Nigeria J. Anim. Sci. 2011, 13:133-142

Estimation of Live Weight of Calves from Body Measurements within Different Genetic Groups

O.O. Oni, R.A. Afolayan, I.A. Adeyinka, O.S. Lamidi and C.B.I. Alawa

National Animal Production Research Institute (NAPRI), Ahmadu Bello University, P. M. B. 1096, Shika - Zaria, Nigeria

Target Audience: Beef cattle producers, Livestock researchers, Animal breeders/scientists

Abstract

Body weight, chest girth, body length and wither height were monitored on 731 animals comprising 228 Bunaji or White Fulani (WF), 70 Sokoto Gudali (SG), 380 Friesian x White Fulani (Fr x WF) and 53 Charlolais x Sokoto Gudali (Ch x SG) calves over a 24-month period at the National Animal Production Research Institute (NAPRI), Shika, Nigeria. The effects of breed, sex, season and body conditions on these measurements were also investigated. All the variables examined, except sex, had significant ($P<0.001$) effects on all body measurements. Sex differences were significant ($P<0.05$) only for wither height. Linear body measurements were significantly ($P<0.05$) greater for the SG than for WF breed at the same age, while differences between the Zebu and the crossbred cattle were not significant. Values obtained for measurements taken during the rainy season were significantly ($P<0.05$) higher than for the dry period. Similarly, fat animals had higher measurements than lean animals, and so were the measurements for male as compared to female animals. All phenotypic correlations between body measurements were positive and significant ($P<0.001$). The highest correlation coefficient was found between chest girth and body weight. The polynomial equation using chest girth as an independent variable predicted body weight more accurately within breed as compared to the linear equation.

Key words: Calves, body measurements, live-weight

Description of Problem

Growth is one of the important selection criteria for the improvement of meat animals such as beef cattle. Measurements of growth are usually concerned with the increase in size or body weight at a given age, especially weaning or yearling. Weighbridges serve as the most reliable means of measuring live-weight changes. However, recent studies have shown that body measurements could serve either to supplement body weight as a measure of productivity (1, 2,) or as predictors of some less visible characteristics (3). In addition, body dimensional traits could be used to predict liveweight fairly well in situations where weighbridges are not available (4, 5, 6,). Almost all of these reported studies were carried out on animals older than two years of age. It has been recognized that prediction equation would not hold over all ages (6). In order to improve the accuracy of live weight prediction it was suggested that such prediction should be carried out within younger age groups. The objective of the present study was to fit a suitable equation that would predict live weight based on a linear body measurement or a combination of body measurements in young growing calves less than 18 months of age.

Materials and methods

The data used for this study were obtained from 731 calves kept at the National Animal Production Research Institute, Shika, comprising of purebred Bunaji or White Fulani (WF), purebred Sokoto Gudali (SG), as well as their crosses with Friesian (Fr x WF) and Charolais (Ch x SG) breeds of cattle. The description of location and climatic condition of Shika, Nigeria, where the observations were made had been given elsewhere (7). All the animals were raised exclusively on pasture during the rainy season. During the dry season they receive hay or silage and concentrates made up of cotton seed cake and sorghum (ratio 1 to 2). The animals were herded off grass at 08.00h, confined to cattle crushes and the following body measurements taken:

a) chest girth, the circumference of the body measured perpendicular to the median immediately posterior to the shoulder blade at 6th-7th rib.

b) body length, the distance from the point of the shoulder corresponding to the outer and central tuberosity of the left humerus to the left tuber ischii.

c) wither height, the vertical height from the floor to a point just above the spinous processes of the second and third vertebrae on the left side.

A caliper was used for measuring body length and wither height, while chest girth was measured with a tape. Body condition score (CS) was assessed and scored by two scorers using the technique outlined by Pullan (8). Animals were weighed immediately afterwards before being moved to pasture.

