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Body weight prediction model analysis based on the body size of female Sakub sheep in Brebes District, Indonesia

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Abstract. *Jannah ZN, Atmoko BA, Ibrahim A, Harahap MA, Panjono. 2023. Body weight prediction model analysis based on the body size of female Sakub sheep in Brebes District, Indonesia. Biodiversitas 24: 3657-3664.* Calculation of body weight is one of the important factors in seeing the performance of sheep (Ovis aries), breeding stock selection, and livestock management, such as the basis for consideration of feeding, medicine dosage, slaughter time, and growth evaluation. However, in smallholder farms, the availability of scales is an obstacle, not to mention the inadequacy of the pens' construction, making the weighing process more difficult. The present study was conducted to analyze correlation and regression models and determine the best and most accurate regression model for predicting the body weight of female Sakub sheep using body sizes. Data on 150 female Sakub sheep kept by smallholder farmers and raised intensively in Paguyangan and Sirampog District, Brebes District, Central Java, Indonesia, were obtained. The Body Weight (BW) of Sakub sheep was weighed, and their body sizes, including body length (BL), chest girth (CG), and shoulder height (SH) were measured. The correlation was calculated using the Pearson correlation, regression models were analyzed and determined using simple, multiple, and automatic linear regression methods. Pooled means of 36.21±12.31 kg for BW and 67.13±7.97, 82.51±10.47, and 65.76±6.24 cm for BL, CG, and SH, respectively, were obtained in the present study. The body size has a positive and high correlation with BW, BL has the highest correlation with BW, which is 0.810, followed by CG (0.807) and SH (0.782). Meanwhile, the correlation of body size combination between BL, CG, and WH has the highest value, 0.883, followed by BL and CG (0.875), between CG and SH (0.875). The best body size and the most accurate (77.40%) to predict BW of female Sakub sheep is the combination of the three BL+CG+SH with regression equation model BW = 67,004+0.589BL+0.453CG+0.399SH. Meanwhile, the prediction of BW with a single body size is BL with the regression equation BW = -47,658 + 1,249BL with an accuracy of 65.40%. This study concludes that body size, namely BL, CG, and SH, can be used to predict BW of female Sakub sheep, either single or in 2 or 3 combinations. The prediction model BW using a combination of 3 body sizes has the highest accuracy, followed by a combination of 2 body sizes (BL+CG), and the last is BL as a single predictor.

Keywords: Bio prediction, correlation analysis, phenotypic characteristics, regression model, Sakub sheep

INTRODUCTION

Indonesia has diverse livestock genetic resources, a great asset in livestock development efforts. Sheep have a large population and are quite popular in Indonesia. The sheep population in Indonesia in 2021 amounted to 15.6 million heads (Ministry of Agriculture 2022). They have a high economic value, can adapt to Indonesia's topography, are quite easy to develop, and do not require large land areas to maintain (Udo and Budisatria 2011). Local sheep have a very strategic position in society economically, socially, and culturally. Various breeds of local sheep (*Ovis aries)* are kept by farmers and each nation has unique and different characteristics according to the location and region of origin (Ibrahim et al. 2021). Currently, there are ten breeds of sheep that have been established and released by the Government of Indonesia as genetic resources for local sheep according to their respective characteristics, namely Priangan, Garut, Compass Agrinak, Bahtera Agrinak, and Garut-Agrinak Composite sheep in West Java, Sapudi sheep East Java, Palu sheep in Central Sulawesi, Kisar sheep in Maluku, Batur and Wonosobo sheep in Central Java (Ministry of Agriculture 2022; Ibrahim et al. 2023).

It is estimated that many local sheep in Indonesia still have not been characterized, and some may be threatened with extinction before their potential is explored. Sheep raised in one area generally have different characteristics from those in other areas. In Brebes District, there are sheep that the local community calls Sakub sheep, which are growing quite well, especially in the highlands. Based on the Central Agency on Statistics of Brebes District (2021) the population of Sakub sheep in the region reached 17,318 heads. The government only established this breed as one of the new local Indonesian sheep breeds in 2022 based on the Decree of the Minister of Agriculture of the Republic of Indonesia No. 882/KPTS/PK.010/M/12/2022, so more research needs to be done on its profile and characteristics. Characteristics such as body weight and body size are important because they serve as a reference and standard for livestock characteristics (FAO 2012).

