Indian J. Anim. Res., 49 (4) 2015 : 527-531
Print ISSN:0367-6722 / Online ISSN:0976-0555

AGRICULTURAL RESEARCH COMMUNICATION CENTRE
www.arccjournals.com/www.ijaronline.in

Morphological differentiation of indigenous goats in different agro-ecological zones of Vhembe district, Limpopo province, South Africa

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Received: 30-10-2014 Accepted: 29-12-2014 DOI: 10.5958/0976-0555.2015.00052.7

ABSTRACT

The study was carried out to differentiate indigenous female goats in different agro-ecological zones based on their morphological traits. 551 mature female goats from semi-arid, dry sub-humid and humid agro-ecological zones were considered in this study. The morphological traits analysed were Body Weight, Body Length, Shoulder Height, Hip Height and Heart Girth. Stepwise discriminant analysis was used to check the discriminating power of the variables. Canonical discriminant procedure was applied to determine differences between indigenous goats in different zones. The analysis showed that all the variables measured have discriminating power. In canonical discriminant analysis, the first canonical variable determined was significant and accounted for 91.87% of the variation, but the second canonical variable was not significant and accounted 8.13% of the variation. The pairwise Mahalanobis distances between indigenous goats in semi-arid and dry sub-humid as well as between semi-arid and humid were significant. The pairwise distance between goats in dry sub-humid and humid was not significant. Discriminant model function correctly allocated 60.31% (semi-arid), 58.06% (humid) and 38.46% (dry sub-humid) of indigenous goats into their original agro-ecological zone.

Key words: Agro-ecological zones, Co-variation, Indigenous goats, Morphological traits.

INTRODUCTION

The knowledge of morphological traits is important in characterization of animal genetic resources and classification of different breed ecotypes (Dossa *et al.*, 2007; Agga *et al.*, 2011). Morphological traits can be used to predict body weight in livestock, thereby making it easier for farmers to determine body weights by using measuring tape (Botsime, 2006; Coopman *et al.*, 2009). According to Odubote (1994), characterizing the indigenous goats phenotypically is one of the cheapest, indirect and alternative ways of improving their productivity.

The widespread distribution of indigenous goats in Limpopo Province of South Africa has led to a broad variation in morphology that can be attributed to several phenomena. These morphological characteristics developed over period of time due to breeding, genetics and environmental conditions (Riva *et al.*, 2004; Okpeku *et al.*, 2011). The Limpopo province consists of several agro-ecological zones to which indigenous goats are adapted but there is limited information on morphological trait variations in these indigenous goats. The dependence of differences in morphology of goats on the environmental conditions has been documented (Traoré *et al.*, 2008a) and it is suggested that variation in morphology of goats is a result of the climatic and other environmental conditions in which they occur. The importance and uses of morphological traits in livestock have been recognized (Dossa *et al.*, 2007; Coopman *et al.*, 2009; Yakubu *et al.*, 2011b).

Recent studies on indigenous goats in rural communities of South Africa focused mainly on reproductive performance (Sebei *et al.*, 2004; Webb and Mamabolo, 2004). Gwaze *et al.* (2009) reported that there is insufficient description of indigenous goats which has led to poor understanding of their potential for reproduction and growth. Therefore, the objectives of this study were to determine effect of different agro-ecological zones on morphological traits and co-variation relationships between various morphological traits of female indigenous goats in Vhembe District of Limpopo province.

MATERIALS AND METHODS

Study area: The study was carried out in Vhembe District of Limpopo Province, South Africa, having representation of all major agro-ecological zones of the province. The district can be divided into four main agro-ecological zones (arid,

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semi-arid, dry sub-humid and humid) according to climatic conditions (Thomas, 2003). All the zones differ in altitudes and soil types which have created various vegetation types (Low and Robelo, 1996). The vegetation types included in the study area were: Mopane veld (MOV), North eastern mountain sourveld (NMV), Lowveld sourveld (LSV), Arid sweet bushveld (ASV), Sourish mixed bushveld (SMV) and Arid lowveld (ALV).

