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A Study of Relationship between Body Weight and Morphological Traits by using Path Analysis in South African Indigenous Sheep

Thobela Louis Tyasi[1]* Yolisa Florance Tyasi[2] Akhona Lucy Tyasi[3] Siyasanga Lagu[4] Simthembile Ngambu[5]
1. Department of Animal Genetics, Breeding and Reproduction, College of Animal Science and Technology Jilin Agricultural University, Changchun .130118, P. R. China
2. Bozwana Village, P. O. Box 2228, Lady Frere, Emalahleni Local Municipality, Chris Hani District Municipality, Eastern Cape Province, South Africa
3. Department of Biotechnology, Vaal University of Technology Andries Potgieter Blvd Vanderbijlpark Gauteng Province, South Africa
4. Department of Livestock and Pasture Science, University of Fort Hare, Private Bag X1314, Alice, Eastern Cape, South Africa
5. Departments of Rural Development and Agrarian Reform, Komani Hospital, P. O. Box 112, Queenstown 5320 Eastern Cape Province, South Africa
*E-mail of the corresponding author: tyasi1921@gmail.com

Abstract
The aim of this study was to determine the relationship between five body measurement traits [hip height (HH), shoulder height (SH), body length (BL), heart girth (HG) and head width (HW)] and body weight of South African indigenous sheep (rams). For this purpose, data was collected from 96 rams of community farmers. Correlations and path analysis were executed for identifying the significant contribution of some morphological traits on body weight. Results of this study indicated that these body measurement traits especially body length and heart girth could be used as selection criteria for body weight in South African indigenous rams during breeding purposes.
Keywords: sheep, shoulder height, body weight, body length, heart girth, head width, morphometric

1. Introduction

Path analysis is an extension of the multiple regression models, which permits determination of the explanatory variables that mostly affect the response variable (Yakubu, 2010). According to Yakubu (2011) path analysis sometimes called causal modelling examines the web of relationships among measured variables. However, path analysis is a complementary method to regression analysis in the sense that a set of additional regressions is added to the original analysis to trace indirect effects (Yakubu, 2011; Cankaya and Abaci, 2012; Yakubu and Mohammed, 2012). This allows for determination of all causal effects (Ogah et al., 2009). The direct effect is a directional relationship between two variables while the indirect effect is the effect of an independent variable on a dependent variable through one or more intervening or mediating variables (Siddik et al., 2005).

The relationship between body weight and morphological traits of South African indigenous sheep has not been examined using a classical statistical tool such as path analysis. The objectives of this study was to establish direct and indirect causal effects between body weight and linear body measurements of indigenous sheep and also to develop functional model for predicting body weight using different body measurements.

2. Materials and methods

2.1 *Study area*

The study was conducted at the Thornhill communal farms situated in the sweet thornveld areas of Chris Hani District Municipality, Eastern Cape of South Africa. The farm coordinates are 31S:26E and falls under the Inxuba Yethemba local municipality, on the left hand side, along the R61 road between Queenstown and Cradock. Dominating plant species in the area is *Acacia Karroo* while the livestock species are sheep and goats.