Calculation of body weight is an important factor in seeing sheep's performance. Livestock body weight is also important in breeding stock selection, livestock slaughter, determining animal feed levels, and describing livestock conditions (Hartati and Putra 2021). Meanwhile, body size can also be used for genetic selection to improve livestock performance and growth. Livestock body size can also be used as a visible identity and to determine growth patterns. Body weight determines the value of animal and livestock management, such as the basis for consideration of feeding, medicine dosage, slaughter time, and growth evaluation (Ibrahim et al. 2021). Body weight is obtained from weighing. However, in smallholder farms, the availability of scales is an obstacle, not to mention the inadequacy of the pens' construction, making the weighing process more difficult (Lukuyu et al. 2016). Therefore, the prediction and estimation of the body weight of livestock using body size can be used as an appropriate and precise alternative (FAO 2018).

Several studies reported a close match between body weight and body size in sheep and goats. Mavule et al. 2013, Waheed et al. 2020, Dakhlan et al. 2020, Rather et al. 2021 stated that live body weight has a positive correlation with linear measures of body dimensions, including chest girth, body length, and body height. Many studies have been conducted to examine the correlation between linear body dimensions and live body weight. Research on body weight prediction by using body sizes in sheep has been carried out by many researchers (Yilmaz et al. 2013; Kumar et al. 2018; Iqbal et al. 2019; Worku 2019; Sabbioni et al. 2020; Ibrahim et al. 2021). Predicting body weight using body sizes is considered simpler and more applicable than weighing livestock, especially if it is done at the smallholder farm level (FAO 2018). Sakub sheep raised by farmers can be easily characterized and observed for productivity through body weight and body size. This effort also helps relevant stakeholders in the standardization framework and developing Sakub sheep development programs (Setiadi 2016). Information and equation of body weight prediction model based on body size of Sakub sheep need to be done. Thus, this study was conducted to analyze correlation and regression models and determine the best and most accurate regression model for predicting the body weight of female Sakub sheep using body sizes kept by smallholder farmers in Brebes District, Central Java, Indonesia.

MATERIALS AND METHODS

Ethical clearance

This study was approved by the Animal Care and Use Committee of the Faculty of Veterinary Medicine, Universitas Gadjah Mada, Yogyakarta, Indonesia with the ethical clearance number 036/EC-FKH/Eks/2022.

Research area and material

The research was conducted from May to September 2022 in Paguyangan and Sirampog Sub-Districts, Brebes District, Central Java Province, Indonesia. The research location was chosen based on the recommendation from the Department of Animal Husbandry and Animal Health of Brebes District, which had been designated as the location for the development centers of Sakub sheep farms. Paguyangan and Sirampog Sub-Districts are located at the longitude and latitude coordinates -7.275891, 109.104998 and -7.246486, 109.116349, with an area of 108.17 km² and 74.19 km². Paguyangan and Sirampog Sub-Districts are at an average altitude of 1377 and 1211 above sea level. Those areas have an average temperature of 23°C, humidity of 84%, and rainfall in these sub-districts are 10,761 and 3,640 mm/year (Central Agency on Statistics of Brebes District 2021). This research location is on the slopes of Slamet Mount in Central Java, and the temperature is low, so this area is classified as cold for a tropical area. Most of the local communities create horticultural lands and plantations. The location of data collection is presented in Figure 1.