Animal management and data collection: Indigenous non-descript goats used in the study were found under smallholder communal farming system in rural communities of Vhembe District. A total of 551 female mature indigenous goats from the semi-arid, dry sub-humid and humid agro-ecological zones were used for this study. The distribution of goats in different agro-ecological zones and vegetation type is shown in Table 1. Morphological measurements were collected from adult female goats, aged between weaning (less than one year) and two years. The age was determined by permanent incisors dentition, as outlined by Abegaz *et al.* (2011). The choice of female goats in this study was attributed to the very low numbers of males in the study area. Farmers tend to keep more reproductive active females to maintain a constant flock size as compared to the males. Additionally, the number of males gets smaller as age advances due to producers' preference to retain females while the males are either slaughtered for household food demand, sold to generate income during times of financial need or used during rituals and sacrifices. Other researchers have also observed very few males in their studies (Katongole *et al.*, 1996; Hagan *et al.*, 2012). The animals were extensively managed with little or no provision for shelter in the night. The animals grazed freely on communal grazing land and had access to crop residue after harvest of summer grain crops. Goats were provided with water at individual owner's yard but in some areas communal watering points were available. Five morpho-biometrical characteristics were measured on each animal in the morning before leaving for grazing. Measurements were restricted to healthy goats that conformed to the classification descriptors of each breed. Goats were restricted and placed on a flat platform and measurements were taken when the animals were relaxed. The morphological measurements recorded were hip height (HH) (measured in cm vertically from the tip of the hip bone (rump) to the ground using a measuring ruler (Botsime, 2006)), shoulder height (SH) (measured in cm vertically from the thoracic vertebrae to the ground using a measuring ruler), heart girth (HG) (measured in cm around the chest just posterior to the front legs using a measuring tape), body length (BL) (measured in cm horizontally from the point of the shoulder to the aitchbone (pin bone) using a measuring ruler (Fourie *et al.,* 2002)) and body weight (BW) (measured in kg using a mobile electronic weighing scale).

Data analysis: Stepwise Discriminant Analysis (Statistical Analysis Systems, version 9.3) was used to check the discriminating power of the variables. Canonical discriminant analysis of SAS was applied to determine differences between indigenous goats in semi-arid, dry sub-humid and humid zones. Similarly, canonical discriminant (CANDISC) procedure of SAS was used to perform canonical analyses to derive canonical functions, linear combinations of the morphometric traits that summarize variation between agro-ecological zones and compute the between-Zones Mahalanobis distance matrix. Discriminant (DISCRIM) procedure of SAS was used to determine the ability of the derived canonical functions to assign each individual goat to its agro-ecological zone (Statistical Analysis Systems, 2009).

The General Linear Model (GLM) procedures of SAS ver. 9.2 were used to analyse the effect of agro-ecological zone on quantitative morphological traits. Means separation was undertaken when it was significant to reveal the difference between means using Duncan's Multiple Range method. The following model was used:

$$Y_{ijk} = \mu + G_i + Aj + eijk;$$

Y_{ijk} = The observation on linear body measurements;
μ = Overall mean;
G_i = Fixed effect of agro-ecological zone (i = 1 to 4);
Aj = Fixed effect of age;
eijk = Random error.

TABLE 1: Distribution of goats in different agro-ecological zone and vegetation type.

Vegetation type	Agro-ecological zones		
	Semi-Arid	Dry Sub-humid	Humid
Arid lowveld	55		
Arid sweet bushveld	76		
Mopane veld	58		
Lowveld sourveld	59	61	
Sourish mixed bushveld	41	48	
North eastern mountain sourveld	31	60	62
Total	320	169	62
Grand total			551

RESULTS AND DISCUSSION

The results of the stepwise discriminant analysis showed that the measured variables were significant (P<0.01). However, BL had more discriminant power than the others as revealed by its highest R^2 and F-values. This implies that taking this basic measurement (BL) consistently could be more important in differentiating these indigenous goats in their different ecological zones. Cam *et al.* (2010) observed that morphometric measurements can roughly describe the animal's production status and breed characteristics. Some of the discriminating variables obtained in this study are similar to those reported by Dossa *et al.* (2007); Yakubu and Akinyemi, (2010) and Yakubu *et al.* (2010) in the morpho-structural differentiation of sheep and goats respectively.

Results of the effect of different agro-ecological zones on BL, BW, HG, HH and SH of female indigenous goats are presented in Table 2. Agro-ecological zones had significant effect (P<0.05) on the observed morphological traits. The results revealed that the female indigenous goats in semi-arid zone were different from those in dry sub-humid and humid agro-ecological zones. However, the morphological variables of female indigenous goats in humid and dry sub-humid zones were the same. Traoré *et al.* (2008a) found morphological trait (HW) of indigenous goats in Burkina Faso to differ across all the zones. However, BL of indigenous goats in Burkina Faso did not differ across all the zones (Traoré *et al.*, 2008a). The morphological traits (BL and HG) of indigenous goats recorded in Canary by Capote *et al.* (1998) were found to be the similar across some of the island groups. It should be noted that linear body measurements also reflect management conditions under which the animals are kept. The significant differences observed in this study in the different ecological zones could also be attributed to differences in availability of feed resource base (in terms of quality and quantity), availability of natural grazing field and the management conditions which the animals were subjected to (Cam *et al.*, 2010). In this present study, there was an age effect as expected. Body measurements increased as the animal ages.

Standardized coefficients for the canonical discriminant function, the canonical correlation, the eigenvalue and share of total variance accounted for in this study revealed that the first canonical variable determined (CAN1) was significant, but the second canonical variable (CAN2) was not significant. CAN1 and CAN2 accounted for 91.87% and 8.13% of the variation respectively. The CAN1 was dominated by the high positive loading of HH and high negative loading of SH, while the CAN2 was determined by the high positive loadings of BL and HG and high negative loading of BW. In a study by Traoré *et al.* (2008b) and Ogah (2013), all the canonical variables extracted were found to be significantly different. The results of the percentage total variation for CAN1 and CAN2 in Traoré *et al.* (2008b) were 90.9 and 9.1 % respectively and while in Ogah (2013), they were 59.7 and 40.3 respectively. Zaitoun *et al.* (2005) who worked with native goat breeds found that CAN1 and CAN2 had 82.4% and 10.7% of the

TABLE 2: Least squares means ± SE of morphological measurements in female indigenous goats across agro-ecological zones.

