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CORRELATION BETWEEN CHEST GIRTH, BODY LENGTH, AND BODY HEIGHT ON WITHER WEIGHT OF ROTE SHEEP EWES

Ni Made Paramita Setyani[1*], Wilmientje Marlene Nalley[1], Thomas Mata Hine[1], Agustinus Ridlof Riwu[1], Kirenius Uly[1], Petrus Kune[1], Yustiany Yuliana Bette[1], Alvrado Bire Lawa[1], Simon Edison Mulik[1], Adyanto Nessy Banamtuan[1], Roni Markus Jami Riwu[1], Yanna Nailla Zulfa[2], Rut Listyadi[3]

[1]Animal Husbandry Study Program, Faculty of Animal Husbandry, Marine and Fisheries, Universitas Nusa Cendana, Kupang, Indonesia
[2] Putra Sang Fajar State Community Academy, Blitar, Indonesia
[3]Animal Husbandry Study Program, Faculty of Animal Husbandry, Universitas Udayana, Bali, Indonesia

*Corresponding Author. Email: made.setyani@staf.undana.ac.id

ABSTRACT

This study aimed to analyze the relationship between linear body measurements including chest girth (CG), body length (BL), and wither height (WH) and body weight (BW) in Rote sheep ewes across different age groups to determine the most reliable predictor of body weight. The research employed a quantitative method through direct field measurements and weighing. Data collected including vital statistics (CG, BL, WH) and BW from Rote sheep ewes categorized into three age groups (I0, I2, and I4). The data were analyzed statistically using correlation coefficient (r), the coefficient of determination (R^2), and bias analysis to evaluate the accuracy of weight estimation. The results revealed that chest girth exhibited the highest correlation with body weight, particularly in the I0 group (r = 0.93; R^2 = 86.05%), indicating a strong positive relationship and high predictive accuracy. Body length showed a moderate relationship (r = 0.87; R^2 = 76.11%) in the same group, while wither height demonstrated a relatively weaker correlation (r = 0.73; R^2 = 53.94%). Across all age groups, the predictive strength of body measurements decreased with increasing age, suggesting that skeletal growth contributes less to body weight variation in mature sheep. In conclusion, chest girth was identified as the most accurate and reliable linear measurement for predicting body weight in Rote sheep ewes, particularly in younger age groups, and can therefore be used as a practical and non-invasive tool for estimating livestock weight.

Keyword: Body length, Chest girth, Correlation, Rote sheep, Wither height

INTRODUCTION

East Nusa Tenggara (NTT) is an archipelagic province with a semi-arid tropical climate that is more extreme compared to most other regions in Indonesia (Fuah *et al*., 2015; Setyani *et al*., 2024). The dry climate limits the availability of animal feed, thereby affecting livestock productivity and the expression of their genetic potential. This condition poses a challenge to the development of livestock-based superior commodities in the region.

One of the local commodities currently being developed is the Rote sheep in Rote Ndao Regency. For the local community, sheep are not only a source of animal protein but also have the potential to produce premium-quality meat. The superiority of Rote sheep meat is reflected in its nutritional profile (high-quality protein, essential amino acids, vitamins, and micronutrients), mild mutton odor, and favorable carcass characteristics (Gunawan *et al*., 2019; Suhendra *et al*., 2024). Carcass traits such as live weight, carcass weight, and carcass percentage are strongly influenced by live body weight and age (Gunawan and Noor, 2006).

Body weight is a key quantitative trait closely related to productivity, economic value, and the success of sheep management. In addition to serving as a selection indicator, body weight is also used to determine feeding requirements and market value (Gunawan and Noor, 2006). However, direct weighing is often difficult for smallholder farmers due to limited facilities and the relatively large size of ruminants. Therefore, body weight estimation through linear body measurements offers a more practical alternative. Previous studies have shown that linear body measurement, including chest girth, body length, and wither height, are highly correlated with body weight (Bekele and Tadesse, 2021; Castillo *et al*., 2023; Firdaus *et al*., 2025). Among these, chest girth has been reported as the strongest predictor of body weight, as most of the animal's body mass is concentrated between the chest and hip regions.

