Buletin Peternakan 42 (1): 20-25, February 2018

ISSTAP
Indonesian Society for Sustainable Tropical Animal Production

Bulletin of Animal Science

ISSN-0126-4400/E-ISSN-2407-876X Acredited: 36a/E/KPT/2016
http://buletinpeternakan.fapet.ugm.ac.id/

Doi: 10.21059/buletinpeternak.v42i1.29840

Body Weight Estimation of Bali Cattle in Banyumulek Techno Park, West Nusa Tenggara using Several Morphometric Parameters

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Article history
Submitted: 2 November 2017
Accepted: 24 January 2018

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ABSTRACT

This study was conducted to find the best linear regression equation to estimate the body weight (BW) of female Bali cattle in Banyumulek Techno Park, West Nusa Tenggara based on three morphometric parameters, i.e. withers height (WH), body length (BL), and heart girth (HG). Data collection was conducted by random sampling of female Bali cattle (1-5 years of age) in Banyumulek Techno Park. A total of 63 female Bali cattle were used in this study. The parameter of WH (distance from the ground level to the highest point of withers) and BL (distance from the shoulder joint (*later tuberosity of humerus*) to the pelvic bone) were measured with a measuring stick. The HG data (circumference around the chest at the fourth rib) was measured with a measuring tape. Identification of age was carried out based on the animal recording book and incisors condition. The descriptive statistic analysis (mean value, standard deviation, the coefficient of variation, minimum and maximum value) of the morphometric and BW data were performed using MS Excel 2017 program. The linear regression equation analysis and the comparison between actual and estimated BW values (Independent sample T-test) were performed using SPSS 16.0 program. The BL and BW parameters had the highest correlation coefficient (r) value (0.86). The test result showed that the predicted BW value of female Bali cattle was not significantly different with the actual BW when using G model of linear regression equation (three variables used). The G model of linear regression equation had the highest R^2 value (0.84). However the R^2 value in the F model with two variables (BL and HG) was also high (0.83). It can be concluded that the simple linear regression equation BW=(0.96)(WH)+(1.26)(BL)+(1.57)(HG)-284.92 are the best model to estimate the BW value of female Bali cattle in Banyumulek Techno Park.

Keywords**:** Bali cattle, Body measurement, Body weight, Correlation, Regression

Introduction

Banyumulek located in the province of West Nusa Tenggara (NTB) has developed into a livestock-based industrial region. Since 2015, Banyumulek was attempted to become one of the Techno Park regions in Indonesia through cooperation between Indonesian Institute of Sciences (LIPI), Department of Animal Husbandry and Animal Health of NTB, and academics. The development program of Bali cattle in this region could be done by the support of local government institutions such as Artificial Insemination Center of Banyumulek region (BIBD) for providing Bali cattle breed, Ruminant Feed Processing and Development Center (BP3TR) for providing quality feed (Sari *et al*., 2017), and Animal Slaughterhouse (RPH). The presence of these institutions can become economic drive of the society around the Techno Park (TP) of Banyumulek, NTB.

Bali cattle is a native cattle of Indonesia (Mohamad *et al*., 2009; Martojo, 2012) it is the dominant cattle in NTB province, especially in Banyumulek region. Maintenance pattern and Bali cattle breeding programs in the region need to be given attention to avoid genetic quality decline due to inbreeding or adverse selection. The selection of superior female Bali cattle as a prospective heifer is very important to do, so improvement of the genetic quality of cattle can be achieved. The criteria for choosing a good Bali cattle heifer can be done by following the standard in SNI 7651-4: 2017 on Bali cattle breed. However, the selection of heifer candidate of Bali cattle have to pay attention to the purity of Bali cattle, the condition of the reproduction organ, and body weight (Gunawan and Jakaria, 2011).

