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Using Morphological Traits to Predict Body Weight of Dorper Sheep Lambs

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ABSTRACT

The Dorper sheep are known to be a fast-growing breed with a very good body conformation that produces high-quality carcass. The recent study was conducted to determine the relationship between body weight (BW) and morphological traits, such as heart girth (HG), rump height (RH), body length (BL), withers height (WH), and sternum height (SH). A total of 51 Dorper sheep lambs (29 female and 22 male lambs) were used as experimental animals. The data was collected 24 hours after birth. Data were analyzed using Pearson's correlation and simple regression to attain the objectives. The obtained results indicated that BW had a positively high statistically correlation with HG (r = 0.81), RH (r = 0.766), BL (r = 0.893), WH (r = 0.874), and SH (r = 0.618) in female Dorper sheep lambs. Furthermore, results showed that BW had a positively high statistically significant association with HG (r = 0.886), RH (r = 0.590), BL (r = 0.900), WH (r = 0.613), and SH (r = 0.707) in male Dorper sheep lambs. Simple regression models for morphological traits indicated that BL had the highest coefficient of determination (R^2 = 0.80) and the lowest mean square error (MSE = 2.83) in female Dorper sheep lambs, and also the highest coefficient of determination (R^2 = 0.81) and mean square error (MSE = 1.07) in male Dorper sheep lambs. In conclusion, the findings indicated that improving HG, RH, BL, WH, and SH might result in the enhancement of BW in Dorper sheep lambs. Simple regression results suggested that BL could be selected as a facilitating factor in the breeding programs to improve the BW of Dorper sheep lambs at birth.

Keywords: Body weight, Morphological traits, Pearson's correlation, Simple regression

INTRODUCTION

Dorper sheep are the meat-type larger than merino breed developed by crossing Dorset Horn and the Blackhead Persian sheep (Desalegn, 2019). Therefore, morphological traits are used as selection criteria to improve the growth rate of animals (Tyasi et al., 2020a). Rotimi et al. (2020) reported that morphological traits are used to estimate the body weight (BW) of animals. To evaluate the performance traits such as body weight of sheep, adaptability to existing environmental conditions looking at different stages of the life cycle can be used (Rather et al., 2021). There are simple phenotypic correlation associations among body weight and morphological factors (Gül et al., 2019). Due to the lack of weighing scales, the communal farmers find it hard to determine the live body weight, so in that case, morphological traits can be used to predict the body weight of the Dorper sheep lambs (Ulutaş et al., 2018). However, as far as the researchers are concerned, there are inadequate studies on the determination of the relationship between morphological traits and body weight in the Dorper sheep lambs. Therefore, the objectives of the present study were to determine the association among the morphological traits (heart girth, rump height, body length, withers height, and sternum height) and body weight of Dorper sheep lambs, and to determine the influence of the morphological traits on the body weight of the Dorper sheep lambs. The findings of the current study can assist the communal farmers farming with Dorper sheep to identify which morphological traits might be used as selection criteria during the breeding program to enhance the body weight.

MATERIALS AND METHODS

Ethical approval

The data for the current study was collected following the procedures of the University of Limpopo Animal Research Ethics Committee (AREC).

Study site and animal management

University of Limpopo Experimental Farm was used to conduct the current study as described by Tyasi et al.

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(2020a). A total of 51 newborn Dorper sheep lambs (29 female lambs, 22 male lambs) were used as experimental animals. The data was collected 24 hours after birth. The data was collected once per lamb from February to June 2020.

Measurements of studied traits

Sheep crate scale 300 kg × 01 kg, scale Tronic Services (PTY) Ltd, F34, Supreme Industrial Park Cnr. (Heidelberg and Klipriviersberg roads, Steeldale Johannesburg) was used to measure the body weight after birth while the measuring tape and the wood ruler were used to determine the morphological traits. All measurement procedures of traits were followed according to Kumar et al. (2018). Briefly, heart girth (HG) was calculated by measuring the body circumference behind the scapula. Rump height (RH) was measured from the pelvic girdle to the ground surface of the hind legs. Body length (BL) was measured as the distance between the humerus to the distal of the pubic bone. Withers height (WH) was measured from the ground of forelegs to the highest point of the shoulder (WH). Sternum height (SH) was measured as the vertical position from the lower tip of the sternum to the ground as the animal was standing. The measurements were all processed by one person.

