ASSESSMENT OF THE RELATIONSHIP BETWEEN BODY WEIGHT AND BODY MEASUREMENTS IN INDIGENOUS GOATS USING PATH ANALYSIS

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ASSESSMENT OF THE RELATIONSHIP BETWEEN BODY WEIGHT AND BODY MEASUREMENTS IN INDIGENOUS GOATS USING PATH ANALYSIS

BY

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DECLARATION

I declare that this dissertation hereby submitted for the degree of Master of Science in Agriculture (Animal production) to the University of Limpopo, is my own original work, has not been submitted for any other purposes to any other university and all literatures in this paper has been acknowledged accordingly.

Name: MOELA A. K.

Signature…………………………….. Date……………………………..

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DEDICATION

I dedicate this work to my late beloved parents Mr. Phako John (Nape) and Mrs. Makganyane Betty (Mahlako Legokgo) Monyela “I have achieved your dreams”

ABSTRACT

Body measurements have been used in animals to estimate body weight especially in rural areas where scales are not readily available. The study was conducted in Sekhukhune District of the Limpopo province, South Africa where the goats between the ages of 20 and 30 months were used. Body weight and four morphological traits were taken on each goat in the morning before they were released for grazing in a total of 613 indigenous goats of both sexes (62 male and 551 female). Body weight was measured in kilogram (kg) using a balance scale, hip height and shoulder height measurement (cm) were done using a graduated measuring stick and the body length and heart girth were measured in centimetre (cm) using a tape rule. Means, standard deviations (SD) and coefficients of variation (CV) of body weight and morphological traits were calculated. Pair wise correlations among body weight and morphological traits were also determined and range from 0.81-0.91 for male and 0.72-0.89 for female goats, respectively and were significant ($P<0.01$). The direct effect of heart girth on body weight was the strongest in both sexes (path coefficient of 0.58 and 0.62 in males and females, respectively). Body length (males) and body length and hip height (females) also positively ($P<0.05$) influenced body weight. The direct effects of other linear type traits on body weight in both sexes were non-significant as revealed by t-test. These traits were indirectly realized mostly via heart girth. Thus, they were removed from the final regression equations to obtain much more simplified prediction models. The optimum multiple regression equation for male goats included heart girth and body length, In female goats, however, the variables included in the final prediction model were heart girth, body length and shoulder height. The forecast indices obtained in this study could aid in weight estimation, selection and breeding programmes.

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CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

1.1 Background

Major determinants of profitability in a meat goat enterprise are the growth and body traits (Supakorn and Pralomkarn, 2012). Weight, growth rate and conformation are important components influencing the profitability of goats and are essential objectives in selection strategies (Yakubu and Mohammed, 2012; Supakorn and Pralomkarn, 2012). The success of selection depends on the choice of selected traits. Furthermore, the potential for genetic improvement is largely dependent on the heritability of the trait and its genetic relationship with other traits of economic importance upon which some selection pressure may be applied (Das and Sendalo, 1990).

Morphological traits have been used in animals to estimate body weight (Yakubu, 2010). This has largely been the case in rural communities where scales are not readily available. The common measures of estimation of body weights has been simple correlation coefficients between body weight and morphometric measures or regression of body weight on a number of body measurements (Kuzelove et al., 2011). These however are inadequate in explaining complex relationships. The use of path analysis which measures a direct and indirect effect of one variable on another and also separates the correlation coefficients of the variables into components of direct effect, indirect effect and compound path has been found to be more useful (Yakubu and Mohammed, 2012).

1.2 Research Problem

1.2.1 Problem statement

The biological relationship between body weight and morphological traits is complex. The common methods of estimating the association of body weight and body measurements and/or predicting body weight from body measurements do not adequately measure the causal effects among biologically related variables.

1.2.2 Motivation of the study

Path analysis is an extension of the multiple regression model which permits the determination of explanatory variables that affect mostly the response variable. The study offers opportunity to estimate body weight with a high degree of accuracy using body measurements as forecast indices. This will contribute better selection of animals for breeding purposes based on morphometric traits.

1.2.3 Hypothesis

There are no association and causal effects among body weight measurements and body measurements.

1.3 Aim and Objectives

1.3.1 Aim

The aim of the study was to establish a comprehensive relationship between body weight and morphological traits of indigenous goats found in the Limpopo Province of South Africa using path analysis.

1.3.2 Objectives

The specific objectives of the study were:

i. Establish direct and indirect causal effects between body weight and linear body measurements of indigenous goats.

ii. Develop functional model for predicting body weight using different body measurements

CHAPTER 2

LITERATURE REVIEW

2.0 LITERATURE REVIEW

2.1 Introduction

Goat rearing has taken a lead role in the sustainable rural development programmes in developing countries (Rastogi *et al*., 2006). They have played multiple roles in the support of mankind for over 7000 years (Aziz, 2010). While goats were originally domesticated in southwest Asia they quickly moved into Africa and now can be found in every environment on the continent. Goats are deeply embedded in almost every African culture and are true friends to the rural people of Sub-Saharan Africa in particular (Peacock, 1996).

In South Africa, the small stock industry is of crucial importance as 80% of the agricultural land is unsuitable for intensive agricultural production (Schoeman et al., 2010). In Nigeria, goats contribute about 25% of the total meat supply (Adebambo, 2003,Oni, 2002). Goats are one of the cheapest sources of animal protein because of their high fertility rate and quick maturity traits (Jansen and Burg, 2004). They are kept primarily for meat and contribute substantially to household income and food security in most households in the rural areas (Adeyinka and Mohammed, 2006). In South Africa, Kwazulu-Natal has the third largest goat population of South Africa’s nine provinces (Anon., 1996), and the majority of these goats are of the indigenous Nguni-type, found in the small-scale farming sector.

