Body weight prediction of Brakmas and Bali cattle using body measurements

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Abstract

In the rural areas facilities for farm animal weighing are often difficult to find and the construction of such facilities is relatively expensive. Therefore a study was conducted with the objective to estimate body weight of Brakmas and Bali cattle using prediction equations of linear body measurements. Data of body weight and body measurements, namely withers height, body length and heart girth from 279 heads of Brakmas (age 1 to 10 y old) and 74 heads of Bali (age 1 to 10 y old) cows were collected. The animals were in average body condition of 3 (1= emaciated, 3= moderate fat cover, and 5= excess fat cover). The correlation analysis showed that body weight of Brakmas cattle was highly correlated with its body length, heart girth and withers height with the correlation coefficients of 0.967, 0.964 and 0.942, respectively, while body weight in Bali cattle had the highest correlation with heart girth followed by body length and height at withers with the correlation coefficient of 0.985, 0.954 and 0.945, respectively. Regression analysis showed that body length provided a good estimate of live body weight with high precision as it accounted for 91.6% of the variability in body weight in Brakmas cattle, while heart girth accounted 97.1% of body weight variability in Bali cattle. The combination of body length-withers height, body length-heart girth and body length-withers height-heart girth showed an improvement in terms of predictive precision with the changes of 0.21%, 0.21% and 0.44%, respectively, in coeficient of determination (R^2) compared to a single measure of body length in Brakmas cattle. The combination of heart girth-body length did not show any change in R^2 in Bali cattle compared to a single measure of heart girth. Combining heart girth-height at withers and the combination of all body measurements showed the increment in coefficients of determination at 0.41% and 0.51%, respectively as compared to heart girth. Although the combination of body measurements showed the highest coefficient of determination, the use of a single measure of body measurement - body length in Brakmas cattle and heart girth in Bali cattle -to predict the body weight is more practical under field condition as they accounted for most of the variability in body weight of Brakmas and Bali cows.

Keywords: Brakmas cattle, Bali cattle, body weight, body measurements, regression models

Introduction

Growth is usually defined as the increase in size at a given age (Afolayan *et al.*, 2006) and one of the selection criteria for the improvement of meat animals is to select animals with above average body weight. Measurement of body weight is very important in order to evaluate the animals' performance and to determine the market value of the animals. Body weight can be accurately measured using a weigh-bridge or a weighing scale, however the availability of such weighing equipment and facilities to

collect and restrain the animals for proper weighing are rarely found in the rural area. It becomes a major constraint in evaluating and selecting farm animals for genetic improvement and production as the holding yard and weighing scales are very expensive, especially to the smallholders.

Livestock breeders have used measures of body size to select animals for breeding and genetic improvement. The prediction of body weight using body measurements was first investigated in what sp.? in England (Sekerden *et al.,* 1991). Body measurements can be used to predict the body weight in the condition where weighing scales are not available (Parés *et al.,* 2012). The use of body measurements is simple as they are easily measured for estimating live weight although it is unlikely to be more accurate than using a weighing scale due to errors in the location of reference points and the anatomical distortions of muscle tone produced when the animal changes its position or posture (Sawanon *et al.,* 2011). Body dimension and muscular development can serve either as a measure of productivity (Afolayan *et al.,* 2002a, b) or as a predictor to other less visible characteristics such as carcass characteristics (Gilbert *et al.,* 1993). An accurate estimation of body weight by using body measurements is important to develop an appropriate management system and nutritional approaches to improve the production efficiency as well as animal welfare. It is important to estimate the body weight accurately as it helps in drug administration and marketing the animals, which is often done by visual assessment at the place where a weigh bridge and proper facilities are unavailable (Putra *et al.,* 2015; Sawanon *et al.,* 2011). Furthermore, the ability of the producers and buyers to relate the body measurements to growth characteristics is important for optimum production and value-based trading system, and also to reward the livestock producers rather than the middlemen (Afolayan *et al.,* 2006). In Malaysia, 80% of cattle ranchers are smallholders who could not afford to build a complete weighing facility that is expensive and beyond their reach to construct.

The objectives of this study were to study the relationship of body weight and body measurements of Brakmas and Bali cattle and to estimate the live weight based on linear body measurements.