Statistical analysis

Data of the current study were analyzed by Statistical Package for Social Sciences software, version 27 for windows (IBM SPSS, 2020). The descriptive statistics (mean, standard error, Coefficients of Variation) of BW and other independent variables were determined. The association between body weight and morphological traits (HG, RH, BL, WH, and SH) was determined using Pearson's correlation. Simple regression was used to determine the influence of morphological traits on body weight. The following regression model was performed (Formula 1).

$$Y = a + bX \quad (1)$$

Where; Y is the dependent variable (body weight), a refers to regression intercept, b signifies the coefficient of regression, X denotes independent variables (Morphological traits). Mean square error (MSE) and coefficient of determination (R^2) were used to select the best-fitted regression model. Probability of 5% was defined for the level of significance and probability of 1% was for highly significant differences between traits.

RESULTS

Boxplot

Boxplot showed that there was no significant variance in body weight among both sexes ($p > 0.05$). Figure 1 indicates the results of the boxplot, including lower percentile (first quartile), median percentile (third quartile), and higher values of BW among different sex of Dorper sheep lambs. In all portions of the boxplot counting smallest (> 20 kg), first quartile, median (> 30 kg), third quartile (> 40 kg), and largest (60 kg) the male Dorper sheep lambs indicated a higher BW than female Dorper sheep lambs.

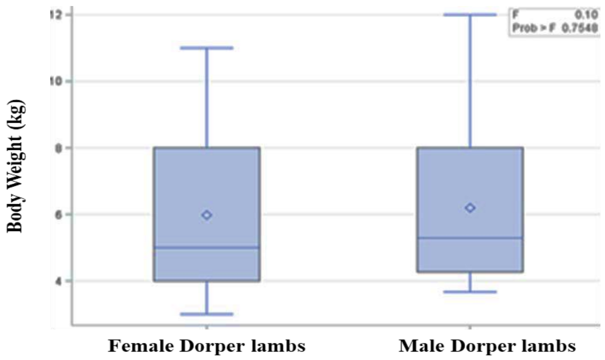

Figure 1. Median, minimum, maximum of 25th and 75th percentile values of body weight between female and male Dorper sheep lambs.

Descriptive statistics of the studied traits

The results of BW and morphological traits, such as heart girth (HG), rump height (RH), body length (BL), withers height (WH), and sternum height (SH) of Dorper sheep lambs are presented in Table 1. Descriptive statistics for morphological traits showed that the male Dorper lambs had higher numerical mean values in all the traits than female Dorper lambs.

Table 1. Descriptive statistics of the Body Weight and morphological traits of Dorper sheep lambs based on sex

Traits	Female lambs	N = 29	Male lambs	N = 22
	Mean ± SE	CV (%)	Mean ± SE	CV (%)
BW (kg)	5.98 ± 2.57	42.98%	6.2 ± 2.32	37.50%
HG (cm)	40.62 ± 5.98	14.72%	42.30 ± 4.71	11.13%
RH (cm)	33.68 ± 4.89	14.52%	35.86 ± 3.38	9.43%
BL (cm)	37.08 ± 6.57	17.72%	37.92 ± 5.15	13.58%
WH (cm)	34.41 ± 4.02	11.68%	35.44 ± 3.87	11.68%
SH (cm)	26.48 ± 2.89	10.91%	28.18 ± 4.26	10.92%

SE: Standard error, CV: Coefficient of variance; BW: Body weight; WH: Withers height; RH: Rump height; BL: Body length; HG: Heart girth; SH: sternum height

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Association among body weight and morphological traits