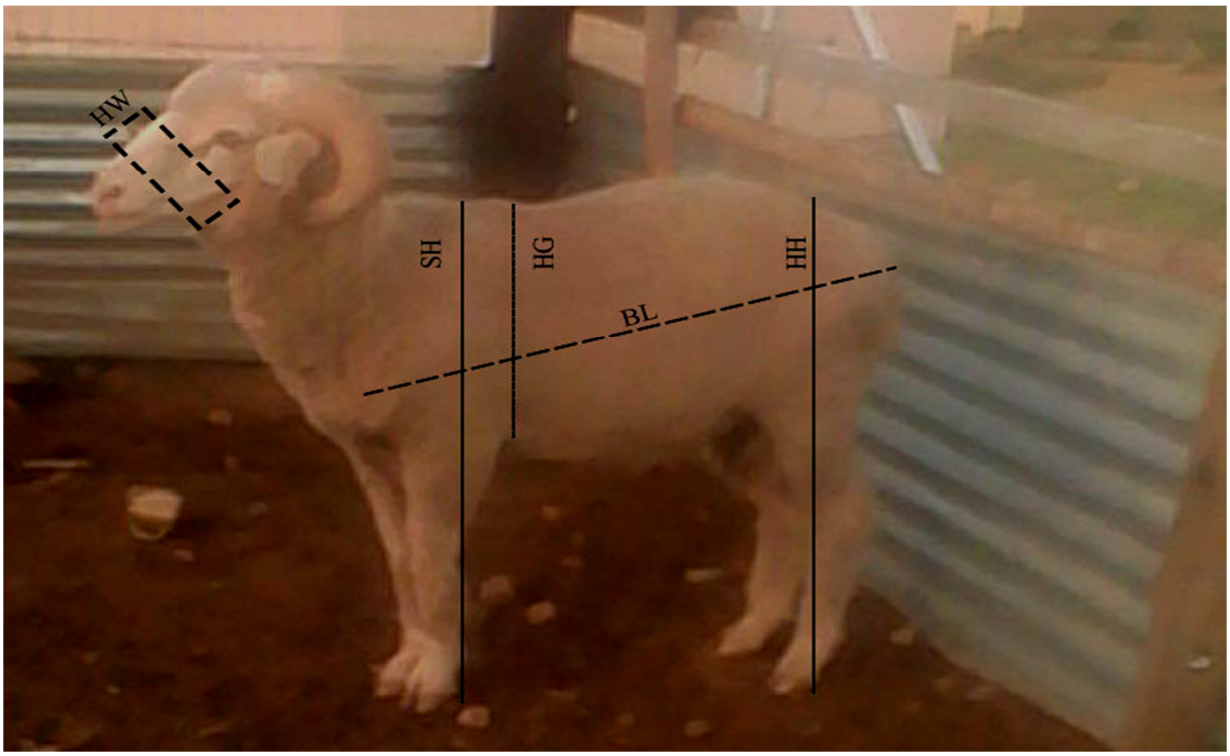
2.2 *Animal management*

Animals were subjected to the traditional management grazing system which allowed them to move freely grazing during day time and recalled back at night to owner care where they were provided with water. These animals were between the ages of 20 to 30 months old.

2.3 *Data collection*

Body weight and five morphological traits of a total of 96 indigenous sheep (rams) were measured on each animal in the morning before they were released for grazing. Morphological traits measurements include hip height, shoulder height, body length, heart girth and head width. Body weight was measured in kilogram (kg) using a balance scale, hip height (cm) measurement was done using a graduated measuring stick and the body

length, heart girth and head width were measured in centimetres (cm) using a tape rule.



HW=Head width, SH=Shoulder height, HG=Heart girth, HH=Hip height

Figure 1: South African indigenous ram showing morphological traits measured in this study

2.4 *Statistical analysis*

Means, standard deviations (SD) and coefficient of variation (CV) of body weight and morphological traits were calculated. Pearson correlation among body weight and morphological traits were also determined using SAS version 9.0. Path coefficients were calculated using Microsoft offices excel. This was to allow direct comparison of values to reflect the relative importance of independent variables to explain variation in the dependent variable. The path coefficient from an explanatory variable (X) to a response variable (Y) as described by Mendes et al. (2005) is shown below:

$P_{Y.Xi} = b_i S_{Xi}/S_Y$ (1)

Where:

$P_{Y.Xi}$ = path coefficient from X_i to Y (i= HP, SH, HG, BL), b_i = partial regression coefficient, S_{Xi} = standard deviation of X_i and SY= standard deviation of Y.

The following multiple linear regression model was adopted:

$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + e$ (2)

Where:

Y = endogenous variable (body weight), a = intercept, b's = regression coefficients, X's = exogenous variables (HP, SH, HG, BL, HW) and e = error term.

The indirect effects of X_i on Y through X_j were calculated as follows:

$IE_{YXi} = r_{XiXj}P_{Y.Xj}$ (3)

Where:

IE_{YXi} = the direct effect of X_i via X_j on Y, r_{XiXj} = correlation coefficient between ith and jth independent variables and $P_{Y.Xj}$ = path coefficient that indicates the direct effect of jth independent variable on the dependent variable.

3. Results and Discussion

Descriptive statistics and correlation coefficients for all traits were shown in table 1 and table 2; then, table 3 and table 4 presented results of path analysis, and direct and indirect effects of morphological traits on body weight of indigenous sheep.