Body weight of a cattle can only be known precisely through weighing. In certain situations and conditions (especially in smallholder farms) there are rarely or not available cattle scales, so a more practical way to estimate the weight of livestock is needed. Based on some research results, it is known that there is a relationship between Bali cattle morphometry with body weight, so that it can be made a linear regression equation

to estimate body weight at specific age and gender (Gunawan and Jakaria, 2011; Zurahmah and The, 2011). Nevertheless, these linear regression equations have limitations regarding accuracy of their use. The linear regression equation used to estimate body weight of Bali cattle in Bangka Belitung Province (Ni'am *et al*., 2012) has a different level of accuracy when used to estimate body weight of Bali cattle on the Bali island (Gunawan and Jakaria, 2011). Therefore, an appropriate linear regression equation is required for use in Bali cattle population in certain areas which have cultural diversity, maintenance patterns, and geographic conditions. The purpose of this study was to find the appropriate linear regression equation to estimate body weight based on morphometric data of female Bali cattle in Banyumulek TP, NTB.

Materials and Methods

Research materials

Data collection was conducted by random sampling of Bali cattle group (1-5 years of age) in Banyumulek Techno Park. A total of 63 female Bali cattle were used in this study to obtain age, body weight (BW), and morphometric data. Morphometric data included withers height (WH), body length (BL), and heart girth (HG).

Measurement methods

Measurement methods of livestock morphometric data were treated according to Ozkaya *et al*. (2016). The BW data were obtained by weighing the animal on a 0.5 kilograms scale (Iconix FX-1, New Zealand) with a perpendicular position to the surface. The BL data were obtained by measuring the distance between the shoulder joint (*later tuberosity of humerus*) to the edge of the pelvic bone. The WH data were obtained by measuring the distance from the withers to the surface by the perpendicular line. WH and BL parameters were measured using measuring stick (Hauptner, Germany) on a scale of 1 cm. The HG data were obtained by circling the measuring tape (Rondo, Switzerland) scale 1 cm on the chest or body behind the shoulder. The identification of the age of Bali cattle was based on livestock recording book owned by livestock owners and observation on the incisors condition.

Data analysis

The morphometric and BW data obtained were classified into four age categories: age group (1.1 - 2 years, 2.1 - 3 years, 3.1 - 4 years, 4.1 - 5 years). Grouping of data by age category of cattle was done for data analysis (testing the result of linear regression equation). Analysis of descriptive statistics was conducted on morphometry and BW data in each age group to get mean value, standard deviation, coefficient of variation, minimum value, and maximum value using MS Excel 2007 program.

The linear regression equation was analyzed according to the formula of Steel and Torrie (1993) as followed: $Y=\alpha+\beta_1.X_1+\beta_2.X_2+\beta_3.X_3+E$, where Y=dependent variable (BW), α=constant, β=regression coefficient, X_1=independent variable 1 (WH), X_2=independent variable 2 (BL), X_3=independent variable 3 (HG), E=error. The result of BW estimation value based on the linear regression equation then compared with actual BW value using Independent Sample T-test analysis. The analysis was conducted to determine the accuracy of the linear regression equation to real BW value (actual). The analysis of linear regression equation and Independent Sample T-test was done using SPSS 16.0 program.

Results and Discussion

Body weight and morphometry

The analysis result of descriptive statistics of morphometry and BW data of female Bali cattle in Banyumulek Techno Park was presented in Table 1.

The coefficient of variation on the BW parameter was higher than the morphometric parameters in each age group. It could be interpreted that BW parameter in female Bali cattle in Banyumulek TP more varied than morphometric parameters. The Government of Indonesia had decided WH, BL, and HG parameters as a measurement of vital statistics that was become a criteria for female Bali cattle through the publication of SNI 7651-4: 2017. Based on the SNI, the minimum value of WH parameter in female Bali cattle aged 1.5 to 2 years (two permanent incisors) was class I (107 cm), II (104 cm), and III (100 cm) and for parameter BL that was class I (112 cm), II (105 cm), and III (101 cm). Meanwhile, the minimum value of HG parameter was class I (139 cm), II (130 cm), and III (124 cm). Morphometry of female Bali cattle based on SNI 7651-4: 2017 and its comparison with the results of this study were presented in Table 2.