Materials and Methods

Animals

Cross-sectional data of body weight, body length, withers height and heart girth were collected from 279 heads of Brakmas and 144 heads of Bali cows. Body weight was taken using a digital weighing scale and recorded in kilogram. Heart girth was measured as the circumference of the chest just behind the foreleg and body length measured horizontally from the point of the withers to the ischium or the pin bone, using a measuring tape in centimetre. Wither height was measured from the ground to the dorsal point of the withers in centimetre, using a height measuring apparatus with a horizontal rod for better accuracy. The data were distributed over four age groups as shown in Table 1. The age of the animal was determined from farm records where date of birth and date of weighing were available.

Table 1. The number of female Brakmas and Bali cattle by age groups in months

Age group	Brakmas	Bali
0-12	166	16
13-24	34	7
25-36	47	11
>36	32	40
Total	279	74

Linear regression models to predict the body weight were constructed by using the body measurements (heart girth, body length and withers height) as independent variables while body weight as the dependent variable. The linear effect of independent variables on body weight was described as follows:

$$W_{iik} = a + ß_1X_1 + ß_2X_2 + ß_3X_3 + Ɛ_{ijk}$$

where W_{ijk} is the body weight of ijkth animal, a is the intercept, $ß_1$, $ß_2$, and $ß_3$ are the corresponding linear regression coefficients for heart girth (X_1), body length (X_2) and withers height (X_3), respectively, and $Ɛ_{ijk}$ is the standard error of regression.

Statistical analysis

Data were analysed using SAS (2003). PROC CORR was used to determine the relationship between body measurements and body weight while PROC REG was used to generate equations for body weight prediction using linear body measurements of body length, withers height and heart girth. Coefficient of determination (R^2) was used to determine the best fit linear equation in body weight prediction as suggested by Gbangboche *et al.* (2011).

Results and Discussion

The result showed that body length, withers height and heart girth were highly correlated with body weight with correlation coefficients at 0.967, 0.942 and 0.964, respectively, in Brakmas cattle (Table 2). Although all body measurements were highly correlated with body weight, body length showed the highest correlation, followed by heart girth and withers height. This was contradictory to the findings reported by Topal and Macit (2004), Atta and Khidir (2004) and Afolayan *et al.* (2006) in sheep, Heinrichs *et al.* (1992, 2007), Goe *et al.* (2001) in cattle and Khan *et al.* (2006) and Nsoso *et al.* (2003) in goats, where heart girth was found to be highly correlated with body weight. Gunawan and Jakaria (2011) and Putra *et al.* (2015) also found a similar trend where height at withers showed the lowest correlation with body weight in yearling Bali cattle and Aceh cattle. It was also revealed that the body weight-body measurements were positively correlated, indicating that body weight tended to increase as the animal body grew in length, depth and height - similar to the finding in Aceh cattle (Putra *et al.,* 2015).

A similar pattern of relationship was observed in Bali cattle as was described for Brakmas cattle as body length, height at withers and heart girth were positively correlated with body weight with the correlation coefficients of 0.954, 0.945 and 0.985, respectively, and body weight-height at withers showed the lowest correlation (Table 2). However, a different trend was found in Bali cattle compared to Brakmas

cattle where heart girth showed the highest correlation with body weight, and agrees with Topal and Macit (2004), Atta and Khidir (2004) and Afolayan *et al.* (2006) in sheep, Heinrichs *et al.* (1992, 2007), Goe *et al.* (2001) in cattle and Khan *et al.* (2006) and Nsoso *et al.* (2003) in goats, where heart girth was found to be highly correlated with body weight. The results from this study agree with Heinrichs *et al.* (1992) as the relationship between body measurements and body weight differ for each breed, age and condition of the animals.

Table 2. Correlation coefficients between body weight, body length, withers height and heart girth of Brakmas and Bali cattle

Body measurement	Body length		Withers height		Heart girth	
	Brakmas	Bali	Brakmas	Bali	Brakmas	Bali
Body weight	0.957	0.954	0.934	0.945	0.880	0.985
Body length			0.952	0.955	0.890	0.960
Withers height					0.890	0.971

