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Use of adobe photoshop for body measurements of crossbred beef cows and prediction of body weight after regression analysis

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Abstract A total of 160 crossbred beef cows in Thailand were recorded using a digital weighing scale and their body condition score (BCS) categorized to be thin, moderate, and fat. All cows were photographed with a mobile phone camera and the images were analyzed for chest depth (CD) and body length (BL) using Adobe Photoshop software. The average actual BW was 423.99 ± 84.66 kg. The best models to predict actual BW from CD, BL and BCS were as follows: thin, BW = 5.69(CD) + 4.19 (BL) - 463.82; moderate, BW= 16.16(CD) + 1.06(BL) - 606.42 and fat, BW = 5.21(CD) + 4.52(BL) - 426.39, with an adjusted R^2 of 0.8749 and a root mean square error (RMSE) of 30.06 corresponding to 7.09% of the mean actual BW. The difference between actual BW and BW predicted from the simple linear regression models was not significant (P> 0.05). The correlation coefficients were 0.938. Results indicated that body measurement (CD and BL) extracted from images using Adobe Photoshop combined with BCS in the regression equations that developed in this study can accurately predict the BW of crossbred beef cows. The method is proved to beviable, rapid, and not involves in physical contact with the animal's body.

Keywords: Chest depth, Body length, Body condition score, Body weight, Crossbred cows

Introduction

The body weight (BW) of beef cows is used as the practical basis for several management purposes, including assessment of feed efficiency, evaluation of nutritional requirements, medicine dosage calculation, and determination of growth rate and general health (Tariq *et al.*, 2013). BW is also used for determining ration amounts and sale prices of animals (Wangchuk *et al.*, 2018). Therefore, accurate estimation of live BW is of fundamental importance to livestock production (Wangchuk *et al.*, 2018). Globally, the most widely accepted method of measuring BW is the use of a calibrated electronic or mechanical scale. However, such equipment is not readily available in a

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smallholder farming context because it is expensive (Dingwell *et al.,* 2006; Kashoma *et al.*, 2011; Musa *et al.*, 2011).

The estimation of BW from body measurements has been long practiced, and in cattle the two are closely related (Gilbert *et al.*, 1993; Isik *et al.*, 2009; Yan *et al.*, 2009; Lesosky *et al.*, 2012; Lukuyu *et al.*, 2016; Wangchuk *et al.*, 2018). For example, heart girth and body length (BL) can be used to accurately estimate live BW in dairy cows (Lukuyu *et al.*, 2016; Tebug *et al.*, 2018) and beef cows (Mekonnen and Biruk, 2004; Rashid *et al.*, 2016; Comlan *et al.*, 2017; Paputungan *et al.*, 2018; Vanvanhossou *et al.*, 2018).

The taking of body measurements may have negative consequences for cows due to the animals being under stress during the process of forcing them into a position necessary for collecting accurate data. Additionally, the possibility of making inaccurate measurements is high. For such reasons, farmers may choose to subject their animals to the measuring process less often and accept that they are not keeping abreast of the data (Enevoldsen and Kristensen, 1997; Wilson *et al.*, 1997; Tasdemir *et al.*, 2008). Recent studies have applied digital image analysis by computer software to determine and track body measurements, live weight, and growth of beef cattle (Bozkurt *et al.*, 2007; Ozkaya and Yalcin, 2008; Ozkaya *et al.*, 2016; Gomes *et al.*, 2016) and dairy cattle (Tasdemir *et al.*, 2011).

In a several of studies, Adobe Photoshop software has been used to measure the size and length of items in a digital photograph, such as the *longissimusdorsi* muscles and backfat in cattle (Bruckmaier *et al.*, 1998), the breast in women (Santo *et al.*, 2001), leaf area in plants (Kapetch *et al.*, 2011), the body in pigs (Wongmanopanit, 2011) and rib eye area and backfat thickness in beef carcasses (Nilchuen *et al.*, 2016). The aims of this study were to measure the bodies of crossbred beef cows using digital photographs and Adobe Photoshop, and to apply regression analysis to the data to predict their actual BW.

