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Article

Morphometric characterization of Brahman crossbred cattle and prediction of live weight using linear body measurements

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Abstract: The present work was conducted to evaluate the variability in linear body measurements; to investigate the relationship between body linear measurements and live weight and to predict live weight of F_1 Brahman crossbred cattle using body measurements. A total of 123 male and 87 female F_1 Brahman crossbred cattle of 6-36 months age and weighing from 63 to 535 kg were used for the study over a period from 2010 to 2014. The study revealed that that most of the morphological measurements were linearly increased with the advances of age. The body weight had highest correlation coefficient with the heart girth around the chest (r=0.96, p<0.001) and lowest with canon bone length (r=0.49, p<0.001) compared with other body measurements. The correlations of body weight with tail length, ear length, canon bone length and canon bone width were at medium level (r=0.51-0.79). Grouping of data according to age indicated that heart girth in >24 months group had highest correlation coefficient (r=0.96) with body weight compared to ≤12 months (r=0.92) and >12-24 months (r=0.95) group. The stepwise regression models revealed that heart girth singly accounted highest variation (93%) in body weight for all animals. Thus, the general equation for prediction of live weight of Brahman crossbred cattle was Y=4.07HG–356 (±6.96) where Y=live weight (Kg), HG=heart girth around the chest (cm). The regression equations for the live weight were Y=2.71HG–191 (±13.5), Y=4.05HG–357 (±9.77) and Y=4.87HG–471 (±23.0) for ≤12, >12-24 and >24 months age groups. The best model for estimating body weight was obtained using HG and body length (BL) for all animals Y=2.83HG+1.80BL–392 (±6.69). These results suggested that prediction equations based on HG or in combination of HG and BL can be used efficiently in Brahman crossbred cattle to predict live weight.

Keywords: body measurements; heart girth; correlations; regression equations

1. Introduction

Live body weight plays an important role in determining several characteristics of the farm animals, especially the economically important characteristics (Pesmen and Yardimci, 2008). Prediction of live weight using body measurements is practical, faster, easier and cheaper in the rural areas where the resources are insufficient for the breeder (Nsoso *et al*., 2003). A crossbreeding program between Brahman sire and native cows was undertaken by the Department of Livestock Services in different areas of Bangladesh in order to meet the growing demand of meat, which has resulted in an increased number of Brahman crossed cattle in rural areas. The smallholder farmers are frequently being involved in fattening of these crossbred cattle in recent years. However, the fundamental knowledge of body weight estimation of these cattle is often unavailable to farmers due to unavailability of weighing scales, which are costly to obtain, need technical maintenance and heavy to transport to farmers' house especially in remote and rural areas. At present, animal owners, livestock assistants and cattle traders depend on visual assessment (eye ball judgment) to measure live weight. Hence, the farmers have to rely on questionable estimates of the body of their animals leading to inaccuracies in decision-making and husbandry (Moaeen-ud-Din *et al*., 2006).

The main method of determining the weight of animals in the absence of weighing scales is to estimate the weight using a number of body characteristics that are readily measured. Typically, weight is regressed on body measurements to determine a weight-prediction equation (Yakubu, 2010; Kashoma *et al.*, 2011). In addition, accuracy of functions developed to predict body weight from linear body measurements could improve selection efficiency for growth by enabling the breeder to recognize early maturing and late maturing animals of different sizes. Several studies have been reported on the use of body linear measurements to estimate the live body weight in cattle (Dineur and Thys, 1986; Goe *et al*., 2001; Mekonnen and Biruk, 2004; Abdelhadi and Babiker, 2009). Msangi *et al*. (1999) and Nicholson and Sayer (1987) reported that heart girth can be used with great accuracy in estimating the live weight for all classes of crossbred dairy cattle and Boran cattle, respectively. However, different models might be needed to predict body weight in different environmental conditions and breeds (Touchberry and Lush, 2007). Body linear measurements of Brahman crossbred cattle reared at on-station having weighing facilities would be a good use of estimating live weight of these similar genotypes under field conditions.

Hence, the objectives of this study were to evaluate the variability in linear body measurements; to investigate the relationship between body linear measurements and live weight and to formulate equations for Brahman crossbred cattle to predict live weight on the bases of one or more body measurements.