Table 2 shows phenotypic correlation matrix outcomes. Phenotypic correlation coefficients between measured traits of female lambs are presented above the diagonal line. The findings of Pearson's correlation indicated that BW had a positively high association with all major traits ($p < 0.01$). These results also indicated that HG had a highly positive significant correlation with RH, BL, WH, and SH ($p < 0.01$). The results also showed that RH had a highly positive significant correlation ($p < 0.01$) with BL and WH and again RH had no correlation with SH and the outcomes also discovered that BL had a positively high statistical correlation ($p < 0.01$) with WH, and SH. Correlation results of male lambs are presented below the diagonal line. The findings presented that BW had a high positively statistically significant association with all the major traits ($p < 0.01$). Heart girth had a high positively significant association with only RH, BL, and SH ($p < 0.01$), again the RH had a positive significant correlation with BL, WH, and SH ($p < 0.05$). Body Length had a highly positive significant association with WH and SH ($p < 0.01$). Finally, the WH had a high positively significant association with SH ($p < 0.01$).

Table 2. Pearson's correlation between body weight and morphological traits of female Dorper sheep lambs on the upper diagonal and the male Dorper sheep lambs on the lower diagonal

Traits	BW (kg)	HG (cm)	RH (cm)	BL (cm)	WH (cm)	SH (cm)
BW (kg)	1.000	0.811**	0.766**	0.893**	0.874**	0.618**
HG (cm)	0.886**	1.000	0.736**	0.750**	0.839**	0.475**
RH (cm)	0.590**	0.659**	1.000	0.723**	0.746**	0.246ns
BL (cm)	0.900**	0.781**	0.493*	1.000	0.831**	0.553**
WH (cm)	0.613**	0.451*	0.476*	0.738**	1.000	0.567**
SH (cm)	0.707**	0.563**	0.349*	0.825**	0.664**	1.000

**: correlation is significant at $p < 0.01$, *: correlation is significant at $p < 0.05$, highly significant, ns: not significant, BW: Body weight, HG: Heart girth, RH: Rump height, BL: Body length, WH: Withers height, SH: sternum height.

Influence of heart girth on body weight at birth

Table 3 shows the influence of heart girth on body weight using the simple linear regression analysis among body weight and heart girth. The outcomes indicated a high positively statistical correlation between body weight and heart girth ($r = 0.81$) with $R^2 = 0.66$ and MSE = 2.33 in female Dorper sheep lambs. Heart girth described around 66% of the difference in the body weight of female Dorper sheep lambs. Figure 2a shows a linear regression equation as indicated in formula 2.

$$BW = - 8.17 + 0.35HG \qquad (2)$$

Where, - 8.17 is constant, 0.35 refers to regression coefficient, BW signifies body weight, and HG denotes heart girth. The regression model indicated that increasing 1 cm of heart girth can increase body weight by 0.35 kg. The results documented a positive statistical association between body weight and heart girth ($r = 0.89$) with $R^2 = 0.79$ and MSE = 1.22 in male lambs. The heart girth described around 79% of the difference in the body weight of male Dorper sheep lambs. Figure 2b shows the linear regression equation as shown by formula 3.

$$BW = - 12.29 + 0.44HG \qquad (3)$$

Where, - 12.29 is constant, 0.44 shows regression coefficient, BW stands for body weight, HG denotes heart girth. The regression model showed that increasing 1 cm of heart girth increases body weight by 0.44 kg in male Dorper sheep lambs.

Table 3. Regression analysis between body weight and heart girth on female and male Dorper sheep lambs

	Sources	Sum of squares	DF	Mean square	R	R^2	Adjusted R^2
Female lamb	Regression	121.480	1	121.480	0.811**	0.658	0.646
	Residual	63.021	27	2.334			
	Total	184.501	28				
	Sources	**Sum of squares**	**DF**	**Mean square**	**R**	**R^2**	**Adjusted R^2**
Male lamb	Regression	89.126	1	89.126	0.886**	0.785	0.775
	Residual	24.370	20	1.219			
	Total	113.497	21				

R: Correlation coefficient; R^2: Coefficient of determination; Adjusted R^2: Adjusted coefficient of determination; DF: Degree of freedom; ** Significantat $p < 0.01$.