Materials and methods

Animals

This study was carried out at a beef cattle farm at Tubkwang Research Station, Department of Animal Science, Faculty of Agriculture, Kasetsart University, Saraburi, Thailand. The breed used was Kamphaeng Saen, crossbred cattle whose bloodline contained 25% Thai native cattle, 25% Brahman and 50% Charolais. A total of 160 cows were used. Their age range in the postpartum period (90 days) was between 3 and 10 years. The cows were kept off feed and water for 12 hours before body measurements, live body weight and photographs were taken.

Body condition scoring

Cows were assessed and given a body condition score (BCS) from 1-9, where 1 = emaciated and 9 = fat (Rae *et al.*, 1993).The cows were categorized into groups using their BCS as follows; thin: 1-4 (68 cows), moderate: 5-7 (50 cows) and fat: 8-9 (42 cows).

Live body weight

The weight (kg) of all animals was measured using a digital cattle weighing scale mounted on a steel platform. The scale was calibrated before and periodically during the data collection exercise.

Photography

All animals were photographed with a mobile phone camera (Zenphone, Asus®) positioned 1.3 m above the ground at a distance of 2.5 m from the animal using an image aspect ratio of 16:9 (width : height). Before each photograph was taken, a 73 cm ruler was placed near the body of the animal as a dimensional reference.

Image analysis

All images were analyzed using Adobe Photoshop CS6 software (Adobe Systems Inc., San Jose, CA). Analysis of the images was carried out according to the following protocol. An image was opened, and the menu was used to choose image > analysis > set measurement scale > custom, after which the ruler tool becomes automatically selected. The ruler tool was then dragged along the dimensional reference in the image (the abovementioned 73 cm ruler; Figure 1, labeled A) which generates the item's length in pixels. The logical length (reference ruler length) and logical units (cm) were then entered for this pixel length. In this way, the pixel : cm ratio could be set for each photograph, and pixel measurements taken from the photographs of the animals could be converted into cm (Figure1, labeled B). To perform a measurement, the menu option image > analysis > ruler tool was chosen, which activated a ruler tool that was used to measure the length of an item in the image area. To record measurements, the menu option image > analysis > record measurements was chosen, which produced a measurement log panel permitting display and recording of measurement data.

Chest depth (CD) was measured as the distance between the top of the back just behind the shoulder and the bottom of the barrel behind the front leg (Figure 2, line A-B). BL was measured as the distance from the point of the shoulders to the pin bone (Figure 3, line A-B).

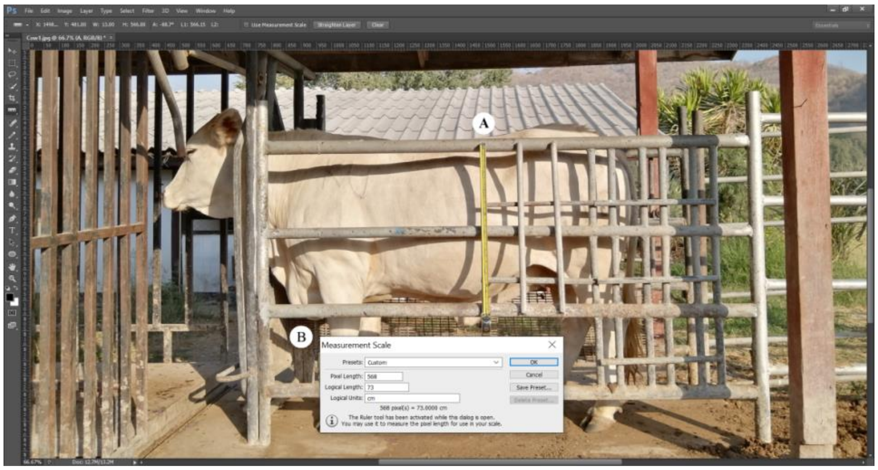

Figure 1. Typical screenshot showing body measurement in Adobe Photoshop software (A: ruler dimensional reference, B: setting of the pixel: cm ratio by measuring the numbers of pixels contained in the ruler dimensional reference)