2. Materials and Methods

2.1. Experimental animals and their management

Live body weight and linear body measurements of 123 male and 87 female F_1 Brahman crossbred cattle (Figure 1) reared at Central Cattle Breeding Station (CCBS), Savar, Dhaka, were recorded manually at different ages (6 to 36 month) over a period from the year 2010 to 2014. The age of animal was determined from the birth register maintained in the CCBS. The animals were living in intensive management system with little grazing.

2.2. Parameters measured

Live body weight (LBW) and eight morphometric traits were taken on each animal. The body parts measured were heart girth (HG), body length (BL), hip height (HH), wither height (WH), ear length (EL), tail length (TL), canon bone length (CBL) and canon bone width (CBW). All measurements were taken in the morning before the animals were fed. Each dimension taken was recorded in centimeter while the weight was recorded in kilogram.

The body weight was taken using a mobile platform weighing scale and recorded to the nearest kilogram (Kg), and the linear body measurements were taken using the tailor's tape measure. The WH and HH measurements were taken using the measuring plastic tape marked in centimeter (cm) and a special measuring stick made with two arms; one (plastic made) which is held vertical and the other (wooden) at right angle to it sliding by hand vertically up and down to record height while the animals were in standing position on four legs with head maintained in an upright position as described by Goe *et al*. (2001).

Heart girth was measured taking a circumferential measure by the measuring tape around the chest just behind the front legs and withers. Body length was measured as the distance between the point of the shoulder (lateral tuberosity of the humerus) and the pinbone (tuber ishii), which was taken from the left-side of the animal. Care was taken to ensure that the backbone is straight in both vertical and horizontal planes. Hip height was measured as the distance from the surface of a platform on which the animal stands to the mid-sacrum on the dorsal midline. Wither height was measured as the distance from the surface of a platform to the highest point on the withers. Tail length was measured as the distance between the tip of the tail and the base end tail touching the body of the animal. Ear length was measured as the distance between the tip of the ear and the base of the ear. Fore canon bone length was measured as the length of the lower part of the leg (metacarpus bone) extending from the carpal joint to the fetlock joint. Canon bone width was measured as the circumference of left metacarpus at its narrowest. All measurements were taken by the same individuals throughout the study period.

2.3. Data management

In total, 531 sets of HG, BL, HH and WH measurements, 311 sets of EL and TL measurements, 274 CBL measurements and 266 CBW measurements were considered for morphometric analysis. The data were divided into eight age categories for morphometric analysis; >6-9 months, >9-12 months, >12-15 months, >15-18 months, >18-21 months, >21-24 months, >24-27 months and >27-32 months age group.

A total of 544 sets of HG, BL, HH and WH measurements, 322 sets of EL and TL measurements, 280 CBL measurements and 272 CBW measurements were considered to calculate correlation coefficient and coefficient of determination between LBW and linear measurements, and the data were divided into three age groups; Group A (≤12 months), Group B (>12-24 months) and Group C (>24 months) age group.

2.4. Statistical analysis

The data obtained were expressed as least squares mean. Collected data were handled in Microsoft Excel whereas statistical analyses were done by using Statistical Analysis System (SAS, 2003). The general linear model (GLM) procedure was used to get descriptive statistics and correlation coefficient between LBW and linear measurements. Stepwise multiple regression analysis was used by including HG, BL, HH and WH measurements individually and collectively to identify the best predictor variable for estimating the LBW. The choice of the best fitted regression model was selected using the coefficient of determination (R^2). Each model was assessed using R^2, adjusted R^2 and RMSE (Root mean squares error).

3. Results

3.1. Linear body measurements

Table 1 shows overall body weights and morphometric measurements of Brahman crossbred cattle. Age had significant influence ($P<0.001$) on all morphometric measurements. Body weight was linearly increased with the increase of age, but no difference was found between >15-18 and >18-21 months and between >21-24 and >27-32 months age categories. Similar results were observed for BL and HG. HH and WH were significantly increased with the increase of age, but they did not differ between >15-18 and >18-21, between >21-24 and >27-32 months and between >24-27 and >27-32 months age categories. TL, EL and CBL were influenced by age ($P<0.001$) and were increased with the increase of age. Animals of >27-32 months age category showed inferior value of TL, EL and CBL compared to those in the animals of >24-27 months age. This could be due to having maximum number of observations form female animals in that group. CBL and CBW did not vary ($P>0.05$) among the animals aging more than 15 months.