Knowing the body weight of a goat is important for a number of reasons, related to breeding (selection), feeding and health care (treatment doses of antibiotics, anthelmintics, and so forth). However, this fundamental knowledge is often unavailable to those working with goats in the small-scale farming sector, due to the unavailability of scales. Whilst professionals can overcome this obstacle, farmers are usually unable to do so, because even a simple weighing scale may be unaffordable. Hence, farmers have to rely on questionable estimates of the body weight of their goats, leading to inaccuracies in decision-making and husbandry. Such difficulties can be overcome by developing a simple, yet reasonably accurate method to predict the body weight. For instance, a prediction equation can be established, based on a linear body measurement (Morrison, 1949; Quinn, 1980; Anon., 1988; Gatenby, 1991; Thys & Hardouin, 1991). However, such measurements do not apply across breeds and climatic zones and thus specific models that give the best fit should be developed (Islam *et al*., 1991; Benyi, 1997). The most often used body weight prediction models do not adequately give the causal effects among morphological and body weight traits and other methods such as path analysis have been found to be more appropriate.

2.2 Importance of goats

Goat is a multi-functional animal and plays a significant role in the economy and nutrition of landless, small and marginal farmers in many developing countries (Khan *et al*., 2006; Khan *et al*., 2006). In sub-saharan Africa, most of the goat production is found in small-scale production systems (Adebambo, 2003 and Oni, 2002). Goats can efficiently survive on available shrubs and trees in adverse harsh environment in low fertility lands where no other crops can be grown.

Goats are hollow-horned small ruminants and together with sheep are sometimes referred to as poor man's cow. They are so referred because of their ability to provide adequate meat, milk and skin for the small-holder or subsistence farmers' own use as well as a little extra for sale (Abanikannda and Leigh 2002). They contribute to the livestock industry in terms of milk, meat skin and hair (Adebambo, 2003). According to Khan *et al*., (2006) and Fisher (1983), in comparison with other domestic animals, goats are usually prejudiced and neglected, but they have nevertheless fulfilled a most useful task of supplying a large part of the human population with milk, meat, hair, leather and other products. Goats are generally kept for their milk, meat, hair (mohair, cashmere) and skins. However, they provide their owners with an additional broad range of products and socioeconomic services such as being used as gifts, dowry; used in religious rituals and rites of passage (Peacock, 1996; (Nsoso et al., 2004) and used for controlling bush encroachment. Additional income from goats come in the form of value-adding operations including the manufacture of goat leather products such as handbags, slippers and key chains, goat meat products such as spiced meat cuts, and milk products such as drinking yoghurt, cheese and amasi (Peacock, 2005). Goats are known to be especially useful to people in semi-arid zones, where goats can sustain themselves on sparse forage and extreme climate where other species of animal may perish.

2.3 Prediction of body weight from morphological characteristics

Traditionally, animals are visually assessed, which is a subjective method of judgement (Abanikannda and Leigh, 2002). Therefore, the development of objective means (linear body measurements) for describing and evaluating body size and conformation characteristics would overcome many of the problems associated with visual evaluation (Yakubu and Ibrahim, 2011; Jimcy *et al*., 2011). Some body measurements have been found to be correlated with live weight could be used in objectively estimating body weight. Some of these measurements include body length, withers height, hip height, heart girth, shoulder width and chest depth.

Body weight is often the most common and informative measure of animal performance (Adeyinka and Mohammed, 2006). The heart girth measurement has often been used as a predictor of body weight in animals, for example in cattle, horses, and sheep (Morrison, 1949; Quinn, 1980; Anon, 1988; Gatenby, 1991; Thys and Hardouin, 1991). The relationship between heart girth and body weight in Nguni goats was studied by Myeni and Slippers (1997), and it was found that heart girth explained 86.3 and 89.2% of the weight variation of bucks and does respectively. In cattle, various lengths, heights and girths of live animals havebeen measured to assess the relationship between these variables and the live weight (Dineur and Thys, 1986; Goe *et al*., 2001; Mekonnen and Biruk, 2004; Abdelhadi and Babiker, 2009), in sheep (Valdez *et al*., 1997; Atta and El khidir, 2004; Sowande and Sobola, 2008; Kunene *et al*., 2009; Oke and Ogbonnaya, 2011) while in goats, these measurements have been used to estimate body weight (Mohammed and Amin, 1997; Nsoso *et al*., 2004b; Adeyinka and Mohammed, 2006; Fajemilehin and Salako, 2008).

Amongst body measurements, high correlation coefficient values have been found between chest girth and body weight (Bello, and Adama, 2012; Myeni and Slippers, 1997). Slippers et al., (2000) indicated that body weight of Nguni goats can be predicted with confidence from heart girth measurements.

