LINEAR BODY MEASUREMENTS AS PREDICTORS OF LIVE WEIGHT OF THE LARGE WHITE PIG IN NORTHERN GHANA

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ABSTRACT

This study was undertaken to determine the correlation between live weight and three linear body measurements: heart girth (HTG), body length (BDL) and pin bone to pin bone (PB-PB) of 105 (30 – 240+ days old) Large White pigs (LWP) and to develop a regression equation for body weight based on these measurements. This is to facilitate easy determination of the live weight of pigs by measuring specified sections of its body with a tape measure. The correlation coefficient of the various variables for pigs up to 90 days old showed no significant difference ($P>0.05$). For age ranges 121 to 240 days and above, correlation was high and significant ($P<0.05$). The high significance of correlation from age 121 to 240 days and above showed that linear body measurements had high relationship between one another and with weight. The correlation of HTG with BWT was 0.954, BDL with BWT was 0.952 and PB-PB with BWT was 0.891. From the regression analysis, when all the variables were fitted in a model, only BDL, HTG and Age range were found to be significant ($P<0.05$). The final equation for live weight was BWT (kg) = $- 3.95 + 4.8 \times 10^{-5}$ $[(HTG)^2 \times BDL] + 3.98$ (Age range) with a coefficient of determination of $R^2 = 93.5\%$ and adjusted $R^2 = 93.3\%$ which were reasonably high. Thus, given the age of the pig, HTG and BDL, the BWT can be predicted using this model to near 94% surety.

Keywords: *Large White pig, body weight, heart girth, body length, pin-bone, correlation, regression*

INTRODUCTION

Weight is an important parameter in animal production. Feeding and medication are based on the body weight of the animal. According to Holness (1991), growth is measured by increase in body weight. While Kosum *et al.* (2004) noted that weight is an important selection objective. Otoikhian *et al.*, (2008) summed it all by stating that weight is the pivot on which animal production thrives. Pricing of animals is based on live weight. When animals are priced and bought by visual appraisal as in our traditional practice, invariably, the middlemen gain and farmers lose. This can be addressed by weighing and selling the animal on price per kg live-weight basis.

Most Ghanaian farmers who are mainly small scale producers cannot afford the cost of weighing scales and accessories and the skills to use and maintain them properly. Hence the need for effective alternative ways of determining weight in pigs. Researchers, including Lawrence and Fowler, (1997), Baffour-Awuah *et al.* (1999) and Groesbeck *et al.* (2003) had used linear body measurements (LBM) to determine the live weight of cattle, sheep and pigs.

This work sought to determine the correlation of live weight of the Large White pig (LWP) with linear body measurements (LBM) such as body length (BDL), heart girth (HTG) and pin -bone to pin-bone (PB-PB) and to develop a regression equation for body weight based on the LBM. By this, a simple tape measurement may then be used to determine the animal's weight.

MATERIALS AND METHODS

Location of the Study

The study was conducted at the Pong-Tamale Livestock Breeding Station of the Ministry of Food and Agriculture (MoFA), in the Northern Region, Ghana, located between latitude 9° 40" S and longitude 0° 52" W. This is a government station that multiplies purebred LWP for sale to farmers. The Station falls within the Guinea Savanna grassland agro-ecological zone of Ghana.

Management of Pigs on the Station

Pigs were intensively managed and penned in groups according to age and production stage. Feeding was twice daily using conventional and non conventional feed ingredients including, maize, fish meal, corn chaff, wheat bran, grower concentrate, salt and vitamin premix.

The weaner and grower-finisher diets contained 18 and 12% crude protein and 12 and 11 MJ/Kg metabolizable energy, respectively. Water was given *ad libitum.* The best 10% were retained for breeding, while the next 20% best were released for on-farm breeding programmes and the rest sold for meat production.

Parameters Measured

Body length, heart girth and distance between the iliac crest on either side of the waist (pin-bone to pin-bone) were taken using a tailor's tape. Each pig was weighed just after the linear measurements. Data on 105 pigs, (42 males and 63 females) were taken. All parameters were measured in the morning before feeding.