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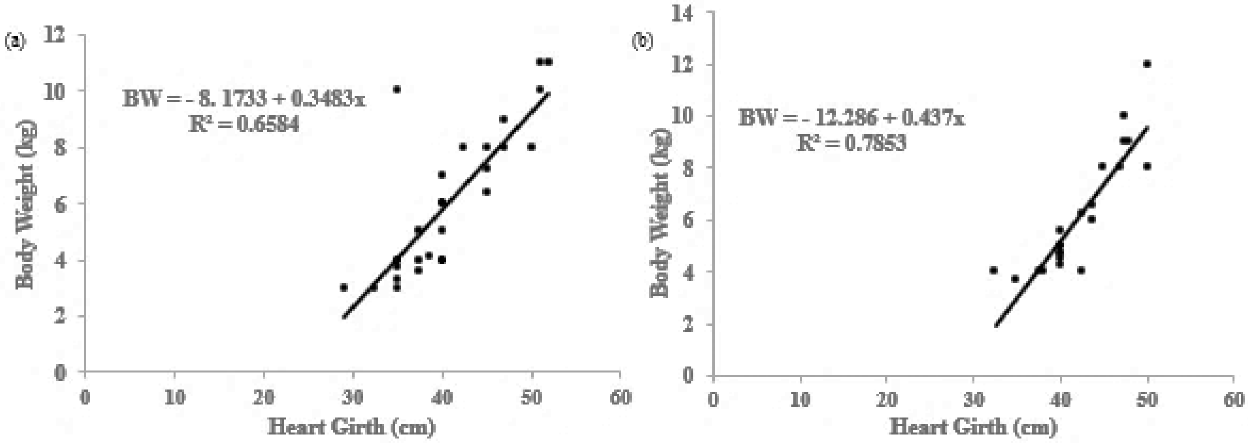

Figure 2. Effect of heart girth on body weight of female Dorper sheep lambs **(a)** and male Dorper sheep lambs **(b)**. BW: Body weight (24 hours after birth).

Influence of rump height on body weight at birth

Table 4 shows the influence of rump height on body weight using the simple linear regression analysis between body weight and rump height. The outcomes showed a highly positive statistical association between body weight and rump height (r = 0.77) with R^2 = 0. 59 and MSE = 2.83 in female Dorper sheep lambs. The rump height described around 58.70% of the difference in the body weight of female Dorper sheep lambs. Figure 3a demonstrates a linear regression equation as indicated by formula 4.

BW = - 7.56 + 0.40RH (4)

Where, BW signifies body weight, RH refers to rump height, -7.56 is constant, and 0.4 indicates regression coefficient. The regression model indicated that increasing 1 cm of rump height increases body weight by 0.4 kg. In male Dorper sheep lambs, the outcomes documented a positive statistical correlation between body weight and rump height (r = 0.59) with R^2 = 0.35 and MSE = 3.70. The rump height described around 35% of the variation in the body weight of male Dorper sheep lambs. Figure 3a shows a linear regression equation as revealed by formula 5.

BW = - 8.37 + 0.41RH (5)

Where, BW denotes body weight, RH suggests rump height, -8.365 is constant, 0.41 refers to regression coefficient. The regression model indicated that increasing 1 cm of rump height will increase body weight by 0.41 kg in male Dorper sheep lambs.

Table 4. Regression analysis between body weight and rump height on female and male Dorper sheep lambs

	Sources	**Sum of squares**	**DF**	**Mean square**	**R**	**R^2**	**Adjusted R^2**
Female lamb	Regression	108.223	1	108.223	0.766**	0.587	0.571
	Residual	76.278	27	2.825			
	Total	184.501	28				
	Sources	**Sum of squares**	**DF**	**Mean square**	**R**	**R^2**	**Adjusted R^2**
Male lamb	Regression	39.564	1	39.564	0.590**	0.349	0.316
	Residual	73.933	20	3.697			
	Total	113.497	21				

R: Correlation coefficient; R^2: Coefficient of determination; Adjusted R^2: Adjusted coefficient of determination; DF: Degree of freedom; ** Significantat $p < 0.01$.

