Mesopotamia Journal of Agriculture

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THE USE OF LINEAR BODY MEASUREMENTS PREDICTORS OF BODY WEIGHT OF DONKEYS AT BLOUBERG LOCAL MUNICIPALITY, LIMPOPO, SOUTH AFRICA

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Article information
Article history:
Received:7/3/2022
Accepted:12/6/2022
Available:30/6/2022

Keywords:
Correlation; Regression; Withers height; Body length; Rump height;

DOI:
https://10.33899/magrj.2022.132799.1160

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ABSTRACT

In animal breeding, linear body measurements are identified as predictors of body weight. The current study was conducted to estimate body weight (BW) by using body measurements including thoracic circumference (TC), withers height (WH), body length (BoL), rump height (RH) and front leg length (FLL) of donkeys. The study was conducted at three villages (Thorne, Archibalt, and Genau) of Blouberg Local Municipality, Limpopo, South Africa. A total of 74 donkeys (40 males and 34 females) aged from 3 to 4 years were used in the current study. Data were analyzed using Pearson correlation and simple linear regression. Correlation results indicated that in female donkeys, BW had positive and highly statistical significant ($p < 0.01$) correlation with WH ($r = 0.67$) and not significant correlated ($p > 0.05$) with TC ($r = 0.14$) and FLL ($r = 0.28$). In male donkeys, BW had positive and highly statistical significant ($p < 0.01$) correlation with RH ($r = 0.60$) and not significant correlated ($p > 0.05$) to FLL ($r = 0.27$). Regression findings indicated that WH had the highest $r^2 = 0.45$ and MSE = 8.17 in female donkeys, while RH had the highest $r^2 = 0.36$ and MSE = 8.86 in male donkeys.

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INTRODUCTION

Donkeys play an important role in the socio -economic life of a farmer, they can be used as a working animals by helping the farmers transport goods in and out of villages to assist other livestock production systems as well as to the rural markets (Nininahazwe *et al*., 2017). In animal breeding, linear body measurements are identified as predictors of body weight and considered as extremely helpful for determining reproductive efficiency and growth of animals, also when these measurements are related to the animal's age, they can be used to establish the health of the animal and as well as to determine the weaning time (Martinson *et al*., 2016). Farmers do not have the necessary skill to estimate body weights and the common method for measuring body weight is measurement scales, but these scales are costly (Brice *et al*., 2017). Raji *et al*. (2008) indicated that there must be a suitable method to predict donkey's body weight since there are some studies indicating the body measurements might be used to predict body weight of other livestock species in the absence of weighing scales such as goats (Moela, 2014; Eyduran *et al*., 2017; Peşmen, and Yardımcı, 2020; Singh *et al*., 2020 and Idorenyin *et al*., 2016), sheep (Afolayan *et al*., 2006; Kumar *et al*., 2017; Anežka

et al., 2021; Alek *et al*., 2021 and Belay *et al*., 2018) and cattle (Sèyi *et al*., 2018; Assogba *et al*., 2017; Weber *et al*., 2020; Wesly *et al*., 2021and Stanly *et al*., 2018). However, based on the level of our knowledge no documented information about the estimation of body weight using linear body measurements of donkeys at Blouberg Local Municipality, Limpopo, South Africa. Hence, the objectives of this study were to 1) determine the association between linear body measurements and body weight of donkeys and 2) configure a formula to estimate body weight using linear body measurements of donkeys. The present study will help the farmers to pay a closer attention to the animal, to anticipate the growth of donkeys by analyzing live body weight.

MATERIALS AND METHODS

Study Area

The current study was conducted in the Blouberg Municipality which is 195.8 km away from University of Limpopo, under the Capricorn District Municipality of Limpopo province, South Africa. Mild winters, with few touches of frosts, and very hot, often dry summers characterize the municipality. Has an average annual rainfall of about 455mm, which generally occurs in the form of afternoon thunderstorms between November and March. Average minimum temperature is 12.10°C and the maximum temperature is 26.02°C.

Sampling Procedure and Data Collection

A snowball sample as described by Saunders *et al*. (2012), to determine farmers to participate, where one farmer referred to the next one. A total of 74 donkeys aged from 3 to 4 years were used (40 males and 34 females). Linear body measurements were measured as shown in (Figure 1) according to Pearson and Ouassat, (2014).