When compared with SNI, the mean values of WH, BL, and HG of female Bali cattle in Banyumulek TP of age group >24-36 months in this study were included in class II. Nevertheless, there were several female Bali cattle in Banyumulek TP of age group >24-36 months in this study which entered in class I based on SNI 7651-4: 2017. Therefore, a breeding program to obtain superior breed of female Bali cattle and in accordance with SNI from Banyumulek TP was very possible with the implementation of the correct and consistent recording system. When compared with Bali cattle kept on Sumbawa island (Soekardono *et al*., 2009), female Bali cattle in this study had lower mean values of WH, BL, and HG parameters, but they had higher

Table 1. Mean value of morphometric and body weight data of female Bali cattle in Banyumulek Techno Park, NTB

Age/parameter	Morphometry (cm)			BW (kg)
	WH	BL	HG	
1.1 – 2.0 years (N = 28)				
Mean	105.86	105.07	133.50	157.91
Standard deviation	3.48	7.67	6.82	23.30
Coefficient of variation (%)	3.29	7.30	5.11	14.75
Minimum	100.00	85.00	121.50	130.50
Maximum	113.00	119.00	147.00	224.50
2.1 – 3.0 years (N = 21)				
Mean	108.14	107.90	135.10	164.83
Standard deviation	5.27	7.60	7.16	22.96
Coefficient of variation (%)	4.87	7.05	5.30	13.93
Minimum	103.00	99.00	124.00	141.00
Maximum	122.00	125.00	150.00	221.50
3.1 – 4.0 years (N = 7)				
Mean	111.14	113.71	140.14	181.00
Standard deviation	5.67	7.70	6.62	17.21
Coefficient of variation (%)	5.10	6.77	4.72	9.51
Minimum	105.00	104.00	134.00	165.50
Maximum	121.00	125.00	153.00	211.00
4.1 – 5.0 years (N = 7)				
Mean	126.64	128.64	150.36	237.00
Standard deviation	8.25	7.04	7.84	37.35
Coefficient of variation (%)	6.51	5.47	5.21	15.76
Minimum	113.00	120.00	138.00	185.5
Maximum	135.50	138.00	159.50	276.00
Total (N = 63)				
Mean	109.52	109.60	136.64	171.68
Standard deviation	8.00	10.39	8.65	34.25
Coefficient of variation (%)	7.31	9.48	6.33	19.95
Minimum	100.00	85.00	121.50	130.50
Maximum	135.50	138.00	159.50	276.00

N = number of observations; WH = withers height; BL = body length; HG = heart girth; BW = body weight.

Table 2. Mean value of morphometric data of Bali cattle and its comparison with SNI 7651-4:2017 and another study

Age (months)	Parameter	Unit	This study	Lombok[a]	Sumbawa[a]	Class[b]		
						I	II	III
12-24	WH	cm	105.86	105.27	107.60	-	-	-
	BL	cm	105.07	106.73	107.36	-	-	-
	HG	cm	133.50	133.00	144.57	-	-	-
>24-36	WH	cm	108.14	-	-	110	106	104
	BL	cm	107.90	-	-	114	110	105
	HG	cm	135.10	-	-	147	135	130

[a]Based on Soekardono *et al*. (2009); [b]Based on SNI 7651-4: 2017.

mean values of WH and HG parameters compared to female Bali cattle on Lombok island (Table 2).

Coefficient of correlation and coefficient of determination

Based on morphometric data and body weight of female Bali cattle in the Banyumulek TP grouped into four age categories, obtained the different number of observation samples (n) for each age category. Therefore, the analysis to obtain the linear regression equation in this study used all observation samples (n = 63) without age grouping with the consideration in limitations of the number of samples in some age groups. In addition, the use of all the observation samples without age grouping was also useful to test the linear regression equation obtained for the four age groups in this study in the hope that the equation could be used in all age groups.