2.4 Methods of predicting body weight

In recent years, there have been a growing number of reports on the prediction of body weight from a variety of body traits measured at different growth periods of sheep (Riva *et al.,* 2004; Afolayan *et al.,* 2006; Kunene *etal.,* 2009; Cam *et al.,* 2010a) and goat (Gorgulu*et al.,* 2005; Khan *et al.,* 2006; Moaeen-ud-Din *et al.,* 2006; Rahman, 2007; Cam *et al.,* 2010b). In any livestock operation, body weight (BW) is a crucial piece of information that a producer needs to know to make proper management decisions. De Brito Ferreira *et al*. (2000) indicated that body weight measurement is used the most to evaluate body development in animals, but it is not easily measured in the field. This is due to the time and energy expended while determining it (Singh and Mishra 2004; Gorgulu *et al*., 2005; Oke and Ogbonnaya 2011). However, purchasing scales to accurately measure BW can be a costly endeavour for the producer and many part-time producers are not willing to make this investment. Without an accurate BW measurement, making sound management decisions is daunting, if not impossible (NASS, 2007). Body weight of the animal is needed for many purposes like feeding and breeding management, for marketing, health care, choosing replacement males and females etc. (Dineur and Thys (1986); Goe et al. (2001); Mekonnen and Biruk (2004); Abdelhadi and Babiker (2009); Valdez et al. (1997); Atta and El khidir (2004); Sowande and Sobola (2008); Kunene et al. (2009); Oke and Ogbonnaya (2011); Mohammed and Amin (1997); Nsoso et al. (2004b); Adeyinka and Mohammed (2006); Fajemilehin and Salako (2008)). In the field, weighing facilities may not be available and visual determination of the body weight is the only available method. However, this method is largely inaccurate for determining body weight (Chitra *et al*., 2012). The most intuitive way to assess body mass is weighing animals with a spring balance, a steelyard balance or any suitable scale. However, such devices are too expensive for most of small farmers. Using spring or steelyard balances can be painful because animals need to be lifted up. The spring in the scale can permanently stretch with repeated or out-of-bounds use, resulting in biased measurement. Scales must be installed on a horizontal base (concrete floor) and checked regularly for setting and calibration. Any defect in the base building can result in a bias in the measurements, as well as any lack of calibration. Scale calibration and maintenance require skilled technicians. Therefore, the conditions for accurate weighing are seldom met in the field. Moreover, the live weight (LW) is only an estimation of body mass because it varies continuously with feeding, watering, dropping, urinating, breathing, sweating and so on. Thiruyenkanden (2005) reported that knowledge of determination of best fitted regression model for estimation of body weight is often unavailable to those working with goats due to unavailability of weighing scales; hence decision making and husbandry are based on questionable and subjective estimates of body weight.

Different univariate models and multivariate approaches have been used to determine relationships among body weight and several body measurements. Other studies have utilized correlations to express the relationship between body measurements variables, body weightand carcass traits. Regression equations have been established to estimate body weight from body dimensions (Singh and Mishra 2004; Gorgulu et al., 2005; Oke and Ogbonnaya 2011). These regression models allow a fast evaluation of the body weight of an animal; and are also used for the optimization of feeding, determination of optimum slaughtering age, and selection criteria. Bhadula et al. (1979) also reported that the best method of weighing animals without scales is to regress body weight on certain body characteristics which can be readily measured. Body weight and linear measurements such as heart girth, body length and height at wither have been used in predicting carcass composition in goats (Singh et al., 1983; Raghavan, 1988; Rahman, 2007).

Although initial growth periods of living organisms are mostly linearly modeled, more sophisticated methods could be used to model the later stages of growth. This explains the slight edge, the allometric and quadratic models had over the linear equation (Kocaba et al 1997). The findings in the study of Kocaba *et al*. (1997) are also in agreement with the reports of Benyi and Karbo (1998) that the geometric (allometric) equation estimated live weight with a high degree of reliability compared to the linear equation. This is an indication that allometric growth equation offered a quantitative description of meat conformation. This was corroborated by the reports of Thys and Hardouin (1991) and Osinowo *et al*. (1992) that the relationship between body measurements and body weight are curvilinear and well defined by geometric regression equations. Smail and Da (2006) reported that the quadratic model gave a better fit to the body parameters investigated by its higher R^2 and lower MSE (residual mean square) compared to the simple linear model.

Several studies using linear body measurements of have shown their possible use for estimating the animals live weights (Mason, (n.d); Robinet, 1967; Ngere *et al.*, 1979, Moruppa and ngere, 1986; Ibiwoye and Oyatogun, 1987; Osinowo *et al*., 1989; Islan *et al*., 1991; Singh and Mishra, 2004; Slipper *et al*., 2000). Moderate and high coefficients of determination obtained in these studies are indication that linear body measurements may successfully describe variation in body weight. Gorgulu *et al*.

(2005) reported highest R^2 values from equations with heart girth, hip height and withers height among others. Prediction of body weight from linear body measurements seemed to be better in kids than adult goats (Khan et al., 2006). The study showed that as age advanced, coefficients of determination decreased while residual mean square increased. This is in consonance with the findings of Thiruvenkadan (2005). Height at withers and rump height have been reported to be limited in their values as indicators of weight. However, in the study of Khan *et al*. (2006), they have been found to best explain variation in body weight in kids than body length and heart girth. The findings of Khan *et al*. (2006) are consistent with the submission for Aziz and Sharaby (1993) that height at withers could be considered as a better predictor for body weight in lambs. Similarly, Boggs and Merkel (1984) noted that height at withers is the most accurate and repeatable measurement for frame size. This trend was reversed in adult non-descript goats where the model including heart girth was found to be better in estimating body weight. The superiority of heart girth over other body measurements have been reported by several other workers (Topal *et al*., 2003; Thiruvenkadan, 2005; Yakubu, 2010a and b). This is not unexpected considering the high environmental sensitivity of heart girth. Salako (2004) reported that heart girth and body weight, grow in response to environmental components such as feed and management; as such, they are used to assess environmental impact on breeds. The higher association of body weight with chest girth could also be attributed to the relatively larger contribution in body weight by chest girth, which consists of bones, muscle and viscera. It has been documented that body weight and linear body measurements of meat animals has been relevant in estimating body size and shape (Kabie *et al*., 2006; Ogah *et al*., 2009; Lariviere *et al*., 2009; Cam *et al*., 2010a; Onyimonyi *et al*., 2010; Lavvaf *et al*., 2012; Ojedapo *et* *al*., 2012). Body linear measurements in addition to body weight measurements are better tools to describe an individual or a population as opposed to the weighing and grading methods (Hill, 1990).

