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Accuracy of heart girth for predicting live weight of Aceh cattle

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ABSTRACT: Data on live weight (LW) at 550 days of age and body measurements such as withers height (WH), body length (BL) and heart girth (HG) of Aceh bull and heifer have been collected from 79 animals (39 males and 40 females) managed at the Indrapuri's Breeding and Forages Centre (IBFC) of Aceh Cattle, Indrapuri District, Aceh Besar Regency, Aceh Province, Indonesia to estimate the LW from body measurements. The overall means (± SD) for LW, WH, BL and HG of Aceh cattle over sexes were 129.37 ± 30.84 kg, 96.59 ± 7.11 cm, 93.10 ± 11.77 cm and 118.15 ± 11.08 cm, respectively. The study revealed that HG was the best predictor of LW and this variable alone contributed 70% (female), 86% (male) and 74% (all animals) of the variation in the LW of Aceh cattle. It was concluded that highest determination coefficient (R^2) value of simple linear regression model was found on model LW (kg) = -172.47 + 2.59HG (cm), whereas this model were more effective and efficient for predicting the LW of male Aceh cattle.

Key words: Aceh cattle, body measurements, live weight estimation, regression models.

ABSTRAK: Data berat hidup (BH) umur 550 hari dan data ukuran tubuh seperti tinggi gumba (TG), panjang badan (PB) dan lingkar dada (LD) dari 79 ekor sapi Aceh (39 jantan dan 40 betina) yang dipelihara di Balai Pembibitan Ternak Unggul – Hijauan Pakan Ternak (BPTU-HPT) sapi Aceh Indrapuri, Kecamatan Indrapuri, Kabupaten Aceh Besar, Provinsi Aceh digunakan dalam pene;litian ini untuk mengestimasi BH berdasarkan ukuran tubuh. Rata-rata (± SD) BH, TG, PB dan LD pada seluruh sapi masing-masing sebesar 129,37 ± 30,84 kg; 96,59 ± 7,11 cm; 93,10 ± 11,77 cm dan 118,15 ± 11,08 cm. Hasil penelitian menunjukkan bahwa LD memberikan kontribusi terbesar terhadap BH seluruh sapi dan LD sendiri memberikan kontribusi sebesar 70% (betina), 86% (jantan) dan 74% (total sapi) terhadap variasi BH pada sapi Aceh. Disimpulkan bahwa nilai koefisien determinasi (R^2) tertinggi terdapat pada model regresi linear sederhana BH (kg) = -172,47 + 2,59 LD (cm), sehingga model ini lebih efektif dan efisien untuk menduga BH pada sapi Aceh jantan.

Kata kunci: Sapi Aceh, ukuran tubuh, pendugaan berat hidup, model regresi

INTRODUCTION

Aceh cattle are one of several Indonesian native cattle that have been the subjects of research and development since 2011 by Indrapuri's Breeding and Forages Centre (IBFC) of Aceh Cattle at Indrapuri district, Aceh province, Indonesia. It is a crossbred between *Bos indicus* and *Bos sondaicus* since a hundred years ago. The 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, a tropical climate, high prevalence of diseases and parasites. As Aceh cattle is the native cattle in Indonesia, there should be intensive genetic improvement by government (breeding centre) and the breeders to increase the performance parameters. Most animals are located in the rural areas of Indonesia, and are owned by rural households, farmers and minor businesspersons among others.

Often, the marketing of animals is based on visual assessment, while drugs are administrated mostly by estimation, because the use of live weight (LW) criterion in feeding, marketing and drug administration requires sophisticated facilities such as weighing scales, which are expensive and not readily affordable by many small rural households. In addition to lacking weighing scales, most farmers have less access to education to understand how to use the scales properly. Numerous studies have been carried out to develop methods of estimating the LW of cattle using formulae derived from body measurement (Hardjosubroto, 1994). Body measurements are simple and easily measured variables for estimating the LW, although it is unlikely to be more accurate than direct measurement LW (by scales) due to errors in the location of reference points and the anatomical distortions of muscle tone produced when the animal changes position or posture.

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 (HG) or maybe also body length (BL) and withers height (WH) in developing predictive equations. The HG has been reported to have high coefficient of correlation (r) with LW in many breeds of cattle. A high correlation between HG and BW was also found in Bali cattle (Gunawan and Jakaria, 2011), Ongole grade cow (Paputungan *et al.* 2013), male Kamphaengsaen beef cattle (Sawanon *et al.* 1999) and Tanzania Shorthorn Zebu cattle (Kashoma *et al.* 2011). This fact repeatedly calls the attention to the important taking cattle body measurement, and offers opportunity for estimating parameters in relation to the various body measurements. Falconer and Mackay 1996) reported that body weight of animals was an important factor associated with several management practices including selection for slaughter, breeding of ideal heifers weight mated with higher bulls weight, determining feeding levels, and also it good indicator of animal condition. This work was therefore aimed at establishing relationship between HG measurement and LW of Aceh cattle for managerial decisions in rural area of Indonesia.