Nevertheless, research on body weight estimation based on morphometric traits in Rote sheep remains limited, even though this method is essential to support selection programs and the development of local genetic resources. Therefore, this study aims to analyze the relationship between morphometric measurements (chest girth, body length, and wither height) and body weight of Rote sheep, thus providing a basis for developing prediction models and formulating more effective selection strategies.

MATERIALS AND METHODS

Materials

The materials used were 64 Rote sheep ewes from Lobalain Subdistric. To accurately group the animals, we used a standard method SNI (2015) based on their age, which we determined by counting their permanent incisor teeth. The groups were: I0 (n=27): Under 1 year old, I2 (n=29): 12–18 months old, I4 (n=8): 18–24 months old.

Methods

This research employed quantitative methods to collect physical characteristics. Data acquisition involved direct measurement of key morphometric traits (chest girth, body length, and wither height) and weighing for body mass. Statistical analysis was subsequently performed on all data. Samples were selected using a purposive random sampling strategy, specifically targeting Rote sheep ewes categorized into three predetermined age groups: I0, I2, and I4.

Variables

The variables observed in this study were the quantitative traits of Rote sheep ewes, which included:

1. Chest girth is one of the most important body measurements in sheep and is often used as an indirect estimator of body weight. The measurement was taken using a measuring tape placed around the chest of the animal, just behind the forelegs and passing through the largest circumference of the thorax (cm) (Castillo *et al*., 2023).
2. Body length is defined as the distance from the anterior edge of the shoulder to the posterior edge of the hip or ischium (cm) (Şengül and Çelik, 2025).
3. Wither height refers to the vertical distance from the ground to the highest point of the withers (the dorsal part of the scapula) when the sheep is standing upright with both fore and hind legs straight (cm) (Castillo *et al*., 2023).

4. Body weight is a quantitative trait that reflects the total mass of an animal, measured in kilograms (kg). It was obtained using a livestock scale (Novianti *et al.*, 2024).

Data Analysis

The data were analyzed using several statistical methods were coefficient of variation, correlation coefficient, including correlation significance testing (t-test), coefficient of determination, regression analysis, and bias analysis between estimated and actual body weight (Novianti *et al.*, 2024). The formulas are presented as below:

1. Coefficient of variation

The coefficient of variation (CV) is a statistical measure expressed as the ratio of the standard deviation to the mean, usually presented as a percentage. It indicates the relative variability of a dataset, allowing comparison of variation between traits with different units or scales. The formula is as follows:

$$CV = \frac{SD}{\bar{X}} \times 100\%$$

Where:
SD = standard deviation
$\bar{X}$ = mean
Interpretation of the coefficient of variation as presented in Table 1.

Table 1. Interpretation of the coefficient of variation

Coefficient of variation	Value (%)
Low	<10%
Medium	10-20%
High	>20%

2. Correlation coefficient

The correlation coefficient is a statistical measure that quantifies the strength and direction of the linear relationship between two variables, in this study, linear body measurements were chest girth, body length, and lower height with body weight. The formula is as follows:

$$r = \frac{n\Sigma XY - \Sigma X \Sigma Y}{\sqrt{(n\Sigma X^2 - (\Sigma X)^2)}\sqrt{(n\Sigma Y^2 - (\Sigma Y)^2)}}$$

Where:
r = Correlation coefficient
X = Linear body measurements (chest girth, body length, and wither height)
Y = Body weight
n = Number of Rote sheep ewes studied

The correlation coefficient value ranges from -1 to +1. According to Şengül and Çelik (2025), the interpretation of correlation coefficient values, which indicate the degree of association between variable X and variable Y, can be classified as presented in Table 2.

