REVISTA CIENTÍFICA DE PRODUÇÃO ANIMAL
Publicada pela SNPA Sociedade Nordestina de Produção Animal
ISSN Impresso 1415-563X | ISSN On-line 2176-4158
v.22, n.2, p.91-95, 2020 - DOI: http://dx.doi.org/10.5935/2176-4158/rcpa.v22n2p81-89

Body conformation of Mozambican local goats explained by principal components analysis

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ABSTRACT
Phenotypic characterization and body biometric in 13 traits (head length, head width, ears length, body length, thoracic circumference, height at wither, thoracic depth, thoracic length, abdominal circumference, rump width, rump length, rump height, and cannon bone circumference) were recorded in 132 adult landim goats from Moatize Villages state of Mozambique. Traits were analyzed by using varimax rotated (PCA) with Kaiser Normalization to explain body conformation. The principal component analysis revealed tree components that explained about 63.4% of the total variation. First component described the general body conformation and explained 45.2% of total variation. It was represented by significant positive high loading of body length, thoracic circumference, thoracic depth, thoracic length, abdominal circumference, rump width, rump length. The communality ranged from 0.44 (ears length) to a 0.82 (thoracic circumference). Present study suggests that first principal component can be used in the evaluation and comparison of body conformation in landim goats and thus provides an opportunity to use on phenotypic selection program based on small group of biometric traits to explain body conformation on adult goats used in genetic improvement program.

Key words: goats; landim; biometric characterization; phenotype; Mozambique

Análise de componentes principais na caracterização morfologica de caprinos nativos de Moçambique

RESUMO
Características fenotipicas e 13 medidas corporais de caprinos (comprimento da cabeça, largura da cabeça, comprimento das orelhas, comprimento do corpo, perímetro torácico, altura na cernelha, profundidade torácica, comprimento torácico, perímetro abdominal, largura da garupa, comprimento da garupa, altura da garupa e perímetro da canela) foram coletadas em 132 caprinos adultos da Cidade de Moatize, Moçambique. Os paramêtros foram analisados utilizando a metodologia de análise de componentes principais (ACP) com a normalização de Kaiser para explicar a composição corporal. A análise de componentes principais revelou três componentes, das quais, explicaram em 63,4% o total da variação dos dados. O primeiro componente descreveu de forma geral a conformação corporal e explicou em 45,2% o total da variação. O primeiro componente foi positivo e significativamente representado pelo comprimento do corpo, perímetro torácico, profundidade torácica, comprimento torácico, perímetro abdominal, largura da garupa, comprimento da garupa. A comunalidade variou de 0,44 (comprimento da orelha) a 0,82 (perímetro torácico). O presente estudo sugere que o primeiro componente pode ser aplicado na avaliação e comparação da conformação corporal em caprinos landim e, estes demonstram grande aplicabilidade em programas de seleção fenotipica, baseando-se em poucas medidas biométricas para explicar a conformação corporal em caprinos adultos utilizados em programas de melhoramento genético.

Palavras-chave: caprino; landim; caracterização biométrica; fenótipo; Moçambique

Recebido em: 01/10/2020
Aceito em: 21/12/2020
Publicado em: 22/02/2021
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INTRODUCTION

Indigenous goats represent a resource of great value that needs to be preserved given their adaptability to adverse climatic conditions, resistance or tolerance to infectious diseases. Because of these characteristics, they play an important socio-economic role for the rural population and contribute to food security (Dubeuf and Rubiano, 2004). Despite the many advantages, information from the Food and Agriculture Organization of the United Nations (FAO) indicates that the proportion of endangered domesticated breeds in the world will increase from 15 to 17% between 2005 and 2014 (FAO, 2007). Maintenance of indigenous breeds represents the best economic tool for preserving diversity and sociocultural traditions (Chacón et al., 2011).

The influence of improved breeds leads many of the local breeds to endangerment before they have been defined, studied or cataloged. Knowledge of extensive genetic variation within breeds is essential for the development of efficient breeding programs in goats (Fatanzi et al., 2017).

However, prior to this, morphological characterization of breeds and study of variation within and between breeds is imperative (Chacón et al., 2011; Zepeda et al., 2011) since morphological selection may be an effective system in preservation and breeding programs. Several studies are based on the analysis of variance and correlation in the phenotypic characterization and in the genetic relationships between the morphometric characteristics (Yakubu et al., 2011a; Hilal et al., 2016). However, factor analysis using principal component analysis represents a better multivariate statistical tool to be applied in correlated genetic characteristics (Yakubu et al., 2011b). Characterization studies based on the principal components analysis were conducted for indigenous goats from Algeria (Fatanzi et al., 2017), in the evaluation of the diversity of native goats from the north of Morocco (Moutchou et al., 2017). In addition, it was also applied in the separation of carcass measurements of three goat genotypes (Santos et al., 2008).

Goats in Mozambique play an important role in ensuring food and nutritional security for the rural population. However, very few information is available on the genetic and phenotypic characteristics of these, which is important for the development of appropriate breeding programs for each ecosystem. The objective of this study was to evaluate the morphometric characteristics of naturalized goats in Mozambique using multivariate statistical analysis as a way to facilitate their field identification and cataloging.