The effects of genetic group, sex, season and body score on chest girth, body length and wither height were examined by least-squares procedures using the SYSTAT package (9). Genetic group was classified as White Fulani (WF), Sokoto Gudali (SG), F_1 crosses between Friesian x White Fulani (Fr x WF) and F_1 crosses between Charolais x Sokoto Gudali (Ch x SG). Season of measurements were wet (June - September), pre-rains (February - May) and post-rains or harmattan (October - January). Body score classification was either lean (Scores > 3.5) or fat (Scores > 3.5). The mean of the two scores per animal was used for the analyses. The linear model used for the least square analysis was as follows:

$Y_{ijklm} = \mu + B_i + X_j + S_k + C_l + E_{ijkl}$;

Where;

Y_{ijklm} = The observation of the m^{th} animal with the l^{th} body score in the k^{th} season of the j^{th} sex belonging to the i^{th} genetic group.

μ = Overall mean

B_i = fixed effect of the l^{th} genetic group (i = 1, 4)
X_j = fixed effect of the j^{th} sex (j = 1, 2)
S_k = fixed effect of the k^{th} season (k = 1, 3)
C_i = fixed effect of the 1^{th} body score (1 = 1, 2)
E_{ijklm} = random effect associated with each record with expectation 0 and variance σ^2.

Data for any genetic group not found to be significantly different in body measurements were pooled in further analyses. Linear and step-wise multiple regressions were fitted to obtain equations between weight and body measurement variables within significantly different genetic group classes. Regression analyses were also carried out separately for fat and lean animal classifications based on body condition scores. Similarly, phenotypic correlation coefficients between body measurements were computed.

Results

Genetic group effect was significant (P<0.001) for the three body measurements (Table 1). The body measurements of the Zebu (WF and SG) differed significantly (P<0.05), with those of WF being consistently lower than the SG at the same age. However, measurements of the Zebu and their crosses were not significantly different, except for the body length where Fr x WF crossbred was 2% longer than those of the purebred WF. Sex effect was non-significant; except for wither height with bull calves being 1% taller than heifer calves. Season of measurement was an important source of variation especially for chest girth and body length, with measurements taken during the wet season being significantly (P<0.05) higher than those in other seasons. Body score also significantly (P<0.001) influenced body measurements, with fat animals being 11% bigger in chest girth, 8% longer and 6% taller than lean animals (Table 1). Since the measurements for each of the Zebu (WF and SG) and their crosses were pooled together in subsequent analyses; genetic group 1 refers to WF and Fr x WF, while genetic group 2 represents SG and Ch x SG. For convenience and better interpretation of results, they would henceforth be referred to as genetic group 1 and genetic group 2, respectively.

The inter-relationships of the body measurements within genetic groups, determined by simple correlation coefficients, are shown in Table 2. There were positive significant (P<0.001) correlations between the various body measurements as well as between the body weight and the body measurements. For both genetic groups, the body weight was more highly correlated with chest girth than with either body length or wither height. The chest girth accounted for 91% and 92% of variation in body weight in genetic groups 1 and 2, respectively. The second best correlation with body weight was found with body length. The relationship between live weight and chest girth was further studied using linear and polynomial regressions (Table 3). The linear regression coefficient for genetic group 1 was slightly lower than for genetic group 2. The use of second degree polynomial resulted in a reduction of the residual sum of squares for the two genetic groups, but the addition of higher degree polynomials did not result in further changes.

Table 1: Least-squares means (LSM) for body Measurements (cm)

Variable	No.	Chest Girth	Body length	Wither Height
Overall mean	731	112.76	92.02	94.83
Genetic group				
Bunaji (WF)	288	109.88[a]	92.88[a]	93.76[a]
Sokoto (Gudali (SG)	70	114.84[b]	95.32[b]	96.44[b]
Friesian x WF	380	110.70[a]	95.12[b]	92.72[a]
Charolais x SG	53	115.51[b]	96.76[b]	96.39[b]
Sex of calf				
Male	349	113.39	95.52	95.36 [b]
Female	382	112.13	94.52	94.30 [a]
Season of birth				
Pre-rains (February-May)	312	111.45[a]	93.17[a]	94.13
Rains (June-September)	150	114.79[b]	96.59[b]	95.26
Post-rains (December-January)	269	112.03[a]	95.30[b]	95.1
Body condition score				
Lean (<3.5)	403	106.74[a]	91.09[a]	92.17[a]
Fat (>3.5)	328	118.78[b]	98.95[b]	97.49[b]

*Values within each sub-class with different superscripts differ significantly (P<0.05).
No letter indicates subclass group did not show a significant difference in the analysis of variance.

