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Growth Traits as Indicators of Body Weights in Dorper Sheep

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Abstract: The growth traits help rural farmers who lack weighing equipment to anticipate the body weights of their animals for a variety of reasons, including feeding, medication, and breeding purposes. The study aims to predict body weights from the growth traits of Doper sheep. Data on growth traits such as body length, heart girth, sternum height, withers height, rump height, and body weight were collected for one day from 50 Dorper sheep aged 1 to 2 years. Pearson's correlation and simple linear regression analysis were used to achieve the study's objectives. Pearson's correlation results in ewes indicated that body weights had a positive significant relationship with heart girth, wither height, and body length. Whereas in rams, body weights showed to be positively and statistically correlated to withers and sternum height. Simple linear regression demonstrated the highest coefficient with the lowest mean square error on heart girth in ewes and sternum and withers height in rams. Correlations suggest that increasing heart girth, withers height, and body length in ewes and withers and sternum height in rams might cause body weights to increase. The regression analysis in ewes revealed that heart girth contributes 27% of the variation in body weights, whereas sternum or withers height contributes 61% of the variation in rams. In conclusion, to improve body weights, ewes' heart girth, withers height, body length, and rams' withers and sternum heights and heart girth, may be selected.

Keywords: Body Length, Heart Girth, Sternum Height, Withers Height

Introduction

Sheep farming is recognized as the most important industry, supplying a significant amount of food to the human population (Gorlov *et al*., 2017). Valencia *et al*. (2022) documented that sheep contribute to the economy through the production of wool, milk, meat, and skin and their fecal matter is used as fertilizer. Villatoro *et al*. (2021) classified Dorper sheep as the mutton sheep breed that can survive and adapt to extreme macroclimatic conditions moreover, they are adaptable fast-growing animals producing heavy meat resulting in attractive cuts for retailers. Body weight is an important factor in the animal industry when selecting animals for breeding and selling and growth traits are of key interest during breeding for economic traits, particularly for meat purposes (Lakew *et al*., 2018).

However, due to a shortage of measuring scales (weighing scales), rural farmers rely on animal physical appearance and body weight estimates, resulting in bad decisions on medical dosing, selling, and feeding their animals, as well as poor selection criteria (Abdel-Mageed and Ghanem, 2013). Jahan *et al*. (2013), estimating body weights using growth traits is the cheapest and easiest way that communal farmers can use. Asefa *et al*. (2017) revealed that because they are easy and quick to measure, they can be used indirectly to determine body weight. Growth traits, according to Verma *et al*. (2016), provide information on an animal's skeletal structure, growth, and development capabilities. Several authors have used growth traits to predict body weights in many breeds of sheep (Younas *et al*., 2013) because growth traits provide important details about the morphological structure and potential for the development of the animals (Shirzeyli *et al*., 2013).

The purpose of the livestock and meat industry, according to Younas *et al*. (2013), is to establish a reliable and objective assessment method for analyzing the economic features of animals and predicting the weight, prices, and merit of the carcass of a living animal, hence the objectives of the study was to determine the relationship between body weights and growth traits and to estimate the best model to predict live body weights using various growth traits.

Materials and Methods

Study Area

The current study was carried out at the University of Limpopo's experimental farm, which is located 10 kilometers west of the university. The farm experiences semi-arid climatic conditions with temperatures ranging between 5 and 28°C in winter and summer temperatures ranging from 10 to 36°C and the average annual rainfall is less than 400 mm (Kutu and Asiwe, 2010).