The coefficient of correlation value (r) between morphometric and BW parameters showed positive and high results (0.83 < r <0.86) (data presented in Table 3).

The r value between BL and BW parameters of 0.86 was the highest r value in this study. Meanwhile, the r value between WH and BW parameters and between HG and BW parameters also height of each of 0.83. High correlation values between HG and BW parameters were also reported in some cattle breed such as Nyalawi (0.88), Holstein (0.78), and 0.87 in Bali cattle (Alsiddig *et al*., 2010; Ozkaya and Bozkurt, 2009;

Gunawan and Jakaria, 2011). Meanwhile, the correlation values between moderate HG and BW parameters (0.40 < r < 0.70) were reported in Ongole grade cattle at 0.48 (Wijono *et al*., 2007). The correlation values between HG and BW parameters were reported to be very high (r > 0.90) in some cattle breeds such as Tanzania Shorthorn Zebu (0.94), Kamphaengsaen (0.91), and Brown Swiss (0.98) (Kashoma *et al*., 2011; Sawanon *et al*., 2011; Ozkaya and Bozkurt, 2009). A high correlation value between morphometric parameters (WH, BL, HG) and BW parameters showed that most of the volume and dimensions of cattle body were affected by these morphometric parameters, so that WH, BL, and HG parameters in this study could be used to estimate the body weight of female Bali cattle.

A simple linear regression equation based on WH, BL, HG as the independent variable (G Model) had a coefficient of determination (R^2) of 0.84 and included to the high category (0.70 < R^2 < 0.90) (data presented in Table 4).

The morphometric parameter of female Bali cattle in this study had a coefficient of determination (R^2) that was categorized as moderate-high when used in making various models for regression equations, whether in a model using only one parameter (WH, BL, or HG) or using a combination of two or three parameters. Zurahmah and The (2011) reported that linear regression equation using combination of three parameters (WH, BL, and HG) in male Bali cattle could be used to estimate BW values with a high degree of accuracy.

The value of R^2 in G model showed that BW value estimation on female Bali cattle in Banyumulek TP was 84% influenced by combination of WH, BL, and HG parameters and the remaining 16% was influenced by other factors outside the model, e.g. cattle condition when measured or weighed, measurement method, accuracy of measuring instruments, and others. However, simple linear regression equation with a high R^2 value (G model) was the best estimator of BW value. This was supported by the result of analysis which was shown in graph between actual BW value and predicted BW value using G model which was looked close to straight line (Figure 1) so that simple linear regression equation in G model could be used to predict BW value of female Bali cattle especially in region of Banyumulek TP, NTB.

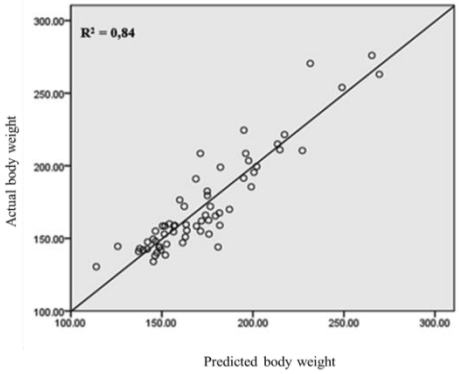

Figure 1. Linear regression of G model (R^2=0.84) estimated body weight of female Bali cattle in Banyumulek Techno Park, NTB.

The results of this study was different with the results of research on Bali cattle as well as other breeds that recommended the use of C model (i.e., HG parameter) with high R^2 values in HG parameters, e.g. in Tanzania Shorthorn Zebu cattle (0.87), Kamphaengsaen (0.75) Nyalawi (0.79), Bali (0.76) and Ongole grade cattle (0.86) (Kashoma *et al*., 2011; Sawanon *et al*., 2011; Alsiddig *et al*., 2010; Gunawan and Jakaria, 2011; Paputungan *et al*., 2013). Meanwhile, R^2 values in moderate C model (0.40 < R^2 < 0.70) were reported in crossbreed dairy cattle (Lukuyu *et al*., 2016). A low R^2 value (0.20 < R^2 < 0.40) was reported in Messairi cattle at 0.38 (Alsiddig *et al*., 2010).