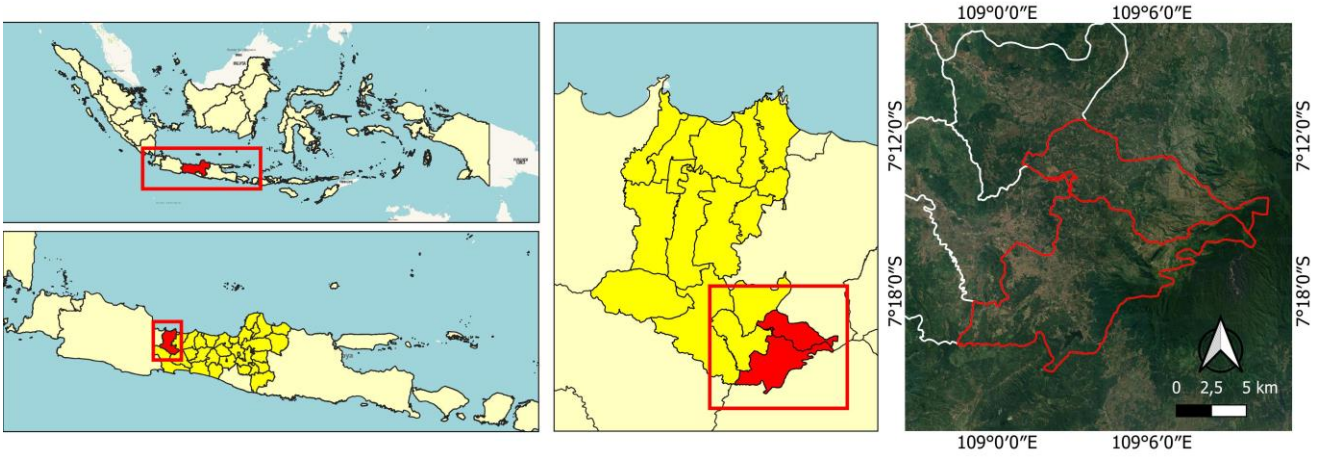

Figure 1. The research location of Paguyangan and Sirampog Sub-Districts, Brebes District, Central Java Province, Indonesia

Body weight and body size were measured on 150 female Sakub sheep kept by smallholder farmers. The sheep were selected by purposive sampling based on the criteria of age, not pregnancy, and healthy animal. The sheep measured are the results of a door-to-door survey based on data collection owned by the Department of Animal Husbandry and Animal Health of Brebes District. Most of the Sakub sheep are kept by smallholder farmers as a side job with the traditional system. Sheep are raised intensively in colony pens. Feeding was carried out two times a day with forage grass and agricultural residues such as carrot leaves, carrots, and cabbage leaves. Concentrated food and drinking water are rarely given to sheep.

Data collection

The Sakub sheep studied were identified by age based on farmers' records and information as well as by examining the change of permanent teeth. Female Sakub sheep with an age range of 3 months to 48 months were selected for analysis of body weight prediction based on body size. The female Sakub sheep were grouped into four categories based on their age, namely groups 3-6 months, >6-12 months, >12-24 months, and >24-48 months.

The Body Weight (BW) of Sakub sheep was weighed with balance WeiHeng© with a capacity of 200 kg and an accuracy of 0.01 kg, and their body sizes were measured with Butterfly© measuring tape and FHK© ruler with an accuracy of 0.1 cm. The body sizes observed included body length (BL), chest girth (CG), and shoulder height (SH). Measurements were made based on the FAO procedure (FAO 2012) by first positioning the sheep in an upright position parallel to the flat plane or the pen floor. The body size scheme showed in Figure 2.

Data analysis

Body weight data are correlated and regressed with body size using the SPSS version 25 platform. The normality of the data distribution was checked using a boxplot and the Kolmogorov-Smirnov and Shapiro tests. The correlation between variables was calculated using the Pearson correlation. The simple and multiple linear regression models are used to determine the equation for the relationship between body size and body weight of female Sakub sheep. Based on the regression model, the regression equation with the highest correlation coefficient (r), 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) were recommended for use in estimating sheep body weights and for obtaining the correlation coefficient (r), coefficient of determination (R^2), adjusted R^2 and residual standard error (RSE). The generalized linear mixed model's method determined the Akaike information criterion (AIC) and Bayesian information criterion (BIC) scores. Based on the regression model, the regression equation with the highest r, R^2, adjusted R^2, and the lowest RSE, AIC, and BIC was recommended to estimate Batur sheep body weights (Dakhlan et al. 2020; Ibrahim et al. 2021). Models with the best fit are also carried out using automatic linear modeling with the best subsets and forward stepwise methods using the Akaike information criterion corrected (AICC) (Cleophas and Zwinderman 2016; Ibrahim et al. 2021).