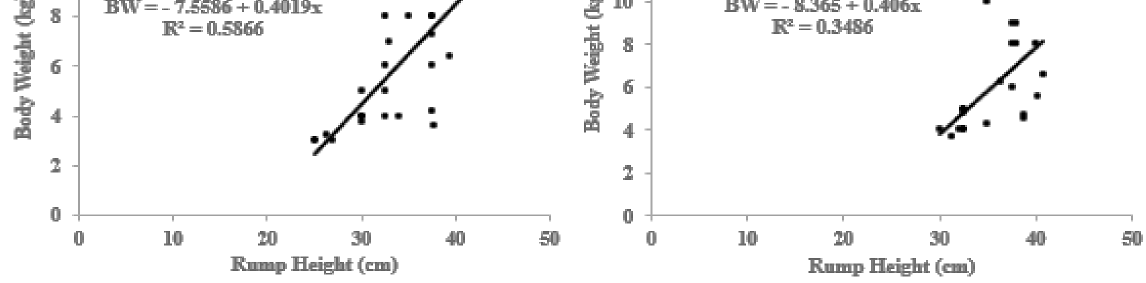

Figure 3. Effect of rump height on body weight of female Dorper sheep lambs **(a)** and male sheep Dorper lambs **(b)**. BW: Body weight (24 hours after birth).

Influence of body length on body weight at birth

Table 5 shows the influence of body length on body weight using simple linear regression analysis between body weight and body length. The findings indicated a high positively statistical association between body weight and body length (r = 0.89) with R^2 = 0.80 and MSE = 2.83 in female Dorper sheep lambs. Body length described around 80% of the difference in the body weight of female Dorper sheep lambs. Figure 4a shows a linear regression equation as by formula 6.

BW = - 6.96 + 0.35BL (6)

Where, - 6.96 is constant, 0.35 expresses regression coefficient, BW shows body weight, and BL denotes body length. The regression model indicated that increasing one cm of body length can increase body weight by 0.35 kg. The results showed a positive statistical association between body weight and body length (r = 0.90) with R^2 = 0.81 and MSE = 1.07 in male lambs. The body length described around 81% of the difference in the body weight of male Dorper sheep lambs. Figure 4b shows the linear regression equation as indicated by formula 7.

BW = - 9.22 + 0.41BL (7)

Where, - 9.22 is constant, 0.41 indicates regression coefficient, BW stands for body weight, BL designate body length. The regression model indicated that increasing one cm of body length increases body weight by 0.41 kg in male Dorper sheep lambs.

Table 5. Regression analysis between body weight and body length on female and male Dorper sheep lambs

	Sources	**Sum of squares**	**DF**	**Mean square**	**R**	**R^2**	**Adjusted R^2**
Female lamb	Regression	147.084	1	108.223	0.893^{**}	0.797	0.790
	Residual	37.417	27	2.825			
	Total	184.501	28				
	Sources	**Sum of squares**	**DF**	**Mean square**	**R**	**R^2**	**Adjusted R^2**
Male lamb	Regression	92.022	1	92.022	0.900^{**}	0.811	0.801
	Residual	21.475	20	1.074			
	Total	113.497	21				

R: Correlation coefficient; R^2: Coefficient of determination; Adjusted R^2: Adjusted coefficient of determination; DF: Degree of freedom; ** Significant at p < 0.01.

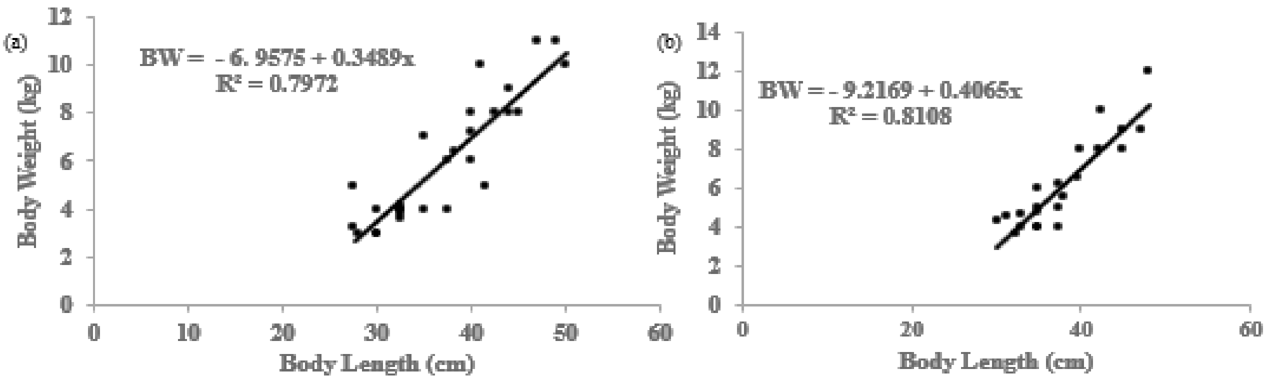

Figure 4. Effect of body length on body weight of female Dorper sheep lambs **(a)** and male Dorper sheep lambs **(b)**. BW: Body weight (24 hours after birth).