Multiple regression and factor analyses have been used to interpret the complex relationships among carcass weight and body measurements. The specific goals of factor analysis are to reduce a large number of observed variables to a smaller number of factors and provide an operational definition (regression equation) for an underlying process by using observed variables (Tabachnick and Fidell, 2001). Factor scores can be derived such that they are nearly uncorrelated or orthogonal. Hence, the use of factor scores as the variables in other analyses is possible and may be very helpful (Tabachnick and Fidell, 2001). Using factor scores in multiple regression analysis provides reliable results after factor scores are calculated by using factor analysis. Reports on combining multiple regression and factor analyses were few (Keskin et al., 2007a; Keskin et al., 2007b; Sangun et al., 2009).

Multivariate data analysis techniques have been used effectively to study latent relationship among measurements (Yaprak *et al*., 2008). Yaprak *et al*. (2008) used canonical correlation analysis to investigate relationship between two sets of variables to produce both structural and spatial inference.

A number of authors have reported on the use of path analysis to establish the relationship between various body measurements and liveweight (Ogah et al., 2009; Yakubu and Mohammed, 2012; Okpeku et al., 2011, Yakubu, 2010; Cankaya and Abaci, 2012). This method is explained in the next chapter.

CHAPTER 3

RESEARCH METHODOLOGY

3.0 RESEARCH METHODOLOGY

3.1 Study area

The study was carried out in the Sekhukhune District of the Limpopo province, South Africa. The district is situated in the eastern part of the Province (Figure 1). The climate is fairly typical of the Savanna Biome: warm, moist summers and cool, dry winters. Mean annual rainfall ranges from 400 mm in the valleys to 600 mm on the mountain slopes (Erasmus 1985) and mean summer temperatures from 25 °C in the north to 20 °C in the south. The average minimum and maximum temperatures recorded in the district range from 15 – 20°C and 25 – 30°C respectively.

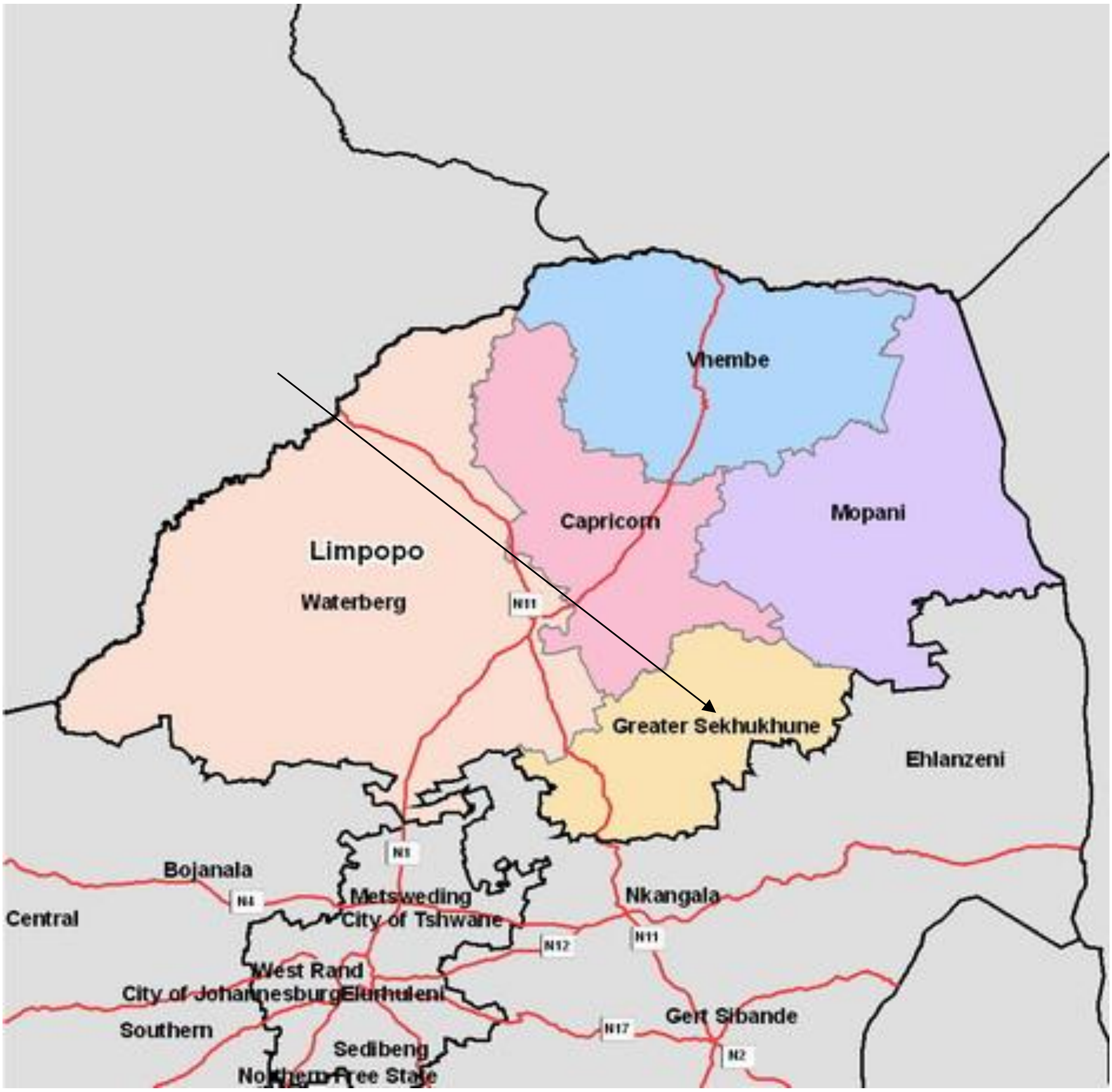
There are four main vegetation types: Sekhukhune Plains Bushveld (Mixed Bushveld), Sekhukhune Mountain Bushveld (Sourish Mixed Bushveld), Sekhukhune Montane Grassland (Bankenveld) and Leolo Summit Sourveld (North-eastern Sandy Highveld). The first two are semi-open woodland with a strong grass component, whereas the latter two are pure grassland (Victor et al., 2005). The vegetation is mainly used for grazing and browsing domestic livestock, primarily cattle and goats, although crops (mainly sorghum) play a very important role in subsistence agricultural production in some areas.

