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Research Article

Nguni Cattle Body Weight Estimation using Regression Analysis

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Abstract | Regression analysis is used for estimating the relationship between the dependent variable and one or more independent variables. The current study was carried out to determine the relationship among measured body measurement traits such as heart girth (HG), body weight (BW), rump width (RW), body length (BL), head length (HL), withers height (WH), ear length (EL), rump height (RH), head width (HW) and sternum height (SH), and to detect the best-fitted regression model for the prediction of BW of Nguni cattle. A total of 70 Nguni cattle (59 females and 11 males) aged 2-4 years were employed in the current study. Pearson's correlation and stepwise regression techniques were employed for the analysis of data. The association findings showed that BW had a positively high significant association ($P < 0.01$) with WH ($r = 0.94$), HG ($r = 0.91$), RH ($r = 0.88$), SH ($r = 0.90$), RW ($r = 0.73$), and a positive statistical significant correlation ($P < 0.05$) with EL ($r = 0.47$), and BL ($r = 0.46$) in males. On the other hand, BW had a positively high remarkable relationship ($P < 0.01$) with HG ($r = 0.75$), RH ($r = 0.69$) and WH ($r = 0.57$), and a positive statistical significant correlation ($P < 0.05$) with BL ($r = 0.43$), SH ($r = 0.38$) and HW ($r = 0.28$) in females. Stepwise regression results showed that the model, including WH, HG, SH, RH, RW, HL, EL, and BL was the best-fitted model ($R^2 = 0.95$, MSE = 817.51) for the estimation of BW in males, and the model with parameters of HG, RH and WH was the best-fitted model ($R^2 = 0.62$, MSE = 4887.31) for the estimation of BW in female Nguni cattle. Correlation outcomes suggest that enhancement of WH, HG, SH, RH, RW, EL, BL, and HW might improve the BW of Nguni cattle. The regression results suggested that BW could be estimated accurately by the combination of two or more biometric traits. The findings might help cattle farmers to predict body weight using biometric traits.

Keywords | Body length, Correlation, Heart girth, Rump height, Sternum height

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INTRODUCTION

Nguni cattle is a small frame breed that is highly adapted to harsh conditions which include poor inadequate grazing and has good important traits that are suitable for low input production systems such as disease resistance, high fertility and good maternal characteristics (Matome et al., 2020). Sanarana et al. (2016), indicated that this cattle breed was developed from North Africa and it is multi-coloured or unicoloured with brown, white, black, grey and red as predominating colours. In communal areas, where there is a lack of resources, predicting body weight from biometric traits is the easiest and affordable procedure that may greatly assist prediction (Hlokoe and Tyasi, 2021). Body weight is an economic significant trait in livestock, and it assists greatly during farm management when feeding, vaccinating, marketing animals and when measuring growth performance (Haq et al., 2020), while biometric traits play a significant role in the prediction of body weight during breeding (Yakubu et al., 2015; Tyasi et al., 2020).

Previous studies were performed to show the significance of biometric traits in the estimation of body weight in Girolando cattle (Weber et al., 2020), in Botswana indigenous goats and sheep (Temoso et al., 2017), and in Batur sheep (Ibrahim et al., 2021). Tyasi et al. (2020) estimated the body weight of Nguni cattle using path analysis. However, based on the knowledge acquired, there is limited documentation on the prediction of body weight using biometric traits with regression method in Nguni cattle. Hence, the objectives of the study were to examine the correlation between body weight using biometric traits such as rump height, body length, ear length, head width, head length, sternum height, withers height, heart girth and rump width and to identify the best fitted regression model to be used for calculation of live weight of Nguni cattle. The present study might assist cattle farmers to select the best biometric traits during breeding selection to enhance body weight.

MATERIALS AND METHODS

Ethical approval

The work was performed following the guidelines of the University of Limpopo Animal Research and Ethics Committee.

Study Site

The experiment was done at the University of Limpopo experimental farm, Limpopo Province, South Africa as described by Brown and Ng'ambi (2018). Briefly, the ambient temperatures range between 20 and 36 °C during summer and between 5 and 25 °C during winter at the study site. Mean annual rainfall is 446.8 mm with the dry season occurring between April and October and the rainy season occurring between November and March.

Experimental Animals And Management

In the study, seventy clinically healthy Nguni cattle (11 males and 59 females) aged 2-4 years old were utilised. The sick and pregnant animals were not included in the study for accurate results. The males and females were placed in separate kraals under extensive production system. The animals were grazing in the camps extensively, consisting of a mixture of grass types with *Panicum maximum*, *Themeda triandra*, *Pennicetum purpureum* and *Chloris gayana* as the dominating grass types. They were allowed to go out in the morning to graze and come back (return) in the afternoon where they were provided with water. Management practices such as dipping and dosing of the animals were done for internal and external parasites control to avoid disease spread.