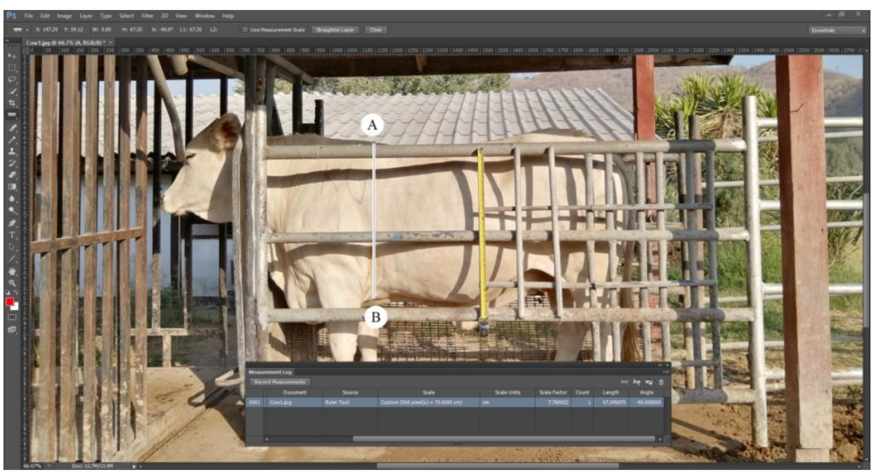

Figure 2. Chest depth was measured along the line A-B

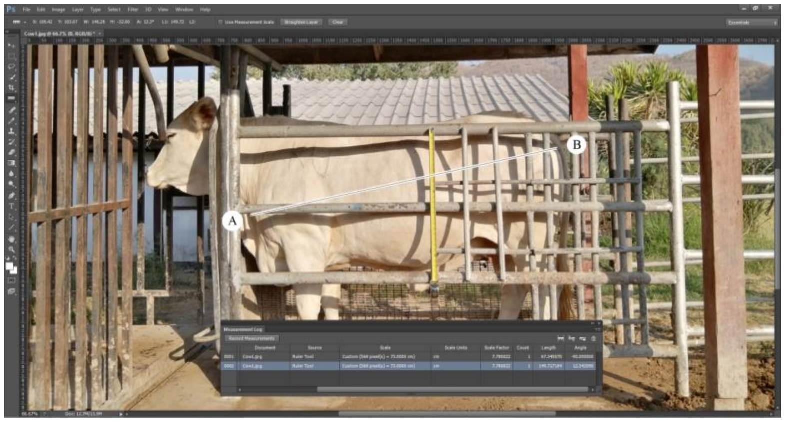

Figure 3. Body length was measured along the line A-B

Statistical analysis

All statistical analyses were performed using R version 3.6.1 (R Core Team, 2020). Regression analysis was used on the recorded data to examine any correlation with body weight (BW). The dependent body measurements were converted to ordinal data (BCS as 3 levels: thin, moderate and fat) as dummy variables for use in linear regression analysis. The model used was:

$Y_i = b_0 + b_1X_1 + b_2X_2 + \varepsilon_i$

where, Y_i is the live weight observation of the i^{th}animal, b_0 is the intercept, b_1 and b_2 are the regression coefficients, X_1 is chest depth, X_2 is body length, and ε_i is the residual error term. The adjusted coefficient of determination (adjusted R^2) was also given for the models, as an indicator of the amount of variance in BW explained by the model. The root mean square error (RMSE; the same as the standard deviation of the residuals), and also the RMSE expressed as a percent of the actual BW, were used as indicators of accuracy of the regression estimates (Yan *et al.*, 2009; Lukuyu *et al.*, 2016). The fit of the regression model was also tested for homogeneity of variance and normality using Bartlett’s test and the Shapiro–Wilk test, respectively.

Comparisons between actual BW and BW predicted from the regression model were determined by paired *t*-test. Correlation between the actual BW and predicted BW was calculated by Pearson's correlation coefficient. A probability of $P \leq 0.05$ was considered significant.