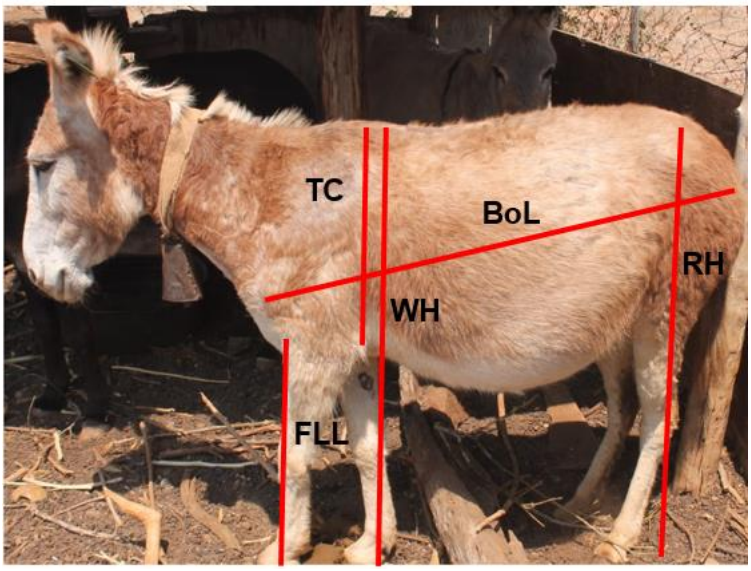

Figure (1): show linear body measurements that were measured during the study

Statistical analysis

Data were analyzed using the statistical package for social sciences (IBM SPSS, 2020) version 27.0. Pearson's correlation and regression analyses were used as statistical techniques to answer the objectives of the study. Coefficient of determination

and mean square error were used to select the best regression model. All the statistical analysis was performed at the 5% significance level.
The following model was used:
$Y = a + b1X1$
Where:
Y = estimated trait (BW)
a = intercept
b's = regression coefficients
X's = linear body measurements (BL, WH, TC, RH, FLL)

RESULTS

Descriptive statistics of measured traits of donkeys

Summary of linear body measurements (TC, RH, B~~o~~L, WH, FLL) and body weight (BW) of females and males of donkeys are presented in (Table 1). The average BW of female donkeys was 108.15kg that is lower than of male donkeys 108.33kg. In female donkeys the mean of RH, BL, WH, FIL and TC were 121.53, 119.15, 112.50, 72.59, 28.59 cm respectively The coefficient of variance ranges from 4.98 to 14.97%. In male donkeys the mean of BL, RH, WH, FIL and TC were 120.13, 119.75, 112.83, 74.18 and 26.58 cm respectively. The coefficient of variance ranges from 4.07 to 15.19%.

Table (1): Summary of linear body measurements and body weight of donkeys.

Traits	Female (n=34)			Male (n=40)		
	Mean	SE	CV	Mean	SE	CV
TC (cm)	28.59	0.73	14.97	26.58	0.64	15.19
B~~o~~L (cm)	119.15	1.27	6.20	120.13	1.56	8.22
WH (cm)	112.50	0.97	5.02	112.83	0.73	4.07
FLL (cm)	72.59	1.30	10.44	74.18	0.98	8.36
RH (cm)	121.53	1.04	4.98	119.75	0.84	4.46
BW (kg)	108.15	1.86	10.05	108.33	1.73	10.11

TC: Thoracic circumference, B~~o~~L: Body length, WH: Withers Height, FLL: Front leg length, RH: Rump height, BW: Body weight, n: Number of observations, SE: Standard error, CV: Coefficient of variance.

Association between linear body measurements and body weight of female Donkeys

Person in all the manuscript correlation is shown in (Table 2) showing a correlation between linear body measurements and body weight. TC as a trait that did not correlate ($p > 0.05$) with BW. BL had a positive significant correlation ($p < 0.05$) with BW. WH had a positively highly significant correlation ($p < 0.01$) with BW, while FLL did not correlate ($p > 0.05$) with BW. RH had a positive highly significant correlated ($p < 0.01$) to BW.

