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Research Article

Regression Models and Correlation Analysis for Predicting Body Weight of Female Ettawa Grade Goat using its Body Measurements

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Abstract | This research aimed to analyse the correlation and regression model and also to find the best regression model for predicting body weight of female Ettawa Grade (EG) goat using its body measurements. This research used 41 female EG goat aged 3–4 years. The method used was a survey with data collection by census, all female EG goats aged 3-4 years in research location were collected. Body weight (BW) data were regressed and correlated to body measurements (body length = BL, chest girth = CG and shoulder height = SH) using linear and multiple linear regression using R program. Pearson correlation was used to calculate correlation coefficient (r). Coefficient of determination (R^2), adjusted R^2, residual standard error (RSE), Akaike information criterion (AIC), Bayesian information criterion (BIC) and step wise regression analysis were used to analyse and find the best and parsimonious model for predicting BW. The results showed that body measurements had positive correlation with the BW, which CG had the highest correlation (0.838); followed by BL (0.744) and SH (0.543). Results also showed that CG was the best predictor for BW compared to BL and SH if using single predictor. Combination of CG and BL resulted in the fittest prediction of BW with model regression BW = -67.86 + 0.87*CG + 0.51*BL with the highest correlation coefficient (r = 0.87), R^2 (0.76), adjusted R^2 (0.75) and the lowest RSE (2.795), AIC (205.51) and BIC (212.36). The results of this study suggested that CG and BL could be used as predictor for body weight and as indicator of indirect selection to improve genetic merit in body weight of EG goat.

Keywords | Ettawa grade goat, Correlation and regression model analysis, Body weight, Body Measurements

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INTRODUCTION

Goat raising is one of the common livestock business carried out either as a side job or as a main job by smallholder farmers. This business of goat keep on rising year after year. One province establishing goat farming in Indonesia is Lampung Province. Lampung Province is an area that has the potential to develop goat farming business. Based on statistics from the Directorate General of Animal Husbandry and Health of Republic Indonesia (2018), the population of goats in Lampung Province has increased from 1,326,103 heads in 2016 to 1,386,009 heads in 2018. While Pesawaran Regency is a district in the province of Lampung which has a very large population of goats. Population of goats in Pesawaran Regency reached 44,150 heads, most of which are Ettawa Grade (EG) goats (Department of Animal Husbandry and Animal Health of Lampung Province, 2017).

EG goats are the result of crossing from male Ettawa goats and female Kacang goats so that these goats have properties between the two pedigrees (Setiaji et al., 2013). This goat has been raised by farmers widely in many regions in Indonesia due to good adaptability to the tropical environment, relatively rapid growth, and be utilised as meat and milk producer. Therefore, it is necessary to weigh

the body weight of the animal in relation to determination of the production of EG goats.

One effort to develop EG goats is by studying the performance of goats through their body weight. Body weight can determine the value of the livestock that is very important, particular in the goat selection program. Additionally, knowledge of goat body weight is useful in deciding the number of feed needs and determining drug dosages as well as for other management interests.

The most accurate determination of a goat's body weight is through weighing. However, it is difficult to obtain scales in the field conditions, particularly on rural farms. To solve this situation, the use of body measurements is an alternative to estimating goat body weight, as some study findings showed a strong connection between body weight and goat weight measurements (Khan et al., 2006; Musa et al., 2012; Shirzeyli et al., 2013; Basbeth et al., 2015; Hazza et al., 2017; Berhe, 2017; Habib et al., 2019; Abdallah et al., 2019; Waheed et al., 2020). Additionally, it is fairly simple and practice to predict goat body weight using its body measurement particularly in rural conditions.

On the other hand, weighing the weight of the livestock itself is felt less effective because sometimes farmers commit fraud by providing food or drink as much as possible to increase the body weight of livestock before being sold. Therefore, it is necessary to estimate body weight through body measurements including body length, chest girth, and shoulder height to estimate the actual body weight of livestock without weighing. The goal of this present study was to examine the correlation and regression models to be used to predict body weight using its female EG goat body measurements.