Experimental Design and Statistical Analysis

All pigs on the Station above 29 days old at the time of data collection were investigated. The data was partitioned into five age groups (30 – 60, 61 – 90, 121 – 180, 181 – 240, and 240^{+} days) to match the various growth and developmental stages of the pigs. There were no pigs in the age group 90-121days as at data collection time. Data were pooled together and Pearson's correlation and regression equations were obtained at 95 % confidence level using the 15^{th} edition of Minitab Software.

RESULTS AND DISCUSSION

Weight and Linear Body Measurements

The average measurements of BWT, HTG, BDL and PB-PB are as presented in Table 1. In general, males showed heavier weight than females in this study. This supports the findings of Lawrie (1985), who reported that muscles in males tended to be weightier than corresponding muscle in females at the same age and management and that males were larger and heavier than female. Muscle size affects weight of animals positively. Females exceeded males in number because males were disposed off more frequently as pigs grew for use as breeding stock on other farms while most of the high performing females were retained in the flock.

In this study males were only narrowly (10.8 and 5.8 % heavier than females at age ranges of 121 - 180 and 181 – 240 days respectively), but lost to the females at age 241 days and above with a percentage difference of 18.3. The difference could be attributed to unequal

Table 1: Mean (±SE) for Body Weight (kg) and Linear Body Measurement (cm)

Age (days)	Sex	NO.	BWT	BDL	HTG	PB-PB
30-60	M	4	8.13±0.38	52.25±1.31	45.25±0.95	17.00±0.41
	F	3	7.00±0.75	50.33±1.76	42.67±1.86	16.33±0.33
	Both	7	7.64±0.42	50.86±0.99	44.14±1.01	16.71±0.29
61-90	M	3	9.33±0.44	52.33±2.60	48.33±1.45	17.67±0.33
	F	2	10.00±0.50	59.00±2.00	48.00±0.00	18.00±1.00
	Both	5	9.60±0.33	55.00±2.26	48.20±0.80	17.80±0.37
121-180	M	7	20.36± 1.19	68.71±1.69	61.00±1.50	18.86±0.46
	F	9	18.83±0.84	67.89±1.91	59.11±0.73	18.44±0.50
	Both	16	19.50±0.71	68.25±1.27	59.94±0.78	18.62±0.34
181-240	M	23	28.87±1.69	76.90±2.30	69.20±1.50	22.22±0.60
	F	19	27.29±1.45	77.00±1.60	68.80±1.70	24.16±0.56
	Both	42	28.21±1.13	76.95±1.43	68.93±1.10	23.10±0.44
241^+	M	5	64.10±9.86	115.80±7.77	93.40±4.76	27.20±1.46
	F	30	78.50±4.30	122.20±3.20	99.40±2.40	29.70±0.70
	Both	35	76.50±3.90	121.30±3.00	98.51±2.18	29.37±0.62

M = Male; F = Female; BWT = Body Weight, BDL = Body length; HTG = Heart girth; PB-PB = Pinbone to pinbone.

sex representation (there were more females than males) in the sample. When the linear body measurements were compared, males and females differed in measurements at the various age ranges. Averagely, females were about 2.8 % longer, 0.2 % broader at the chest and 3.5 % wider at the waist. These may be useful for efficient reproduction.

Pigs grow in a pattern that suits their requirement for survival. After nervous tissue development, the skeleton grows to enhance movement and balance (Lawrence and Fowler 1997). Skeletal growth involves high deposition of minerals such as phosphorous and calcium. However, weight increases more with protein accretion which is accompanied by high water levels and some fat and mineral integration into the tissue. This probably explains why the increase in linear body measurements in the early stage of the pigs did not bring about a corresponding change in weight.

Correlation Analysis

In the correlation analysis (Tables 2 and 3), it was noted that the correlation coefficient of the various variables for the age range 30 – 60 and 61 – 90 days showed no significance ($P>0.05$). At age ranges 121 – 180, 181 – 240 and 241 days and above, there was high significance ($P<0.05$). The non-significance in correlation in the younger age ranges showed that other factors account more to changes in weight than increase in linear body measurements and that the increase in one linear body measurement does not imply an increase in another. In some instances, the correlations between these variables were negative. The linear body measurements in age ranges 30 – 60 and 61 – 90 days have weak correlation except HTG with PB-PB and BDL with HTG. The hind and forequarters form a square with height being equal to length in piglets. Subsequently, the backbone lengthens more rapidly than the limbs thus making the pig longer but relatively shorter (Serres, 1992). This growth pattern might have continued to age 90 days; thus accounting for the low correlation and non significance between the linear body measurements. The non-significance in both BWT and the linear body measurements was explained by Lawrence and Fowler (1995) and English *et al.* (1995) that the growth curve is

Table 2: Correlation Coefficient of BWT, BDL, HTG AND PB-PB.