Influence of withers height on body weight at birth

Table 6 shows the influence of withers height on body weight using a simple linear regression analysis between body weight and withers height. The findings discovered a highly positive statistical correlation between body weight and withers height (r = 0.87) with R^2 = 0.76 and MSE = 1.61 in female Dorper sheep lambs. The withers height described around 76.39% of the difference in the body weight of female Dorper sheep lambs. Figure 5a illustrates the linear regression equation as shown by formula 8.

BW = - 13.22 + 0.56WH (8)

Where, - 13.22 is constant, 0.56 indicates regression coefficient, BW stands for body weight, WH designate withers height. The regression model indicated that increasing one cm of withers height increases body weight by 0.56 kg. The results indicated a positive statistical correlation between body weight and heart girth (r = 0.61) with R^2 = 0.38 and MSE = 3.54 in male Dorper sheep lambs. The withers height described around 37.58% of the difference in the body weight of male Dorper sheep lambs. Figure 5b shows the linear regression equation by formula 9.

BW = - 6.86 + 0.37WH (9)

Where, - 6.86 is constant, 0.37 indicates regression coefficient, BW stands for body weight, WH designate withers

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height. The regression model indicated that increasing 1 cm of withers height increases body weight by 0.37 kg in male Dorper sheep lambs.

Table 6. Regression analysis between the body weight and withers height on female and male Dorper sheep lambs.

	Sources	Sum of squares	DF	Mean square	R	R^2	Adjusted R^2
Female lamb	Regression	140.932	1	140.932	0.874**	0.764	0.755
	Residual	43.569	27	1.614			
	Total	184.501	28				
	Sources	**Sum of squares**	**DF**	**Mean square**	**R**	**R^2**	**Adjusted R^2**
Male lamb	Regression	42.656	1	42.656	0.613**	0.376	0.345
	Residual	70.840	20	3.542			
	Total	113.497	21				

R: Correlation coefficient; R^2: Coefficient of determination; Adjusted R^2: Adjusted coefficient of determination; DF: Degree of freedom; ** Significantat $p < 0.01$.

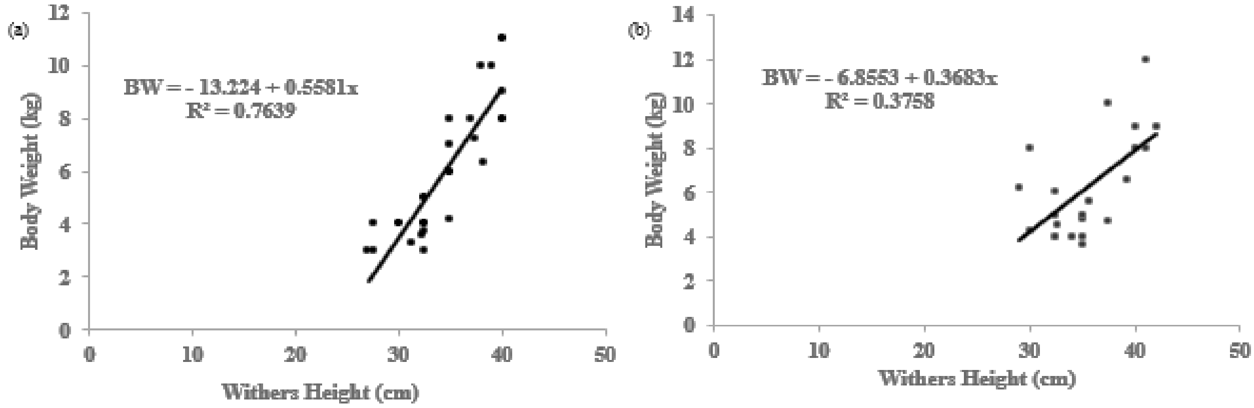

Figure 5. Effect of withers height on body weight of female Dorper sheep lambs **(a)** and male Dorper sheep lambs **(b)**. BW: Body weight (24 hours after birth).

