Relationship between body weight and body measurements of Aceh cattle

Putra[1*], W.P.B., Sumadi[2], Hartatik[2], T. and Saumar[3], H.
[1]Laboratory of Animal Breeding and Genetics, Indonesian Institute of Sciences Bogor, West Java 16911, Indonesia. [2]Department of Animal Production, Faculty of Animal Science, Gadjah Mada University, Yogyakarta 55281, Indonesia. [3]Indrapuri Breeding and Forages Centre (IBFC) of Aceh Cattle, Aceh 23363, Indonesia.
[*]Correspondence author: banchet_putra18@yahoo.co.id

Abstract

Data on body weight (BW) and measurements: withers height (WH), body length (BL) and heart girth (HG) of 79 (39 males and 40 females) of Aceh cattle (average 550 days of age) were collected at the Breeding Station in Indrapuri district, Aceh Besar, Indonesia to estimate the BW from body measurements. The data were subjected to standard statistical analysis using SPSS 16.0 software and linear regression analysis was applied by keeping BW as dependent variable and body measurements of WH, BL and HG as the independent variables. The overall means (± SD) for BW, WH, BL and HG of Aceh cattle over the sexes were 129.37 ± 30.84 kg, 96.59 ± 7.11 cm, 93.10 ± 11.77 cm and 118.15 ± 11.08 cm, respectively. Predicted BW based on C, E, F and G regression models showed no significant difference ($P > 0.05$) with the means of actual BW. The study revealed that HG was the best predictor of BW estimate and this alone contributed more than 80% of the variation in the BW of Aceh cattle. It is concluded that a simple linear regression involving HG as the predictor variable has a high accuracy in predicting BW.

Keywords: Aceh cattle, body measurements, body weight, regression models

Introduction

Aceh cattle is one of several Indonesian native cattle breeds that have been the subjects of research and development since 2011 by Indrapuri Breeding and Forages Centre (IBFC) of Aceh Cattle at Indrapuri district, Aceh province, Indonesia. It is a cross between local Zebu cattle, *Bos indicus*, and Bali cattle since several hundreds years ago (Photograph 1). This cattle breed is yet to be improved with regard to production performance parameters for higher meat yield under stressful tropical conditions such as low quality nutrient feed, tropical climate, diseases and parasites. As this is the native cattle of Indonesia, there should be intensive genetic improvement by the government (breeding centre) and the breeders to increase the mean performance of body weight parameters. Most animals are located in the rural areas of Indonesia specifically in Aceh province and owned by rural households, including farmers and minor business owners with small herd size practising traditional feeding and management system.

Often, the marketing of animals is based on visual assessment, while drugs are administrated mostly by estimation, because the use of live weight criterion in feeding, marketing and drug administration requires a weighing scale, which is expensive and not readily affordable by many small rural households. Besides, most farmers do not have the training to use the weighing scales properly. Several studies have been carried out to develop methods of estimating the live

body weight of cattle using formulae derived from body measurement (Hardjosubroto, 1994). Body measurements are simple and easily measured variables for estimating the live weight, although the derived prediction equation using body measurements to estimate body weight is unlikely to be more accurate than direct measurement of body weight (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 position or posture during the procedure of body measurements.

However, body measurements have been used to evaluate breed performance and characterize animals (Warwick *et al.*, 1990), though general studies have considered only heart girth or may also include body length and withers height in developing predictive equations. The heart girth measurement has been reported to have high correlation with body weight in many breeds of cattle. High correlation between heart girth and body weight were also found in Bali cattle (Gunawan and Jakaria, 2010), Ongole grade cows (Paputungan *et al.*, 2013), male Kamphaengsaen beef cattle (Sawanon *et al.*, 2011) and Tanzania Shorthorn Zebu cattle (Kashoma *et al.*, 2011). This study was therefore aimed at establishing relationship between body measurements and body weight of Aceh cattle for managerial decisions in rural areas of Indonesia.

Photograph 1: A young cow of Aceh cattle

Materials and Methods

A dataset of measurements was compiled from 79 Aceh cattle of average age 550 days at the Indrapuri Breeding and Forages Centre (IBFC) of Aceh Cattle, at Indrapuri district, Aceh province, Indonesia. The cattle sample comprised of 39 males and 40 females. The measurements taken on each animal were body weight (BW) taken using a digital weighing scale, heart girth (HG), measured with a tape measure as circumference of the chest just behind the foreleg, withers height (WH) measured with a stick-ruler as the distance from the surface of the platform to the dorsal point of the withers and body length (BL) measured using a tape measure from the head of the humerus to the end of the posterior.

Collected data were handled in Microsoft Office Excel 2007 whereas statistical analyses were done using SPSS 16.0 software to generate descriptive statistics. Correlation coefficients between

BW and body measurements were obtained. Linear regression models were fitted with BW as the dependent variable and body measurements (HG, WH and BL) as the independent variables to obtain the relationship between BW and body measurements.