Age (days)	Variables	BWT	BDL	HTG
30-60	BDL	0.585^{ns}		
	HTG	0.977^{s}	0.434^{ns}	
	PB-PB	0.555^{ns}	-0.193^{ns}	0.684^{ns}
61-90	BDL	0.935^{s}		
	HTG	0.641^{s}	0.554^{ns}	
	PB-PB	0.242^{ns}	0.118^{ns}	-0.468^{ns}
121-180	BDL	0.767^{s}		
	HTG	0.626^{s}	0.611^{s}	
	PB-PB	0.877^{s}	0.750^{s}	0.511^{s}
181-240	BDL	0.871^{s}		
	HTG	0.903^{s}	0.800^{s}	
	PB-PB	0.534^{s}	0.474^{ns}	0.590^{s}
241^{+}	BDL	0.796^{s}		
	HTG	0.854^{s}	0.746^{s}	
	PB-PB	0.799^{s}	0.713^{s}	0.916^{s}

BWT = Body Weight (kg), BDL = Body length (cm); HTG = Heart girth(cm); PB-PB = Pinbone to pinbone (cm);
(^{s}) = significance (P<0.05), (^{ns}) = non significance (P>0.05)

sigmoid in sheep, cattle and pigs; where, there is a short initial fast growth phase, then a slow one and a faster growth phase until puberty (180 days in LWP).

The high significance of correlation from age range 121 – 180 days to 241^{+} days showed that linear body measurements had high relationship between one another and with weight.

A careful look at the correlation of HTG, BDL and PB-PB with BWT reveals that correlation of BDL with BWT was high in animals between the ages of 61 -90 days while HTG and PB-PB with BWT decreased. On the whole, the correlation of HTG, BDL, PB-PB and BWT with one another has been reasonably high (Table 5), where HTG with BWT was 0.954, BDL with BWT was 0.952 and PB-PB with BWT was 0.891 despite the undulating pattern (Table 5).

The non uniform pattern of correlation especially HTG, BDL and PB-PB with BWT between the age ranges of 30 – 60 days and 61 – 90 days and 121 – 180 days could be accounted for by the small size of the sample (7, 5 and 16 respectively) whereby an individual observation and/or a particular sex could influence the correlation (Table 4).

Generally, females influenced the overall correlation more than males (Table 3) for all the age ranges between 30 and 180 days except the HTG with BWT at age range 121 – 180 days. Males took over from 181 – 241 days and above (when they were sexually mature) except for HTG with BWT and PB-PB (by females).

It could be inferred from the non significance in correlation shown in Tables 4 and 5 that using the prediction equation on the animals in the age range of 30 – 60 days and 61 – 90 days, the accuracy of prediction may be low although the general accuracy of the prediction of the equation is very high.

Predictive Equation for Body Weight

From the regression analysis, fitting all the variables in a full model, only BDL, HTG and Age Range were found to be significant (P<0.05) (Table 5). It should be noted that

Table 3: Correlation Coefficient Between Body Wt. (KG) And Linear Body Measurements (CM)

Age (days)	Sex	BDL	HTG	PB-PB
30-60	M	0.063^{ns}	0.910^{ns}	0.272^{ns}
	F	0.990^{ns}	0.999^{ns}	0.655^{ns}
	Both	0.585	0.977	0.550
61-90	M	0.968^{ns}	0.954^{ns}	-0.756^{ns}
	F	1.000^{s}	1.000^{s}	1.000^{s}
	Both	0.935	0.641	0.242
121-180	M	0.765^{s}	0.927^{s}	0.884^{s}
	F	0.823^{s}	0.049^{ns}	0.912^{s}
	Both	0.767	0.626	0.877
181-240	M	0.902^{s}	0.889^{s}	0.605^{s}
	F	0.827^{s}	0.952^{s}	0.636^{s}
	Both	0.871	0.903	0.534
241^{+}	M	0.998^{s}	0.997^{s}	0.823^{ns}
	F	0.769^{s}	0.836^{s}	0.784^{s}
	Both	0.796	0.854	0.799