MATERIAL AND METHOD

Measured traits

A cross sectional was compiled from 79 Aceh cattle (550 days of age) at Indrapuri's Breeding and Forages Centre (IBFC) of Aceh Cattle, Indrapuri

district, Indonesia comprising of 39 males and 40 females. Measurements of bulls and heifers were taken from March to May 2014 on each Aceh population including heart girth (HG), measured with a tape measure as circumference of the chest just behind the foreleg, withers height (WH), measured with a stick-rule as the distance from the surface of the platform to the dorsal point of the withers, body length (BL) measured using a tape measure from distance between the site of pins (*tuber ischii*) to tail drop (*tuberositas humeri*). Animals were also weighed directly using the manual scale equipment tool with the maximum capacity of 1000 kg.

Statistical analysis

The data collected on each animal were analyzed using the Insert Function Prosedure of the related statistical category in datasheet of Microsoft Office Excel (2003) within the animal sex groups. The interrelationship of body weight and body measurements was estimated by simple correlation and regression (Steel and Torrie, 1980). The fixed effect considered was sex of animal. The model used was follows:

$$Y_{ijk} = \mu + \alpha_i + \Sigma\, b_t\, X_{ijk}\, (\alpha_i) + \varepsilon_{ijk}$$

where Y_{ijk} was record of LW of each animal, μ was overall mean, α_i was the fixed effect of sex of the animal and ε_{ijk} was random error associated with record of each animal. Comparisons between means were determined by Duncant Multiple Range Test (DMRT) method.

The best estimation equation for LW from other traits (WH, BL and HG) as independent variables was determined. Descriptive statistics and regression analysis of LW on each of independent variable were performed using SPSS 16.0 software to obtain descriptive statistics (means, standard deviation, range and coefficient of variation). The regression technique was made by keeping LW as a dependent variable and different body measurements as independent variables and was also used to obtain the relationship between LW and HG for each sex and total sample.

Correlation coefficients were also obtained from LW and body measurements. Linear effects of independent variables on LBW were included in the following model:

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

where Y_i the live weight (LW) observation of an *i*-th animal, β_0 the intercept, β_1, β_2, β_3 the corresponding linear regression coefficient of WH, BL and HG, and E_i the residual error term.

RESULTS AND DISCUSSIONS

Body measurements

Descriptive statistics of body measurements are shown in Table 1. Aceh cattle were 96.59 $\pm$ 7.11 cm from the ground. This is an indicator of the size of the animal at mature age. Aceh cattle were one of smallest native breeds in Indonesia. The LW (1.5 years old) of several native breeds in Indonesia such as Bali (170.84 $\pm$ 20.52 kg), Brahman cross (254.32 $\pm$ 47.91 kg), Pesisir (127.00 $\pm$ 17.42 kg), Ongole crossbred (152.30 $\pm$ 32.00 kg) and Katingan were 182.02 $\pm$ 26.60 kg (Zurahmah and The, 2011; Duma, 1997; Wirdahayati and Bamualim. 2007; Wijono *et al.* 2007; Utomo *et al.* 2010). Abdullah *et al.* (2007) reported that the LW of Aceh cattle (1.5 years old) were 123.34 $\pm$ 25.38 kg (males) and 116.70 $\pm$ 25.83 kg (females) and smaller than this research. These differences might be due to the variation in genetic effects, environment and different of management practice.

However, the mean weight of Aceh cattle in the present study is higher than that reported earlier by Abdullah *et al.* (2007). Several body measurements at 1.5 years old of native cattle in Indonesia were observed by Putra (2010) for Ongole crossbred were WH (131.30 ± 6.23 cm), BL (121.73 ± 10.69 cm) and HG (168.08 ± 10.63 cm).

Table 1. Least square of means of live weight and body measurements of Aceh cattle

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

LW: live weight; WH: withers height; BL: body length; HG: heart girth; SD: standard deviation; CV: coefficient of variance

Table 2. Coefficients of correlation between variables of Aceh cattle

Variables	WH	BL	HG	LW
Males (39)				
WH	1.00	0.87	0.38	0.48
BL	-	1.00	0.12	0.26
HG	-	-	1.00	0.93
LW	-	-	-	1.00
Females (40)				
WH	1.00	0.82	0.80	0.73
BL	-	1.00	0.84	0.81
HG	-	-	1.00	0.84
LW	-	-	-	1.00
Total (79)				
WH	1.00	0.85	0.52	0.57
BL	-	1.00	0.38	0.45
HG	-	-	1.00	0.86
LW	-	-	-	1.00

WH: withers height; BL: body length; HG: heart girth; LW: live weight

Table 3. Simple and multiple regression models for predicting live 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			
Males (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
Females (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
Total (79)								
A	WH	-110.78	2.49	-	-	25.44	0.57	0.33
B	BL	18.72	-	1.19	-	27.66	0.45	0.21
C	HG	-154.32	-	-	2.40	15.70	0.86	0.74
D	WH; BL	-123.45	2.91	-0.30	-	25.54	0.58	0.33
E	WH; HG	-196.07	0.73	-	2.16	15.15	0.88	0.77
F	BL; HG	-172.58	-	0.40	2.24	15.20	0.87	0.76
G	WH; BL; HG	-188.68	0.45	0.19	2.18	15.20	0.88	0.77