Data Collection

Fifty (forty-three ewes and seven rams) Dorper sheep between the age of 1 and 2 years were used. The animals were raised extensively and water was always provided. Vaccination and dipping programs were conducted regularly during lambing, weaning, and breeding. A cross-sectional experimental design with one replicate per Dorper sheep was used as an experimental design. All Dorper sheep were chosen at random for their growth traits. Body Length (BL), Heart Girth (HG), Sternum Height (SH), Withers Height (WH), and Rump Height (RH) of Dorper sheep were measured using a measuring tape calibrated in centimetres (cm). At the same time, the body weight of each sheep was measured in kilograms (kg) using an ST-0606 sheep, goats, and pigs professional scale (crate scale 300 kg × 100 g) from Scale Tronic services. Data collection occurred for one. Growth traits measurements were taken following the recommendations of (Birteeb *et al*., 2012). Shortly, withers height is defined as the vertical distance from the highest point of the shoulder (wither) to the ground surface concerning the level of the forelegs, and body length is defined as the distance between the anterior shoulder point and the posterior extremity of the pin bone, sternum height is defined as the vertical distance from the lower tip of the sternum to the ground as the animal stands and rump height is defined as the distance from the top of the pelvic girdle to the ground surface (Fig. 1). To avoid variation, arguments, and bias, measurements were all taken by the same person.

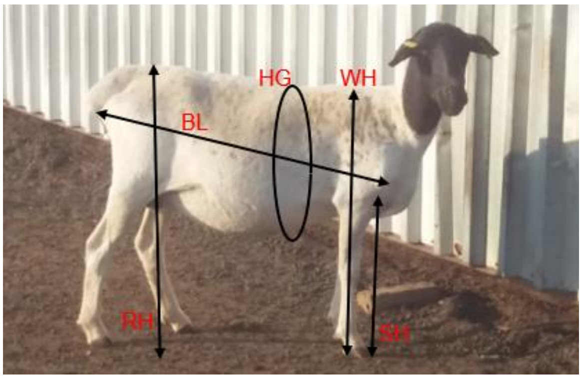

Fig. 1: Demonstrate different growth traits that were measured on a Dorper sheep

Statistical Analysis

For statistical analysis, the Statistical Package for Social Sciences (IBM SPSS, 2020) software version 27 was used, Pearson's correlation coefficient was used to estimate the relationships between body weight and growth traits, and simple linear regression analysis was used to estimate the best model to predict live body weights using various growth traits. Body weight was used as a dependent variable and growth traits were used as independent variables; only correlated variables were used, beginning with the most highly correlated. The following model was used for regression analysis:

$$Y = a + b_1 X_1$$

where:

Y = Dependent variable (body weight)
a = Regression intercept
b = Coefficient of regression
X_1 = Independent variable (s) (withers height, body length, sternum height, heart girth, and rump height)

The accuracy of the models was evaluated by the goodness of fit tests such as determination coefficients (R^2), Root Mean Squared Error (RMSE), Akaike Information Criterion (AIC), and Bayesian Information Criterion (BIC). The following criteria were used:

$$R^2 = 1 - \left(\frac{SST}{SSE}\right)$$

$$RMSE = \sqrt{\frac{SSE}{N - p - 1}}$$

$$AIC = NLn\left(\frac{SSE}{N}\right) + 2_p$$

$$BIC = pLn\left(\frac{SSE}{N}\right) + pLn\,N$$

where:

R^2	=	Coefficient of determination
SST	=	Is the total sum of a square
SSE	=	Is the residual sum of a square
RMSE	=	Is the residual mean square error
N	=	IS the number of observations
P	=	Is the number of parameters in the regression equation
AIC	=	Is the Akaike information criterion
BIC	=	Is the Bayesian information criterion
Ln	=	Is the natural logarithm in the calculator

Results

Data of all the measured traits for ewes and rams were summarised by descriptive statistics as revealed in Table 1. The summary revealed that ewes had a higher numerical mean value of 33.35 kg than rams (30.53 kg). Ewes had higher WH, SH, HG, and lower RH and BL while rams had a lower WH, SH, HG, and higher RH and BL In ewes, the coefficient of variance ranges from 5.98 to 20.42%, while in rams, the coefficient of variance ranges from 3.81 to 84.81%.