Table 2: Coefficient of Phenotypic correlation between body measurements*

Genetic grp	Variables	Chest girth	Body length	Wither height
1	Bodyweight	0.95	0.89	0.83
2		0.96	0.91	0.84
1	Chest girth		0.88	0.86
2			0.89	0.90
1	Body length			0.87
2				0.87

* All correlations are highly significant (P<0.001)
* Breed 1 represents Bunaji and Friesian x Bunaji
Bread 2 represents Sokoto Gudali and Charolais x S/Gudali.

Table 3: Linear and polynomial regressions of live weight on chest girth

Genetic grp	Constant	B	b_1	b_2	R^2
Linear					
1	-217.074	2.976			0.911
2	-224.696	3.001			0.923
Polynomial					
1	51.978		-1.809	0.021	0.924
2	162.838		-3.727	0.029	0.951

*As in Table 2.

A stepwise multiple regression analysis was also carried out with the addition of other body measurements, one at a time, to chest girth. The essence was to determine how other body measurements would influence the precision of live-weight predictions compared to using the chest girth alone. It was observed that for the two genetic groups, body length appeared to be an important variable to be used with chest girth based on the reduction in sums of squares due to the added variable (Table 4).

Table 4: Multiple regression analysis of live weight on chest girth plus other variable(s)*

Genetic grp	Variable	Intercepts	b_1	b_2	b_3	R^2	R^2 Change
1	Body length	-231.70	2.445	0.774	-	0.919	+0.008
2	Body length & wither height	-211.75	2.6654	1.328	-1.039	0.942	+0.019

*As in Table 2.
*Estimate of the increase in R^2 over that obtained with the linear regression model.

Table 5: Second degree polynomial regression of live weight on chest girth in lean and fat animals

Genetic Grp	Body Condition	No	Constant	b	b_1	r^2
1	Lear	303	-4.579	-0.605	0.014	0.896
	Fat	266	79.261	-2.03	0.021	0.901
2	Learn	73	-71.878	0.856	0.007	0.899
	Fat	44	128,992	-2.963	0.025	0.929

*As in Table 2.

In this study, body score was found to greatly influence measurements (Table 1). Therefore, polynomial regression analyses were carried out separately for lean and fat animals within breed-classes. Quadratic terms were significantly lower for the lean animals (Table 5). The polynomial equations that best fitted the lean and fat groups of the two breed classes were:

Lean animals:
$Y = - 4.579 - 0.605X + 0.014X^2$ (Genetic group 1)

$Y = - 71.878 + 0.856X + 0.007X^2$ (Genetic group 2)

Fat animals:
$Y = 79.261 - 2.03X + 0.021X^2$ (Genetic group 1)

$Y = 128.992 - 2.963X +0.025X^2$ (Genetic group 2),

where X and Y represented chest girth (cm) and weight (kg) respectively. The predicted body weights obtained from the polynomial regressions are shown in Table 6. It was observed that for the same chest girth, fat animals had higher predicted weights than lean animals. Suffice to say however that the chest girth measurements for which predictions were made considered only the range of values obtained in this study.

Discussion

The results of this study showed that body measurements were influenced by factors such as genetic group differences, sex of calf, season of birth and body condition score. Hence, live-weight estimates using linear body measurements should consider adjusting for such factors in order to improve the accuracy of the estimates for the prediction equations. Most important were the effects of genetic group and body condition. It was observed that some measurements (e.g., chest girth and wither height) obtained on the zebu crosses were higher than those of zebu. This could be attributed to sire breed differences, since the maternal environment for the zebu and their crosses were similar. In a crossbreeding experiment involving Brahman (*Bos indicus*) and Hereford (*Bos taurus*), there was a similar increase in wither height as the amount of Brahman blood increased (10, 11).

Table 6: Estimated live weight by chest girth class and body condition within breed classes*

Chest girth	Predicted weight (kg)**			
	Genetic grp 1		Genetic grp 2	
	Lean	Fat	Lean	Fat
70-74	25	-	-	-
75-79	32	-	-	-
80-84	40	-	-	-
85-89	49	62	56	-
90-94	58	70	66	71
95-99	69	80	77	81
100-104	79	91	88	91
105-109	91	103	100	103
110-114	103	115	112	116
115-119	116	129	124	130
120-124	130	144	137	146
125-129	144	160	150	163
130-134	160	177	163	181
135-139	175	195	-	200
140-144	-	215	-	221
145-149	-	234	-	243
150-154	-	256	-	266

*As in Table 2
*Estimated weights are mans values for the respective chest girth class.

