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Body Measurements of Male Kamphaengsaen Beef Cattle as Parameters for Estimation of Live Weight

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ABTRACT

In countries where the marketing of beef cattle is carried out by live weight, the need for weighing equipment in the market place causes substantial difficulties for developing countries, especially where cattle production involves rural households. A dataset consisting of 504 male Kamphaengsaen beef cattle was collected at Kasetsart University, Thailand, comprising 234 feedlot cattle (FL) and 270 grass-fed cattle (GF). Measurements were recorded for body weight (BW), heart girth (HG), withers height (WH), body length (BL), shoulder width (SW), hip width (HW), shin circumference (SC), and tail circumference (TC). The correlation as measured by the coefficient of determination, between BW and linear body measurements was highly ($P < 0.0001$) significant. All of the seven body measurements were modeled and the three body measurements that provided the best fit were HG, BL and TC accounting for 90% of the body weight in the feedlot animals and 87% in the grass-fed animals. The high values for coefficients of determination between the body weight and the linear body measurements of the Kamphaengsaen cattle in this study indicated that the variables or their combination could be used to estimate or predict the live body weight of these cattle. The prediction equations in the present study showed no significant ($P = 0.99$) difference (with means of live body weight of feedlot and grass-fed respectively in brackets) between actual live body weight (413.2521 ± 88.6010, 216.0667 ± 50.0380) and live body weight predicted with the equations from the present study (413.2307 ± 84.3010, 216.0536 ± 46.8750).

Keywords: Kamphaengsaen cattle, body weight estimation, linear measurement

INTRODUCTION

Kamphaengsaen beef cattle are the first Thai beef breed that has been the subject of research and development by Kasetsart University, Thailand. It is a cross breed between *Bos taurus* (50% Charolais) and *Bos indicus* (25% Brahman and 25% Thai native). This animal breed is yet to be improved with regard to production performance parameters for higher meat yields under stressful tropical conditions such as low quality nutrient feed, a tropical climate, diseases and parasites. As this is the first new breed for Thailand, there should be intensive genetic improvement by breeders to increase the performance parameters. Most animals are located

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in the rural areas of Thailand, 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 criteria 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 famers do not have the education to understand how to use the scales properly. Numerous studies have been carried out to develop methods of estimating the live body weight of cattle using formulae derived from body measurements (Touchberry and Lush, 1949; Goe *et al.,* 2001; Adeyinka and Mohammed, 2006a; Ojedapo *et al*., 2007; Sownade and Sobola, 2008). Body measurements are simple and easily measured variables for estimating the live weight, although it is unlikely to be more accurate than direct measurement of live weight (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 (Sownade and Sobola, 2008), though general studies have considered only heart girth or maybe also body length in developing predictive equations. The aim of this study was to develop a regression equation for predicting or estimating the live weight of Kamphaengsaen beef cattle and to contribute possibly to the existing knowledge to develop measurement standards for this breed of cattle.

MATERIALS AND METHODS

A dataset of measurements was compiled from 504 male Kamphaengsaen beef cattle at Kasetsart University, Thailand, comprising 234 feedlot cattle, which had a live body weight greater than 300 kg, and 270 grass-fed cattle, which had a live body weight less than 300 kg. Each animal was restrained and calmed before measurements and weighing, to ensure they were not unnecessarily stressed. The measurements taken on each animal were:

Body weight (BW), taken using a digital weighing scale;

Hearth 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 the head of the humerus to the end of the posterior;

Shoulder width (SW), measured using a vernier as the distance between the left and right head of the humerus;

Hip width (HW), measured using a vernier as the distance between the spina illiaca dorsalis.

Shin circumference (SC), measured using a tape measure as the smallest circumference of the tibia of the foreleg; and

Tail circumference (TC), measured using a tape measure as the circumference at the base of the tail.

All measurements were taken in the morning before the animals were fed. Each dimension was recorded in centimeters and each weight in kilograms. The data collected were analyzed using SAS software (SAS, 2003). The correlation between body weight and linear body measurements was based on the Pearson correlation procedure (Ojedapo *et al*., 2007). The regression equations for predicting the body weight of the cattle in the present study were improved by means of stepwise multiple regression analysis (Adeyinka and Mohammed, 2006a; Sownade and Sobola, 2008). The live body weight was predicted for both cattle groups using the prediction equations developed in the present study. Hence, it was possible to make comparisons amongst actual live body weight measurements and predicted live body weights by means of a paired t-test (Slippers *et al*., 2000).