Association between linear body measurements and body weight of male Donkeys

Person correlation is shown in (Table 3) to show a correlation between linear body measurements ~~traits~~ and body weight TC and BL as a traits that had a positive significant correlation ($p < 0.05$) with BW. WH and RH had a positive highly significant correlation ($p < 0.01$) with BW. While FLL did not correlate ($p > 0.05$) with BW

Table (2): Association between linear body measurement traits and body weight of female donkeys.

Traits	TC	BoL	WH	FLL	RH
TC (cm)					
BoL (cm)	0.40*				
WH (cm)	0.39*	0.52*			
FLL (cm)	0.44*	0.59**	0.38*		
RH (cm)	0.45*	0.56**	0.81**	0.35*	
BW (kg)	0.14ns	0.36*	0.67**	0.28ns	0.64**

TC: Thoracic circumference, BoL: Body length, WH: Withers Height, FLL: Front leg length, RH: Rump height, BW: Body weight, ns: non-significant at $p > 0.05$. ** Significant at $p < 0.01$. *: Significant at $p < 0.05$.

Table (3): Association between linear body measurements and body weight of male donkeys.

Traits	TC	BoL	WH	FLL	RH
TC (cm)					
BoL (cm)	0.37*				
WH (cm)	0.18ns	0.15ns			
FLL (cm)	0.47*	0.21ns	0.29ns		
RH (cm)	0.46*	0.19ns	0.56**	0.49*	
BW (kg)	0.33*	0.34*	0.58**	0.27ns	0.60**

TC: Thoracic circumference, BoL: Body length, WH: Withers Height, FLL: Front leg length, RH: Rump height, BW: Body weight, ns: non-significant at $p > 0.05$. **: Significant at $p < 0.01$. *: Significant at $p < 0.05$.

Simple linear regression of thoracic circumference on body weight

Simple linear regression analysis of thoracic circumference and on body weight is shown in (Table 4). In female donkeys, the findings a non-significant correlation between thoracic circumference and body weight ($r = 0.14$) with $R^2 = 0.02$ and mean square error (MSE = 10.93). The simple linear regression equation was established as:

$$BW = 98.02 + 0.35TC$$

Where BW = body weight, TC = thoracic circumference, 98.02 constant, 0.35 regression coefficient. In male donkeys, the findings statistical significant correlation between body weight and thoracic circumference ($r = 0.33$) with $R^2 = 0.11$ and mean square error (MSE = 10.49). The linear regression equation was established as follows:

$$BW = 84.81 + 0.88TC$$

Where BW= body weight, TC= thoracic circumference, 84.81 constant, 0.88 regression coefficient.

Simple linear regression of body length on body weight

Simple linear regression analysis of body length on body weight is shown in (Table 5). In female donkeys, the findings a statistical significant association between body weight and body length ($r = 0.36$) with $R^2 = 0.13$ and mean square error (MSE = 10.29). The simple linear regression equation was established as:

BW = 44.72 + 0.53B~~o~~L

Where BW= body weight, B~~o~~L= body length, 44.72 constant, 0.53 regression coefficient. In male donkeys, the findings a statistical significant correlation between body weight and body length (r = 0.34) with R^2 = 0.12 and mean square error (MSE = 10.43). The linear regression equation was established as follows:

BW = 62.84 + 0.38B~~o~~L

Where BW= body weight, B~~o~~L= body length, 62.84 constant, 0.38 regression coefficient.

Table (4): Regression analysis between body weight and thoracic circumference.

Source	Sum of squares	DF	Mean square	R	R^2	Adjusted R^2
	Female					
Regression	75.83	1	75.83	0.14ns	0.02	-0.01
Error	3822.43	32	119.45			
Total	3898.26	33				
	Male					
Regression	497.71	1	497.71	0.33*	0.11	0.08
Error	4181.06	38	110.03			
Total	4678.78	39				

R: Correlation coefficient, R^2: Coefficient of determination, Adjusted R^2: Adjusted coefficient of determination, DF: Degree of freedom, ns: Not significant at $p > 0.05$, *: Significant at $p < 0.05$.

Table (5): Regression analysis between body weight and body length.