Sex effect was not significant for most of the body measurement traits except for the wither height, where males were taller than females. This result was similar to that reported by Gilbert *et al.* (3). In that report, steers were larger than heifers in height at withers, body length and head length, head width, muzzle width and cannon bone circumference, but not in height and width at hips and frame score. However, since the level of significance ($P<0.05$) in the only trait (wither height) was low herein, the prediction equation for liveweight in one sex could serve the other in these composite breeds. Seasonal effect was due to pasture availability. Seasonal pasture productivity induced by climatic factors was an evidence of pasture availability (12), with pasture quality and quantity being better in the higher rainfall months than in the drier months. It was therefore expected that measurements taken during the wet season would be higher since most of the animals would be in better condition because of the abundant and better quality pasture growth during this period compared to the dry periods (pre- & post-rains). Consequently, it was not surprising that body condition significantly influenced body measurements, with fat animals having higher values

The chest girth accounted for over 90% of the body weight in the two composite breeds. It was found to predict body weight with higher precision, and also better than the other measurements (e.g., body length and wither height) in estimating live weight. The second best correlation with body weight was found in body length. These observations agree with that reported by Umoh and Buvanendran (13). Similarly, Afolayan (14) obtained higher genetic correlation between live weight and girth or length as compared to correlation between live weight and height at weaning and post-weaning ages in Jersey and Limousin cross bred cattle. This observation may suggest that girth and length are genetically more related to live weight than height trait. Thus (in some practical management situation where scale could not be accessed), measurement of girth or length may be better indicator of weight rather than height as suggested by Vargas *et al.* (15) for Brahman cattle. However, in a contrary report by Buvanendran *et al.* (5), body length had the weakest correlation with live-weight.

The results of the multiple regression analyses indicated that the addition of other measurements to chest girth resulted in significant improvement in accuracy of prediction, though the extra gain was small. However, under field conditions, live-weight estimation using chest girth alone would be preferable to combinations with other measurements because of the difficulty of proper animal restraint during measurement. This thus reduces the practical usefulness of using other body measurements in conjunction with chest girth (5). On the other hand, girth can be measured more accurately and is less influenced by the stance of the animal (16).

It was observed that body condition greatly influenced the relationship between live-weight and chest girth. Thus, animals in “better” condition (fat) had higher regression coefficients of live-weight on chest girth than those in "low" condition (lean). This probably suggests that fat animals had a higher change in live-weight per cm of chest girth than the lean group (5, 17). Afolayan *et al.* (2) opined that the observed differences between fat and lean animals could be attributed to the impact of the quantity and quality of pasture available for grazing across seasons, on the magnitude and direction of post-weaning body compositional traits. The amount of fat and muscle lost in the dry season by genotypes affected the level of gain on these traits in the subsequent wet season in Jersey and Limousin cross bred cattle (2). Comparable results were obtained also for post-weaning growth of steers (18) and heifer calves (11) from Hereford, Brahman and their crosses. Therefore, the use of a common equation to estimate live weights irrespective of the body condition of animals may be inaccurate. Earlier reports had even indicated that while steers are bigger in weight, height, length, girth and more muscular than heifers at weaning and post weaning ages, heifers are usually fatter in any of these ages (1, 2), a possible justification for further separation of equations between sexes.

Conclusion and applications

In this study,

1. The coefficients of variation of the difference between observed and predicted weights did not exceed 8% in both genetic groups.
2. Animals comprising each genetic group were all within a narrow age range (5-18 months), thus, the high correlations between body weight and chest girth would imply that live-weight could be predicted fairly accurately from chest girth within the age group.
3. It was thus suggested that linear body measurements, such has chest girth, could be used to predict live-weight in the calves of the studied breed groups.

Acknowledgement

The authors wish to thank Mr. S. Haruna for technical assistance and data compilation. The kind permission of the Director, NAPRI, to publish this work is acknowledged.

