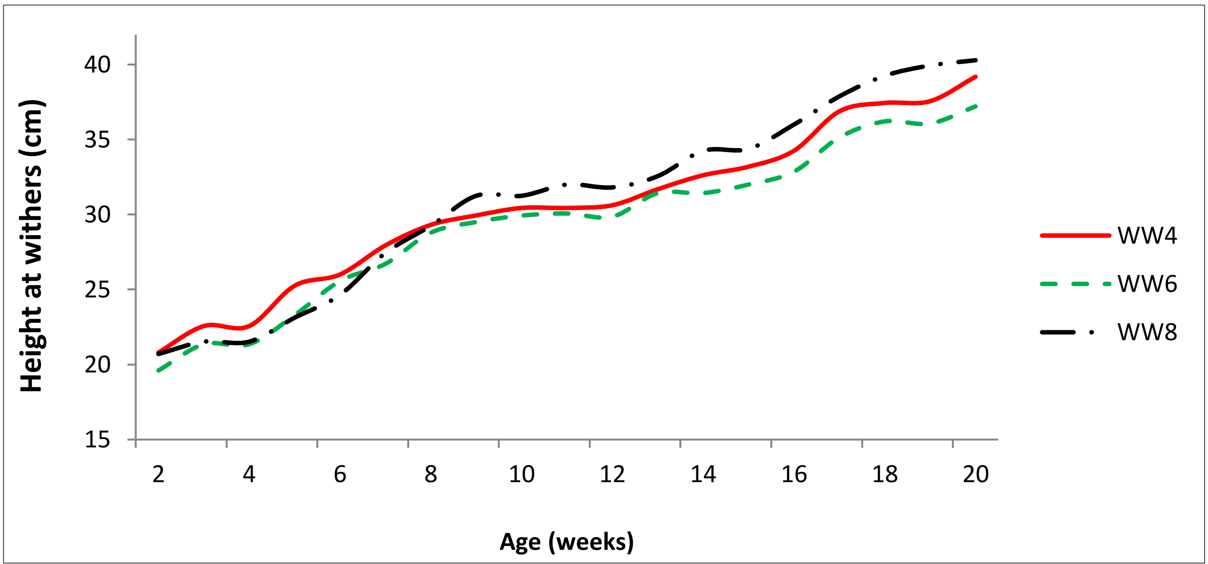

Fig. 3: *Growth Pattern of Wither Height as Influenced by Weaning Age. WW4= Weaned at Week 4, WW6= Weaned at Week 6, WW8= Weaned at Week 8.*

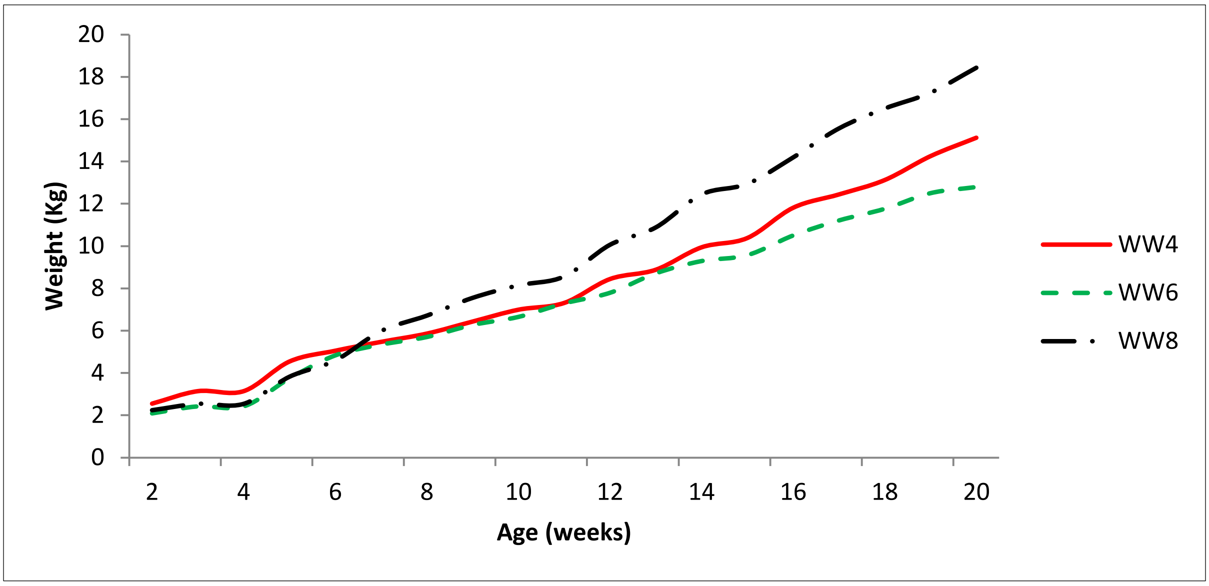

Fig. 4: *Growth Pattern of Live Body Weight as Influenced by Weaning Age. WW4= Weaned at Week 4, WW6= Weaned at Week 6, WW8= Weaned at Week 8.*

Prediction of Body Weight from Linear Body Measurements

The correlation coefficients between pairs of body traits were very highly significant (P<0.001) for all ages (Table 2). From 5th to 15th weeks, the highest correlations were obtained between body weight and chest girth, while the least correlation was recorded in the 10th week between body weight and height at withers. The high correlations of the traits indicate that, LBM (body length, chest girth and height at withers) have strong relationships with one another.