Data Collection

Body weight (BW) was measured for each animal using a weighing scale calibrated in kilograms (kg) and nine biometric traits were measured with a measuring tape calibrated in centimetres (cm). All the biometric traits such as body length (BL), head length (HL), head width (HW), ear length (EL), rump height (RH), sternum height (SH), withers height (WH), rump width (RW), and heart girth (HG) were taken as explained by Lukuyu et al. (2016). One person was taking the measurements to avoid individual variations.

Statistical Analysis

Statistical Package for Social Sciences version 27 (IBM SPSS, 2020) was used to analyse the data. Pearson's correlation was used to detect the association between biometric traits and BW with the probability of 5 % significant differences and 1 % highly significant differences. Stepwise regression was employed to discover a model to estimate the BW. The coefficient of determination (R2) and mean square error (MSE) were utilised to determine the best-fitted model. The following regression model was adopted:

$Y = a + bX$

Where,

Y = dependent variable (BW), a = intercept, b = regression coefficient, and X = independent variable (biometric trait). Independent traits were added one by one in the regression model following the stepwise regression procedure.

RESULTS

Descriptive Statistics

Table 1 shows the summary of body weight (BW) and biometric traits viz. body length (BL), head length (HL), head width (HW), ear length (EL), rump height (RH), sternum height (SH), withers height (WH), rump width (RW), and heart girth (HG) of male and female Nguni cattle. The findings revealed that male Nguni cattle had a lower mean value for BW (205.90 ± 103.21), compared to female Nguni cattle with a higher mean value (324.82 ± 109.38). The summary outcomes further showed that all the biometric traits mean values for females were higher except for HW (22.80 ± 1.06), HL (53.43 ± 7.17), BL (130.65 ± 18.03), and SH (67.51 ± 4.76).

Phenotypic Correlation

The results of the association between measured traits are displayed in Table 2. The Pearson's correlation results showed that BW had a positively high significant association with WH (r = 0.94), HG (r = 0.91), RH (r = 0.88), SH (r = 0.90) and RW (r = 0.73) ($p < 0.01$), a negatively high remarkable association with HL (r = -0.52) ($p < 0.01$), and a positive statistically significant correlation with EL (r = 0.47), and BL (r = 0.46) ($p < 0.05$). The findings further showed that BW had no statistical association ($P > 0.05$) with HW (r = 0.06) in male Nguni cattle. The results

Table 1: Descriptive statistics of body weight and biometric traits of male and female Nguni cattle.

Traits	Male Mean ± SD	Female Mean ± SD
BW	205.90 ± 103.21	324.82 ± 109.38
HW	23.95 ± 0.92	22.80 ± 1.06
HL	54.71 ± 5.22	53.43 ± 7.17
EL	14.86 ± 1.56	15.73± 3.19
BL	147.10 ± 51.46	130.65 ± 18.03
RH	117.57 ± 9.90	126.61 ± 10.60
WH	108.95 ± 12.97	116.73 ± 12.59
SH	69.67 ± 6.34	67.51 ± 4.76
RW	39.52 ± 4.41	41.80 ± 4.49
HG	155.38 ± 21.09	174.47 ± 22.65

BW = body weight, HW = head width, HL = head length, EL = ear length, BL = body length, RH = rump height, WH = withers height, SH = sternum height, RW = rump width, HG = heart girth

Table 2: Phenotypic correlation between biometric traits, with female above diagonal and male below diagonal.

Traits	BW	HW	HL	EL	BL	RH	WH	SH	RW	HG
BW	1	0.28*	0.17^{ns}	-0.09^{ns}	0.43*	0.69**	0.57**	0.38*	-0.09^{ns}	0.75**
HW	0.06^{ns}	1	0.24^{ns}	-0.12^{ns}	0.35*	0.40*	0.35*	0.13^{ns}	-0.23^{ns}	0.31*
HL	-0.52**	0.06 ^{ns}	1	-0.71**	0.27*	0.52**	0.19^{ns}	0.24^{ns}	-0.18^{ns}	0.39*
EL	0.47*	0.07^{ns}	-0.76**	1	-0.07^{ns}	-0.33*	-0.05^{ns}	-1.11^{ns}	0.33*	-0.15^{ns}
BL	0.46*	-0.18^{ns}	0.09^{ns}	-0.02^{ns}	1	0.48*	0.38*	0.17^{ns}	0.12^{ns}	0.48*
RH	0.88**	0.14^{ns}	-0.48*	0.56**	0.55**	1	0.58**	0.48*	-0.20^{ns}	0.75*
WH	0.94**	0.11^{ns}	-0.62**	0.59**	0.43*	0.95**	1	0.38*	-0.03^{ns}	0.58*
SH	0.90**	0.17^{ns}	-0.64**	0.65**	0.33*	0.93**	0.93**	1	-0.14^{ns}	0.54**
RW	0.73**	0.13^{ns}	-0.78**	0.55**	0.002^{ns}	0.60**	0.70**	0.70**	1	-0.12^{ns}
HG	0.91**	0.01^{ns}	-0.58**	0.60**	0.60**	0.93**	0.94**	0.89**	0.63**	1

