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Morphological structure of Zulu sheep based on principal component analysis of body measurements

B.S. Mavule[a,*], V. Muchenje[b], C.C. Bezuidenhout[c], N.W. Kunene[a]

[a] Department of Agriculture, University of Zululand, Private Bag X1001, 3886, South Africa
[b] Department of Livestock and Pasture Science, University of Fort Hare, Private Bag X1314, Alice 5700, South Africa
[c] School of Environmental Science and Development, North-West University (Potchefstroom), Private Bag X6001, Potchefstroom, 2520, South Africa

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ABSTRACT

Information regarding morphology of indigenous sheep in South Africa is scant, and even where data exist it is rarely presented using standardised methodologies. Principal component analysis (PCA) was applied to 13 body measurements in order to provide an objective description of the body shape and size of 1665 Zulu sheep, obtained from rural communities of KwaZulu Natal. Data was analysed separate for young (no permanent incisors) and adult sheep (≥2 pairs of permanent incisors). On average mature males measured higher than mature ewes in most morphometric traits. The correlation coefficients between different body measurements in young sheep were all significant except for correlation between ear length and tail length whilst in adult sheep 79 out of 96 combinations showed significant correlation. Body weight and heart girth had the highest correlations in both age groups. Ear length and tail length related combinations had lower correlation coefficients in both age groups. The PCA of morphometric traits extracted two components with a total variance of 66.85% in young sheep and four components in adult sheep which explained a total variance of 62.13%. The first factor (PC1) in each case had high loadings for variables relating to body size, whilst PC2 had high association with traits reflecting body shape. The PC3 had high factor loadings for head length and head width, and thus defined head size. Tail length, ear length and whither height on the other hand contributed least towards total variation. The use of principal components was more appropriate than the use of original correlated variables in predicting body weight of Zulu sheep. PCA was able to identify traits with greater variability, these can be improved with greater success in breeding programmes and also the number of variables was reduced to give a concise picture of morphological structure (body size and shape) of a Zulu sheep. These components can as well be used in predicting body weight of Zulu sheep.

1. Introduction

The need to characterise and document indigenous breeds prior to strategizing means of their conservation, improvement and sustainable utilisation, cannot be over emphasised (FAO, 2007; Franklin, 1997; Rege and Lipner, 1992). A global strategy involves identifying and understanding a unique genetic resource in a particular region and developing the proper use of the associated diversity (FAO, 2007). Zulu sheep are indigenous to South Africa, particularly naturalised in the province of KwaZulu Natal. However, breed standards and judging panels for morphological evaluation do not exist for Zulu sheep, since its standards have not been fully established. Moreover very little attention from researchers in South Africa has been

* Corresponding author. Tel.: +27 799149337; fax: +27 359026056.
E-mail addresses: bafosibanda@yahoo.com, bafosibanda@gmail.com (B.S. Mavule).

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given to the breed compared to other sheep breeds. Preliminary work done by Kunene et al. (2007) has used a few body measurements (body weight, heart girth and wither height) to describe the breed.

Several researchers have used body measurements in describing morphological structure of different livestock species (Taye et al., 2010; Ibe, 1989; Ogah, 2011; Salako, 2006; Yakubu, 2009). Linear body measurements together with body weight describe more completely an individual or population than the conventional methods of weighing and grading (Riva et al., 2004; Salako, 2006). A quantitative measure of conformation will enable reliable genetic parameters for the traits to be estimated and this will make it possible for conformation to be included in breeding programmes (Ogah, 2011). Moreover linear body measurements have also been used to predict body weight in sheep (Ibiwoye and Oyatogun, 1987; Kunene et al., 2009; Taye et al., 2010). However, biological relationship existing among the linear body variates may be different if these body measurements are treated as bivariates rather than multivariates (Yakubu and Ayoade, 2009). Thus principal component analysis, a multivariate technique, can be used with much success when morphological traits are intercorrelated, in the size and shape of a breed.