RESULTS AND DISCUSSION

The mean ± standard deviation of the body weight and the body measurements of the feedlot and grass-fed cattle are presented in Table 1. The overall means of body weight and linear measurements for HG, WH, BL, SW, HW, SC and TC of the feedlot cattle were 413.25 ± 88.60 kg, 173.02 ± 14.56, 124.86 ± 5.79, 136.49 ± 9.47, 43.43 ± 5.95, 44.43 ± 4.76, 20.08 ± 1.73, and 25.74 ± 2.75 cm, respectively, while those of the grass-fed cattle were 216.06 ± 50.03 kg, 135.11 ± 11.75, 107.97 ± 6.41, 114.38 ± 8.99, 31.58 ± 3.9, 34.73 ± 3.39, 16.27 ± 1.55, and 19.3 ± 2.33 cm, respectively.

Table 2 presents values for the coefficients of determination (R^2) for the relationships between body weight and linear body measurements of Kamphaengsaen cattle (feedlot and grass-fed). The correlation was highly ($P < 0.0001$) significant between body weight and all traits measured. The correlation (as measured by the coefficient of determination shown in brackets after each of the following parameters) between body weight and SW was the highest (0.9374) followed by HG (0.9085), BL (0.8534), HW (0.8477), WH (0.7142), TC (0.6632) and SC (0.3036), respectively, for feedlot cattle. For grass-fed cattle, the correlation between body weight and HG was the highest (0.8670) followed by BL (0.8360), SW (0.8322), HW (0.7672), TC (0.7176), WH (0.6664) and SC (0.6378), respectively. These results implied that these variables or their combination could be used to estimate or predict the live body weight of Kamphaengsaen cattle. These findings were consistent with those reported by Heinrichs *et al.* (1992), Adeyinka and Mohammed (2006b),

Table 1 Statistics for the sample of Kamphaengsaen cattle use in the study.

Group	Variable	No.	Minimum	Maximum	Mean ± standard deviation
Feedlot	BW (kg)	234	300	654	413.25 ± 88.60
	HG (cm)	234	140	209	173.02 ± 14.56
	WH (cm)	234	106	138	124.86 ± 5.79
	BL (cm)	234	117	160	136.49 ± 9.47
	SW (cm)	234	33	61	43.43 ± 5.95
	HW(cm)	234	37	62	44.43 ± 4.76
	SC (cm)	234	16	26	20.08 ± 1.73
	TC (cm)	234	17	38	25.74 ± 2.75
Grass-fed	BW (kg)	270	110	298	216.06 ± 50.03
	HG (cm)	270	105	163	135.1 ± 11.75
	WH (cm)	270	94	129	107.97 ± 6.41
	BL (cm)	270	81	133	114.38 ± 8.99
	SW (cm)	270	21	43	31.58 ± 3.90
	HW (cm)	270	27	47	34.73 ± 3.39
	SC (cm)	270	13	23	16.27 ± 1.55
	TC (cm)	270	12	27	19.30 ± 2.33

BW = body weight, HG = heart girth, WH = withers height, BL = body length, SW = shoulder width, HW = hip width, SC = shin circumference, TC = tail circumference.

Table 2 Coefficient of determination values for the variables use to estimate the live body weight of Kamphaengsaen cattle.

Group		BW	HG	WH	BL	SW	HW	SC	TC
Feedlot	BW	1.0000	0.9085***	0.7142***	0.8534***	0.9374***	0.8477***	0.3036***	0.6632***
	HG		1.0000	0.7425***	0.7465***	0.8732***	0.7892***	0.3574***	0.6395***
	HW			1.0000	0.6252***	0.6682***	0.6690***	0.4080***	0.5564***
	BL				1.0000	0.8245***	0.7676***	0.1856***	0.4858***
	SW					1.0000	0.8813***	0.2417***	0.6279***
	HW						1.0000	0.2795***	0.5740***
	SC							1.0000	0.2978***
Grass-fed	BW	1.0000	0.8670***	0.6664***	0.8360***	0.8322***	0.7672***	0.6378***	0.7176***
	HG		1.0000	0.6809***	0.6708***	0.8176***	0.6971***	0.6760***	0.6081***
	HW			1.0000	0.6431***	0.5784***	0.5478***	0.5854***	0.4572***
	BL				1.0000	0.7232***	0.6975***	0.5350***	0.6820***
	SW					1.0000	0.7072***	0.5995***	0.6140***
	HW						1.0000	0.5602***	0.5904***
	SC							1.0000	0.5043***

BW = body weight, HG = heart girth**,** WH = withers height, BL = body length, SW = shoulder width, HW = hip width, SC = shin circumference, TC = tail circumference.