3.2. Pairwise correlations

Bivariate correlations among LBW and body dimensions of Brahman crossbred cattle are shown in Table 2. LBW was positively and highly associated with morphometric traits (r=0.49-0.96; $P<0.001$). The body weight had highest positive correlation with heart girth (0.96) and lowest with canon bone length (0.49). The correlations of LBW with TL, EL, CBL and CBW were at medium level (0.51-0.79). The relationships of TL, EL, CBL and CBW with either of LBW, HG, BL, HH and WH were similar. Among the linear type traits, the highest correlation was observed between HH and WH (0.98) while the lowest estimate (0.37) was recorded for EL and CBL. LBW, HG, BL, HH and WH shows higher correlations with CBW (0.79) compared to CBL (0.51).

The correlation coefficients between live body weight and the morphometric measurements according to age group and sex of animals studied are shown in Table 3. The correlation coefficients between live weight and all morphometric measurements in all age groups and both sexes were significant ($P<0.001$) except CBL in animals of >24 months age, which shows non significant correlation.

In the ≤12 months age group, the strong positive correlations were between HG (r=0.92), BL (r=0.86), HH (r=0.87) and WH (r=0.81). This means Brahman cattle of 12 months and less age group having relatively high HG, BL, HH and WH were likely to have high LBW. In the >12-24 months age group, the strong positive correlations were between HG (r=0.95), BL (r=0.90), HH (r=0.85) and WH (r=0.85). This means Brahman cattle of >12-24 months age group having relatively high HG, BL, HH and WH were likely to have high LBW. Similarly, in the >24 months age group, the strong positive correlations were between HG (r=0.96), BL (r=0.89), HH (r=0.88) and WH (r=0.86). This means Brahman cattle of more than 24 months age having relatively high HG, BL, HH and WH were likely to have high LBW.

The correlation coefficients between live weight and heart girth increased with the advancement of age (0.96 for >24 months age group), indicating a greater accuracy of heart girth in predicting live weight of adult cattle compared with cattle of less than 24 months old. Correlation coefficients for most of the traits were similar in both sexes and that of EL and CBL was higher in male than female cattle.

3.3. Regression models for the prediction of body weight

Table 4 summarizes the prediction equations to estimate body weight from body linear measurements using Stepwise Multiple Regression Analysis for Brahman crossbred cattle. The stepwise regression models revealed that heart girth singly accounted highest variation in LBW compared to BL and HH in all ages, which was 84, 91 and 92% in ≤12, >12-24 and >24 months age group. The RMSE in this case was 14.0, 18.1 and 23.5 for three age groups, respectively. However, the variation due to HG was increased to 93% for all animals. The model involving heart girth and body length slightly improved the efficiency of the prediction equations (R^2 and RMSE were 0.87, 0.94 and 0.93 and 12.8, 14.6 and 22.1, respectively in three age groups). A slight or no improvement was obtained from the model involving the combination of HG, BL, HH and WH. However, the best model for estimating LBW was obtained using HG and BL for all animals. This was because both the R^2 (0.94) and adjusted R^2 (0.94) of this model were highest, while the RMSE (18.5) was lowest.

All prediction models from the present study indicate that heart girth around the chest is the most reliable measurement for prediction of live weight and easiest to measure. The regression equation of LBW (y) on HG (x) for live weight of all animals indicated that an increase or a decrease of one cm of heart girth around the chest gave an increase or a decrease of 4.07 kg of live weight: Y=4.07 X – 356 (±6.96)

The regression equations for the live weight on HG of Brahman crossbred cattle according to age and sex were:

≤12 months	: Y=2.71 HG – 191 (±13.5)
>12-24 months	: Y=4.05 HG – 357 (±9.77)
>24 months	: Y=4.87 HG – 471 (±23.0)
Male animal	: Y=4.17 HG – 369 (±9.62)
Female animal	: Y=3.88 HG – 333 (±9.86)

The separate equations of three age groups estimated that a one cm change in heart girth would result in weight change of 2.71 to 4.87 Kg, which were 3.88 and 4.17 Kg for female and male cattle, respectively. The regression equation for three age groups provides an accurate estimate of live weight of Brahman crossbred cattle, when heart girth measurements and live weights ranged from 91 to 148 cm and 63 to 255 Kg, from 107-186 cm and 88 to 436 Kg and from 118 to 196 cm and 131 to 535 Kg, respectively for ≤12, >12-24 and >24 months age group.