MATERIALS AND METHODS

Description of the study area

The experiment was carried out by the random selection of 132 goats of the landim breed (110 females and 22 males) in different regions of the District of Moatize, Tete Province. All animals were older than 20 months, which was determined by the presence of two to eight permanent incisor teeth as described by Matika et al. (1990). The animals were managed in an extensive system and supplemented with agricultural byproducts or kitchen remnants if they existed.

Data collection

Measurements were taken using a tape measure. In total, 13 morphometric measurements were performed: head length (HL); head width (HW); ears length (EL); body length (BL); thoracic circumference (TC); height at wither (HT); thoracic depth (TD); thoracic length (LC); abdominal circumference (AC); rump width (RW); rump length (RL); rump height (HR) and cannon bone circumference (CC). For its effectiveness, the animals were kept in station position in a flat plane and with the help of two field assistants. The measurements were taken during the morning before the animals went to pasture. All measurements were taken by the animal's left flank and by the same person to avoid variations between individuals.

Statistical analysis

Was performed the descriptive analysis of all body measurements and correlations between different measures were estimated using partial correlation.

Principal component analysis

Among several methods of multivariate analysis, principal component analysis is simple and powerful which has been employed in population genetic analysis. The purpose of principal component analysis is to summarize the maximum of the portion of the variation present in the original data in variables with a minimum number of variation. Kaiser-Meyer-Olkin (KMO) sample adequacy measure was computed to determine the appropriate commonality of the factor, and values less than 0.5 were not accepted, and the Bartlett sphericity test was computed to validate the test. The Kaiser criterion was used to determine the number of factors (retaining only those factors that have auto values greater than 1) and the orthogonal rotation method varimx was applied in the rotation of the matrix to allow interpretation of the analysis. All analyzes were performed using the statistical program, SPSS v 20.

RESULTS AND DISCUSSION

Morphological traits

Descriptive statistics of the morphometric characteristics are presented in Table 1. Low values of the coefficient of variation reported in the present study ranged from 5.64 to 10.09 and were similar to those obtained in Madgyal sheep (Yadav et al., 2016) and different from the observed Algerian indigenous goats (Fatanzi et al., 2017) and in West African Dwarf goats and Red Sokoto goats (Yakubu et al., 2011b). Therefore, changes in body measurements can be observed that may be due to several factors such as environmental and management that may affect the animal and its growth rate (Contreras et al., 2011; Gonzalez-Martinez et al., 2014).

Table 1. Means, standard errors of means (SEM), standard deviations (SD) and coefficient of variation (CV) for the biometric traits (centimeter) of Mozambican local goats.

Traits (cm)	Mean+SEM	SD	CV
Head length	17.28±0.13	1.31	7.58
Head width	11.43±0.08	0.79	6.91
Ears length	13.09±0.90	0.87	6.64
Thoracic circumference	73.42±0.53	5.22	7.11
Body length	66.34±0.52	5.15	7,76
Height at wither	58.01±0.37	3.63	6.25
Thoracic depth	32.28±0.27	2.69	8.33
Thoracic length	35.46±0.39	3.83	10.08
Abdominal circumference	79.71±0.69	6.76	8.48
Rump width	15.16±0.15	1.53	10.09
Rump length	20.77±0.13	1.29	6.21
Rump height	59.54±0.34	3.36	5.64
Cannon bone circumference	8.00±0.05	0.54	6.75

Phenotypic correlation

Values of the correlation coefficients between the different characteristics are presented in Table 2. The study shows that body measurements often have positive and significant correlation ($p < 0.05$). A total of 78 correlations between the characteristics was estimated where it varied from 0 for HW and TD to 0.73 for AC and CT, of which 43 were positively significant. However, the values of the observed correlations were lower than those observed in Madgyal sheep (Yadav et al., 2016) and similar to those pointed out in Moroccan indigenous Draa goat (Ibnelbachyr et al., 2015) and Rampur-Bushair sheep (Sankhvan et al., 2018). The positive and significant correlations suggest a high prediction between the different biometric characteristics and may be important in the definition of the selection criteria, depending on the conditions of the production systems, production and selection purpose, and socioeconomic particularities.

Principal component analysis

The analysis of the anti-image correlation revealed that it was low indicating the existence of factors in the data set which was later supported by the adequacy measure of the KMO sample. The KMO observed in the present study was 0.88, which demonstrates the proportion of the variance between different biometric characteristics caused by underlying factors. The overall significance of the correlation was tested by Bartlett's sphericity test for biometric features and provided further support in the validation of principal component analysis.