(^{s}) = significance ($P<0.05$), (^{ns}) = no significance ($P>0.05$);

Table 4: Summarised Correlation Matrix

Variables	BWT	BDL	HTG
BDL	0.953 (0.000)		
HTG	0.954 (0.000)	0.950 (0.000)	
PB-PB	0.891 (0.00)	0.885 (0.000)	0.932 (0.000)

(0.000) = significance ($P<0.05$)

Table 5: Regression Analysis – Full Model

Predictor	Coefficient	SE Coefficient	T	P
BDL	0.51	0.08	5.97	0.00
HTG	0.92	0.16	5.93	0.00
PB-PB	0.08	0.39	0.22	0.829
SEX	-1.19	1.61	0.74	0.461
AGE RANGE	-4.43	1.15	-3.86	0.00

HTG which gives the measure of the cross sectional area has the highest correlation (0.954) with BWT (Table 4). This is in support by the findings of Baffour-Awuah *et al.* (1999) and Groesbeck *et al.* (2003). If BWT as a function of volume, and volume is a function of BDL and cross-sectional area $(HTG)^2$, a new variable can be developed to take account of volume based on $(HTG)^2$ and BDL, i.e. volume, V = Cross-sectional area x Length = $\pi r^2 l$; where C is the circumference of the cross -sectional area (Baffour-Awuah *et al.* 1999). Taking HTG as the circumference of the cross -sectional area, one has Volume α $(HTG)^2$ x BDL. Consequently the general form of the body weight proposed is, BWT (kg) = $B_o + B_1$ $[(HTG)^2 \times BDL] + B$ (Age Range). With the data available, the final equation for live weight is then; BWT (Kg) = $-3.95 + 4.8 \times 10^{-5}$ $[(HTG)^2 \times BDL]$ + 3.98 (Age range) with a coefficient of determination R^2 = 93.5% and adjusted R^2 = 93.3% which are reasonably high.

This is far higher than what was reported by Baffour-Awuah *et al.* (1999) in the prediction equation (75.2%) for sheep using the same predictors, but lower than that of Groesbeck *et al.* (2003), i.e. R^2 = 98% where only HTG was used as the predictor of live weight in pigs.

Lawrence and Fowler (1997) reported that, there is little to be gained by including one or more variable other than heart girth in the body weight prediction equation. On the contrary, it was found out in this experiment that, regression of BWT on HTG and BDL showed R^2 to be 91.1 % and 90.7 % respectively, meaning that the regression that takes care of BWT as a function of volume gives better and more accurate predictive equation. This is explained by Baffour-Awuah *et al.* (1999-) who showed that the new predictor variable, i.e. $[(HTG)^2 \times BDL]$ takes into account the volume of an animal based on its HTG and BDL accounts for much of the variation in the BWT.

The new variable $[(HTG)^2 \times BDL]$ is referred to as the index of volume (Gordor and Howard, 1999). In the analysis, Age Range is considered as 'time variable' with (1, 2, 3, 4, and 5) for age range 30 – 60 days, 61 – 90 days, 121 – 180 days, 181 – 240 days and 241days and above. Thus given the age of the animal, HTG and BDL, the animal's BWT can be predicted from the model with a much higher accuracy at 95 % confidence level.

CONCLUSION

Correlation of body length and heart girth were generally high, indicating that body weight can be read from these linear measurements and the best single determinant of weight is heart girth in the Large White pig with a prediction of 95 % surety using the regression equation:

BWT (kg) = $-3.95 + 4.8 \times 10^{-5}$ $[(HTG)^2 \times BDL]$ + 3.89 (Age range). Pin bone to pin bone measure showed no significance in the regression analysis.

RECOMMENDATION

It is recommended that, the work be repeated when pigs, in the age range of 91 – 120 days, are available and with a larger animal population. The developed prediction equation should be validated by trying it on Large White pigs on farms.

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