Principal component analysis (PCA) analyses relationships among several quantitative variables measured on a single object, reducing the number of variables under analysis to a small number of indices (called the principal components) that are linear combinations of the original variables (Morrison, 1976). The analytic tool, in this case, combines the morphometric variables to produce indices or components that are uncorrelated. This allows data to be viewed from different dimensions (Manly, 1994). Moreover data can be adequately described by a few variables (components). Thus simple patterns of relationships among the variables are discovered. In particular, the observed variables can now be explained largely or entirely in terms of a much smaller number of variables (components). In summary its general objectives are (1) data reduction and (2) ease of interpretation of data. This tool has been shown to be useful in describing morphostructure of breeds.

Several researchers have employed principal component analysis to extract factors contributing towards variation amongst individual animals based on body measurements (Ogah, 2011; Shahin et al., 1993; Yakubu and Ayoade, 2009; Yakubu et al., 2009). Salako (2006) has employed the tool in ten linear body measurements in an effort to elicit an objective description of body shape in 0–14 months old Uda sheep. He was able to reduce the linear body measurements into two principal components that accounted for 75% of total variation. The first component was designated to represent body size whilst the second represented body shape. Okpeku et al. (2011) in their study used extracted principal components to predict body weight of goats in southern Nigeria. They concluded that the resultant factor score coefficients could be used to predict body weight with more accuracy than the original interdependent variables.

The purpose of this study was to define the morphological structure of Zulu sheep, examining changes in body measurements and their relationships in different age groups, to examine percentage contributions of body measurements towards total dimensional variation of the breed. It also tested the hypothesis that the relationships involving body weight and morphological traits may be different when factor scores derived from the principal component analysis are used instead of the inter-correlated original morphological variables.

Fig. 1. Morphometric variables studied and their reference points. BW, body weight; HG, heart girth; WH, whither height; RH, rump height; TD, thorax depth; BL, body length; TL, tail length; TC, tail circumference; HL, head length; HW, head width; ShC, shin circumference; EL, ear length; RW, rump width; RL, rump length.

2. Methods and materials

2.1. Study area

The distribution of the breed was identified through discussions with officers of the Department of Agriculture and Environmental Affairs (DAEA) in respective municipalities. Sheep were sampled from 11 rural communities, distributed across 5 districts of northern KwaZulu Natal. Areas studied were Empangeni and Eshowe in UThungulu District, Hlabisa, Jozini, Ngwavuma and Mtubatuba in UMkhanyakude District, Nongoma and Ulundi in Zululand Districts, Msinga and Nqutu in UMzinyathi District and Estcourt in Uthukela District. These areas are located between latitudes 27°7′ to 29°0′S and longitudes 29°52′ to 31° 59′E, with the altitude ranging from 80 to 1900 m above sea level. Annual rainfall in these areas range from 600 mm in the drier valley to over 1400 mm near the coast.

2.2. Data collection

In each of the locations, farmers with sheep were randomly selected and records taken on a randomly selected sample of more than 10 sheep per farmer depending on the flock size and the number of farmers owning sheep per given area. Data was collected during the period between June and August 2010. A scale was used to determine body weight of sheep. Animals were weighed in the morning before their release for feeding to minimise post-prandial variation. Pregnant ewes were excluded from sampling, as it has been shown in preliminary studies that pregnancy in its different stages has an effect on body weight (Kunene et al., 2007). Different body dimensions were measured using a tape measure (with records taken to the nearest cm) after restraining and holding the animal in an unforced position. The body parts measured were as described by Taye et al. (2010) and Yakubu et al. (2010). Reference points recorded are as shown in Fig. 1 and were head length (HL), head width (HW), ear length (EL), heart girth (HG), body length (BL), wither height (WH), thorax depth (TD), rump height (RH), rump width (RW), rump length (RL), shin