Pearson's correlation was used to establish the relationship between growth traits (BW and HG, WH, BL, SH, RH) of Dorper sheep (Table 2, ewes result below diagonal and rams' results above diagonal). Pearson's correlation in ewes demonstrated the relationship between growth traits ranges 0.10 to 0.51, BW showed a highly positive statistical correlation to HG at $p < 0.01$, and a positive statistical correlation to WH and BL at $p<0.05$, however, no significant relationship with RH and SH was revealed. Amongst traits, WH was positively correlated to RH and HG ($p<0.05$) whereas not significant to BL and SH while RH ($p>0.05$), BL, SH, and HG had no statistical relationship with each other.

Correlation results above diagonal (rams) revealed that relationship the between growth traits ranged from - 0.28 to 0.78. BW showed a high positive statistical correlation with WH and SH at $P<0.01$ moreover had a negative statistical correlation with RH and a positive statistical correlation with HG at $p<0.05$ however no significant relationship was observed with BL. Relationship within traits, WH was negatively highly correlated to RH, highly positively correlated to SH at $p<0.01$, and positively correlated to BL ($p<0.05$) but had no significant correlation with HG, RH was not significantly correlated to HG however it was found to be negatively correlated to BL and SH ($p<0.05$), BL was found not significant towards SH but negatively correlated to HG ($p<0.05$) lastly SH showed a highly statistical correlation with HG ($p<0.01$).

The cause-effect relationship between variables was achieved through simple linear regression. The model for the prediction of BW using WH, BL, SH, and RH as independent variables generated from simple linear regression analysis of ewes and rams is shown in Table 3. In ewes, the highest R2 (0.27) with the lowest AIC (74.82) and BIC (74.52) was obtained from HG indicating that the model (BW = -18.47 + 0.62HG) may be used to estimate the BW of Dorper sheep. In rams, SH and WH may be used to predict and improve body weights. Their model (BW = - 3.70 + 0.84SH) and (BW = - 5.55 + 0.60WH) showed equal highest R2 value of 0.61 with the lowest AIC (-0.98) and BIC (-3.07) for SH and lowest AIC (-2.77) and BIC (-3.07) for WH.

According to the current results of the ewe regression analysis, heart girth contributed 27% of the variations in body weights. In rams, SH and WH had the same coefficient of determination, accounting for 61% of the variations in body weights.

Table 1: Descriptive statistics of growth traits of Dorper sheep

Traits	Minimum	Maximum	Mean	Std. Deviation	CV (%)
Ewes					
BW (Kg)	20.40	44.50	33.35	6.81	20.42
WH (cm)	55.00	69.00	60.74	3.63	5.98
RH (cm)	55.00	72.00	62.28	4.78	7.68
BL (cm)	60.00	88.00	68.47	6.33	9.27
SH (cm)	37.00	49.00	41.21	3.07	7.45
HG (cm)	74.00	97.00	83.95	5.69	6.78
Rams					
BW (Kg)	25.20	36.00	30.53	4.13	84.81
WH (cm)	56.00	69.00	60.71	5.41	8.91
RH (cm)	61.00	78.00	66.86	6.23	9.32
BL (cm)	69.00	88.00	74.86	6.57	8.78
SH (cm)	38.00	49.00	40.86	3.85	9.42
HG (cm)	78.00	87.00	82.71	3.15	3.81

BW: Body Weight, WH: Withers Height, RH: Rump Height, BL: Body Length, SH: Sternum Height, HG: Heart Girth, CV: Coefficient of Variance, Std. Deviation: Standard Deviation

Table 2: Phenotypic correlation between growth traits of Dorper sheep with ewes below diagonal and rams above diagonal

Traits	BW	WH	RH	BL	SH	HG
BW (Kg)		0.78^{**}	-0.28^{*}	0.06^{ns}	0.78^{**}	0.34^{*}
WH (cm)	0.49^{*}		-0.76^{**}	0.39^{*}	0.79^{**}	0.19^{ns}
RH (cm)	0.10^{ns}	0.35^{*}		-0.41^{*}	-0.45^{*}	0.14^{ns}
BL (cm)	0.41^{*}	0.14^{ns}	0.11^{ns}		0.05^{ns}	-0.36^{*}
SH (cm)	0.10^{ns}	0.25^{ns}	0.04^{ns}	-0.15^{ns}		0.70^{**}
HG (cm)	0.51^{**}	0.34^{*}	0.18^{ns}	0.17^{ns}	0.19^{ns}	