RESULTS AND DISCUSSION

Body weights and body sizes

The descriptive statistical data on body weight and body size of female Sakub sheep based on age category are presented in Table 1. Meanwhile, data on body weight and body size of female Sakub sheep without being categorized by age are presented in Figure 2. The data are grouped and stratified by age (3-6, >6-12, >12-24 and >24-48 months). This is important to facilitate the characteristics of body weight and body size of livestock, which will differ according to their age. Livestock age is important in this parameter. Younger sheep usually show a smaller body size than older sheep. Ibrahim et al. (2020) reported that the BW and SH of adult female Batur sheep (24-48 months) were much higher than young female Batur sheep (12-24 months), which was 64.37 compared to 63.12 kg in BW and 62.08 compared to 59.48 cm in SH. In addition, according to Ibrahim et al. (2021), using a long and varied life span can increase accuracy in the analysis of BW prediction in livestock so that the resulting regression equation is not only used for adult sheep but can also be used for each age group.

The standard deviation of the female Sakub sheep in the older age category (Table 1) was higher than that of the younger sheep, particularly in BW and CG. This can be influenced by differences in genetic potential to grow considering environmental factors such as feed management and relatively uniform rearing systems. Thus, a high BW variation can be used as an indicator of the success of a good selection program (Dakhlan et al. 2021). Table 1 shows that the female Sakub sheep had an average BW of 20.76, 30.15, 36.54 kg, and 46.32 kg, respectively, in the age group of 3-6, >6-12 >12-24, and >24-48 months.

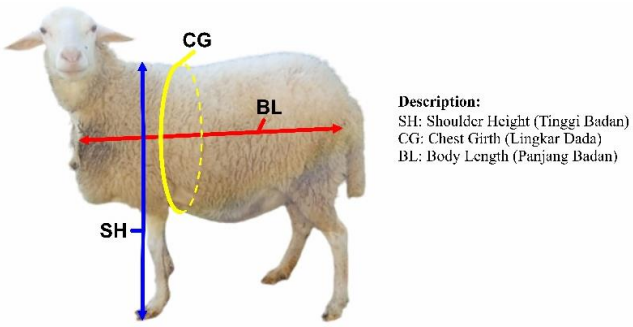

Figure 2. The body sizes observed included body length (BL), chest girth (CG), and shoulder height (SH) in female Sakub sheep

Table 1. The mean and standard deviation of the body weight and body sizes in female Sakub sheep based on aged category

Age	N	Body weight (kg)	Body length (cm)	Chest girth (cm)	Shoulder height (cm)
3-6 months	28	20.76±5.45	57.14±5.94	68.11±6.92	57.32±3.57
>6-12 months	32	30.15±4.81	65.22±5.18	80.69±6.51	63.59±4.06
>12-24 months	29	36.54±7.97	67.86±5.53	84.45±9.07	66.90±4.15
>24-48 months	61	46.32±9.30	72.36±6.15	89.15±6.74	70.24±4.21
3-48 months	150	36.21±12.31	67.13±7.97	82.51±10.47	65.76±6.24

When compared with the results of previous studies in Brebes District, they were much larger than that of the BW of Compass Agrinak sheep (sheep introduced by the Center for Livestock Research and Development, Ministry of Agriculture in 2014) at 12 months of age which only weighed 25-30 kg (Munyaneza et al. 2019). Meanwhile, when compared with the BW of adult female Batur and Wonosobo sheep as local breeds of sheep in Central Java originating from Banjarnegara and Wonosobo District, the sheep weighed lower at 32.7 kg and 32.8 kg in the >6-12 months (Hakim et al. 2019; Haren et al. 2020) Figure 3 shows that BW has a normal distribution. No outliers were found in the analyzed data.

The BL represents the development of the vertebrae, including the thoracic, lumbar, and sacrum, and the SH represents the growth of the rib eye and meat attached to the bone. Meanwhile, SH represents the bones that comprise the forelegs and upper legs according to their function as body supports (Ibrahim et al. 2020, 2021). Figure 3 shows that all female Sakub sheep body sizes were normally distributed, and there are no outliers in the analyzed data. The body sizes (Table 1) showed an increase with increasing age of the sheep. As a comparison in this study, based on Table 2, the body size of the Batur and Wonosobo sheep, as local breeds in Central Java, the BL Sakub sheep are lower than the Batur sheep in the >12-24 months age group, but higher in the >24-48 months age groups, namely 68.43, and 70.96 cm (Ibrahim et al. 2020) respectively. Meanwhile, when compared with Wonosobo sheep, the BL of Sakub sheep is similar in the age group >12-24 months, namely 67.83, but lower in >24-48 months at 69.15 cm (Hakim et al. 2019). The CG of the Sakub sheep is lower than Batur sheep at the group age of >12-24 and >24-48 months which are 98.35 and 102.96 cm, respectively (Ibrahim et al. 2020), but higher than that of the Wonosobo sheep age group >12-24 and >24-48 months were 79.61 and 81.15 cm (Hakim et al. 2019). The SH of Sakub sheep is higher than Batur sheep at the age group of >12-24 and >24-48 months, which are 59.48 and 62.08 cm, respectively (Ibrahim et al. 2020) and compared to Wonosobo sheep aged >12-24 and >24-48 months were 60.04 and 61.78 cm. (Hakim et al. 2019). The body weight and body size of sheep are highly influenced by environmental factors, resulting in varying body sizes (Dakhlan et al. 2021).