Table 2: *Phenotypic Correlations of Body Weight and Linear Measurements at Some Selected Ages.*

Age (Weeks)	Body Traits	Body Length	Chest Girth	Height at Withers
5	Body Length			
	Chest Girth	0.785**		
	Height at Withers	0.745**	0.841**	
	Body Weight	0.826**	0.963**	0.867**
10	Body Length			
	Chest Girth	0.853**		
	Height at Withers	0.837**	0.717**	
	Body Weight	0.854**	0.903**	0.809**
15	Body Length			
	Chest Girth	0.844**		
	Height at Withers	0.904**	0.827**	
	Body Weight	0.897**	0.929**	0.840**
20	Body Length			
	Chest Girth	0.943**		
	Height at Withers	0.911**	0.879**	
	Body Weight	0.884**	0.936**	0.897**

***Very Highly Significant (P<0.001; Pearson Correlation Analysis).*

From Table 3, there were relatively high levels of significance (P<.001) associated with all the regression equations of the linear models. The worst predictor of body weight was HW at 10 weeks while the best predictor was CG at 5 weeks. The prediction accuracies ranged from moderate in week 10, to high in week 5. The multiple linear models (Table 4) predicted live body weight of piglets better (with over 80% accuracy) than most of the simple (one trait) linear models. Weight prediction accuracy from multiple regression models was least in the 10th week while the best multiple regression model was recorded at the 5th week with the equation:

$$BW = 0.0433(BL) + 0.211(CG) + 0.0594(HW) - 6.109 \quad (3)$$

Table 3: *Parameter Estimates for Simple Linear Regression of Live Body Weight (kg) on Linear Body Measurements (cm) at Selected Ages.*

Ages (wks)	Trait	Parameter		P-value	Adj. R^2
		β_0	β_1		
5	BL	–4.11	0.2453	<0.001	0.652
	CG	–5.767	0.2841	<0.001	0.923
	HW	–3.496	0.3146	<0.001	0.728
10	BL	–8.83	0.3627	<0.001	0.724
	CG	–9.28	0.3963	<0.001	0.769
	HW	–11.20	0.6036	<0.001	0.645
15	BL	–15.51	0.4841	<0.001	0.802
	CG	–17.46	0.5863	<0.001	0.861
	HW	–25.54	1.0990	<0.001	0.699
20	BL	–20.66	0.5746	<0.001	0.787
	CG	–22.61	0.7047	<0.001	0.875
	HW	–29.85	1.1600	<0.001	0.783

β_0 and β_1 are parameters estimated in the simple linear regression analysis.
The P-values are the probabilities of each simple linear regression;
Adj. R^2 is coefficient of determination which indicates prediction accuracy of each regression model.
BL= Body Length, CG= Chest Girth, HW= Height at Withers.

Table 4: *Parameters for Multiple Linear Regression of Live Body Weight on Linear Body Measurements.*

Age	Trait	Parameter				Adj.R^2
		β_0	β_1	β_2	β_3	
5	BL+CG+HW	–6.109	0.0433	0.2110	0.0594	0.937
	P-value	<0.001	0.11	<0.001	0.11	
10	BL+CG+HW	–12.56	0.0605	0.2452	0.226	0.830
	P-value	<0.001	0.50	0.003	0.07	
15	BL+CG+HW	–17.99	0.2325	0.3838	–0.071	0.897
	P-value	<0.001	0.02	<0.001	0.74	
20	BL+CG+HW	–27.33	–0.085	0.581	0.430	0.886
	P-value	<0.001	0.59	0.002	0.06	

β_0, β_1, β_2 and β_3 are the parameters estimated in the multiple regression analysis.
Adj. R^2 is coefficient of determination which indicates prediction accuracy of each regression model.
P-values are the probabilities of each regression parameter in multiple linear regression.
BL= Body Length, CG= Chest Girth, HW= Height at Withers.

DISCUSSION

Growth Performance of Piglets Weaned at Three Different Ages

Since the initial measurements of the live weight and all traits on neonates were done at birth, the statistical homogeneity of these traits suggest that maternal effects (sows) did not have differential influences on development of foetus during gestation. The significantly highest chest girth and weight of piglets weaned at 8 weeks in this research contradict a much earlier report that early weaning resulted in higher growth performance [16], but agree with another research which observed that an increase in weaning age improved the productivity of piglets [13]. The superior performance of the late weaned piglets may be attributed to the fact that they were well nourished from milk intake and had physiologically matured digestive systems for effective digestion of solid food. Researchers opined that piglets weaned at much younger age spent short time with their mothers thereby not getting enough nourishment and not having a physiologically matured digestive system for the digestion of solid food [12]. The similarities in body lengths and also in heights at withers of all the piglets implied that the animals were generally similar in physical appearance (body size). It suffices to say that in the large white piglets under study, differential development resulting from weaning at different ages occurred only in the chest girth, eventually translating into the differential live body weight of the animals. It has been observed that inconsistent growth performance throughout the finishing phase; abnormal feed intake and variation were some of the disadvantages of early weaning of piglets [17].