Table 2. The interpretation of correlation coefficient values

Correlation coefficient	Positive	Negative
Weak	0.1 to 0.3	-0.3 to -0.1
Medium	>0.3 to 0.5	>-0.5 to -0.3
Strong	>0.5 to 1.0	>-1 to -0.5

3. Coefficient of determination

The coefficient of determination (R^2) is a statistical measure that indicates the proportion of the variance in the dependent variable (body weight) that can be explained by the independent variables (linear body measurements) in a regression model. The formula is as follows:

$$R^2 = r^2 \times 100\%$$

Where:
R^2 = Coefficient of determination

r = Correlation coefficient

4. t-test

The t-test was employed to assess the statistical significance of the correlation. The formula is as follows:

$$\text{t-test} = r\sqrt{\frac{n-2}{1-R^2}}$$

Where:
r = Correlation coefficient
n = Number of Rote sheep ewes studied
R^2 = Coefficient of determination

5. Regression analysis

$$Y = a + bX$$

Where:
Y = Body weight
a = Constant
b = Regression coefficient
X = Linear body measurements

6. Bias analysis

$$\%\ \text{Bias} = \frac{Estimated\ BW - Real\ BW}{Real\ BW} \times 100\%$$

Where:
BW = Body weight

RESULTS AND DISCUSSION

Linear Body Measurements and Body Weight of Rote Sheep Ewes

The results of quantitative traits including chest girth, body length, wither height and body weight in Rote sheep ewes are presented in Table 3.

Table 3. Quantitative traits in Rote sheep ewes

Variables	Age group	N	Mean ± SD	CV (%)
BW (kg)	I0	27	9.50 ± 4.76	50.14
	I2	29	24.52 ± 2.72	11.10
	I4	8	31.13 ± 2.03	6.53
CG (cm)	I0	27	47.06 ± 9.42	20.02
	I2	29	68.39 ± 4.43	6.48
	I4	8	72.80 ± 2.63	3.61
BL (cm)	I0	27	44.69 ± 9.14	20.45
	I2	29	56.19 ± 5.58	9.93
	I4	8	59.40 ± 3.85	6.47
WH (cm)	I0	27	42.99 ± 7.36	17.11
	I2	29	56.86 ± 3.86	6.80
	I4	8	60.74 ± 3.80	6.25

Additional information: BW (body weight), CG (chest girth), BL (body length), WH (wither height), n (number of Rote sheep ewes used), CV (coefficient of variation)

The average BW each group of Rote sheep ewes were 9.50±4.76 kg, 24.52±2.72 kg, 31.13±2.03 kg for groups I0, I2, and I4, respectively. The results of BW for I0 and I2 were lower than the BW of Garut sheep ewes with the same group were 22 kg for the I0 group, and 29 kg for the group I2. However, the I4 group demonstrated an average body weight of 31 kg, which is comparable to that of Garut sheep (SNI, 2015). Different breeds, variations in environmental conditions, management practices, and feeding strategies have a

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significant impact on sheep body weight (Ananda *et al*., 2021).

The average CG for each group of Rote sheep ewes were 47.06±9.42 cm, 68.39±4.43 cm, 72.80±2.63 cm for group I0, I2, and I4, respectively. The results of CG for group I0, I2 and I4 were lower than the CG of Garut sheep ewes with the same group were 67 cm for group I0, and 72 cm for group I2, and 76 cm for group I4 (SNI, 2015). Furthermore, the CG of groups I0 and I4 in this study were lower than that of the Sapudi sheep, measuring 64 cm in group I0 and 74 cm in group I4. In contrast, the CG of group I2 in this study was higher than that of the Sapudi sheep, reaching more than 64 cm (SNI, 2018).

The average BL for each group of Rote sheep ewes were 44.69±9.14 cm, 56.19±5.58 cm, 59.40±3.85 cm for group I0, I2, and I4, respectively. The results of BL for group I0 was lower than the BL of Garut sheep ewes with the same group were 49 cm for group I0. However higher than group I2 and I4 were 51 cm and 56 cm respectively (SNI, 2015). Furthermore, the BL of groups I0 and I4 in this study were lower than that of the Sapudi sheep, measuring 51 cm in group I0 and 60 cm in group I4. Where the BL of group I2 in this study indicates the same average BL with the Sapudi sheep was 56 cm (SNI, 2018).