**Correlation significant ($P < 0.01$), *Correlation significant ($P < 0.05$), ns = not significant, BW = body weight, HW = head width, HL = head length, EL = ear length, BL = body length, RH = rump height, WH = withers height, SH = sternum height, RW = rump width, HG = heart girth.

Table 3: Regression models, coefficient of determination (R^2) and mean square error (MSE) for estimation of body weight of male Nguni cattle.

Model	R^2	MSE
BW = -604.21 + 7.44WH	0.87	1415.33
BW = -592.13 + 5.85WH + 1.04HG	0.88	1435.77
BW = -650.06 + 4.72WH + 0.93HG + 2.83SH	0.88	1472.15
BW = -593.90 + 5.26WH + 1.17HG + 3.75SH – 1.84RH	0.89	1530.51
BW = -659.26 + 4.19WH + 1.20HG + 2.11SH – 0.49RH + 3.37RW	0.89	1510.29
BW = -1296.18 + 5.39WH + 1.97HG + 6.24SH – 5.19RH + 8.34RW + 8.31HL	0.95	829.15
BW = -1222.42 + 5.18WH + 1.98HG + 6.41SH – 4.91RH + 8.06RW + 7.54HL – 3.00EL	0.95	882.03
BW = -1273.57 + 7.37WH + 0.12HG + 9.32SH – 7.90RH + 9.40RW + 8.02HL + 3.72EL + 0.49BL	0.95	817.51

BW = body weight, HW = head width, HL = head length, EL = ear length, BL = body length, RH = rump height, WH = withers height, SH = sternum height, RW = rump width, HG =heart girth

also revealed that BW had a positively high remarkable relationship with HG ($r = 0.75$), RH ($r = 0.69$) and WH ($r = 0.57$) ($p < 0.05$), and a positive statistically significant correlation with BL ($r = 0.43$), SH ($r = 0.38$) and HW ($r = 0.28$) ($p < 0.05$). The findings further revealed that BW had no remarkable association with HL ($r = 0.17$), EL ($r = -0.09$) and RW ($r = -$ 0.09) ($p > 0.05$) in female Nguni cattle.

Table 4: Regression models, coefficient of determination (R^2) and mean square error (MSE) for estimation of body weight of female Nguni cattle.

Model	R^2	MSE
BW = -310.19 + 3.64HG	0.57	5278.80
BW = -505.83 + 2.59HG + 3.00RH	0.61	4935.20
BW = -548.81 + 2.36HG + 2.52RH + 1.23WH	0.62	4887.31
BW = -555.49 + 2.32HG + 2.42RH + 1.20WH + 0.23BL	0.62	4984.37
BW = -488.92 + 2.45HG + 2.56RH + 1.24WH + 0.17BL – 1.55SH	0.62	5058.92
BW = -431.69 + 2.44HG + 2.65RH + 1.29WH + 0.20BL – 1.60SH - 3.24HW	0.62	5168.73

BW = body weight, HW = head width, HL = head length, EL = ear length, BL = body length, RH = rump height, WH = withers height, SH = sternum height, RW = rump width, HG =heart girth