Source	Sum of squares	DF	Mean square	R	R^2	Adjusted R^2
	Female					
Regression	509.57	1	509.58		0.13	0.10
Error	3388.69	32	105.90	0.34*		
Total	3898.26	33				
	Male					
Regression	545.34	1	545.34	0.35*	0.12	0.09
Error	4133.43	38	108.77			
Total	4678.78	39				

R: Correlation coefficient, R^2: Coefficient of determination, Adjusted R^2: Adjusted coefficient of determination, DF: Degree of freedom, *: Significant at $p < 0.05$.

Simple linear regression of withers height on body weight

Simple linear regression analysis of withers height on body weight as shown in (Table 6). In female donkeys, the findings recognized a highly statistical significant correlation between body weight and withers height (r = 0.67) with R^2 = 0.45 and mean square error (MSE = 8.17). The simple linear regression equation was established as:

BW= -37.66 + 1.30WH

Where BW= body weight, WH= withers height -37.66 constant, 1.30 regression coefficient. In male donkeys, the findings a highly statistical significant correlation

between body weight and withers height (r = 0.58) with R^2 = 0.33 and mean square error (MSE = 9.07). The linear regression equation was established as follows:
BW = -46.48 + 1.37WH
Where BW= body weight, WH= withers height, 62.84constant, 0.38 regression coefficient.

Table (6): Regression analysis between body weight and withers height.

Source	Sum of squares	DF	Mean square	R	R^2	Adjusted R^2
	Female					
Regression	1764.57	1	1764.57	0.67**	0.45	0.45
Error	2133.69	32	66.68			0.44
Total	3898.26	33				
	Male					
Regression	1550.81	1	1550.81	0.58**	0.33	0.33
Error	3127.96	38	82.31			0.31
Total	4678.78	39				

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

Simple linear regression of front leg length on body weight

Simple linear regression analysis of front leg length on body weight is shown in (Table 7). In female donkeys, the findings a non- significant correlation between body weight and front leg length (r = 0.28) with R^2 = 0.08 and mean square error (MSE = 10.60). The simple linear regression equation was established as:
BW = 79.28 + 0.40FLL
Where BW = body weight, FLL = front leg length, 79.28 constant, 0.40 regression coefficient. In male donkeys, the findings a non- significant correlation between body weight and front leg length (r = 0.27) with R^2 = 0.07 and mean square error (MSE = 10.69). The linear regression equation was established as follows:
BW = 73.22 + 0.47FLL
Where BW= body weight, FLL= front leg length, 73.22 constant, 0.47 regression coefficient.

Table (7): Regression analysis between body weight and front leg length.

Source	Sum of squares	DF	Mean square	R	R^2	Adjusted R^2
	Female					
Regression	299.86	1	299.86	0.28ns	0.08	0.08
Error	3598.40	32	112.45			
Total	3898.26	33				
	Male					
Regression	335.86	1	335.86	0.27ns	0.07	0.05
Error	4342.92	38	114.29			
Total	4678.78	39				

R: Correlation coefficient; R^2: Coefficient of determination; Adjusted R^2: Adjusted coefficient of determination; DF: Degree of freedom; ns: Not significant at $p > 0.05$.

Simple linear regression of rump height on body weight

Simple linear regression analysis of rump height on body weight is shown in (Table 8). In female donkeys, the findings a highly statistical significant correlation between body weight and rump height (r = 0.64) with R^2 = 0.40 and mean square error (MSE = 8.52). The simple linear regression equation was established as:

BW = -30.44 + 1.14RH

Where BW= body weight, HR= rump height, -30.44 constant, 1.14 regression coefficient. In male donkeys, the findings a highly statistical significant correlation between body weight and rump height (r = 0.60) with R^2 = 0.36 and mean square error (MSE = 8.86). The linear regression equation was established as follows:

BW = -39.52 + 1.23RH

Where BW= body weight, RH= rump height, -39.52 constant, 1.23 regression coefficient.

Table (8): Regression analysis between body weight and rump height.