The average WH each group of Rote sheep ewes were 42.99±7.36 cm, 56.86±3.86 cm, 60.74±3.80 cm for group I0, I2, and I4 respectively. The results of WH for group I0, I2, I4 were lower than WH of Garut sheep ewes with the same group were 59 cm, 60 cm, 65 cm, respectively (SNI, 2015). Furthermore, the WH of groups I0, I2, and I4 in this study was also lower than that of the Sapudi sheep were 54 cm, 58 cm, 63cm for each groups, respectively (SNI, 2018).

The diversity of the samples used also influenced the average BW, CG, BL, and WH of Rote sheep ewes in each group. Group I0 had high variation in BW, CG, and BL, however, moderate variation in WH. Group I2 had moderate variation in BW, however, low variation in CG, BL, and WH. Whereas group I4 had low variation for BW, CG, BL, and WH. Setyani *et al.* (2017) stated that a smaller coefficient of variation indicates lower diversity.

Correlation between Chest Girth and Body Weight of Rote Sheep Ewes

Results of analysis of correlation coefficient (r), coefficient of determination (R^2), the regression equation, and the average deviation in chest girth and body weight can be seen in Table 4.

Table 4. Correlation coefficient (r), coefficient of determination (R^2), regression equation, and average deviation in chest girth with body weight

Group	n	r	R^2	Regression Equation	Average Bias
I0	27	0.93*	86.05%	BW= -12.57+0.47CG*	4.23%
I2	29	0.40*	16.04%	BW=7.93+0.25CG*	1.00%
I4	8	0.33*	10.83%	BW=12.79+0.25CG*	0.30%

Additional information: * (significant P<0.05), n (number of Rote sheep ewes used), r (correlation coefficient), R^2 (coefficient of determination)

The regression analysis indicates that chest girth (CG) serves as a strong morphological indicator of body weight (BW) in Rote sheep ewes, although its predictive strength varies across age groups. Group I0 exhibited the strongest correlation between CG and BW (r = 0.93; R^2 = 86.05%), suggesting that CG effectively explains most of the variation in BW among younger sheep. This result implies that body weight in young Rote sheep increases proportionally with chest development, as this region reflects both skeletal and muscular growth (Bekele and Tadesse, 2021). The results of the regression analysis can be concluded that the regression equation of the relationship between chest girth and body weight is significant (P<0.05) in all groups.

In contrast, group I2 showed a moderate correlation (r = 0.40; R^2 = 16.04%), while group I4 demonstrated the weakest relationship (r = 0.33; R^2 = 10.83%). The decline in the correlation values with age indicates that the predictive reliability of chest girth decreases as sheep mature, likely due to reduced muscular growth and increased fat deposition around the thoracic area (Aisyah *et al*., 2024). Despite this decline, the regression equations of the groups were BW = -12.57 + 0.47CG (I0), BW = 7.93 + 0.25CG (I2), and BW = 12.79 + 0.25CG (I4). All regression equations maintained positive slopes, confirming that chest girth remains positively associated with body weight across all ages.

These results align with Tırınk *et al*., (2023), who found that chest girth is one of the most stable predictors of body weight due to its close relationship with heart girth circumference and internal organ capacity. However, as growth progresses, variations in muscle distribution and fat accumulation reduce the linearity of this relationship. The relatively low bias values across groups (4.23%, 1.00%, and 0.30% for I0, I2, and I4, respectively) further confirm that chest girth-based equations can still provide accurate estimates of body weight in Rote sheep ewes, even in older age categories, albeit with diminished explanatory power.

Correlation between Body Length and Body Weight of Rote Sheep Ewes

Results of analysis of correlation coefficient (r), coefficient of determination (R^2), the regression equation, and the average deviation in body length and body weight can be seen in Table 5.