4. Discussion

The mean values of live weight, heart girth, wither height and hip height measurements of >21-24 month age group in the present work were very similar to those reported by Abdelhadi and Babiker (2009) for Sudanese indigenous Baggara bulls (266 kg, 150.6 cm, 120 cm and 126.2 cm, respectively). Alsiddig *et al.* (2010) observed similar wither height (115.6 and 119.1 cm) and heart girth (139.8 and 148.8 cm) and slight higher body length (121.4 and 128.6 cm) for Baggara zebu bulls (Nyalawi) of 217 and 267 kg average live weight, respectively in comparison to those of >18-21 and >21-24 months age groups.

Hadiuzzaman *et al*. (2010) reported that heart girth, body length, hip height and wither height measurements of RCC at different age groups were much lower compared to those for similar age group of this study. Bag *et al*. (2010) obtained wither height, body length and heart girth for adult female RCC of 54 months as 105.9, 106.9 and 136.8 cm whereas theses were 93.9, 105.2 and 127.0 cm, respectively for North Bengal Grey cows of similar age (Al-Amin, 2004). Namikawa *et al*. (1984) reported that the wither height and hip height at 24 months of age were 100.3 and 103.4 cm, respectively for Bangladeshi native cattle. The results of the aforementioned studies were greatly lower compared to the present study. However, in accordance with this study Namikawa *et al*. (1984) measured heart girth of Bangladeshi native cattle at more than two years old to be 150.8 cm. Bhuiyan *et al.* (2007) observed wither height and body length of 118.2 and 147.6 cm for Pabna cows, which were agreed to some extent by the present study. Mwambene *et al.* (2014) reported that the body weight, heart girth, body length and height at withers were 299 and 246 kg, 148 and 142 cm, 110 and 106 cm and 105 and 101 cm, respectively for mature bulls and mature cows of indigenous cattle populations in the Southern

Highlands and Eastern of Tanzania. Although body weight corresponded well with >21-24 and >24-27 months group of this work, other characteristics were lower than those of same groups of this study. All these differences between present study and other works might be due to the variation in genotypes, environment and management practices.

Table 1. Body weight and morphometric measurements (LSM±SE) of Brahman crossbred cattle.

Parameters	Age (months)							
	>6-9 (M=47, F=23)	**>9-12 (M=25, F=20)**	**>12-15 (M=84, F=46)**	**>15-18 (M=37, F=24)**	**>18-21 (M=46, F=32)**	**>21-24 (M=30, F=35)**	**>24-27 (M=14, F=29)**	**>27-32 (M=6, F=34)**
Age (month)	6.85±0.11 (70)	11.1±0.16 (45)	13.3±0.08 (130)	16.8±0.13 (61)	19.4±0.10 (78)	22.7±0.11 (65)	25.4±0.14 (43)	29.5±0.26 (40)
Body weight (kg)	115±3.07^{f} (70)	154±4.80^{e} (45)	177±3.96^{d} (130)	225±7.41^{c} (61)	226±6.10^{c} (78)	256±7.21^{b} (65)	295±13.2^{a} (43)	262±13.1^{b} (40)
Hip height (cm)	104±0.75^{f} (70)	112±0.84^{e} (45)	115±0.48^{d} (130)	120±0.65^{c} (61)	121±0.71^{c} (77)	123±0.83^{b} (65)	127±1.07^{a} (43)	125±1.16^{ab} (40)
Wither height (cm)	100±0.80^{f} (70)	108±0.8^{e} (45)	111±0.47^{d} (130)	116±0.68^{c} (61)	117±0.70^{c} (77)	119±0.79^{b} (65)	122±1.12^{a} (43)	120±1.13^{ab} (40)
Body length (cm)	97.0±0.86^{f} (70)	105±0.96^{e} (45)	110±0.72^{d} (130)	119±1.28^{c} (61)	119±1.06^{c} (77)	124±1.30^{b} (65)	129±1.92^{a} (43)	126±2.11^{b} (40)
Hearth girth (cm)	113±1.06^{f} (70)	127±1.53^{e} (45)	133±1.09^{d} (130)	144±1.76^{c} (61)	143±1.35^{c} (77)	151±1.57^{b} (65)	158±2.51^{a} (43)	150±2.65^{b} (40)
Tail length* (cm)	67.0±1.29^{g} (67)	73.7±1.77^{f} (22)	78.5±0.89^{e} (66)	79.7±1.24^{de} (26)	85.0±1.30^{bc} (50)	89.2±1.99^{ab} (26)	91.7±1.91^{a} (26)	83.8±1.73^{cd} (28)
Ear length* (cm)	22.3±0.24^{d} (67)	23.1±0.53^{cd} (22)	23.6±0.27^{c} (66)	24.1±0.60^{bc} (26)	25.0±0.35^{ab} (50)	25.9±0.59^{a} (26)	26.0±0.61^{a} (26)	25.1±0.44^{ab} (28)
Canon length* (cm)	20.8±0.20^{d} (66)	21.2±0.26^{cd} (20)	21.7±0.17^{bc} (63)	22.5±0.30^{ab} (24)	22.6±0.26^{a} (36)	22.5±0.22^{ab} (23)	22.8±0.44^{a} (16)	22.7±0.35^{a} (26)
Canon width* (cm)	12.8±0.23^{c} (64)	13.7±0.19^{b} (16)	13.8±0.11^{b} (61)	14.9±0.31^{a} (24)	15.7±0.30^{a} (36)	15.4±0.29^{a} (23)	15.3±0.28^{a} (16)	15.0±0.24^{a} (26)