Table1: Descriptive statistics of body weight and morphological traits of South African indigenous sheep

Trait	Number	Mean	Standard Deviation	Coefficient of Variation
Body weight	96	28.193	8.579	30.432
Hip height	96	61.036	5.203	8.524
Shoulder height	96	59.979	5.860	9.770
Body length	96	59.354	6.279	10.578
Heart girth	96	69.672	6.785	9.738
Head width	96	8.640	0.879	10.177

All of the correlation coefficients between body weight and morphological traits were significant at 5 % level except head width which is negatively correlated with all the other traits, similar to what Yakubu and Mohammed (2012) reported. However, simple correlations measure all associations between two variables whether influenced directly or indirectly so the path analysis was needed for that.

Table 2: Correlation coefficients among all traits

	BW	HH	SH	BL	HG	WH
BW		-	-	-	-	-
HH	0.850*		-	-	-	-
SH	0.857*	0.978*		-	-	-
BL	0.888*	0.833*	0.831*		-	-
HG	0.878*	0.800*	0.801*	0.809*		-
WH	-0.059^{ns}	-0.061^{ns}	-0.097^{ns}	-0.009^{ns}	-0.042^{ns}	

*Significant at P≤0.05, ns non-significant.

The direct effect of the morphological traits on body weight were compared according to their magnitude, the higher the direct values compared to others, the better they are in explaining the trait of interest directly. It was the same even on indirect effect of morphological traits on body weight, the higher the indirect values the better they were in explaining the trait of interest indirectly.

Table 3: Results of path analysis

	HH	SH	BL	HG	HW
HH	-0.046*	0.359	0.455	0.382	0.010
SH	-0.045	0.367*	0.454	0.383	0.016
BL	-0.038	0.305	0.546	0.387	0.002
HG	-0.036	0.294	0.442	0.478	0.007
HW	0.003	-0.022	-0.005	-0.020	-0.167*

*Significant at P≤0.05, R^2=0.876

According to the results, coefficients of variables in the model can be written as following:

$$BW = -0.046HH + 0.367SH + 0.546BL + 0.478HG - 0.167HW \quad (4)$$

Table 4: Direct and indirect effects of morphological traits on body weight of South African indigenous sheep

Trait	Correlation Coefficient with body weight	Direct effect	Indirect effect				
			HH	SH	BL	HG	HW
HH	0.850*	-0.046*		0.359	0.455	0.382	0.010
SH	0.857*	0.367*	-0.045		0.454	0.383	0.016
BL	0.888*	0.546	-0.038	0.305		0.387	0.002
HG	0.878*	0.478	-0.036	0.294	0.442		0.007
HW	-0.059^{ns}	-0.167*	0.003	-0.022	-0.005	-0.020	

Body weight versus hip height: The correlation coefficient between body weight and hip height was 0.850 respectively; it was positive and significant at p≤0.05. Hip height has indirect effect on body weight since having the highest indirect effect (0.455). However, hip height affects the body weight via body length.

Body weight versus shoulder height: The shoulder height does not have any direct effect but have an indirect effect on body weight since having the second highest indirect effect (0.454), and then it affects the body weight via body length. The correlation coefficient between body weight and shoulder height was 0.857 respectively and positive, and significant at p≤0.05.

Body weight versus body length: The correlation between body weight and body length was 0.888 respectively, it was positive and significant at p≤0.05. It was the highest correlation coefficient among all the morphological traits. Body length has a direct effect on body weight since having the highest direct effect (0.546). Therefore the body length is the morphological trait that can be used for improving the body weight of the South African indigenous sheep (rams).

Body weight versus heart girth: Heart girth does not have both an indirect and direct effect on body weight. The correlation coefficient between body weight and heart girth was 0.878 respectively and was the highest

correlation coefficient among all the traits. The correlation was positive and significant at $p \leq 0.05$.

Body weight versus head width: The correlation coefficient between body width and head width was negative and this trait showed negative correlations among all the traits. Head width does not have both an indirect and direct effect on body weight.

4. Conclusion

In this study, simple correlation discovered that body weight was positively and highly correlated with hip height, body length, shoulder height, and heart girth but negatively correlated with head width. However, path analysis revealed that the body length had the highest direct effect on body weight, chronologically followed by heart girth, respectively. Shoulder height had a lowest positive direct effect on body weight. On the other hand path analysis indicated that hip height had the highest indirect effect on body weight. Therefore, an increase in body weight of indigenous rams is associated with an increase in body length and hip height via body length. It is clear that path analysis is a supplement of simple correlation to provide a true understandable picture of association between body weight and morphological traits of indigenous rams. It can be proposed that for increase in body weight of indigenous rams, body length and hip height can be used as criteria for selection respectively.

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