Table 5. Correlation coefficient (r), coefficient of determination (R^2), regression equation, and average deviation in body length with body weight

Group	n	r	R^2	Regression Equation	Average Bias
I0	27	0.87*	76.11%	BW= -9.93+0.45BL*	7.05%
I2	29	0.31*	9.51%	BW= 16.16+0.15BL*	1.08%
I4	8	0.41*	16.57%	BW= 18.71+0.21BL*	0.27%

Additional information: * (significant P<0.05), n (number of Rote sheep ewes used), r (Correlation coefficient), R^2 (Coefficient of determination)

The regression analysis presented in Table 5 demonstrates the relationship between body length (BL) and body weight (BW) across different age groups of Rote sheep ewes (I0, I2, and I4). The findings reveal variations in the strength of this relationship, which tend to decrease with age. The results of the regression analysis can be concluded that the regression equation of the relationship between body length and body weight is significant (P<0.05) in all groups.

In group I0, the correlation between BL and BW was the strongest (r = 0.87; R^2 = 76.11%), indicating that approximately 76% of the variation in body weight could be explained by changes in body length. The regression equation (BW = -9.93 + 0.45BL) shows a positive and substantial linear relationship, suggesting that each additional 1 cm in body length corresponds to an increase of 0.45 kg in body weight. This pattern aligns with early growth stages, where skeletal elongation is closely linked to overall mass gain. Similar findings were reported by Bekele and Tadesse (2021) and Aisyah *et al*., (2024), who noted that in younger sheep, body length is a reliable indicator of structural and muscular growth. The moderate bias value (7.05%) also suggests that the model provides an acceptable level of predictive accuracy for estimating body weight at this stage.

In group I2, both the correlation coefficient (r = 0.31) and the coefficient of determination (R^2 = 9.51%) decreased markedly compared to group I0. The regression model (BW = 16.16 + 0.15BL) implies that body length accounts for only about 9.5% of the total variation in body weight. This weaker association indicates that as the animals age, skeletal growth slows down, and weight gain becomes more influenced by muscle hypertrophy and fat deposition rather than frame development. These findings are consistent with Kebede *et al*., (2024), who emphasized that the predictive capacity of body length diminishes as growth shifts from linear to volumetric dimensions in older sheep. Nevertheless, the bias value (1.08%) remains low, showing that while the relationship is weaker, the model still produces accurate estimates of body weight.

Interestingly, group I4 displayed a slightly stronger correlation than group I2 (r = 0.41; R^2 = 16.57%), with the regression equation (BW = 18.71 + 0.21BL). The modest increase in R^2 compared to group I2 suggests some degree of proportionality between body length and body weight, possibly due to the accumulation of body tissue along the axial frame in mature sheep. However, the overall predictive capacity remains limited compared to group I0. The very low bias value (0.27%) indicates a high precision in estimation despite the relatively weak correlation. This pattern may reflect biological stabilization, where frame size has reached maturity and further increases in body weight occur independently of length measurements (Tırınk *et al*., 2023).

Comparatively, among the three age groups, group I0 exhibited the highest predictive accuracy and correlation strength, indicating that body length serves as a more effective estimator of body weight in younger Rote sheep ewes. In contrast, groups I2 and I4 demonstrated medium correlations, suggesting that body length becomes less relevant as an indicator of body mass with increasing age. This aligns with general growth principles in small ruminants, where early-stage development is dominated by skeletal expansion, while later stages emphasize muscle and fat accretion (Bekele and Tadesse, 2021).

Correlation between Wither Height and Body Weight of Rote Sheep Ewes

Results of analysis of correlation coefficient (r), coefficient of determination (R^2), the regression equation, and the average deviation in wither height and body weight can be seen in Table 6.