Influence of sternum height on body weight at birth

Table 7 shows the influence of sternum height on body weight using a simple linear regression analysis between body weight and sternum height. The findings revealed a highly positive statistical association between body weight and sternum height (r = 0.71) with R^2 = 0.50 and MSE = 2.84 in female Dorper sheep lambs. The outcomes indicated that the sternum height described around 50% of the difference in the body weight of male lambs. The figure 6b below shows the linear regression equation as shown by formula 10.

BW = - 8.55 + 0.55SH (10)

Where, - 8.55 is constant, 0.55 indicates regression coefficient, BW stands for body weight, SH designate sternum height. The regression model showed that increasing one cm of sternum height will increase body weight by 0.55 kg. In male lambs, the results revealed a positive statistical association among body weight and sternum height (r = 0. 62) with R^2 = 0.38 and MSE = 4.22 in male Dorper sheep lambs. The sternum height described around 38% of the difference in the body weight of female lambs. Figure 6a indicates the linear regression equation as shown by formula 11.

BW = - 4.67 + 0.39SH (11)

Where, - 4.67 is constant, 0.39 indicates regression coefficient, BW stands for body weight, SH designate sternum height. The regression model indicated that increasing one cm of sternum height will increase body weight by 0.39 kg in female Dorper sheep lambs.

Table 7. Regression analysis between the body weight and sternum height on female and male Dorper sheep lambs.

	Sources	Sum of squares	DF	Mean square	R	R^2	Adjusted R^2
Female lamb	Regression	56.803	1	56.803	707**	0.500	0.476
	Residual	56.694	20	2.835			
	Total	113.497	21				
	Sources	**Sum of squares**	**DF**	**Mean square**	**R**	**R^2**	**Adjusted R^2**
Male lamb	Regression	70.509	1	70.509	0.618 **	0.382	0.359
	Residual	113.993	27	4.222			
	Total	184.501	28				

R: Correlation coefficient; R^2: Coefficient of determination; Adjusted R^2: Adjusted coefficient of determination; DF: Degree of freedom; ** Significantat $p < 0.01$

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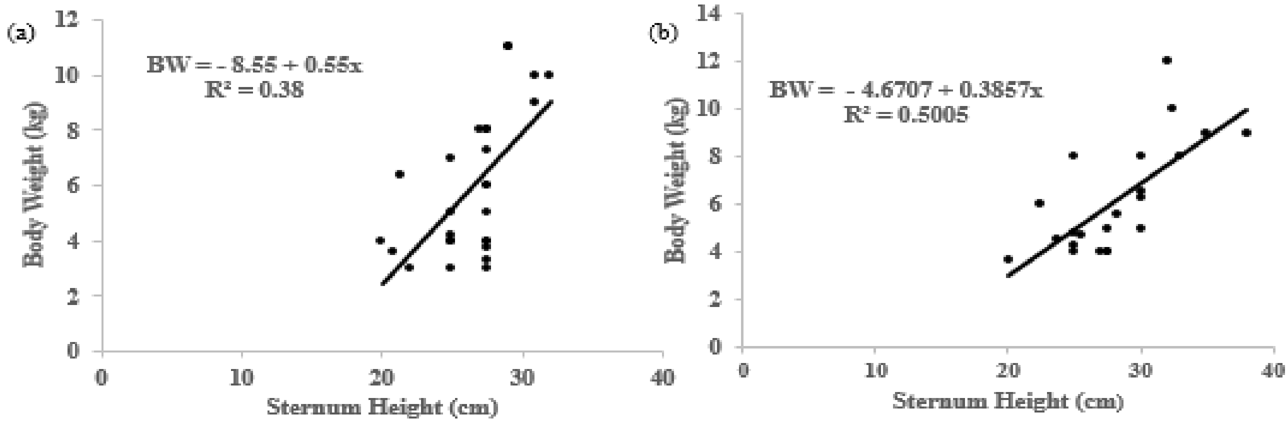

Figure 6. Effect of sternum height on body weight of female Dorper sheep lambs **(a)** and male Dorper sheep lambs **(b)**. BW: Body weight (24 hours after birth).