In Brakmas cattle, body length showed the highest predictive value for body weight of 0.916, followed by withers height and heart girth with R^2 values of 0.875 and 0.774, respectively, for single body measurement as independent variable (Table 3). Heart girth and withers height showed large difference when compared to body length with the differences of -15.50% and -4.48%, respectively. Multiple regression analysis was carried out by adding other body measurements to body length to determine how the other body measurements would influence the precision of body weight prediction compared to using body length alone as the independent variable. The result showed that the addition of other body measurements to body length would improve the precision in predicting live body weight of Brakmas cows as shown by the increase in R^2 values. By including withers height to body length as the predictor variables, it resulted in 0.21% of R^2 increment, while adding heart girth to body length showed the same R^2 increment. Combining all three body measurements (body length, withers height and heart girth) showed the highest R^2 change at 0.44% compared to a single measure of body length. However, under field conditions, live weight estimation by using body length alone seems to be more practical compared to the other body measurements because of the difficulty to restrain the animals during measurement (Afolayan *et al.*, 2006; Gunawan and Jakaria, 2011). This condition reduces the practical usefulness of using other body measurements or their combinations (Berge, 1977). Furthermore, the body length accounted for 91.6% of the variability in body weight of Brakmas cows in this study, indicating that a single measurement of body length can predict the body weight with high precision. Afolayan *et al.* (2006) and Gunawan and Jakaria (2011) also indicated that using heart girth alone was more practical compared to other body measurements and their combinations as heart girth alone accounted almost 90% of body weight in Yankasa sheep and 75% in yearling Bali cattle, respectively. Similar studies conducted by Kashoma *et al.* (2011) and Milla *et al.* (2012) also showed high precision of prediction when using single body measurement as independent

variable in Tanzania Shorthorn Zebu cattle and Nilotic cattle.

Table 3. Multiple regression analysis for body weight prediction using body length (BL), withers height (HW) and heart girth (HG) as independent variables, and coefficient of determination (R^2) of the models tested for Brakmas cattle

Models	Independent variables	Intercept	Regression coefficient			R^2	R^2 changes (%)
			HW	BL	HG		
A	BL	-272.65	-	4.08	-	0.916	-
B	HG	-238.57	-	-	3.36	0.774	-15.50
C	HW	-499.04	6.74	-	-	0.875	-4.48
D	BL, HW	-325.42	1.41	3.28	-	0.918	0.21
E	BL, HG	-278.02	-	3.67	0.42	0.918	0.21
F	BL, HW, HG	-320.85	1.18	3.08	0.33	0.920	0.44

Table 4 shows the results of multiple regression analysis to predict body weight from body measurements in Bali cattle. Single body measurement that was heart girth showed the highest coefficient of determination at 0.971, followed by body length and withers height with the coefficient of determinations at 0.910 and 0.894, respectively. Comparing predictive values of body length and withers height to heart girth showed large differences at -6.26% and -7.93%, respectively. By adding body length to the equation, it did not show any changes in R^2 value. However, by adding height at withers to heart girth, it resulted in an increase of 0.41% in R^2. It showed a similar trend as in the Brakmas cattle as the highest R^2 change was recorded when all three body measurements were used in the equation compared to single measure of heart girth at 0.51%.

Table 4. Multiple regression analysis for body weight prediction using body length (BL), withers height (HW) and heart girth (HG) as independent variables, and coefficient of determination (R^2) of the models tested for Bali cattle

Models	Independent variables	Intercept	Regression coefficient			R^2	R^2 changes (%)
			HW	BL	HG		
A	HG	-233.03	-	-	3.05	0.971	-
B	BL	-278.09	-	4.38	-	0.910	-6.28
C	HW	-480.35	6.57	-	-	0.894	-7.93
D	HG, BL	-235.66	-	0.16	2.95	0.971	0
E	HG, HW	-151.52	-1.96	-	3.91	0.975	0.41
F	HG, BL, HW	-149.30	-2.22	0.52	3.68	0.976	0.51

Conclusion

The strong relationship between the body weight and body measurements in Brakmas and Bali cattle indicated that body measurements can be used to estimate the live body weight of these cattle with high degree of precision. Body length was highly correlated with body weight of Brakmas cattle, and heart girth was found to be highly correlated with body weight in Bali cattle, thus it can be used to generate body weight prediction equation with high precision alone or in combination with other body measurements. Although the combination of body measurements showed the highest coefficient of determination, the use of a single measure of body measurement - body length in Brakmas cattle and heart girth in Bali cattle - to predict the body weight seems to be more practical due to the unavailability of proper animal restraining facility in the rural areas. Furthermore, a single measure of body measurement already gave high precision to predict live body weight of the animals.

Several limitations of this method were identified in this study. Different breeds will show different relationship of body measurements-body weight, therefore it is essential to study the relationship of body measurements-body weight of every breed of cattle as the equation generated is specific to a particular breed.

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