M=number of observation from male; F=number of observation from female; Least squares means without a common superscript differed significantly (P<0.001); Figures in the parenthesis indicate the number of observation; *Some data could not be obtained during body measurements

Table 2. Phenotypic correlations of body weight and morphometric measurements in Brahman crossbred cattle (6-36 month of age)*.

Parameters	**HG**	**BL**	**HH**	**WH**	**TL**	**EL**	**CBL**	**CBW**
LBW	0.962	0.931	0.892	0.886	0.771	0.545	0.488	0.789
HG		0.910	0.905	0.893	0.788	0.557	0.497	0.780
BL	-	-	0.894	0.881	0.792	0.575	0.501	0.772
HH	-	-	-	0.975	0.796	0.592	0.561	0.728
WH	-	-	-	-	0.783	0.586	0.564	0.739
TL	-	-	-	-	-	0.567	0.487	0.621
EL	-	-	-	-	-	-	0.372	0.483
CBL	-	-	-	-	-	-	-	0.422

LBW=Live body weight, HG=Heart girth, HH=Hip height, BL=Body length, WH=Wither height, TL=Tail length, EL=Ear length, CBL=Canon bone length, CBW=Canon bone width; *Significant at P<0.001 for all correlations

Table 3. Age and sex wise correlation coefficients between live body weight and morphometric measurements of Brahman crossbred cattle.

Measurements (cm)	Age group (months)						Sex of animals				All animals	
	≤12		>12-24		>24		Male		Female			
	N	r	N	r	N	r	N	r	N	r	N	r
Heart girth	112	0.92***	335	0.95***	97	0.96***	289	0.96***	255	0.96***	544	0.96***
Body length	112	0.86***	335	0.90***	97	0.89***	289	0.94***	255	0.93***	544	0.93***
Hip height	112	0.87***	335	0.85***	97	0.88***	289	0.90***	255	0.88***	544	0.89***
Wither height	112	0.81***	335	0.85***	97	0.86***	289	0.90***	255	0.87***	544	0.88***
Tail length	86	0.52***	170	0.72***	66	0.71***	152	0.77***	170	0.80***	322	0.76***
Ear length	86	0.47***	170	0.48***	66	0.29*	152	0.59***	170	0.50***	322	0.54***
Cannon bone length	83	0.41***	148	0.40***	49	0.14NS	122	0.54***	158	0.43***	280	0.51***
Cannon bone width	77	0.39***	146	0.88***	49	0.63***	116	0.78***	156	0.82***	272	0.79***