3.2 Animal management

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

3.3 Data collection

The following morphological measurements of goats were collected (Figure 2): hip height (HP); shoulder height (SH), heart girth (HG), body length (BL) and body weight (BW). Body weight and four morphological traits were taken on each animal in the morning before they were released for grazing. Body weight was measured in kilogram (kg) using a balance scale, hip height measurement (cm) was done using a measuring stick while body length, shoulder height and heart girth were measured in centimeters (cm) using a tape ruler. A total of 615 records were taken.



Source: Demarcation Board (www.demarcation.org.za)

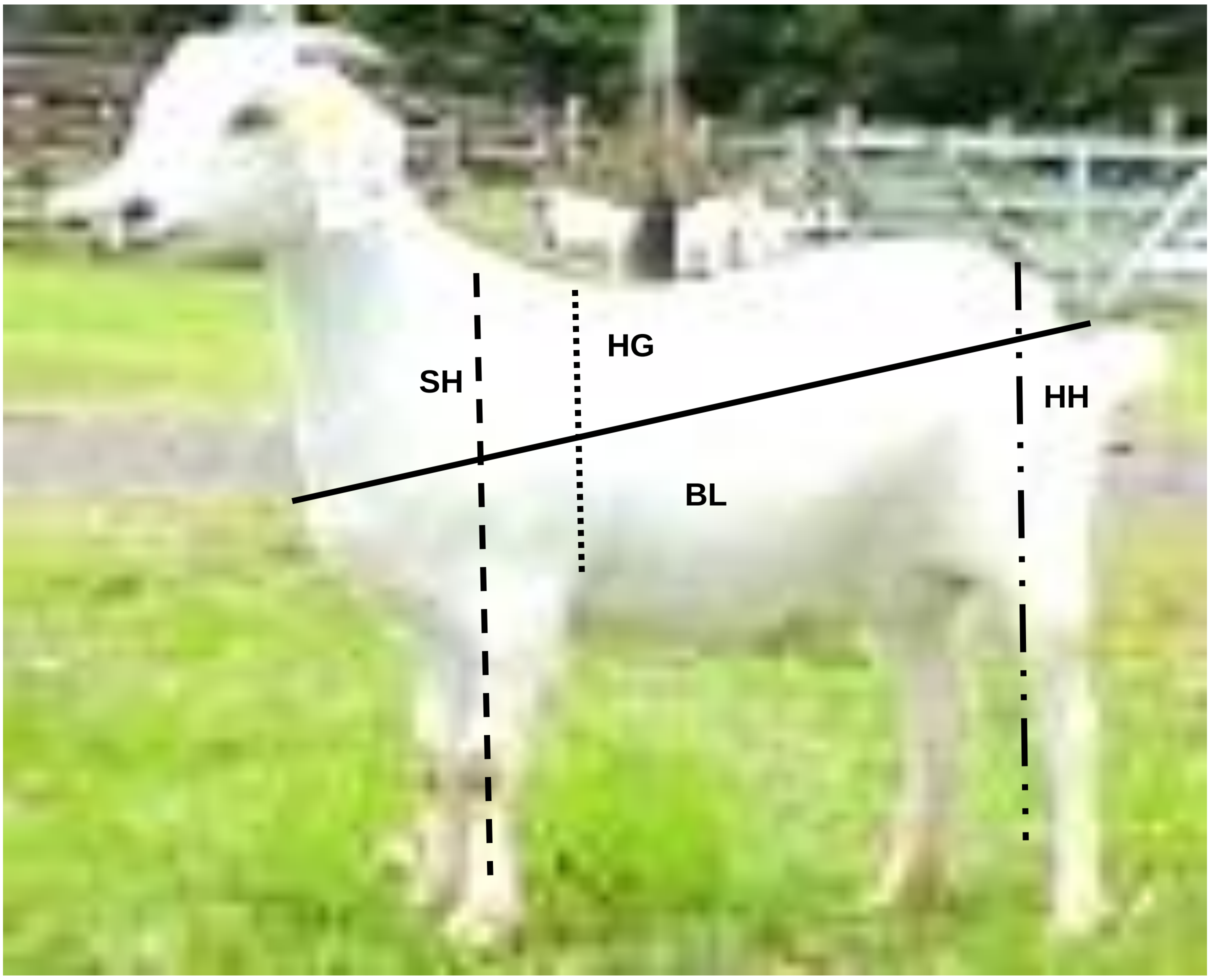


Figure 2: Indigenous goat showing the anatomical parts measured in this study.