Results

The average actual BW of the cows in this study was 423.99 ± 84.66 kg. The correlation coefficient for BW versus CD obtained in this study was high (r

= 0.854), and that for BW versus BL was also high (r = 0.863). When simple linear regression was used to construct a prediction equation based on a single body measurement obtained from images analyzed using Adobe Photoshop, the regressing for BW versus CD measurement was statistically significant (P< 0.001), with an adjusted R^2 of 0.7269 and RMSE of 42.24 correspondings to 10.43% of the mean actual BW (Table 1).

Multiple linear regression analysis based on two body measurements and body condition scoring parameters was performed to design a BW prediction model. Regressing BW on CD and BL measurements was statistically significant (P< 0.001), with an adjusted R^2 of 0.8053 and RMSE of 37.35 corresponding to 8.81% of the mean actual BW (Table 1).

Table 1. Simple and multiple linear regression of body weight (BW) on independent variables using measurements from images analyzed in Adobe Photoshop

Parameter	Regression Model	Adjusted R^2	RMSE[a]	RMSE as % Actual BW
CD	BW= 14.94(CD)-419.55	0.7269	42.24	10.43
CD and BL	BW= 7.74(CD)+4.34(BL)-576.88	0.8053	37.35	8.81

CD = Chest depth, BL = Body length
[a]Root mean square error

Regression using a combination of CD and BCS on BW was statistically significant (P< 0.001), with an adjusted R^2 of 0.8190 and an RMSE of 36.01 corresponding to 8.49% of the mean actual BW. Regressing BW on CD, BL, and BCS was statistically significant (P< 0.001), with an adjusted R^2 of 0.8739 and an RMSE of 30.06 corresponding to 7.09% of the mean actual BW (Table 2).

Table 2. Simple and multiple linear regression of body weight (BW) and body condition scores (BCS) on independent variables using measurements from images analyzed in Adobe Photoshop

Parameter	BCS	Regression Model	Adjusted R^2	RMSE[a]	RMSE as % Actual BW
CD	Thin	BW= 11.42(CD)-247.01	0.8190	36.01	8.49
	Moderate	BW= 18.38(CD)-591.09			
	Fat	BW= 12.61(CD)-260.57			
CD and BL	Thin	BW= 5.69(CD)+4.19(BL)-463.82	0.8739	30.06	7.09
	Moderate	BW= 16.16(CD)+1.06(BL)-606.42			
	Fat	BW= 5.21(CD)+4.52(BL)-426.39			

CD = Chest depth, BL= Body length
[a]Root mean square error

The differences between actual BW and predicted BW from all regression models were not significant (P> 0.05). The correlation coefficients were: 0.854 for the CD regression model; 0.899 for the CD and BL regression model; 0.908 for the CD and BCS regression model; and 0.938 for the CD, BL, and BCS regression model (Figure 4).

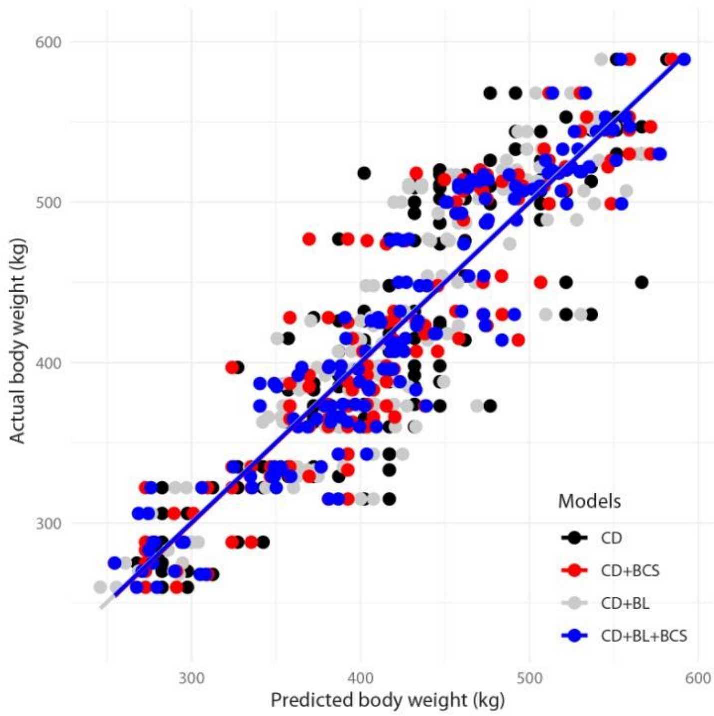

Figure 4. Scatterplot comparing actual and predicted BW using the regression models based on measurements of CD, BL, and BCS