The correlation between body size and body weight

The correlation analysis between body size and BW of the female Sakub sheep in this study was carried out thoroughly and not based on age group. The correlation analysis results show that body size positively correlates with BW. The BL has the highest correlation (r) with BW, which is 0.810, followed by CG (0.807) and SH (0.782). Meanwhile, the correlation analysis between each body size also showed a positive correlation, with the highest value in the correlation of body sizes combination between BL, CG, and SH, which is 0.883, followed by BL and CG (0.875), between CG and SH (0.875), and the lowest in BL and SH is 0.848. The results of the correlation analysis in this study are the same as the previous research, namely Mavule et al. (2013) on Zulu sheep, Waheed et al. (2020) on Beetal goats, Haq et al. (2020) in Jabres cattle, Rather et al. (2021) on Kashmiri Merino sheep and Ibrahim et al. (2021) on female Batur sheep. The correlation between independent variables is less than 0.90, indicating the absence of multicollinearity.

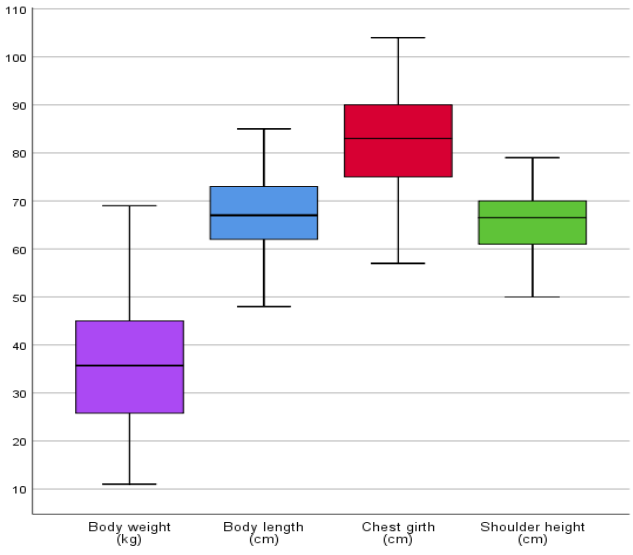

Figure 3. Boxplot of body weight and body sizes of female Sakub sheep

Table 2. Comparison of body weight and body size of Sakub sheep with other sheep in Central Java, Indonesia

Breed/age	Body weight (kg)	Body length (cm)	Chest girth (cm)	Shoulder height (cm)	Reference
Sakub sheep					
>12-24 months	36.54±7.97	67.86±5.53	84.45±9.07	66.90±4.15	*This research*
>24-48 months	46.32±9.30	72.36±6.15	89.15±6.74	70.24±4.21	
Batur sheep					
>12-24 months	63.12±13.80	68.43±7.45	98.35±19.71	59.48±6.57	Ibrahim et al. 2020
>24-48 months	64.37±12.30	70.96±5.82	102.96±18.75	62.08±6.37	
Wonosobo sheep					
>12-24 months	40,17	67.83	79.61	60.04	Hakim et al. 2019
>24-48 months	44.13	69.15	81.15	61.78	

Multicollinearity is a phenomenon when two or more predictors are correlated. If that happens, then the standard error coefficient will increase, which means that the coefficients for some or all of the independent variables can differ significantly from 0. One sign of multicollinearity is the large correlation between predictors. Multicollinearity can create some variables that are not statistically significant even though they should be significant. This will affect the most influential predictor in the model that has been created (Khan et al. 2014; Daoud 2017). The correlation group is divided into three based on Guilford's rule, if the correlation coefficient (r) is 0.0-0.70 shows moderate correlation, 0.70-0.90 shows high correlation, and if the (r) is more than 0.9, then it shows a very high correlation (Inozemtseva and Holmes 2014).