The mean value of estimated body weight using the linear regression equation G model and its comparison with actual body weight was presented in Table 5.

Table 3. Phenotype correlation value of morphometry and body weight of the Bali cattle in Banyumulek Techno Park, NTB

Morphometry	WH	BL	HG	BW
Withers height (WH)	1.00	0.85**	0.71**	0.83**
Body length (BL)	-	1.00	0.74**	0.86**
Heart girth (HG)	-	-	1.00	0.83**
Body weight (BW)	-	-	-	1.00

** Significant at P<0.01.

Table 4. Regression coefficient value of morphometry and body weight of female Bali cattle in Banyumulek Techno Park, NTB

Model	Independent variable	Intercept	Coefficient of regression			SE	R^2
			WH	BL	HG		
A	WH	-216.25	3.55	-	-	19.59	0.68
B	BL	-140.88	-	2.86	-	17.53	0.74
C	HG	-280.43	-	-	3.31	19.17	0.69
D	WH; BL	-193.65	1.41	1.93	-	16.64	0.77
E	WH; HG	-322.03	2.03	-	1.99	15.37	0.81
F	BL; HG	-258.90	-	1.80	1.71	14.51	0.83
G	WH; BL; HG	-284.92	0.96	1.26	1.57	14.07	0.84

WH= withers height; BL= body length; HG= heart girth; SE= standard error; R^2= coefficient of determination).

Table 5. Mean value of estimated body weight of female Bali cattle in Banyumulek Techno Park, NTB based on G model (R^2=0.84)

Age (year)	Mean of estimation (kg±SD)	Mean of actual (kg±SD)	KV (%)	Min.	Max.	P
1.1 – 2.0	158.69±20.66	157.91±23.30	13.02	113.98	197.66	0.916
2.1 – 3.0	166.96±22.12	164.83±22.96	13.25	137.17	217.35	0.408
3.1 – 4.0	185.08±15.71	181.00±17.21	8.49	168.68	214.82	0.574
4.1 – 5.0	234.81±28.13	237.00±37.35	11.98	199.10	269.46	0.150
Total	172.83±31.57	171.68±34.25	18.27	113.98	269.46	0.417

SD= standard deviation; KV= coefficient of variation; Min.= minimum value; Max.= maximum value; P= significant value.

The test results showed that the average value of BW estimation was not significantly different with actual BW when using linear regression equation G model. G Model with three variables had the highest coefficient of determination (R^2) was 0.84. Nevertheless, the linear regression equation F model with two variables (BL and HG) also had a quite high R^2 value (0.83). Thus, the use of three measurement variables was strongly recommended to obtain an estimation of the BW value close to the actual BW value with the model or linear regression equation, i.e. BW=(0.96)(WH)+(1.26)(BL)+(1.57)(HG)-284.92. However, when the measurement of morphometric parameters of cattle was limited by the availability of measuring stick to obtain parameter data of WH and BL, then the linear regression equation C model with R^2 value of 0.69 using only the HG parameter could still be used to estimate the value of BW in female Bali cattle in Banyumulek TP region, NTB.

Conclusion

The simple linear regression equation BW+(0.96)(WH)+(1.26)(BL)+(1.57)(HG)-284.92 using a combination of WH;BL; HG parameters as independent variables (G model) has the highest R^2 value (0.84), so it is the best estimator for BW value of female Bali cattle in Banyumulek TP region.

Acknowledgment

This research was part of Banyumulek Techno Park Development activities in NTB which got funding support from DIPA Biotechnology Research Center, LIPI in 2015. We want to thank the Head of Animal Husbandry and Animal Health Department of NTB Province, Head of Banyumulek BIBD, and Kerangkeng Bangkit Farmer Group.

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