Table 6. Correlation coefficient (r), coefficient of determination (R^2), regression equation, and average deviation in wither height with body weight

Group	n	r	R^2	Regression Equation	Average Bias
I0	27	0.73	53.94%	BW= -9.91+0.48WH	12.10%
I2	29	0.50*	25.45%	BW= 4.68+0.36WH*	0.89%
I4	8	0.46*	21.32%	BW= 16.52+0.25WH*	0.26%

Additional information: * (significant P<0.05), n (number of Rote sheep ewes used), r (Correlation coefficient), R^2 (Coefficient of determination)

The regression analysis between wither height (WH) and body weight (BW) in Rote sheep ewes across age groups (I0, I2, and I4) demonstrates varying levels of association, indicating that the predictive ability of WH for estimating BW decreases with advancing age. The results of the regression analysis can be concluded that the regression equation of the relationship between wither weight and body weight for I0 is insignificant (P>0.05) and significant (P<0.05) in group I2 and I4.

In group I0, the relationship between WH and BW was the strongest (r = 0.73; R^2 = 53.94%), showing that approximately 54% of the variation in BW can be explained by WH. The regression equation (BW = -9.91 + 0.48WH) indicates a clear positive linear trend, where each 1 cm increase in WH corresponds to an estimated 0.48 kg increase in BW. This strong correlation reflects the developmental stage of young sheep, where skeletal frame growth is the major contributor to overall body mass (Yakubu *et al*., 2011). However, the high bias value (12.10%) implies moderate predictive precision, possibly caused by variability in posture and growth rates among individuals at this early growth phase (Molosi *et al*., 2025).

For group I2, the correlation weakened (r = 0.50; R^2 = 25.45%), indicating that only 25% of BW variation was explained by WH. The regression equation (BW = 4.68 + 0.36WH) suggests that as sheep mature, increases in height contribute less to weight gain. This aligns with findings by Michael *et al*., (2016), who reported that skeletal growth in adult sheep stabilizes, while body weight becomes more influenced by muscle and fat deposition rather than frame height. The relatively low bias value (0.89%) suggests that although the correlation is weaker, the prediction model remains fairly accurate.

In group I4, the weakest association was observed (r = 0.46; R^2 = 21.32%), with the regression equation (BW = 16.52 + 0.25WH). This indicates that WH accounts for only about 21% of the variation in BW among the oldest sheep. The small slope value reflects the reduced contribution of height to body mass once skeletal growth has plateaued (Tırınk *et al*., 2023; Rohman and Maylinda, 2024). Despite the low R^2, the model showed high estimation accuracy with a minimal bias (0.26%), suggesting that the predictive relationship, though weak, is consistent.

When comparing all groups, group I0 demonstrated the highest correlation, highlighting that wither height serves as a better predictor of body weight in younger sheep, as their body mass is still strongly influenced by skeletal development. Conversely, the declining correlation in groups I2 and I4 indicates that as sheep mature, body weight variation is increasingly determined by tissue composition and fat accumulation rather than height. These findings are consistent with the studies of Aisyah *et al*. (2024), Kebede *et al*., (2024), and Yakubu *et al*. (2011), who noted that morphometric traits related to body width or circumference (e.g., chest girth) typically maintain stronger correlations with body weight than vertical measures like wither height. Similar trends have also been observed in Barbari, Garut, and Washera sheep, where WH exhibits moderate correlations at young ages but declines with maturity (Sun *et al*., 2020; Markos *et al*., 2023; Megersa *et al*., 2025).

Overall, the analysis confirms that wither height is a useful but age-dependent predictor of body weight, being most effective in early growth stages and less so in mature individuals. Future predictive models should therefore incorporate multiple morphometric traits to improve accuracy, as recommended by Megersa *et al*. (2025).

CONCLUSION

It is concluded that chest girth, body length, and wither height all have positive correlations with body weight in Rote sheep ewes, though the strength of these relationships differs across age groups. Among the three body measurements, chest girth demonstrates the strongest and most consistent association with body weight, reflecting its close link to muscle and skeletal development in the thoracic region. Body length also contributes to body weight prediction, particularly in younger animals, but its influence tends to decrease as growth stabilizes with age. Wither height shows the weakest correlation, suggesting that vertical growth alone is a less reliable indicator of body mass. Overall, the results indicate that as sheep mature, body weight becomes increasingly influenced by muscle and fat deposition rather than skeletal dimensions, making chest girth the most effective measurement for estimating body weight across age groups.

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