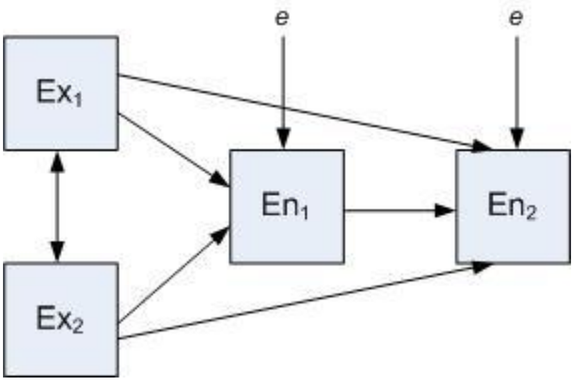
3.3 Statistical analysis

3.3.1 Background to path Analysis

Path analysis was developed around 1918 by geneticist Sewall Wright, who wrote about it more extensively in the 1920s. It has since been applied to a vast array of complex modelling areas, including sociology and econometrics and to a lesser extent in animal science. Path analysis is an extension of multiple regression. It goes beyond regression in that it allows for the analysis of more complicated models. In particular, it can examine situations in which there are several final dependent variables and those in which there are "chains" of influence, in that variable A influences variable B, which in tum affects variable C(Steiner, 2005). Path analysis is extremely powerful for examining complex models and for comparing different models to determine which one best fits the data. As with many techniques, path analysis has its own unique nomenclature, assumptions, and conventions. Some of the assumptions include:

1. All relations are linear and additive. The causal assumptions (what causes what) are shown in the path diagram.
2. The residuals (error terms) are uncorrelated with the variables in the model and with each other.
3. The causal flow is one-way.
4. The variables are measured on interval scales or better.
5. The variables are measured without error (perfect reliability).

A simple illustration of pathanalysis is depicted in Figure 3. In the model, the two exogenous variables (Ex_1 and Ex_2) are modeled as being correlated and as having both direct and indirect (through En_1) effects on En_2 (the two dependent or 'endogenous' variables). In most real models, the endogenous variables are also affected by factors outside the model (including measurement error). The effects of such extraneous variables are depicted by the "e" or error terms in the model.



Using the same variables, alternative models are conceivable. For example, it may be hypothesized that Ex_1 has only an indirect effect on En_2, deleting the arrow from Ex_1 to En_2; and the likelihood or 'fit' of these two models can be compared statistically.

3.2. Data Analysis

Means, standard deviations (SD) and coefficients of variation (CV) of body weight and morphological traits were calculated. Pairwise correlations among body weight and morphological traits were also determined. Path coefficients were calculated using SPSS (2001). This was to allow direct comparison of values to reflect the relative importance of independent variables in explaining variation in the dependent variable.

The path coefficient from an explanatory variable (X) to a response variable (Y) as described by Mendes *etal*. (2005) is shown below was used:

$$\mathbf{P_{Y.Xi} = b_i S_{Xi}/S_Y}$$

where*:*

$\mathbf{P_{Y.Xi}}$= path coefficient from X_i to Y (i= HP, SH, HG, BL)

b_i = partial regression coefficient,

S_{Xi} = standard deviation of X_i

S_Y= standard deviation of Y

The following multiple linear regression model was adopted:

$$\mathbf{Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + e}$$

where:

Y = endogenous variable (body weight),

a = intercept,

b's = regression coefficients,

X's = exogenous variables (HP, SH, HG, BL)

e = error term

Since the data for all traits were standardized, standardized partial regression coefficient obtained from the above equation are called path coefficient. These allow direct comparison of values to reflect the related importance of independent variable (traits) to explain variation in the dependent variables or traits (Keskin 2005).

The significance of each path coefficient in the statistical model was tested by t-test using the following model:

tj = bj –βj ˜ tα (n-p-1) ; j = 1, 2,----------------, p

√var (bj)

Where,

var(bj) = the diagonal member of matrix S2 (X'X)-1

S2 = mean square of residual obtained from ANOVA

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

$$\mathbf{IE_{YXi} = r_{XiXj} P_{Y.Xj}}$$

where:

IE_{YXi} = the direct effect of X_i via X_j on Y,

r_{XiXj} = correlation coefficient between ith and jth independent variables,

$P_{Y.Xj}$ = path coefficient that indicates the direct effect of jth independent variable on the dependent variable.

CHAPTER 4

RESULTS

4.0 RESULTS

4.1 Morphological traits

Descriptive statistics for all traits are shown in Table 1. Male had higher body weight, hip height and shoulder height while females had higher body length and heart girth.

Table 1: Descriptive statistics for all traits in male (n = 62) and female (n = 551) indigenous goats.

Trait variation	Sex	Mean	Standard deviation	CV
BW (kg)	F	27.12	6.92	25.52
	M	27.35	8.09	29.57
HH (cm)	F	59.84	3.84	6.42
	M	60.64	4.48	7.39
SH (cm)	F	58.27	3.82	6.55
	M	59.37	4.92	8.29
BL (cm)	F	59.40	5.32	8.95
	M	59.20	5.80	9.80
HG (cm)	F	69.33	6.10	8.79
	M	68.85	6.67	9.69

F= Female M= Male

4.2 Bivariate correlations

Pairwise correlations among body weight and linear type traits of the two goat sexes are shown in Table 2.