The results of the correlation analysis in this study are different from previous studies that also predict sheep BW with body size where the highest correlation is in CG body size compared to BL and SH, namely Somalia Blackhead sheep (Feyissa et al. 2018), Arsi Bale sheep (Worku 2019), Cornigliese sheep (Sabbioni et al. 2020), female Batur sheep (Ibrahim et al. 2021). The BL became the best single predictor of body weight for Sakub sheep, although it only had a very small correlation (r) value with CG in this study (0.810 vs. 0.807). While in previous studies, it was widely reported that CG was the best predictor of body weight in sheep, this was possible because the development of CG was in line with the development of ribs, muscles, and fat, where there was an increase in the proportion of carcass fat and rib weight and then expressed in growth and fat accumulation (Dakhlan et al. 2020). Sakub sheep's weight was predicted by three combinations of body size in multiple linear regression analysis, namely BL, CG, and SH (0.883). Meanwhile, the correlation between BW and the combination of BL and CG of 0.875 has almost the same value as the three predictor combinations. The results of the multicollinearity test of the BW regression model with all predictors of the combination of BL, CG, and SH show a tolerance value >0.10 and a VIF value <10.00, which means that there is no multicollinearity in the model (Daoud 2017).

Regression model between body size and body weight

In this study, regression analysis between body size and BW of female Sakub sheep was not carried out based on age group but on body size as a predictor, namely single, 2 combinations, or 3 combinations. The regression equation between body size and body weight of female Sakub sheep is presented in Table 3. The scatter plot and regression line of the regression model using three body sizes as a single predictor are shown in Figure 4. The best regression equation is selected based on the highest r, R^2, adjusted R^2 values, and the lowest RSE, AIC, and BIC values. Table 3 shows that single body size (BL) as the best predictor of BW, as evidenced by the highest value of r (0.810), R^2 (0.657), and adjusted R^2 (0.654) and lowest value of RSE (7.24), AIC (1,022.195), and BIC (1,025.165). This result is also supported by the Gaussian curve, which shows the thickest line at BL followed by CG and then the thinnest at SH (Figure 5). Meanwhile, Table 4 shows the results of testing with an automatic linear model using the best subsets method, which also shows that BL is in a more fit rank, as evidenced by the lowest AICC (534,028) compared to CG (540.911) and SH (564.788). This result differs from previous research on BW prediction by body size, which states that CG can reflect body weight along with development and growth, so it is most appropriate to be used as a predictor of BW of livestock. This was reported in Somali blackhead sheep (Feyissa et al. 2018), Arsi Bale sheep (Worku 2019), and female Batur sheep (Ibrahim et al. 2021)

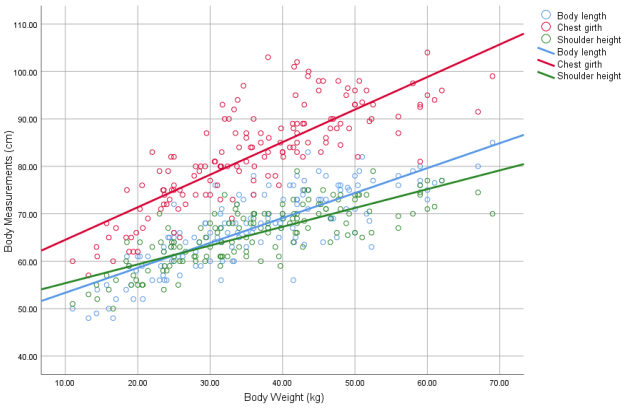

Figure 4. Scatter plot and regression line of body weight and three single predictors on female Sakub sheep

Table 3. Regression equation of body sizes with the body weight of female Sakub sheep

Regression equations	r	R^2	Adj. R^2	RSE	AIC	BIC
BW =-47.658 + 1.249BL	0.810**	0.657	0.654	7.24	1,022.195	1,025.165
BW =-42.048 + 0.948CG	0.807**	0.651	0.649	7.30	1,025.120	1,028.089
BW =-65.148 + 1.541SH	0.782**	0.611	0.608	7.71	1,040.231	1,043.201
BW =-58.718 + 0.739BL + 0.549CG	0.875**	0.765	0.762	6.00	969.392	972.355
BW =-67.323 + 0.970BL + 0.768SH	0.848**	0.719	0.716	6.57	994.454	997.417
BW =-65.454+ 0.594CG + 0.801SH	0.851**	0.725	0.721	6.50	992.192	995.155
BW =-67.004+ 0.589BL + 0.453CG + 0.399SH	0.883**	0.779	0.774	5.85	962.780	965.736