Source	Sum of squares	DF	Mean square	R	R^2	Adjusted R^2
	Female					
Regression	1574.08	1	1574.08	0.64**	0.40	0.39
Error	2324.19	32	72.63			
Total	3898.26	33				
	Male					
Regression	1694.17	1	1694.17	0.60**	0.36	0.35
Error	2984.60	38	78.54			
Total	4678.78	39				

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

DISCUSSION

Linear body measurements are reported as a suitable tool to estimate the live weight of an animal (Martinson *et al*., 2016). The current study first examined the association between linear body measurement traits and body weight. Results revealed that body weight had a positive highly significant relation with withers height, and rump height in female donkeys, and in male donkeys the results revealed that body weight had positive highly significant relation with rump height and withers height. These findings are in line with several studies (Lukuyu *et al*., 2016; Nininahazwe *et al*., 2017and Zhenwei *et al*., 2021). Zhenwei *et al.* (2021) reported that there was a relation between body weight with thoracic circumference, withers height, rump height and body length in Dezhou donkey. Bila *et al*. (2021) indicated that body length had a negative statistical correlation with body weight. Current correlation results disagree with the results reported by (Quaresma *et al*., 2019) on males, disagreement may be due to breed used and the environment. Findings of the current study suggest that wither height and rump height might be used to improve the body weight of donkeys in the study area. This information on correlation results will assist donkey farmers to know which linear body measurements might be used in selection for breeding to improve body weight. Regression models were developed for the prediction of body weight using linear body measurements. In female donkeys, withers height had the highest coefficient of determination and low mean square error followed by rump height. In male donkeys, rump height had the low mean square error and highest coefficient of determination followed by withers height. These findings are in line with Tyasi *et al*. 2020 who indicated that show that body weight can be predicted from withers height and rump height. Regression findings had disagreement with the studies of (Patel Ashwini *et al*., 2019 and Ozkaya and Bozkurt, 2009) who discovered that thoracic circumference had a low mean square error and highest coefficient of determination. Also, regression results of Aluja *et al*. (2005) suggest that the best fit model was one using the thoracic circumference of Donkey in Central México. Also, the current regression findings disagree with results reported by Gichure *et al.* (2020) which show that the best fit model was one using heart girth and body length of donkeys in the Central Highlands in Kenya.

CONCLUSION

In conclusion, the current study results suggest that there is a relationship between body weight and rump height, withers height, and body length in female donkeys. In male donkeys, there is relationship between body weight and rump height, withers height, body length and thoracic circumference in male donkeys. The results of Simple linear regression suggest that withers height in female and rump height in male donkeys had a high impact on body weight. The findings of the current study will help farmers in selection for breeding to improve body weight.

الخلاصة

ان مقاييس الجسم الخطية في مجال الإنتاج الحيواني، تستخدم كمقاييس لتوقع وزن الجسم، أجريت الدراسة الحالية لتحديد وتخمين وزن الجسم باستخدام مقاييس الجسم مثل محيط الصدر وارتفاع الحارك وطول الجسم وارتفاع الردف وطول الساق الامامية للحمير. أجريت الدراسة في ثلاث قرى هي ثرون وارشيبالت وجيناو في بلدية بلوبرغ المحلية– ليمبوبو– جنوب افريقيا. استخدم في الدراسة الحالية 74 حيوانا (40 حمار ذكر و34

انثى حمار) بعمر يتراوح بين 3−4 سنوات. تم تحليل البيانات باستخدام اختبار ارتباط بيرسون والانحدار الخطي البسيط. اشارت نتائج الارتباط في اناث الحمير الى وجود معامل ارتباط معنوي موجب بين وزن الجسم وارتفاع الحارك (r= 0.14) ومع طول الساق الامامي (r= 0.28) عند مستوى احتمال (P≤0.05) ، اما في ذكور الحمير فقد سجل معامل ارتباط معنوي موجب لوزن الجسم مع ارتفاع الردف (r= 0.06) عند مستوى احتمال (P≤0.01) وغير معنوي مع طول الساق الامامي (r=0.27) . وأشارت نتائج معاملا الانحدار الى ان ارتفاع الحارك سجل اعلى قيمة (r^2=0.45) و MSE= 8.17 في اناث الحمير، بينما كان ارتفاع الردف الأعلى في ذكور الحمير r^2= 0.36 و MSE= 8.86.

الكلمات الدالة: ارتفاع الردف، ارتفاع الحارك، الانحدار، معامل الارتباط، الحمير.

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