Linear effects of independent variables on body weight were included in the following model (Steel and Torrie, 1980):

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + E_i$$

where Y_i is the body weight (BW) observation of an *i*-th animal, β_0 is the intercept, β_1, β_2, β_3 are the corresponding linear regression coefficients for WH, BL and HG, respectively and E_i is the error term.

The BW was predicted using the prediction equations developed in the present study. Hence, it was posible to make comparisons amongst actual and predicted BW by means of a paired t-test (Sawanon *et al.*, 2011).

Results and Discussion

Body Measurements

Aceh cattle were 129.37 kg in body weight at 550 d of age, 96.59 cm in height at withers measured from the ground and 118.15 cm in height at withers (Table 1). These were indicators of the size of the animal at 550 days of age. Aceh cattle is one of smallest native breeds in Indonesia. The BW at 550 days of age of several native breeds in Indonesia was reported to be 170.84 $\pm$ 20.52 kg for Bali, 254.32 $\pm$ 47.91 kg for Brahman cross, 127.00 $\pm$ 17.42 kg for Pesisir, 152.30 $\pm$ 32.00 kg for Ongole crossbreds and 182.02 $\pm$ 26.60 kg for Katingan cattle (Zurahmah and Teh, 2011; Duma, 1997; Wirdahayati and Bamualim, 2007; Wijono *et al.*, 2007; Utomo *et al.*, 2010). Abdullah *et al.* (2007) reported that the BW of Aceh cattle (1.5 years old) were 123.34 $\pm$ 25.38 kg (male) and 116.70 $\pm$ 25.83 kg (female). An earlier report by Bakhtiar (2010) revealed the average BW (550 days of age) of Aceh cattle in the same location was 114.75 $\pm$ 19.66 kg (male) and 113.27 $\pm$ 16.29 kg (female). The average BW of Aceh cattle in the present study was higher than those reported by Abdullah *et al.* (2007) and Bakhtiar (2010). These differences might be due to the variation in genetic effects, environmental differences in management practices from year to year (Falconer and Mackay, 1996).

Table 1. Mean body weight and body measurements of Aceh cattle

Variables	Mean	SD	Range	CV (%)
Male (n=39)				
BW (kg)	131.23	27.28	67.00 – 183.00	20.79
WH (cm)	98.41	7.92	84.00 – 132.00	8.05
BL (cm)	94.72	14.56	78.00 – 172.00	15.37
HG (cm)	117.38	9.79	91.00 – 132.00	8.34
Female (n=40)				
BW (kg)	127.55	34.21	71.00 – 223.00	26.82
WH (cm)	94.83	5.78	82.00 – 105.00	6.10
BL (cm)	91.53	8.09	73.00 – 103.00	8.84
HG (cm)	118.90	12.29	96.00 – 145.00	10.34
Total (n=79)				
BW (kg)	129.37	30.84	67.00 – 223.00	23.84
WH (cm)	96.59	7.11	82.00 – 132.00	7.36
BL (cm)	93.10	11.77	73.00 – 172.00	12.64
HG (cm)	118.15	11.08	91.00 – 145.00	9.38

LW: body weight; WH: withers height; BL: body length; HG: heart girth;
SD: standard deviation; CV: coefficient of variation; n = number of observations

Correlation and Coefficients of Determination

Positive correlation was found between body measurement parameters and BW in Aceh cattle indicating as the body measurements increase the body weight also increases. Among these three measurements, HG had the highest correlation coefficient with BW (0.93 for male and 0.84 for female). The correlation coefficients between HG and BW in several breeds of cattle such as Tanzania Shorthorn Zebu (0.94), Kamphaengsaen (0.91), Nyalawi (0.88), Nguni (0.58), Holstein (0.78), Brown Swiss (0.98), Bali (0.87) and Ongole crossbred (0.48) have been reported (Kashoma *et al.*, 2011; Sawanon *et al.*, 2011; Alsiddiq *et al.*, 2010; Serkan and Yalzin, 2009; Gunawan and Jakaria, 2010; Wijono *et al.*, 2007). Nesamvuni *et al.* (2000) reported that the correlation coefficient between HG and BW in male Nguni cattle (0.76) was higher than female cattle (0.62) similar to the finding of the present study. The high correlation between BW and body measurements suggest that HG could provide a good estimate of BW of Aceh cattle.

Table 2. Pearson correlation coefficients between variables of Aceh cattle

Variables	BL	HG	BW
Male (n=39)			
WH	0.87*	0.38	0.48*
BL	-	0.12	0.26
HG	-	-	0.93*
Female (n=40)			
WH	0.82*	0.80*	0.73*
BL	-	0.84*	0.81*
HG	-	-	0.84*

n = number of observation; * = significant value at $P < 0.05$

Table 3 presents a summary of the simple and multiple linear regression analyses and the models generated from predicting BW from the linear body measurements. Based on the regression models (A, B and C) BW could be predicted using parameters that had high coefficient of determination (R^2). The equation for BW from body measurement of HG alone (C models) was Y = -172.47 + 2.59 HG (R^2=0.86) for males and Y = -148.68 + 2.32 HG (R^2=0.70) for females. This showed that when increasing HG by 70 cm in males and females, the corresponding increase in BW could be about 8.83 kg and 13.72 kg, respectively. Kashoma *et al.* (2011) reported that the coefficient of determination (R^2) based on the C models in Tanzania Shorthorn Zebu cattle were 0.88 (males) and 0.87 (females), also Milla *et al.* (2012) reported in Nilotic cattle were 0.95 (males) and 0.94 (females).