MATERIALS AND METHODS

This research was conducted in April-May 2019 at the Regional Technical Implementation Unit of Goat Breeding Center, Gedong Tataan District, Pesawaran Regency. A total of 41 female EG goats aged 3-4 years were used in this study.

The method used in this study was a survey and data collection were done by census, all female EG goats aged 3-4 years in the location were collected. The research variables measured were body weight (BW), body length (BL), chest girth (CG), and shoulder height (SH). Body weight was obtained by weighing female EG goats using a 250 kg capacity scales (Gea brand). Chest girth was measured by wrapping around the chest cavity just behind the forelegs using mater tape. Body length (BL) was measured from the shoulder joint straightly to a lump of sitting bone using a measuring stick. Shoulder height was measured as a distance from the highest part of the shoulder to the ground using a measuring stick (Khan et al., 2006; Nurhayati et al., 2014; Abdallah et al., 2019).

Body weight data obtained were correlated and regressed with body measurements data using the R program (R Core Team, 2020). Correlations between variables were calculated using the Pearson correlation. The regression models used to determine the formula of the relationship between body measurements (BL, CG and SH) with the BW of female EG goat were as follows:

1. $BW = a + b_1*BL$
2. $BW = a + b_2*CG$
3. $BW = a + b_3*SH$
4. $BW = a + b_1*BL + b_2*CG$
5. $BW = a + b_1*BL + b_3*SH$
6. $BW = a + b_2*CG + b_3*SH$
7. $BW = a + b_1*BL + b_2*CG + b_3*SH$

Where; BW is a dependent variable (body weight, in kg), a is a constant or intercept, b1-b3 is the regression coefficient for each independent variable (body measurements), BL, CG and SH are body length, chest girth and shoulder height, respectively, in cm. Based on these regression models, the regression equation with the highest coefficient of determination (R^2) and adjusted R^2 and the lowest residual standard error (RSE), Akaike information criterion (AIC) and Bayesian information criterion (BIC) will be recommended for use in estimating goat body weights.

RESULTS

Body weight and body measurements of female ettawa grade goat

Based on the research, statistics and distribution of body weight and body measurements including body length, chest girth, and shoulder height can be seen in Table 1 and Figure 1.

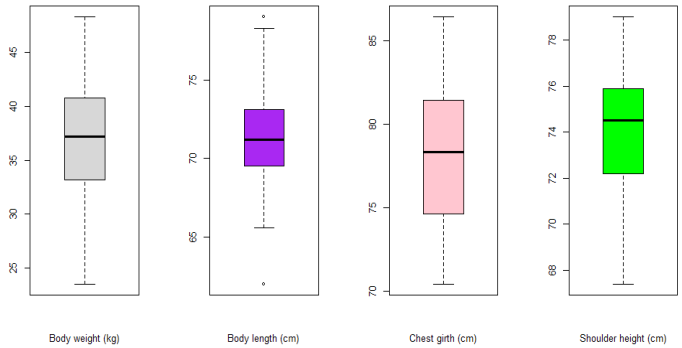

Figure 1: Boxplot of body weight and body measurements of female EG goats.

The data presented in Table 1 reveals that the average body weights and body measurements of female EG goats were similar with their medians indicating that number of data below and upper the median was relatively the same. These results indicated (Figure 1) that in general the body weight and body measurements of female EG goats were normally distributed.

Tabel 1: Statistics of body weight and body measurements of female EG goats.

Variables	Mean	Standard deviation	Median	Minimum	Maximum
Body weight (kg)	37,07	5,58	37,20	23,50	48,30
Body length (cm)	71,27	3,60	71,20	62,00	79,00
Chest girth (cm)	78,33	3,95	78,30	70,40	86,40
Shoulder height (cm)	73,86	2,74	74,50	67,40	79,00

Correlation between body sizes and body weight of female EG goat

Pearson correlation among variables are presented in Table 2. The result of this study showed that body measurements positively correlated to body weight with CG (0.84) showed the the highest correlation to BW followed by BL (0.74) and SH (0.54). Among body measurements the correlation was also positive ranged from 0.57 to 0.67 indicating that there was no multicollinearity because of under 0.90 (Dakhlan, 2019).

Table 2: Correlation coefficient among variables of female EG goats.