*** = Significant at $P < 0.0001$.

Ojedapo *et al*. (2007), Samuel and Salako (2008), and Sownade and Sobola (2008) except for feedlot cattle, where SW had a higher correlation with live body weight than with heart girth, which may have been due to the muscle and fat on the shoulder of Kamphaengsaen beef cattle after fattening had increased more than in any other part.

Table 3 presents a summary of the simple linear regression analysis and the models generated for predicting the body weight from the linear body measurements. The analysis showed that the body weight of Kamphaengsaen cattle (feedlot and grass-fed) could be predicted (with R^2 values for feedlot and grass-fed cattle, respectively, in brackets) using HG (0.82, 0.75), WH (0.51, 0.44), BL (0.72, 0.69), SW (0.87, 0.69), HW (0.71, 0.58), SC (0.09, 0.40) and TC (0.43, 0.51), respectively. In this study, only measured HG and SW provided good predictions (R^2 > 0.80) of the live body weight of feedlot cattle (Haaland, 1989; Hu, 1999).

Based on the simple regression models, live weight changes could be predicted using parameters that had high coefficient of determination values (R^2 > 0.80). However, the coefficients of determination values for body measurements were low, because of differences in the body condition and skeleton of the Kamphaengsaen cattle in each group. Therefore, the use of the simple regression models based on a single measurement to estimate the body weight may not provide a reliable prediction.

Table 4 presents the multiple linear regression models (A) for predicting the body weight of Kamphaengsaen cattle from linear body

Table 3 Simple regression models for predicting weight from linear body measurements of Kamphaengsaen cattle.

Group	Dependent (Y)	Independent (X)	Regression equation	Standard error	R^2
FL	BW	HG	5.5257HG – 542.8699	0.1668	0.8255
	BW	WH	10.9144WH – 949.6284	0.7021	0.5102
	BW	BL	7.9794BL – 675.8945	0.3199	0.7284
	BW	SW	13.9511SW – 192.6705	0.3400	0.8788
	BW	HW	15.7776HW – 287.8082	0.6480	0.7187
	BW	SC	15.5152SC + 101.6735	3.1957	0.0922
	BW	TC	21.3296TC – 135.8035	1.5801	0.4399
GF	BW	HG	3.6906HG – 282.5764	0.1295	0.7517
	BW	WH	5.1969WH – 345.0691	0.3551	0.4441
	BW	BL	4.6488BL – 315.7084	0.1863	0.6990
	BW	SW	10.6676SW – 120.9109	0.4340	0.6926
	BW	HW	11.3060HW – 176.6508	0.5772	0.5887
	BW	SC	20.5766SC – 118.9053	1.5176	0.4069
	BW	TC	15.3601TC – 80.4687	0.9106	0.5150

BW = body weight, HG = heart girth, WH = withers height, BL = body length, SW = shoulder width, HW = hip width, SC = shin circumference, TC = tail circumference.

Table 4 Multiple linear regression models (A) for predicting the live body weight of Kamphaengsaen cattle from linear body measurements.

Group	Regression equation	R^2
Feedlot	1.9405HG + 2.1845BL + 6.1209SW + 2.8098TC – 558.8586	0.9328
Grass-fed	1.7538HG + 1.8170BL + 1.5128SW + 1.5209HW + 2.3701TC – 375.1203	0.8873

BW = body weight, HG = heart girth, BL = body length, SW = shoulder width, TC = tail circumference.

measurements. All of the seven body measurements were fitted into the model and the four body measurements that gave the best fit were HG, BL, SW and TC accounting for 93% of the body weight in the feedlot cattle with five body measurements (HG, BL, SW, HW, and TC) accounting for 88% of the body weight in the grass-fed cattle. The parameter estimates in the multiple linear regression models showed that more than one body measurement may be required to predict the live weight in Kamphaengsaen cattle. In the present study, HG, BL, SW, HW, and TC were the important body measurements required for predicting the live body weight of either feedlot or grass-fed Kamphaengsaen cattle, based on the highest coefficient of determination values of the multiple linear regression equations. However, the accuracy of estimation could be improved if the variables were combined in a multiple regression. This was in agreement with Adeyinka and Mohammed (2006a), Ojedapo *et al*. (2007), Samuel and Salako (2008), and Sownade and Sobola (2008) who reported similar results that variable combinations in a multiple regression could increase the accuracy of live body weight prediction.