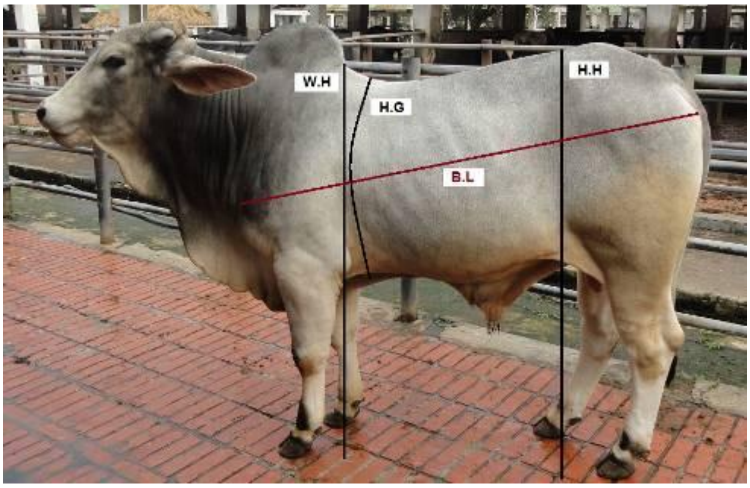
N= Number of observation, r= Correlation coefficients; *= P<0.05; **= P<0.01; ***= P<0.001; NS= Not significant

Table 4. Regression equations for the prediction of live body weight from linear body measurements of Brahman crossbreds.

Category	N	LBW range (kg)	HG range (cm)	Equations	R^2	Adj. R^2	RMSE
Age (month)							
≤12	112	63-255	91-148	BW=3.82WH –263 (±26.7)	0.66	0.66	20.2
				BW=4.06HH – 305 (±23.9)	0.75	0.75	17.4
				BW=3.70BL – 241 (±21.2)	0.74	0.73	17.9
				BW=2.71HG - 191 (±13.5)	0.84	0.84	14.0
				BW=1.95HG + 1.32BL – 234 (±15.2)	0.87	0.86	12.8
				BW=1.58HG + 0.909BL +1.15HH – 271 (±17.6)	0.88	0.88	12.1
				BW=1.58HG + 0.907BL +1.19HH – 0.042WH – 271 (±17.7)	0.88	0.88	12.2
>12-24	335	88-436	107-186	BW=7.82WH –685 (±29.9)	0.73	0.73	31.5
				BW=7.77HH – 711 (±31.3)	0.72	0.72	32.0
				BW=5.08BL – 381 (±15.6)	0.81	0.81	26.3
				BW=4.05HG – 357 (±9.77)	0.91	0.91	18.1
				BW=2.86HG + 1.87BL – 408 (±8.73)	0.94	0.94	14.6
				BW=2.75HG + 1.79BL + 0.399HH – 431 (±16.3)	0.94	0.94	14.5
				BW=2.70HG + 1.74BL – 0.838HH + 1.47WH – 440 (±16.2)	0.95	0.95	14.3
>24	97	131-535	118-196	BW=10.3WH –967 (±75.5)	0.74	0.74	42.1
				BW=10.6HH – 1058 (±73.9)	0.78	0.77	39.3
				BW=5.90BL – 475 (±39.4)	0.80	0.79	37.5
				BW=4.87HG – 471 (±23.0)	0.92	0.92	23.5
				BW=3.90HG + 1.44BL – 506 (±23.3)	0.93	0.93	22.1
				BW=3.63HG + 0.850BL + 1.85HH – 621 (±51.8)	0.93	0.93	21.5
				BW=3.60HG + 0.832BL + 0.942HH + 1.02WH – 625 (±52.0)	0.94	0.94	21.5
Sex of animals							
Male	290	63-535	91-196	BW=7.76WH – 670 (±25.8)	0.80	0.80	37.3
				BW=7.82 HH – 708 (±26.3)	0.81	0.81	36.6
				BW=5.60BL – 434 (±13.7)	0.89	0.89	28.3
				BW=4.17HG – 369 (±9.62)	0.93	0.93	22.6
				BW=2.78HG + 2.07BL – 413 (±9.60)	0.95	0.95	19.7
				BW=2.89HG + 2.16BL – 0.378HH – 395 (±18.6)	0.95	0.950.	19.7
				BW=2.86HG + 2.14BL – 1.16HH + 0.871WH – 397 (±18.6)	0.95	95	19.6