	Body weight	Body length	Chest girth	Shoulder height
Body weight	1.000			
Body length	0.744	1.000		
Chest girth	0.838	0.672	1.000	
Shoulder height	0.543	0.664	0.565	1.000

Regression equation between body measurements and body weight of female EG goat

The regression models resulted from regression analysis between body measurements and body weight are presented in Table 3, while the scatter plot and regression line of the regression model using three single predictor are shown in Figure 2. The result of this study showed that CG was the best predictor for BW if using single body measurement with the highest R^2 (0.702) and adjusted R^2 (0.695) and the lowest RSE (3.09), AIC (212.73) and BIC (217.87). This result indicated that CG influenced 70.20% variation of BW, while the rest was affected by other factors. Step wise regression analysis using all independent variables found that combination of CG and BL was the best predictors for BW with the highest adjusted R^2 (0.750) and the lowest RSE (2.795), AIC (205.51) and BIC (212.36) among the seven models, although the R^2 (0.762) of this regression model was similar with the regression equation 7 (combination BL, CG and SH) (R^2 = 0.763). Furthermore, combination of CG and BL had the highest correlation (0.87) to BW among the seven regression models. This is presumably because the CG is directly related to the chest and abdominal space where most of the body weight of the goat comes from the chest to the base of tail which is BL, so that the greater the CG and the longer the BL, the heavier the body weight.

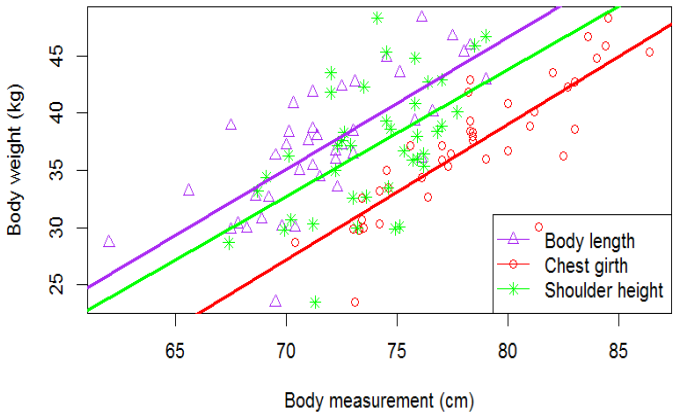

Figure 2: Scatter plot and regression line of body weight and three single predictor.

DISCUSSION

The result of current study was in accordance with the result of Subagyo et al. (2017) reported that body weight of EG goats in three villages ranged from 34,50 ± 2,67 to 37,60 ± 4,00 kg. The EG goat in this study had a lower body size than that reported by Subagyo et al. (2017) that female EG goats had body measurements of BL, CG and SH of 74.93 ± 3.75 cm, 82.80 ± 4.86 cm, and 77.30 ± 3.47 cm, respectively, with average body weight was relatively the same, namely 35.77 ± 3.14 kg.

The difference in body weight and body measurements of the present study with the results of previous study are thought to be influenced by differences in the maintenance environment, such as different feedstuff, feeding management and also different temperature where in the Pesawaran regency (the location of this study) reached 29°C, whereas the average temperature in location of the study of Subagyo et al. (2017) was 25°C. This statement is supported by Devendra and Burn (1994) who stated that environmental factors greatly influence the weight and body measurements of goats, that different maintenance environments resulted in varying body sizes, even for the same breed.

The result of pearson correlation between body weight and body measurements corroborate to the result reported by

Table 3: Regression equation of body measurements with body weight of female EG goat.

Regression equations	r	R^2	Adj. R^2	RSE	AIC	BIC
BW = -45,672 + 1,154BL	0.744**	0.554	0.543	3.777	229.28	234.42
BW = -55,685 + 1,184CG	0.838**	0.702	0.695	3.087	212.73	217.87
BW = -44,754 + 1,107SH	0.543**	0.295	0.277	4.748	248.04	253.18
BW = -67,860 + 0,512BL + 0,870CG	0.867**	0.762	0.750	2.795	205.51	212.36
BW = -52,395 + 1,063BL + 0.179SH	0.719**	0.558	0.535	3.808	230.89	237.74
BW = -64,680 + 1,103CG + 0,208SH	0.807**	0.709	0.694	3.090	213.74	220.59
BW = -64.687 + 0,549BL + 0,884CG - 0,094SH	0.833**	0.763	0.744	2.825	207.31	215.88

Note: BW: body weight; BL: body length; CG: chest girth; SH: shoulder height; r: pearson correlation; R^2: determination coefficient; Adj.R^2: adjusted R^2; RSE: residual standard error; **: significant at level 0.01.