Discussion

The aim of this experiment was developed an easy tool to predict the BW of cows based on body measurements which obtained from digital images processed in Adobe Photoshop software. Several studies in various fields have used images processed in Adobe Photoshop to measure size and length (Bruckmaier *et al.*, 1998; Santo *et al.*, 2001; Kapetch *et al.*, 2011; Wongmanopanit, 2011; Stojkov *et al.,* 2015; Nilchuen *et al.*, 2016). Kapetch *et al.* (2011) found that plant leaf area measured in digital images using Adobe Photoshop were extremely close to the actual area (R^2=0.9999). Similarly, Nilchuen *et al.* (2016) found that measurement of the rib eye area and backfat thickness of beef carcasses using images processed in Adobe Photoshop did not differ significantly from measurements taken by the ruler method, and Wongmanopanit (2011) had similar success with the same procedures for body measurement in digital images of pigs. Santo *et al.* (2001) demonstrated that Adobe Photoshop was effective for breast measurement in women (using raw files) using a specific software package but without the need for specific training (though direct breast measurements were different from the ones obtained using Adobe Photoshop).

In this study, body measurements of cows taken from images using Adobe Photoshop were similar to those obtained using measuring tape. Prediction of BW from the regression model using CD alone was less accurate (within 10.45%) than prediction using the model based on CD and BL together. Similarly, Bozkurt *et al.* (2007) reported that the use of multiple body measurements (BL, wither height, hip height, hip width and chest depth) taken from digital images to predict BW in slaughtered beef cattle was very promising.

However, when BCS was also incorporated together with body measurements, the models had improved accuracy, giving support to the recommendation made by Enevoldsen and Kristensen (1997) to use BCS along with body measurements as a predictor of BW. Several authors have demonstrated that there is a relationship between body measurements, especially BCS and heart girth, and live weight of animals (Nicholson and Sayers, 1987; Nesamvuni *et al.,* 2000; Abdelhadi and Babiker 2009). Body condition scoring, although a subjective technique, is used at regular intervals for assessing the condition of livestock. It is particularly helpful in assessing the body fat reserves of farm animals by visual and manual inspection of the thickness of fat cover and prominence of the bone at the tail head and loin region (Vasseur *et al.,* 2013; Roche *et al.*, 2006, 2007, 2008). Singh *et al.* (2015) studied the relationship between BCS and backfat thickness using real time ultrasonography in transition crossbred cows and found that the correlation coefficient between the two was 0.84, 0.79 and 0.75 for the far off dry, close up dry, and fresh transition periods, respectively. Therefore, combining BCS with body measurements improves BW prediction models.

A comparison of predicted and actual BW in this study showed no significant differences. This is in accordance with the report of Tasdemir *et al.* (2011) who found that the correlation between actual BW and estimates using body measurements was very high (correlation coefficient 0.9787), indicating that digital image analysis was appropriate for BW estimation in Holstein cows.

In this study, although the error in prediction of BW using the models derived from images analyzed using Adobe Photoshop was > 5%, the technique does have advantages; there are savings on time and labor, and most importantly there is no physical contact of the animal's body meaning less stress and fewer accidents caused by handling.

Values for BW estimated using our models were within ± 20% of true weight, which is acceptable for dose calculation for veterinary drugs within safe limits (Machila *et al.*, 2008; Lesosky *et al.*, 2012), though may not be appropriate where animals are sold per kg live weight as it may affect profitability of the enterprise (Machila *et al.*, 2008).

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