Note: ** Correlation is significant at the $p<0.01$ level (2-tailed)

The regression equation model to predict BW using 3 combinations of body size shows that BL, CG and SH are the best compared to using 2 combinations, namely BL and CG, BL and SH, as well as CG and SH. The combination of these 3 body sizes has the highest r (0.883), R^2 (0.779), and Adjusted R^2 (0.774) values and the lowest RSE (8.85), AIC (962.780), and BIC (965,736) values. This result is different from previous studies that reported a combination of two body sizes, namely BL and CG as the best predictor of BW, in Sabbioni et al. (2020) in female Cornigliese sheep, Ibrahim et al. (2021) in female Batur sheep. This accuracy is possible because the CG is connected directly to the thorax and abdomen area, which dominates the volume of body weight from the chest to the base of the tail, known as BL (Dakhlan et al. 2020).

The model-building summary in automatic linear regression using the Forward Stepwise method is presented in Table 5. Body size as a predictor of BW of female Sakub sheep shows their respective accuracy values when used single, 2 combinations, or 3 combinations. Table 5 shows that the prediction model BW using a combination of 3 body sizes, BL, CG and SH, has the highest accuracy (rank 1) with an accuracy of 77.40%, which is then followed by a combination of 2 body sizes BL and CG (rank 2) with an accuracy slightly below that of 76.20%. Meanwhile, with a single predictor, namely BL, the accuracy value decreased by 10% compared to the combined predictor. However, all these models are still feasible, considering the accuracy rate is more than 65%. The results of this study differ from those reported by Ibrahim et al. (2021), where the predictor of BW of female Batur sheep with a combination of 2 (CG and BL) has an accuracy of 77.60%, followed by single (CG) with an accuracy of 74.60%. There was a large difference in the accuracy of a single predictor between CG and BL (in this study) even though it was carried out on the same livestock, namely female sheep. This occurs because there are differences in BW and body conformation between Sakub and Batur sheep. Body weight, BL and CG of adult female Batur sheep are 64.37 kg, 70.96 cm and 102.96 cm (Ibrahim et al. 2020), which are higher than female Sakub sheep in the same age category, namely 46.32 kg, 72.36 cm and 89.15 cm. It can be seen the body proportion of female Batur sheep is more dominant in CG, while in female Sakub sheep is BL, thus confirming body size, which is the sole predictor in both.

Prediction of female Sakub sheep BW with body size can be used for different purposes and levels of difficulty, depending on the situation. Simply put, the use of a single body size (BL) to predict body weight can be done easily and quickly compared to 2 or 3 combinations of body size. Ibrahim et al. (2021) stated that the prediction of BW with body size is easily done by smallholder farmers, for example, for marketing purposes. At the level of smallholder farmers, especially cattle, sheep, and goats, live BW is the main factor in determining selling prices. Usually, farmers cannot weigh livestock with digital scales in buying and selling because they do not have proper scales or pen construction for weighing. Normally, they then sell the livestock in the animal market, where scales are also unavailable. So far, the weight of livestock in traditional trading practices in Indonesia still relies on traders' estimates without using scales (Jakaria et al. 2019).