Category	N	LBW range (kg)	HG range (cm)	Equations	R2	Adj. R2	RMSE
Female	255	64-380	96-177	BW=7.13WH –605 (±29.1)	0.75	0.75	33.4
				BW=7.11HH – 634 (±28.1)	0.78	0.78	31.6
				BW=4.67BL – 338 (±13.8)	0.86	0.86	25.2
				BW=3.88HG – 333 (±9.86)	0.92	0.92	18.4
				BW=2.64HG + 1.74BL – 362 (±8.68)	0.95	0.94	15.7
				BW=2.58HG + 1.66BL+ 0.262HH – 375 (±16.8)	0.95	0.940.	15.7
				BW=2.57HG + 1.65BL – 0.230HH + 0.536WH – 377 (±16.9)	0.95	94	15.7
All animals	544	63-535	91-196	BW=7.53WH –648 (±19.3)	0.78	0.780.	35.7
				BW=7.56HH – 682 (±19.4)	0.80	80	34.7
				BW=5.20BL – 393 (±10.2)	0.87	0.87	28.2
				BW=4.07HG – 356 (±6.96)	0.93	0.93	21.1
				BW=2.83HG + 1.80BL – 392 (±6.69)	0.94	0.94	18.5
				BW=2.83HG + 1.81BL – 0.028HH – 391 (±13.0)	0.94	0.94	18.5
				BW=2.81HG + 1.80BL – 0.912HH + 0.975WH – 392 (±12.9)	0.94	0.94	18.4

N=Number of observations, LBW=Live body weight, HG=Heart girth, BL=Body length, HH=Hip height, WH=Wither height, RMSE=Root mean squares error



W.H: Wither height **H.G:** Heart girth **B.L:** Body length **H.H:** Hip height

Figure 1. Brahman X Local F_1 crossbred bull.

The calculation of the correlation coefficients showed that live weight was highly correlated with HG compared to other measurements, which clearly indicated that HG is the most reliable measurement for prediction of live weight of Brahman crossbred cattle. This is in agreement with the findings of other studies which reported high correlation coefficient between live weight and heart girth measurement (Msangi *et al*., 1999; Malau-Aduli *et al*., 2004; Nwacharo *et al.*, 2006; Abdelhadi and Babiker, 2009; Yakubu, 2010). The strong relationship found between BW and body measurements in this study suggests that either or combination of these morphological traits could be used to estimate live weight in cattle fairly well in the situation where weighbridges or scales are not available.

Body measurements can be used to accurately predict body weight (Yan *et al*., 2009). In the present study, HG accounted the highest variation in LBW compared to BL, WH and HH in all ages, which is consistent with the report of Francis *et al.* (2002), Bagui and Valdez (2007) in Brahman cattle and Yakubu (2010) in White Fulani cow where the prediction of LBW from HG gave R^2 value of 0.97, 0.94 and 0.88, respectively. In a similar study on Azawak Zebu in Niger, Dodo *et al*. (2001) accentuated the significance of HG as a predictor of LBW. A high genetic relationship between LBW and HG had also been reported by Afolayan (2003) thereby justifying its use for selection purposes and weight estimation. The importance of HG in weight estimation could be as a result of the fact that the muscle and a little of fat along with bone structure contribute to its formation (Yakubu, 2010). However, HG and BL combined together gave the best fitted prediction models with LWG in all age categories. The importance of both heart girth and body length for weight prediction agrees with previous study conducted by Mutua *et al*. (2011) in breeding age pigs.

The regression analysis of the results from three age groups, both sex and all animals under study indicated that a linear relationship existed between LBW and HG. This was similar to the results for crossbred dairy cattle (Msangi *et al.,* 1999) and Baggara zebu (Abdelhadi and Babiker, 2009), respectively. However, the equation for >12-24 and >24 month age group is slightly different from that reported by other authors for zebu bulls. Kashoma *et al.* (2011) formulated an equation of LBW=4.55HG–409 (±17.9) for Tanzania shorthorn zebu cattle in Tanzania and Goe *et al*. (2001) got an equation of LBW=4.21 HG–365 for working Abyssinian Short-horned zebu oxen in the Ethiopian highlands while Abdelhadi and Babiker (2009) formulated an equation of LBW=3.19HG–260 (±0.13) for Baggara bulls in Sudan. This variation might be due to the different genetic effects, age of animals and management practices of animals involved in the studies.

5. Conclusions

Most of the morphometric measurements were linearly increased with the advances of age. Bivariate correlations between body weight and body dimensions of Brahman crossbred cattle were positive and highly significant. Body measurements such as heart girth as a single predictor can be used to predict live body weight of Brahman crossbred cattle. Heart girth and body length combined together gave the best fitted prediction models with live body weight in all age categories.

Conflict of interest

None to declare.

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