BW: Body Weight, WH: Withers Height, RH: Rump Height, BL: Body Length, SH: Sternum Height, HG: Heart Girth, **: Correlation is significant at the 0.01 level (2-tailed), *: Correlation is significant at the 0.05 level (2-tailed), ^{ns}: non-significant

Table 3: Simple linear regression of both ewes and rams Dorper sheep

Regression parameters	Model	RMSE	R^2	AIC	BIC
Ewes					
HG (cm)	-18.47+0.62HG	34.88	0.27	74.82	74.52
WH (cm)	-22.61+0.92WH	36.07	0.24	75.55	75.25
BL (cm)	3.29+0.44BL	39.07	0.17	77.57	77.27
SH (cm)	24.11+0.22SH	47.02	0.10	81.30	81.00
RH (cm)	24.35+0.14RH	47.01	0.10	81.30	81.00
Rams					
SH (cm)	-3.70+0.84SH	7.95	0.61	-2.98	-3.07
WH (cm)	-5.55+0.60WH	8.03	0.61	-2.77	-3.07
RH (cm)	42.72-0.18RH	18.87	0.08	15.79	15.49
BL (cm)	27.66+0.04BL	20.34	0.00	17.79	17.12
HG (cm)	5.54+0.30HG	19.33	0.05	16.32	16.01

WH: Withers Height, RH: Rump Height, BL: Body Length, SH: Sternum Height, HG: Heart Girth, RMES: Mean Square Error, R^2: Coefficient of determination, SST: Total Sum of a Square, SSE: Residual Sum of a Square, N: Number of observations, P: Number of parameters in the regression equation, AIC: Akaike information criterion, BIC: Bayesian information criterion, Ln: natural logarithm in the calculator

Discussion

The current study's first goal was to use Pearson's correlation to determine the relationship between body weights and body length, heart girth, sternum height, withers height, and rump height in Dorper sheep. Except for rump height and sternum height in ewes, body weights were found to have positive statistical correlations with all measured traits. Body length was the only trait in rams that did not have a statistical relationship with body weight. Shirzeyli *et al*. (2013), indicated that there is an increase in studies on the prediction of body weights using different growth traits on different animal breeds. Temoso *et al*. (2017) conducted a study on goats and sheep of communal rangelands in Botswana, they agreed with the current study report that there is a positive statistical correlation between body weights and heart girth in ewes, body weights, and sternum height in rams however the same study disagree with the current correlation whereby body weights had no statistical relationship with sternum height in ewes and heart girth in rams, the contrary may be due to use of different breeds and environmental conditions during data collection.

Boujenane and Halhaly (2015) estimated body weights from height girth in Sardi and Timahdite sheep using different models. Their results agreed with current reports that there is a strong relationship between body weight and heart girth. Current correlation reports are consistent with Yakubu (2010) findings on Yankasa lambs, which showed a positive statistical relationship between body weights and heart girth in both ewes and rams. Furthermore, Shirzeyli *et al*. (2013) reported that growth traits can be used as a predictor of body weight and it was concluded that body length can be used as a selection criterion in females because it had a high correlation with body weights. According to Rather *et al*. (2021), wither height was the best predictor of body weight for farmers who do not have a weighing scale. Furthermore, Kumar *et al*. (2018) observed a positive and statistical phenotypic relationship between body weights and body length and heart girth in the prediction of body weights from growth traits in sheep, which agreed with the current results that body length and heart girth are the best variables to be used when predicting body weights and the same author stated that the traits can be further refined. Musa *et al*. (2012) on Sudanese Shogur, Ravimurugan *et al*. (2013) on Kilakarsal sheep, and Kumar *et al*. (2018) on Harnali sheep all agreed with the current results that heart girth can be used to estimate live weights.