References

1. Afolayan, R.A., Pitchford, W.S., Weatherly, A.W. and Bottema, C.D.K. (2002a). Genetic variation in growth and body dimensions of Jersey and Limousin crossbred cattle. 1. Pre- weaning performance. *Asian-Aust. J. Anim. Sci.,* 15 (10): 1371-1377.

2. Afolayan, R.A., Pitchford, W.S., Weatherly, A.W. and Bottema, C.D.K. (2002b). Genetic variation in growth and body dimensions of Jersey and Limousin crossbred cattle. 2. Post- weaning dry and wet season performance. *Asian-Aust. J. Anim. Sci.,* 15(10): 1378-1385.

3. Gilbert, R.P., Bailey, D.R.C. and Shannon, N.H. (1993). Body dimensions and carcass measurements of cattle selected for post-weaning gain fed two different diets. *J. Anim. Sci.,* 71: 1688-1698.

4. Berge, S. (1977). On the estimation of weight and increase in weight by means of the chest girth in Norwegian Red Cattle at the Agricultural University at As, Norway in the years 1972 and 1974. *Acta Agric. Scandinavica,* 27: 65-66.

5. Buvanendran, V., Umoh, J.E. and Abubakar, B.Y. (1980). An evaluation of body size as related to weight of three West African breeds of cattle in Nigeria. *J. Agric. Sci. (Cambridge),* 95: 219-224. -

6. Goonerwardene, L.A. and Sahaayuruban, P. (1983). Analysis of body measurements and prediction of body weight in crossbred Lanka bulls, *Proc. 5th World Conf. Prod.,* 2: 27-

28.

7. Oni, O.O., Buvanendran, V. and Dim, N.I. (1988). Factors affecting birth weight and performance to weaning of Bunaji calves. *J. Agric. Sci. (Cambridge),* 111: 407-410.

8. Pullan, N.B. (1978). Condition scoring of White Fulani cattle. *Trop. Anim. Health and Prod.,* 10: 110-120

9. Wilkinson, L. (1988). SYSTAT. The system for Evanston, IL: SYSTAT, Inc.

10. Comerford, J.W., Benyshek, L.L., Bertrand, J.K. and Johnson, M.H. (1988). Evaluation of performance characteristics in a diallel among Simemmental, Limousin, polled Hereford and Brahman beef cattle. I. Growth , hip height and pelvic size. *J. Anim. Sci,.* 66: 293.

11. Hearnshaw, H., Arthur, P.F., Barlow, R., Kohun, P.J. and Darnell, R.E. (1994). Evaluation of Bos indicus and Bos Taurus straightbreds and crosses. II. Post-weaning growth, puberty, and pelvic size of heifers. *Aust. J. Agric. Res.,* 45: 795-805.

12. Wheeler, J.L. and Freer, M. (1986). Pasture and forage: The feed base for pastoral industries. In: 'The Pastoral Industries of Australia'. (Eds: G. Alexander and O.B. Williams) Revised edition. Pp. 165-82. (Sydney University Press: Sydney, Australia).

13. Umoh, J.E. and Buvanendran, V. (1982). Relationship between measurements and liveweight of crossbreds Friesian X Fulani and Charolais X White Fulani cattle in Nigeria. *Beitrage trop. Landwirthsch Vet. Med.,* 20 (4): 413-419.

14. Afolayan, R.A. (2003). Genetics of Growth and Development in Cattle. PhD dissertation, The University of Adelaide, Australia.

15. Vargas, C.A., Elzo, M.A., Chase Jr., C.C. and Olson, T.A. (2000). Genetic parameters and relationships between hip height and weight in Brahman cattle. *J. Anim. Sci.* 78: 3045-3052.

16. Johannson, I. and Venge, O. (1951). Studies on various morphological characters for the diagnosis of monozygosity of cattle twins. *Zeitschrift Fuer Tierzuchtung Zuchtungsbiologie,* 59: 389-424.

17. Johannson, I. and Hildeman, S.E. (1954). The relationship between certain body measurements and live and slaughter weight in cattle. *Anim. Breed. Abstr.,* 22: 1-17.

18. Arthur, P.F., Hearnshaw, H., Kohun, P.F. and Barlow, R. (1994). Evaluation of *Bos indicus* and *Bos taurus* Straightbreds and crosses. I. Post-weaning growth of steers in different environments. *Aust. J. Agric. Res*., 45: 783-79