Table 2: Pearson correlation coefficient among traits male above diagonal and female below diagonal.

Trait	BW	HH	SH	BL	HG
BW	-	0.81	0.82	0.85	0.91
HH	0.72	-	0.96	0.77	0.77
SH	0.72	0.87	-	0.77	0.79
BL	0.80	0.71	0.69	-	0.77
HG	0.89	0.69	0.71	0.75	-

** Significant at P<0.01

All correlation between measurements were high and significant (P<0.01) in both males and females. The highest correlation was found between hip height and shoulder height in males while in females the highest correlation was found between body weight and heart girth. In males the lower correlations were found between body length and hip height, body length and shoulder height and height girth and hip height respectively. In females, the lower correlations were found between shoulder height and heart girth, hip height and body length respectively.

4.3 Path coefficients of explanatory variables

The direct and indirect effects of morphological measurements on body weight in male goats are shown in Table 3.

Table 3: Direct and indirect effects of biometric traits on body weight of indigenous male goats.

Trait	Correlation coefficient with body weight	Direct effects	Indirect effects				Total
			HH	SH	BL	HG	
HH	0.81	0.11^{ns}		0.03	0.22	0.45	0.70
SH	0.82	0.03^{ns}	0.11		0.22	0.46	0.79
BL	0.85	0.29*	0.08	0.02		0.45	0.55
HG	0.91	0.58*	0.08	0.02	0.22		0.32

*Significant at P<0.05; ns: non-significant

The correlation coefficient between hip height and body weight was high and significant but its direct effect on body weight was low and not significant. However, the total indirect effect of hip height on body weight was high realised largely through heart girth. The direct effect of shoulder height on body weight was also low and insignificant but total indirect effect was high realised mainly through heart girth. The direct effects of body length and heart girth were moderately high and significant (0.29 and 0.58 respectively). The direct effect of body length on body weight though significant was lower the total indirect effect of 0.55. In the case of heart girth, the direct effect was higher than the total indirect effect.

The direct and indirect effects of morphological measurements on body weight in female goats are shown in Table 4.

Table 4: Direct and indirect effects of biometric traits on body weight of indigenous female goats.

Trait	Correlation coefficient with body weight	Direct effects	Indirect effects				Total
			HH	SH	BL	HG	
HH	0.72	0.10*		0.02	0.17	0.43	0.62
SH	0.71	0.02^{ns}	0.09		0.17	0.43	0.69
BL	0.80	0.24*	0.07	0.01		0.47	0.55
HG	0.89	0.62*	0.07	0.01	0.18		0.26

*Significant at P<0.05; ns: non-significant

Unlike in females, the direct effect of hip height on body weight was significant though lower than the total indirect effect of 0.62 realised mainly via heart girth. As in males, the direct effect of shoulder height on body weight was low and insignificant. However, the indirect effect of shoulder height on body weight was high (0.69) achieved mainly through heart girth. Both the direct effects of body length and heart girth were significant. However, the indirect effect of body length was higher than the direct effect. This was not the case with heart girth whose direct effect was higher than indirect effect.

4.4 Standardized regression analysis

Table 5 presents the results of regression analysis for males.

Table 5: Regression analysis for males

Parameter	HH	SH	BL	HG
Coefficient (b)	0.11	0.03	0.29	0.58
SE	0.01	0.01	0.02	0.025
P Value	>0.05	>0.05	<0.05	<0.05
Intercept, a	-60			

Derived regression model for males:

$Y = -60.41 + 0.11HH + 0.03SH + 0.29BL + 0.58HG$

After deletion of non-significant predictor variables, the optimum regression model was found to be:

$Y = -60.419 + 0.29BL + 0.58HG$

Table 6 presents the results of regression analysis for females.

Table 6: Regression analysis for females

Parameter	HH	SH	BL	HG
Coefficient (b)	0.10	0.02	0.24	0.62
SE	0.01	0.01	0.03	0.03
P Value	>0.05	>0.05	<0.05	<0.05
Intercept, a	-53.62			

$Y = -53.62 + 0.10HH +0.02SH + 0.24BL + 0.62HG$

After deletion of non-significant predictor variables, the optimum regression model was found to be:

$$Y = -53.621 + 0.10HH + 0.24BL + 0.62HG$$

CHAPTER 5

DISCUSSION

5.0 DISCUSSION

5.1 Body weight and morphological traits

There was numerical mean differences between males and females in all morphometric measurements. However, these differences were not significant indicating no significant sex-associated differences between males and females. Yakubu (2010) found sex associated differences except for withers height. The same author found no significant differences in body weight and body measurements of between male goats and females in another study (Yakubu, 2009). In a study by Ogah et al., 2009, females had higher values than males except for rump height. In the study by Okpeku et al., 2011, males had higher mean values for all measured morphological measurements. There was a large variation in body weight and other body measurements which could be important for genetic improvement of these traits especially body weight as this is an economically important trait. However, as this is phenotypic variation, this variability may not be translated directly into genetic variation as this could be due to environmental factors. A genetic study would uncover if these morphological traits of goats are genetically controlled. The present study as indicated did not show sexual dimorphism which has been observed in many other studies. The sexual dimorphism in these studies have been attributed to the usual inter-sex differential hormonal action, which leads to differential growth rates in male and female animals.