Regression Analysis

The establishment of regression models for the prediction of BW from biometric traits was done using the stepwise regression technique, and the regression results for males and females are presented in Tables 1 and 2, respectively. The models were established with BW as a dependent variable and biometric traits (BL, HW, EL, HL, RH, SH, WH, RW, and HG) as independent variables. The regression models for male Nguni cattle are obtainable in Table 3. In males, the first trait entered into the model was WH which made a contribution of 87% (R^2 = 0.87) to the variation of BW and Mean Square Error (MSE) of 1415.33. The second and third traits entered into the model were HG and SH, respectively, which both showed the R^2 of 0.88 and MSE of 1435.77 and MSE of 1472.15, respectively. Therefore, RH and RW were the following traits entered to the model which both contributed 89% to the variation of BW (R^2 = 0.89) and the highest MSE of 1530.51 and 1510.29, respectively. The sixth biometric trait included in the model was HL which contributed 95% to the BW (R2 = 0.95) and the MSE of 829.15, and then EL was added to the model as the seventh trait and produced an R^2 of 0.95 as well and MSE of 882.03. The last biometric trait included in the model was BL which displayed a contribution of 95% (R^2 = 0.95) and the lowest MSE of 817.51. The regression models for females are shown in Table 4. In females, the first trait entered into the model was HG which showed the lowest contribution of 57% (R^2 = 0.57) to variation of BW and the highest MSE of 5278.80. The following trait entered was RH with an R^2 of 0.61 and MSE of 4935.20 and the third and fourth traits included in the model were WH and BL which both displayed a contribution of 62% to the variation of BW (R^2 = 0.62) and MSE of 4887.31 and 4984.37, respectively. The fifth trait included in the model was SH which had 62% contribution (R^2 = 0.62) to the model and MSE of 5058.92, and the last trait was HW which also contributed about 62% to the model (R^2 = 0.62) and MSE of 5168.73.

DISCUSSION

Biometric traits are the best predictors of body weight in livestock (Yakubu et al., 2015). The results indicated that body weight had a positive highly remarkable association with withers height, heart girth, rump height, sternum height and rump width, a negative highly remarkable association with head length, and a positive remarkable association with ear length and body length in male Nguni cattle. The outcomes also revealed that body weight had a positive highly remarkable relationship with heart girth, rump height and withers height, and a positive statistically significant correlation with body length, sternum height and head width in female Nguni cattle. It was reported that when traits are positively associated, it is assumed that those traits are controlled by the same gene (Maiwashe et al., 2002). Sahu et al. (2017) reported similar findings in adult female Sahiwal cattle, Lukuyu et al. (2016) in crossbred dairy cattle in smallholder farms in Kenya, Mekparyup et al. (2013) in Holstein-Friesian Cattle and Putra et al. (2015) in Aceh cattle. The findings suggested that the improvement of heart girth, withers height, sternum height, rump height, ear length, rump width, and body length might enhance body weight in male Nguni cattle, whereas the enhancement of heart girth, rump height, withers height, body length, sternum height and head width might improve body weight in female Nguni cattle. Stepwise regression was further used to establish models for prediction of body weight in Nguni cattle. The best regression model for estimation of body weight was chosen using coefficient of determination and mean square error (Shankar et al., 2016). The findings revealed that the model including withers height, heart girth, sternum height, rump height, rump width, head length, ear length and body length showed the highest coefficient of determination and lowest mean square error in males, whereas the model involving heart girth, rump height and withers height displayed the highest coefficient of determination and lowest mean square error in females, and therefore, were considered as the best models for estimation of body weight in males and females, respectively. The results of the study are in accordance with those of Mekparyup et al. (2013) on Holstein-Friesian Cattle and Shankar et al. (2016) on Sahiwal cattle. Singh et al. (2014) also reported similar findings in Koraput sheep, where body length and heart girth were also the biggest contributors to the variation of body weight. The findings of Odadi (2018) indicated that heart girth is the best trait to estimate the body weight of heifers in Northern Kenya. Ashwini et al. (2019) established heart girth, withers height, hip height and head width play a significant role in the body weight of crossbred cattle in India. The findings of the current study suggest that body weight can be predicted accurately by a combination of more biometric traits. Therefore, heart girth, withers height, sternum height, rump height, head length, ear length, rump width, and body length might be selected during breeding for improvement of body weight in male Nguni cattle, while heart girth, rump height and withers height can be involved in selection criteria for prediction of body weight in female Nguni cattle. The findings again showed that 95% and 62% of the variation to body weight were explained by the models for males and females, respectively.

CONCLUSION

The correlation findings revealed that there is a correlation among body weight and biometric traits and further suggested that withers height, heart girth, rump height, rump width, ear length, and body length might be used to enhance body weight in male Nguni cattle. The models established can assist the cattle farmers in choosing the best biometric traits for improvement of body weight. More studies can be conducted with the inclusion of more traits in other cattle breeds or more sample size of Nguni cattle.

CONFLICT OF INTEREST

The authors have shown no conflict of interest.

ETHICAL CONSIDERATION

Ethical issues (including 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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AUTHORS' CONTRIBUTION

Victoria Rankotsane Hlokoe and Thobela Louis Tyasi designed the study, collected and analysed the data. Victoria Rankotsane Hlokoe wrote the original draft of the manuscript. Thobela Louis Tyasi reviewed and edited the manuscript. All authors have read and agreed to the final version of the manuscript.

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