The aim of this study was to develop a multiple regression equation for the prediction of the live body weight of Kamphaengsaen beef cattle and, if possible, to contribute to existing knowledge to develop measurement standards for this breed of cattle. In addition, the aim was for the researcher to be able to use a combination of easily measured parameters in the multiple regression equation. However, the equation developed required the use of SW and HW, which in turn required using a vernier to obtain the data. This meant that a farmer would have to buy two tools (a tape-rule and vernier) to measure an animal. Consequently, the parameters SW and HW were eliminated from the equation, so that all input parameters could be measured more easily using a tape-rule to provide a multiple regression equation for prediction of the live body weight of Kamphaengsaen beef cattle. The multiple regression equation models (B) resulting from this approach are shown in Table 5. Although when compared with the A models, the B models have lower coefficients of determination for both cattle groups (0.9053 and 0.8776, respectively) the input parameters required can be measured using only a tape-rule, which is easy for the farmer.

Table 6 shows that the B models produced no significant (P = 0.99) difference between actual live body weight and predicted live body weight which was consistent with the results reported for Nguni goats by Slippers *et al*.(2000).

Table 5 Multiple linear regression models (B) excluding the parameters SW and HW to predict live body weight of Kamphaengsaen cattle from linear body measurements.

Group	Regression equation	R^2
Feedlot	3.2214HG + 3.6760BL + 4.2916TC – 756.3903	0.9053
Grass-fed	2.2196HG + 2.2156BL + 2.7548TC – 390.4620	0.8776

HG = heart girth, BL = body length, TC = tail circumference.

Table 6 Comparison of the difference between the actual body weights, with the predicted body weight using the multiple linear regression models (B).

Group	Actual body weight (kg)	Predicted body weight (kg)	P-value
Feedlot	413.2521 ± 88.6010	413.2307 ± 84.3010	0.9904
Grass-fed	216.0667 ± 50.0380	216.0536 ± 46.8750	0.9902

CONCLUSION

The strong relationship between the body weight and linear body measurements of Kamphaengsaen cattle indicated that the variables or their combination could be used to estimate or to predict the live body weight of these cattle. Heart girth had the highest correlation to live body weight for both cattle groups. A simple regression model using other body measurement parameters that had high coefficients of determination (greater than 80%) could be utilized. Using multiple linear regressions, these parameters were combined with other linear body measurements to generate prediction equations for live body weight (models A and B). Both of the prediction equations in model B produced no difference between the actual live body weight and predicted live body weight, which suggested that these prediction equations could be used to predict the live body weight of Kamphaengsaen cattle.

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LITERATURE CITED

Adeyinka, I.A. and I.D. Mohummed. 2006a. Accuracy of body weight prediction in Nigerian red Sokoto goats raised in northeastern Nigeria using linear body measurement. **Paki. J. Biolog. Sci.** 9(15): 2828–2830.

______. 2006b. Relationship of live weight and linear body measurement in two breeds of goat of Northern Nigeria. **J. Anim. And Vet. Adv.** 5: 891–893.

Goe, M.R., J.R. Alldredge and D. Light. 2001. Use of heart to predict body weight of working oxen in the Ethiopian highlands. **Livestock. Prod. Sci.** 69: 187–195.

Haaland, P.D. 1989. **Experimental Design In Biotechnology.** Marcel Dekker Inc. New York. USA. 201 pp.

Heinrichs, A.J., G.W. Rogers and J.B. Cooper. 1992. Predicting body weight and wither height in Holstein heifers using body measurements. **J. Dairy Sci.** 75: 3576–3581.

Hu, R. 1999. **Food Product Design: A Computer-Aided Statistical Approach.** Technomic Publishing Co., Ltd. Pennsylvania. USA. 225 pp.

Ojedapo, L.O., T.A. Adedeji, T.B. Olayeni, O.S. Adedeji, A.R. Abdullah and O.O. Ojebiyi. 2007. Influence of age and sex on body weight and some body linear measurements of extensively reared Wad goats in derived savanna zone of Nigeria. **J. Anim. And Vet. Adv.** 6: 114–117.

Samuel, O.K. and A.E. Salako. 2008. Body measurement characteristics of the West Dwarf (WAD) goat in deciduous forest zone of southwestern Nigeria. **Afr. J. Biotech.** 7(14): 2521–2526.

SAS. 2003. **SAS Institute.** SAS Procedure Guide for Personal Computers, Version 6. SAS Institute, Cary, NC. USA. 584 pp.

Slippers, S.C., B.A. Letty and J.F. de Villiers. 2000. Prediction of the body weight of Nguni goats. **S. Afr. Soc. Anim. Sci.** 30: 127–128.

Sowande, O.S. and O.S. Sobola. 2008. Body measurements of West African dwarf sheep as parameters for estimation of live weight. **Trop. Anim. Health Prod.** 40: 433–439.

Touchberry, R.W. and J.L. Lush. 1949. The accuracy of live linear body measurements of dairy cattle. **Journal Paper No. J-1691 of the Iowa Agricultural Station, Ames.** 72–80.