Current phenotypic correlation results in ewes suggested that an increase in heart girth may increase body weight. According to current ram correlations, increasing withers height or sternum height may increase body weights. The discovered relationship between growth traits suggests that these traits are influenced by the same gene (s) (pleiotropy) (Mathapo *et al*., 2022). Correlation experiments, only measure the association between two variables; they do not reveal how they affect each other (cause-effect relationship). As a result, the second study goal was to use simple linear regression to develop models for estimating body weights from body length, heart girth, sternum height, withers height, and rump height in Dorper sheep. The results of the regression analysis agreed with those of Kumar *et al*. (2018), who established a model to predict the body weight of sheep from growth traits, and the highest coefficient was found on heart girth, indicating that it has the greatest variation in body weights, making it a suitable trait to be used as a predictor of body weights. Recent study regression analysis reports are consistent with the findings of Rather *et al*. (2021) on Kashmir merino sheep concluded that a model consisting of withers height is the best equation to use when predicting body weights. The findings of the study suggest that heart girth in ewes, sternum height & withers height in rams, could be used as predictors of body weights in rural areas to determine the weight of their livestock. In rams, the equation with SH showed that an increase in one centimetre of sternum height will increase body weight by 0.84 kg and a model consisting of wither height reveals that an increase in one cm of withers height will lead body weights to increase by 0.60 kg. In ewes, the model with HG implies that an increase in one cm of heart girth will increase 0.62 kg of body weight. Ashwini *et al*. (2019) explained that the regression equation with heart girth for crossbred cattle indicated that an increase in one cm of heart girth gave an increase of 2.048 kg of body weight.

Conclusion

There is a link between body weights and certain growth traits in Dorper sheep. Estimating body weights using growth traits is a practical, faster, easier, and less expensive method that is mostly used by rural farmers. Understanding medication doses, adjusting feed supply, monitoring growth, and selecting replacement rams and ewes all benefit from knowing the body mass of small ruminants. Study reports revealed that there is a correlation between body weight and some growth traits of Dorper sheep. Heart girth, withers height, and body length in ewes, withers height, sternum height, and heart girth in rams may be selected to improve body weight. Current phenotypic correlation results of ewes suggest that an increase in heart girth might cause body weight to improve. Current rams' correlation findings suggest that increasing withers height or sternum height might increase body weight. The relationship discovered between growth traits proposes that these traits are influenced or controlled by the same gene. Regression analysis results of ewes showed that heart girth contributes 27% of variation on body weight while sternum height or withers height contributes 61% of variation on rams. A model consisting of heart girth in ewes and a model consisting of sternum height or withers height in rams might be used by breeders when advising farmers on how to predict and improve their body weight.

The report will assist breeders in advising farmers on how to determine the body weight of their animals without the use of a weighing scale to make proper decisions for feeding, marketing, replacement, and health purposes for management purposes. However, more studies need to be done on the estimation of body weights from the growth traits of Dorper sheep using a larger sample size and more growth traits. It is recommended that rural farmer should be taught more about the relationship between body weight and growth traits such as heart girth, wither height, body length, sternum height, and rump height for herd improvement since these traits affect the body weight and are easy to measure and the importance of body weight should be emphasized mostly on rural farmers for management purposes such as feeding, medication, marketing and breeding purposes.

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Author's Contributions

Molabe Kagisho Madikadike: Project idea, design and execution of the study. Data analysis and manuscript write-up.

Vusi Mbazima and Busisiwe Gunya: Project idea, design and execution of the study. Reviewed manuscript.

Thobela Louis Tyasi: Project idea, design and execution of the study. Data analysis reviewed manuscript.

Ethics

All procedures were performed following the standards and protocols set by the University of Limpopo Animal Research Ethics Committee (AREC) and ethical approval of number AREC/08/2021: PG was granted by the university of Limpopo Animal Research Ethics Committee (AREC) before the commencement of the study.

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