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

Therefore Patmawati *et al.* (2013) reported in Bali were WH (117.61 ± 6.40 cm), BL (123.08 ± 10.07 cm) and HG (156.89 ± 15.15 cm), Utomo *et al.* 2010 reported in Katingan were WH (110.50 ± 9.40 cm), BL (122.00 ± 8.65 cm) and HG (144.00 ± 12.35 cm). Wirdahayati and Bamualim (2007) reported that WH and HG measurements in Pesisir were 107.50 cm and 117.50 cm respectively. Abdullah *et al.* (2007) reported that the body measurements of Aceh cattle (1.5 years old) were WH (93.77 ± 5.82 cm), BL (93.42 ± 8.03 cm) and HG (118.65 ± 8.30 cm) for male meanwhile in female were WH (92.78 ± 6.51 cm), BL (92.01 ± 7.61 cm) and HG (116.19 ± 8.94 cm).

Correlation and determination coefficients

The correlation coefficients (r) among LW and body measurements in Aceh cattle are shown in Table 2. Supiyono (1998) reported several criterion of correlation such as no correlation between two variables (0), very low correlation (0 – 0.25), medium correlation (0.25 – 0.50), high

correlation (0.50 – 0.75), very high correlation (0.75 – 0.99) and perfect correlation (1.00). Positive correlation was found between parameters measured and LW as the body measurements increased while body weight also increased. Among these three measurements, HG had the highest correlation coefficient. The r values between HG and LBW in several breeds 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) (Kashoma *et al.* 2011; Sawanon *et al.* 2011; Alsiddiq *et al.* 2010; Serkan and Yalzin, 2009; Gunawan and Jakaria, 2011; Wijono *et al.* 2007). Nesamvuni *et al.* (2000) reported that the r values between HG and LW in male Nguni cattle (0.76) were higher than female cattle (0.62) and similar to this study.

The high r value between LW and body measurements suggest that either of these variables or their combination could provide a good estimate for predicting LW of Aceh cattle. Correlations between LW and body linear measurements of HG were positive and high criterion. The correlation between all pairs of linear body measurements and LW indicated that frame size of the animal was complementary and that the total size of the animal was a function body LW and circumference measurements of animal body (HG) and body volume.

Table 3 present a summary of the simple and multiple linear regression analyses and the models generated from predicting the body weight from the linear body measurements. Based on the simple regression models (A, B and C) of LW changes could be predicted using parameters that had high coefficient of determination (R^2). Based on the simple regression analysis, the best equation for prediction of the LW from body measurements was by including the HG variable alone (C model) and the equation was Y_i = -172.47 + 2.59 HG (males), Y_i = -148.68 + 2.32 HG (females) and Y_i = -154.32 + 2.40 HG (all animals). This showed that when increasing HG by 70 cm in males and females, the corresponding increase in LW could be about 8.83 kg and 13.72 kg respectively. Kashoma *et al.* (2011) reported that the R^2 values 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).

Thus, HG was the best predictor for the estimation of LW and the variable alone contributed 0.86% (males), 0.70% (females) and 0.74% (all animals) variation in the LW of Aceh cattle. The R^2 value based on the C model ($Y_i = \beta_0 + \beta_1 HG$) in several cattle breeds such as Kamphaengsaen (0.75), Nyalawi (0.79), Messairi (0.38), Holstein (0.61), Brown Swiss (0.91) and Nguni (0.78) were generally high (Sawanon *et al.* 2011; Alsiddiq *et al.* 2010; Serkan and Yalzin, 2009; Nesamvuni *et al.* 2000). Similar findings were reported by Goe *et al.* (2001) in Abyssinian Short-horn (0.75) and Horro (0.87) oxen breeds. Therefore among Indonesian native cattle such as Bali were 0.76 (Gunawan and Jakaria, 2011) and 0.86 (Paputungan *et al.* 2013),

The parameter estimates in the multiple linear regression models showed that more than one body measurements might be required to predict the LW in Aceh cattle. In the present study WH, BL and HG were the important body measurements required for predicting the LW 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. According to these results, the LW estimation of Aceh cattle using WH, BL and HG as independent variables in multiple regression produced the highest accuracies of LW prediction among all animals and sex groups. Consequently, as one of these measurements was decreased then the animal frame size was also decreased, affecting animal body weight.

Although when compared with the G models, the C models had lower R^2 value for each group (Table 3), the input parameters required could be measured using only HG, which is easy and fast for the farmer, especially for male Aceh cattle (R^2 > 0.80). The similar findings reported by Sawanon *et al.* (2011) that C models had high R^2 value (0.83) in male Kamphaengsaen cattle.

CONCLUSION

The strong relationship between the live weight (LW) and linear body measurements of Aceh cattle indicated that the variables or their combination could be used to estimate or to predict the LW of these cattle. Heart girth (HG) had the highest correlation to LW 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 be utilized. The C and G models for male cattle had the high R^2 value (>0.80) and these predicted equations could be used to predict the LW of male Aceh cattle and both models produced no difference (P > 0.05) between the actual and predicted of LW.

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