DISCUSSION

The live body weight of animal might be estimated using morphological traits (Rather et al., 2021). Pearson's correlation was firstly used to determine the relationship among the BW and morphological traits, such as HG, RH, BL, WH, and SH of Dorper sheep lambs. Based on the current study, the BW had a positively high correlation with HG, RH, BL, WH, and SH in female Dorper sheep lambs. Regarding male Dorper sheep lambs, BW had a positively high significant association with HG, RH, BL, WH, and SH. The findings of the current study were similar to those of Kenfo et al. (2017) in indigenous sheep, Shirzeyli et al. (2013) in four breeds of Iranian sheep, Rotimi et al. (2020) in Sahelian goats, Elnahas et al. (2017) in Sohagi Sheep, and Tyasi et al. (2020a) in South African indigenous sheep indicating BW had a highly positive correlation with HG, RH, and BL. Temoso et al. (2017) indicated that the highest correlation coefficient was between BW and HG in goats and sheep of communal rangelands in Botswana. According to Kumar et al. (2018), there were positive and moderate to high correlations between some morphological traits, namely heart girth, paunch girth, head circumference and face length, and live body weight in Harnali sheep. The results agreed with the study of Sowande and Sobola, (2008) in WAD sheep. The results suggested that improving the HG, RH, BL, WH, and SH could contribute more to higher body weight in both male and female Dorper sheep lambs. Therefore, those morphological traits mentioned above can be considered during selection criteria to improve BW at birth. This study also focused on the simple regression technique which was further used to determine the effect of the morphological traits on the BW of the Dorper sheep lambs. The simple regression equations were produced from the regression analysis of morphological traits as independent variables and BW as the dependent variable. The highest coefficient of determination was obtained from BL in male and female Dorper sheep lambs. The current results were in harmony with those of Yilmaz et al. (2013) in Karya sheep and Rotimi et al. (2020) in Sahelian goats. However, the findings of the present study were in contrast to a study by Kumar et al. (2018) indicating that HG can be used to estimate body weight in sheep. The outcomes of the current study were in disagreement with the results of Elnahas et al. (2017) in Sohagi sheep using stepwise regression and Musa et al. (2012) which showed that HG could contribute more to the live body weight in Sudanese Shugor sheep. The variation may be due to different environmental conditions and breed types. The study of Kenfo et al. (2017) was in contrast with the findings of the current study which indicated that chest girth could be used to estimate the live body weight in indigenous sheep. The results suggested that BL contributed more to the variation of BW in male and female Dorper sheep lambs. Therefore, BL can be used during breeding to improve BW at birth.

CONCLUSION

The study documented that sex has influenced on measured traits. The Pearson's correlation outcomes revealed that body weight has a relationship with heart girth, rump height, body length, withers height, and sternum height in both male and female Dorper sheep lambs at birth. Simple regression results revealed that body length trait is the most important factor for estimating body weight and predicting an equation that is suitable for enhancing the higher body weight at birth for females and male Dorper sheep lambs. Therefore, the live body weight of the Dorper sheep lambs can be predicted with the absence of a weighing scale using the body length. This study can help researchers and Dorper sheep farmers to improve body weight by using morphological traits. More studies are required to be performed on the relationship between morphological traits and body weight using different sheep breeds on the big sample size.

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DECLARATIONS

Authors' contribution

Thobela Louis Tyasi designed the study and Lebelo Joyceline Selala wrote the draft manuscript. Thobela Louis Tyasi and Lebelo Joyceline Selala collected and analysed data. The final manuscript draft was confirmed by all authors.

Acknowledgments

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Competing interests

No conflicts of interest.

Ethical consideration

Plagiarism, consent to publish, misconduct, data fabrication and or falsification, double publication and or submission, and redundancy have been checked by all the authors.

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