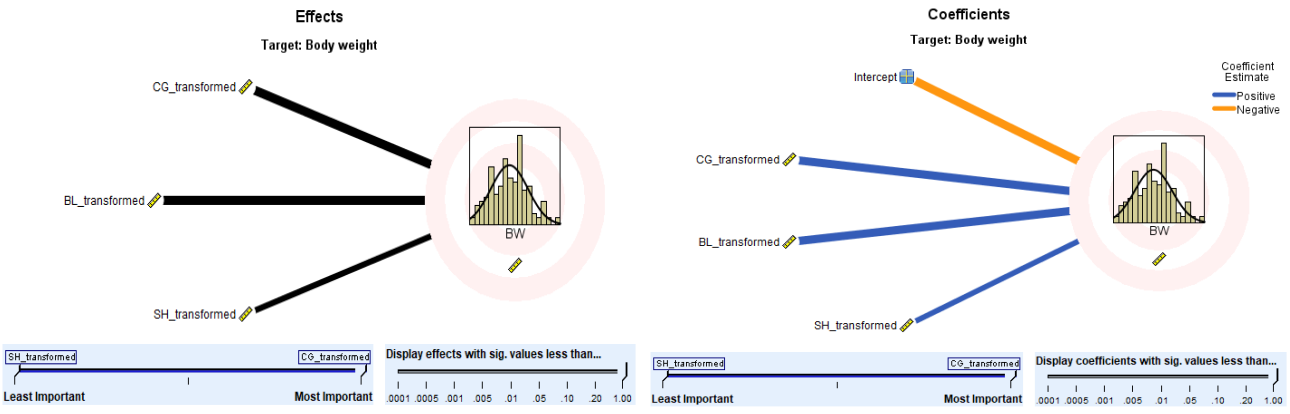

Figure 5. Best fit Gaussian curve with all predictors entered

Table 4. Model building summary in automatic linear regression using the Best Subsets method

Effect (transformed)	Model							
	1	2	3	4	5	6	7	8
BL	√	√		√	√			
CG	√	√	√			√		
SH	√		√	√			√	
Information Criterion	534.028	540.911	564.788	597.729	595.978	598.393	614.757	754.244
p-values	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Note: A checkmark means the effect is in the model.

Table 5. The model building summary in automatic linear regression using the Forward Stepwise method

Predictor	Effect (transformed)	Information criterion	Accuracy (%)	Best's rank	*p*-values
1	BL	595.978	65.40	3	0.000
2	BL+CG	540.911	76.20	2	0.000
3	BL+CG+SH	534.028	77.40	1	0.000

Meanwhile, in Brebes District, Central Java, smallholder farmers transacting in the animal market will estimate and predict the BW of their livestock only by eye assessment, generally known as "jogrog" which will then determine the selling price of the livestock (Haq et al. 2020). The results of the prediction of "jogrog" will certainly have an uncertain accuracy value because it is only based on the experience and skills of each. Most of it will cause inaccuracy it can reduce the bargaining position and the profits gained by farmers are not optimal. Thus, a more accurate and easier live weight prediction method is needed to assist smallholder farmers in obtaining the right selling price for livestock. It is applied to Sakub sheep owned by smallholder farmers in Brebes District by converting body size (BL) to BW. Farmers simply measure the length, which will then obtain a more accurate BW prediction compared to the "jogrog" method, then they can determine the selling price of their sheep in the market.

Meanwhile, the regression model for predicting BW with a combination of body size (more accuracy) can also be used for the characterization of phenotypic traits and the purpose of evaluating the growth and productivity performance of livestock in the context of selection and breeding programs (Jakaria et al. 2019; Dakhlan et al. 2020; Ibrahim et al. 2021). In order to carry out the Sakub sheep development program at the location of the breeding center (Paguyangan and Sirampog Sub-Districts) by the Brebes District government, it is necessary to increase the population and genetic improvement of the Sakub sheep, which are kept by smallholder farmers there. Efforts that can be recommended from the results of this study are to use body sizes such as BL, CG, and SH as selection criteria. This is also in line with the efforts to standardize and develop the Sakub Sheep as genetic resources for local sheep to the Ministry of Agriculture of the Republic of Indonesia, where it is necessary to carry out the phenotypic characterization of Sakub sheep with criteria on BW and body size based on Regulation of the Ministry of Agriculture of the Republic of Indonesia Number 117/Permentan/SR.120/10/2014 (Ministry of Agriculture 2014).

The conclusion of this study is that body size, namely BL, CG and SH can be used to predict BW of female Sakub sheep, either used single or in 2 or 3 combinations. The best body size (r = 0.883) and the most accurate (77.40%) to predict BW of female Sakub sheep is the combination of the three BL+CG+SH with regression equation model BW = 67,004+0.589BL+0.453CG+0.399SH. Meanwhile, the prediction of BW with a single body size is BL with the regression equation BW = -47,658 + 1,249BL. Sakub sheep farmers can apply the prediction of BW with body size to help determine the selling price of their livestock and the Brebes District government to support the Sakub sheep development program.

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