Variables	Agro-ecological zones		
	Semi-Arid	Dry Sub-humid	Humid
	LSM±SEM	LSM±SEM	LSM±SEM
BW (kg)	28.96±0.37[a]	24.45±0.56[b]	24.90±0.84[b]
HH (cm)	60.88±0.21[a]	58.45±0.31[b]	58.36±0.47[b]
SH (cm)	59.00±0.21[a]	57.16±0.32[b]	57.46±0.48[b]
BL (cm)	60.85±0.29[a]	57.61±0.43[b]	56.81±0.65[b]
HG (cm)	70.99±0.33[a]	67.14±0.49[b]	66.73±0.73[b]

[a,b] Means in the same row with different superscripts are significantly different (P<0.05).
BW, body weight; HH, hip height; SH, shoulder height; BL, body length; HG: heart girth
S.E.M: Standard error of means; LSM: Least squares means

TABLE 3: Stepwise discriminant analysis for indigenous goats

Step	Variables entered	Partial R^2	F-Value	P > F	Wilk's Lambda	P < Lambda	Average Squared canonical Correlation	P> ASCC
1	BL	0.1044	31.94	<.0001	0.8956	<.0001	0.0522	<.0001
2	BW	0.0177	4.93	0.0076	0.8797	<.0001	0.0606	<.0001
3	HG	0.0103	2.84	0.0592	0.8707	<.0001	0.0654	<.0001
4	HH	0.0081	2.23	0.1085	0.8636	<.0001	0.0690	<.0001
5	SH	0.0289	8.10	0.0003	0.8386	<.0001	0.0818	<.0001

BL (body length); BW (body weight); HG (heart girth); HH (hip height); SH (shoulder height).

total variation respectively. The discriminant analysis of morphometric traits is a mathematical approach that has been widely used in determining the relationships between different breeds of livestock (Carneiro *et al.,* 2010; Yakubu *et al.,* 2010b; Ajayi *et al.,* 2012). The present results indicate that there is significant morphological differentiation among the female indigenous goats in Vhembe district of Limpopo province. These differences could be attributed to inherent genetic variation in goats, in addition to geographical isolation, ecological variation and community isolation (Sun *et al.,* 2004; Gizaw *et al.,* 2007).

The pairwise Mahalanobis distances between indigenous goats in semi-arid and dry sub-humid as well as between semi-arid and humid were significant. The pairwise distance between indigenous goats in dry sub-humid and humid was not significant. The largest distance (1.05) was between indigenous goats in semi-arid and humid, whereas the smallest distance (0.23) was between goats in dry Sub-humid and humid.

Ndumu *et al.* (2008) found the significant and non-significant distances in Ankole Longhorn cattle in different regions. These results suggest that female indigenous goats across all the agro-ecological zones in dry sub-humid and humid are homogenous in term of morphology.

Discriminant model function correctly allocated 60.31% (Semi-arid), 58.06% (Humid) and 38.46% (Dry sub-humid) of individual indigenous goat into their original agro-ecological zone.

The results showed that the individual female goats in semi-arid were mostly classified into their original source. However 58.06% and 38.46% of individuals were classified into humid and dry sub-humid zones respectively. Birteed *et al.* (2013) found 93.4% and 100% of the individual Sahel and Djallonke ewes and rams correctly classified into their original genetic group respectively. Similarly in goats, Dekhili *et al.* (2013) found most of the individuals in North (73%), Center (66.8%) and South (79.3%) environmental areas classified into their area of origin, with few individuals misclassified. Yakubu and Ibrahim (2011) found Yankasa (45.9%), Uda (33.5%) and Balami (61.5%) sheep classified into their genetic group. The results reported in Yakubu *et al.* (2010a) also indicated that 99.4% of West African Dwarf and 100% of Red Sokoto individual goats were correctly classified into their original groups. The misclassification observed in this study may suggest the level of genetic exchange that has taken place overtime between the goats in different ecological regions.

CONCLUSION

All variables (body length, body weight, heart girth, hip height and shoulder height) measured had discriminating power for classification. Agro-ecological zone had effect on all studied morphological variables. The results revealed that morphological traits are a valuable tool for genetic improvement and conservation. The total variance as explained by the principal component analysis suggests that it can be used in breeding programmes for selecting indigenous goats based on their morphological traits.The results also suggest that it could be important to consider agro-ecological zones in future goat breed improvement programme. The morphological variations observed in this study could assist future decisions on the management, conservation and improvement of the indigenous goat genetic resources.

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