5.2 Pairwise correlations

Bivariate correlation displaying the relationship among body weight and linear body measurements of indigenous goats has been shown in table 2. Body weight was positively correlated with all the morphological measurements. However, the highest and significant correlation in males was observed between the bodyweight and heart girth (r=0.91) followed by body weight and body length (r=0.85; P<0.01). The lowest correlation was observed between body weight and hip height (r=0.81; P<0.01) In females, the highest correlation was observed between the bodyweight and heart girth (r=0.89) followed by body weight and body length (r=0.80) respectively. The body dimensions were also positively and significantly correlated with each other. Similar results had been reported by Yakubu, (2010) in Yankasa lambs. The high correlations have been observed in other studies (Yakubu, 2010, Thiruvenkadan, 2005, Aziz and Sharaby, 1993).

The varying phenotypic correlation coefficients in the two sexes may suggest sexual differences in the genetic architecture of the goats. The implications of the positive relationships in the present study is that body weight could be estimated from body measurements, especially under village conditions where scales are not readily available. The association would also be useful as selection criterion if it is determined that the correlations are under genetic control which would suggest that the under the same gene action.

5.3 Path coefficients of explanatory variables

Path coefficients of the independent variables of male indigenous goats are presented in Table 3. Path analysis permits the partitioning of correlation coefficient into component parts (Marjanovic-Jeromela *et al*., 2008). The first component is the path coefficient (beta weight) that measures the direct effect of the predictor variable on the response variable. The second component estimates the indirect effect of the predictor variable on the response variable through other predictor variables.

The correlation coefficient between body weight and heart girth in the present study was high (r = 0.91), its direct effect on body weight was also the highest (path coefficient = 0.58) and significant (P<0.05) as indicated by the t-test. Its indirect effect was however low (0.32). This indicates that body weight can be improved through direct selection for heart girth. In a study by Yukubu (2010), the direct effect of heart girth was also significant though lower. The indirect effect for heart girth was also lower. The same results were observed in females. The direct effect of heart girth was significant and high (0.62) while the indirect effect was low (0.26). These results are however at variance with the observations made by Ogah et al., 2009.

The direct effects of hip height and shoulder height on body weight were both non-significant (path coefficient = 0.11 and 0.03 respectively, P>0.05). However the total values of indirect effects of these measurements were large (0.79 and 0.70 respectively) and this was largely realized via heart girth. The results suggest that the high correlations found between hip height, shoulder height and body weight (0.81 and 0.82 respectively) was largely due to the indirect effect of heart girth. Although the direct effect of body length on body weight was not the highest (path coefficient = 0.29), it was significant. It could be concluded, therefore, that heart girth and body length are valuable in the estimation of body weight of male indigenous goats.

Path coefficients of the independent traits of female indigenous goats are presented in Table 4. As in males, the highest direct positive contribution to body weight was made by heart girth; followed by body length and hip height (path coefficient = 0.62,0.24 and 0.10 respectively; P<0.05). The direct effects of shoulder height on body weight was non-significant. However, its indirect effect was the highest (0.69) realized through heart girth. As in males, the heart girth had the highest direct and indirect effect on body weight of female indigenous goat as compared to other morphological traits. This has also been observed by Jawasrey and Khasawney, (2007; Kunene et al. (2009). It could be concluded, therefore, that heart girth and body length are valuable in the estimation of body weight of female indigenous goats. Hip height may also be valuable as its direct effect though low was significant.The importance of heart girth has also been found in a study on Bunaji cows. In this study, heart girth was found to have a significant direct effect on milk yield.

In a study by Ogah et al., (2009), body length had direct effect on body weight only in females while in males the effect was high through wither height. In a study by Cankaya and Abaci (2012), the direct effect of body length though lower than indirect effect was significant. The indirect effect was mainly through the chest girth and height at withers. In a study by Yakubu and Mohammed, (2012), withers height though positive had no significant effect on body weight. The high correlation between the variable and body weight was largely due to the indirect effects of body length and chest girth. With respect to body length, the Yakubu and Mohammed (2012), this predictor variable was found to have the highest positive and direct influence on body weight unlike in the present study which found heart girth to have the highest direct effect on body weight. In a related study by Vargas et al. (2007), heart girth, body length and head width had positive and direct effects on body weight.

5.4 Regression equations

From the regression results, the following equations were obtained for males and females respectively:

$Y = -60.419 + 0.11HH + 0.03SH + 0.29BL + 0.58HG$

$Y = -53.621 + 0.10HH + 0.02SH + 0.24BL + 0.62HG$

The coefficient of determination (R^2) obtained were 0.87 and 0.88 for males and females respectively.

The above equations included non-significant traits which after deletion resulted in the following optimum regression models:.

In indigenous male goats, after the deletion of two of the predictor variables (HH and SH), the path coefficients of body length and heart girth in the model can be written as:

$Y = -60.419 + 0.29BL + 0.58HG$

In indigenous female goat, after deletion of only one of the predictor trait (SH) the the path coefficients of hip height, body length and heart girth in the model can be written as:

$Y = -53.621 + 0.10HH + 0.24BL + 0.62HG$

The equations obtained in this study are not the same as in other studies cited above due to the variations in the number and type of morphological measurements used in different studies.

5.5 CONCLUSIONS

Simple phenotypic correlations have shown that body weight was positively and highly correlated with hip height, shoulder height, body length and heart girth. The path analysis has shown that heart girth had the highest direct and indirect on body weight followed by body length. Heart girth and body length may be useful as selection criteria in goat breeding programs where record keeping for genetic evaluations is not well developed or non-existent. The optimum regression equations for males included body length and heart girth while for females, the model included body length, hip height and heart girth. These equations can serve as useful practical tools for weight estimation in the field and for selection purposes

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