The parameter estimates in the multiple linear regression models showed that more than one body measurements may be required to predict the BW in Aceh cattle. In the present study WH, BL and HG were the important body measurements required for predicting the BW of Aceh cattle, based on the highest R^2 values of the multiple linear regression equations. However, the accuracy of estimation could be improved if the variables were combined in a multiple regression.

Table 3. Simple and multiple regression models for predicting body weight (dependent variable) from linear body measurements (independent variable) of Aceh cattle

Models	Independent variables	Intercept	Regression coefficient			SE	r	R^2
			WH	BL	HG			
Male (n=39)								
A	WH	-31.27	1.65	-	-	24.26	0.48	0.23
B	BL	85.74	-	0.48	-	26.72	0.26	0.07
C	HG	-172.47	-	-	2.59	10.29	0.93	0.86
D	WH; BL	-110.26	3.66	-1.26	-	22.81	0.58	0.34
E	WH; HG	-204.98	0.52	-	2.43	9.67	0.94	0.88
F	BL; HG	-192.59	-	0.27	2.54	9.61	0.94	0.88
G	WH; BL; HG	-197.89	0.18	0.19	2.50	9.73	0.94	0.88
Female (n=40)								
A	WH	-279.73	4.30	-	-	23.83	0.73	0.53
B	BL	-186.13	-	3.43	-	20.32	0.81	0.66
C	HG	-148.68	-	-	2.32	19.08	0.84	0.70
D	WH; BL	-233.77	1.15	2.76	-	20.21	0.82	0.67
E	WH; HG	-199.37	1.01	-	1.95	19.00	0.84	0.71
F	BL; HG	-189.25	-	1.57	1.46	18.00	0.86	0.74
G	WH; BL; HG	-195.42	0.15	1.51	1.43	18.24	0.86	0.74

WH: withers height; BL: body length; HG: heart girth; r: correlation coefficient;
R^2: coefficient of determination; SE: standard error of the estimate; n = number of observation

Table 4 shows that the C, E, F and G models produced no significant ($P > 0.05$) difference between actual and predicted body weight for each group. Although when compared with the E, F and G models, the C models had lower R^2 value for each group (Table 3), the input parameters required can be measured using only HG, which is easy and fast for the farmer, especially for male Aceh cattle (R^2= 0.86). Similar findings reported by Sawanon *et al.* (2011) for C models had high R^2 value (0.83) in male Kamphaengsaen cattle.

Table 4. Difference between the actual body weight and the predicted body weight using several regression models

Models	Mean (kg)	SD	Range	CV (%)	Sig.*
Male (n=39)					
A	131.26	13.01	107.33 – 186.53	9.91	S
B	131.21	6.98	123.18 – 168.30	5.32	S
C	131.59	25.31	63.22 – 169.41	19.24	NS
D	130.89	15.67	97.97 – 162.56	11.97	S
E	131.52	25.57	60.87 – 170.55	19.44	NS
F	131.18	25.60	59.88 – 169.96	19.52	NS
G	131.33	25.61	60.10 – 169.84	19.50	NS
Actual	131.23	27.28	67.00 – 183.00	20.79	-
Female (n=40)					
A	128.39	24.76	72.97 – 171.77	19.29	NS
B	127.84	27.72	64.26 – 167.16	21.68	NS
C	127.26	28.58	74.04 – 187.72	22.46	NS
D	128.02	28.02	63.16 – 165.74	21.88	NS
E	128.42	28.88	75.70 – 189.43	22.49	NS
F	128.11	29.46	69.90 – 181.02	22.99	NS
G	127.12	29.37	68.83 – 180.19	23.11	NS
Actual	127.55	34.21	71.00 – 223.00	26.82	-

SD: standard deviation; CV: coefficient of variation; S: significant at $P < 0.05$;
NS: not significant at $P > 0.05$

Conclusion

The strong relationship between body weight and linear body measurements of Aceh cattle indicated that these variables or their combination could be used to estimate the body weight of these cattle. Heart girth had the highest correlation with body weight for each group. Simple and multiple linear regression models using other body measurement parameters that had high coefficient of determination (R^2 >0.80) could also be utilized. The C, E, F and G models for male cattle had the high R^2 value and these predicted equations could be used to predict the body weight of Aceh cattle.

Acknowledgement

The authors expressed appreciation to the Indrapuri's Breeding and Forages Centre (IBFC) of Aceh Cattle at Indrapuri district, Aceh Besar Regency, Aceh province, Indonesia and to the barn employees who were involved in the collection of data.

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