The seemingly higher growth of all the body measurements of the piglets weaned at 8 weeks suggest a form of marginal advantage over piglets weaned at younger ages. Probably when weaning is delayed, piglets receive more milk and care from the mother sow thereby obtaining growth advantage over piglets weaned at much younger ages. This result however disagrees with a much earlier report in which earlier weaned piglets put on weight at a faster rate than those that are weaned latter [16]. It is not clear why piglets weaned at 6 weeks grew generally poorest. Inconsistency in growth pattern of body parameters have been attributed to variations in weaning ages [17]. On the average, piglets weaned at 8 weeks were fast growing and are expected to reach matured size and weight earlier than piglets weaned at earlier ages.

Prediction of Body Weight from Linear Body Measurements

The high correlations of the traits reflect strong relationships among body traits, which may be used to predict body weight with ease. The correlation between heart girth and body weight for pre-weaned large white piglets in this study was comparable to 0.975 obtained in growing to finishing gilts in Nigeria [11], and 0.944 recorded in Landrace and large white pigs in Zimbabwe [9] but higher than 0.81 reported in crossbred hybrid of Nigeria indigenous pig and large white [8]. A recent research reported generally high correlation values between body weight and linear body measurements in indigenous and crossbred pigs in southern Nigeria [10].

The highest correlations of chest girth with body weight at all ages observed herein is in line with earlier findings in pigs [10], sheep [5] and goats [6] in which chest girth exhibited the highest correlations with body weight of live animals. The correlation between body length and body weight in the present study was higher than 0.74 recorded in crossbred piglets in Nigeria [8], but comparable to the findings from a study on Landrace and large white pigs in Zimbabwe [9]. All the correlation coefficients in this study were generally higher than values obtained from Kankrej cows in India [7]. The higher phenotypic correlations of pigs in this study compared to correlations in other livestock species may be attributed to variability in data measurement or the different species of animals, and also suggest better relationship of body measurements in pigs than in most livestock species [5–7]. The knowledge of correlations is particularly important in relation to weight estimation from linear body traits. The live body weight of farm animals is the single most important growth and economic trait that most stockmen and processors of animal products in sub-Saharan

Africa pay keen attention to. In making management or marketing decisions, livestock dealers use any possible means to estimate weight of livestock. Even though the use of conventional weighing scales is the best way of determining the live body weight of an animal, its estimation from linear body measurements is gaining research attention of late [5, 11].

The prediction accuracies of simple linear regressions in this study were lower than 98% reported from grower-finisher for pigs [18]. Higher prediction accuracies of weight ranging from 89.2 to 96% have been reported in Landrace and large white pigs reared under different environmental conditions in Zimbabwe [9]. An accuracy of 92.92% obtained from chest girth was earlier reported in sheep [5]. In general, chest girth was the best predictor of live weight in all the selected ages in the present study, which is in line with earlier reports that chest girth is the most important parameter in the prediction of live weight of animals [5, 10–11]. Previously, it has been suggested that the addition of other linear measurements (like height at withers and body length) to heart girth could improve the predictability of the resultant equations [19]. Such a suggestion was supported by the findings of the present study since the multiple linear models predicted live body weight of piglets better than most of the simple (one trait) linear models (Table 4).The accuracies for multiple regression models in this study were comparable to 86% accuracy obtained in crossbred pigs in Nigeria [8] but slightly lower than 97.2% accuracy obtained for pigs in Zimbabwe [9]. A prediction accuracy of 95.63% had been reported from pigs in Nigeria [11].

In communities or farms where measuring scales are not available, then weight prediction from LBM becomes a laudable alternative because accurate prediction of weight will lead to optimum production and value-based trading system. This will eventually result in adequate reward to swine (livestock) farmers and also serve as motivation to people who are contemplating going into swine production. The findings of this study indicate that, live weight of grower pigs (up to 20 weeks) can be reliably predicted from LBM especially chest girth. It is recommended that a further study which considers cost of feeding and includes more piglets be conducted to determine the economic effects of the selected weaning ages.

CONCLUSION

Weaning age significantly affected chest girth and body weight as piglets weaned at 8 weeks had far larger chests and weighed heavier than those weaned at earlier ages. Among the linear body measurements, chest girth was the best predictor of body weight irrespective of the age of the piglet. Generally, multiple traits gave higher prediction accuracies than single traits. The weights of large white piglets can be predicted with high accuracy using linear body measurements.

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