Victori et al. (2016) in EG goats, Nurhayati et al. (2014) in Jawarandu goats, Afolayan et al. (2006) in Yankasa sheep, and by Sabbioni et al. (2019) in Cornigliese sheep reporting that CG had the highest correlation with BW compared to BL and SH. This might be due to the growth of CG was in line with the growth of ribs, muscles and fat of the animals. Oliveira et al. (2018) reported that there was relationship between high rib yield and the increase of carcass fat proportion, and the increase of rib weight was also related to rapid growth and fat accumulation.

The finding of regression models of current study confirmed with the result reported by Chitra et al. (2012), Adeyinka and Mohammed (2006), and Sabbioni et al. (2019) that combination of CG and BL was the best predictor for BW of goat or sheep. The best predictor of CG and BL for BW might be related to the form of goat body that resemble to a tube shape of which CG as base area and BL as the height of the tube resulted in volume which is body weight, so that the larger CG and BL the hevier the goat body weight (Isroli, 2001). However, Iqbal et al. (2013) reported that combination of three body measurements (body length, withers height and heart girth) was the best predictors for BW with R^2 of 0.69 in females Beetal goats. Actually, the highest R^2 in the current study was regression model with predictor using all body measurements (BL, CG and SH). However, the addition of SH predictor in that equation was actually not significant, that is why the adjusted R^2 (0.744) of regression model using the three body measurements was lower than that if using CG and CG predictor (0.750). Furthermore, based on other criteria such as RSE that measure the quality of a linear regression fit or the average of deviation between actual response (Y) and predicted response ($\hat{Y}$) namely regression line, AIC and BIC both describing how well a regression model fits the data set without overfitting, the regression model using all predictors (RSE= 2.825, AIC= 207.31, BIC= 215.88) was worse compared to using BL and CG (RSE= 2.795, AIC= 205.51, BIC= 212.36). Thus, combination of BL and CG was the best regression model to predict BW.

Figure 2 shows that regression model between BW and the three body measurements (BL, CG and SH) had identical regression coefficients indicated by parallel position of the three regression lines, but different intercept. Based on coefficient determination (R^2), the accuracy of BW prediction using the three body measurements was quite different (0.55, 0.70 and 0.30 for BL, CG and SH, respectively) which CG was the best predictor for BW compared to BL and SH. This is supported by threre was no multicollinearity among body measurements in this study which means we can not replace a body measurements with other measurement to predict BW. On the contrary if there was multicollinearity between body measurements and the coefficient of regression were similar, we would use one of the body measurements to predict BW.

CONCLUSIONS

In conclusion, the chest girth (CG) had the highest correlation (0.838) and the best predictor for body weight (BW) of Ettawa Grade (EG) goats; followed by body length (BL, 0.744) and shoulder height (SH, 0.543) if using single body measurement. Combination of chest girth and body length resulted in the fittest prediction of BW with model regression BW = -67.86 + 0.87*CG + 0.51*BL with the highest r (0.87), R^2 (0.76) and adjusted R^2 (0.75) and the lowest RSE (2.795), AIC (205.51) and BIC (212.36). The result of this study suggested that CG and BL could be used as predictor for body weight and would be useful indicator of indirect selection to improve genetic merit in body weight of EG goat.

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AUTHORS CONTRIBUTION

All authors contributed to the work, discussed the results and approved to the final manuscript. Akhmad Dakhlan designed research, analysed data, and made revision of the manuscript. Angga Saputra collected and tabulated the data. Muhammad Dima Iqbal Hamdani studied literature. Sulastri made interpretation for the result and drafted the manuscript.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

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