The results of the principal component analysis demonstrated that three components were extracted based on the Kaiser criterion from the 13 morphometric characteristics. The other criterion used was the escarpment chart (Figure 1). The three main components extracted explained 63.4% of the data variance (Table 3). The first major component was sufficient to explain about 45.2% of the total variance among the 13 body measurements and was represented by

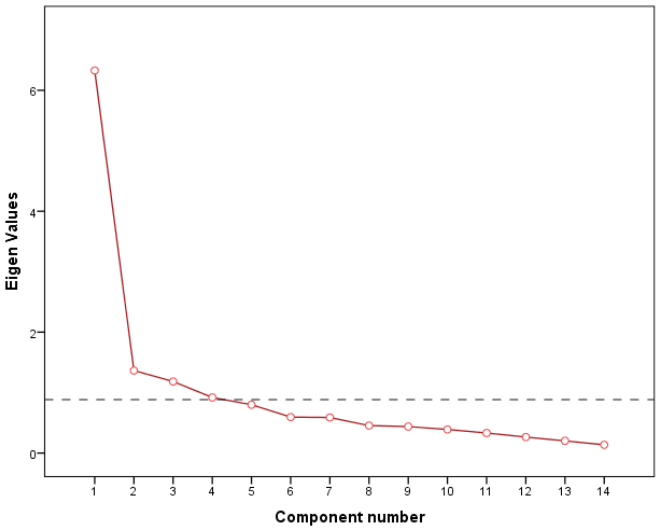

Figure 1. Scree plot showing component number with Eigen values.

Table 2. Coefficients of phenotypic correlation among 13 morphometric traits of Mozambican local goats.

	HW	EL	TC	BL	HT	TD	LC	AC	RW	RL	HR	CC
HL	0.4*	0.19ns	0.68**	0.49**	0.44**	0.24ns	0.3ns	0.45**	0.53**	0.46**	0.41*	0.44*
HW		0.02ns	0.32ns	0.21ns	0.2ns	0ns	0.15ns	0.24ns	0.17ns	0.25ns	0.29ns	0.37*
EL			0.14ns	0.1ns	0.25ns	0.17ns	0.23ns	0.2ns	0.04ns	0.12ns	0.10ns	0.04ns
TC				0.64**	0.42**	0.58**	0.56**	0.73**	0.71**	0.63**	0.48**	0.49**
BL					0.4*	0.57**	0.55**	0.6**	0.56**	0.53**	0.37**	0.37**
HT						0.34ns	0.28ns	0.39*	0.32ns	0.38*	0.54**	0.16ns
TD							0.58**	0.50**	0.38*	0.44*	0.25ns	0.22ns
LC								0.61**	0.47**	0.44*	0.26ns	0.37*
AC									0.63**	0.56**	0.41*	0.39*
RW										0.63**	0.24ns	0.29ns
RL											0.32ns	0.32ns
HR												0.29ns

HL- Head length; HW- Head width; EL- Ears length; BL- Body length; TC- Thoracic circumference; HT- Height at wither; TD- Thoracic depth; LC- Thoracic length; AC- Abdominal circumference; RW- Rump width; RL- Rump length; HR- Rump height and CC- Cannon bone circumference. * $p < 0.05$, ** $p < 0.01$, ^{ns} non significative.

Table 3. Total variance explained by different component in adult Mozambican local goats.

Component	Initial eigen values			Extraction sum of square loadings		
	Eigenvalue	Percentage of variance	Cum percent	Total	Percentage of variance	Cum percent
1	6.328	45.197	45.197	6.328	45.197	45.197
2	1.365	9.747	54.945	1.365	9.747	54.945
3	1.184	8.457	63.402	1.184	8.457	63.402
4	0.920	6.569	69.971			
5	0.800	5.712	75.683			
6	0.596	4.254	79.937			
7	0.589	4.206	84.143			
8	0.455	3.249	87.392			
9	0.438	3.131	90.524			
10	0.391	2.791	93.315			
11	0.331	2.367	95.682			
12	0.265	1.894	97.576			
13	0.202	1.446	99.022			
14	0.137	0.978	100.000			

the characteristics TC, BL, TD, AC, LC, RW and RL (Table 4). The first component in general explained the conformation and body size of goiter landim. Other studies in Northern Morocco goats (Moutchou et al., 2017), in Madgyal sheep (Yadav et al., 2016), Rampur-Bushir sheep (Sankhyan et al., 2018), in beef cattle from India (Verma et al., 2015) and buffaloes (Vohra et al., 2015), pointed out that the first major component generally estimated body size.

The second component explained in 9.7% the total variation of the data with the characteristics head length, head width and perimeter of the cinnamon present significant correlation with the component and characteristics ear length and height of the withers were that presented significant correlation with the third component, whose east, explained in 8.4% of the total variation.

In practice, there is no limit to the number of characteristics to be evaluated in genetics programs or in experiments; however, it is relevant to use adequate statistics to identify important and informative variables among the large set of characteristics (Barbosa et al., 2005). In this context, in the present study three main components were extracted different from what was observed in the studies conducted by (Yakubu et al., 2011a) for West African Goat and Northern Morocco goat (Moutchou et al., 2017). Which shows that these characteristics can be explored in selection programs, allowing producing animals in smaller time with better size and conformation and with reduced costs.

The estimate of commonality ranged from 0.44 for ear length to 0.82 for thoracic perimeter. Different from that observed for West African Dwarf and Red Sokoto goats where commonality ranged from 0.56 to 0.97 (Yakubu et al., 2011b). The low estimate of the observed commonality for the EL characteristic may probably be the result of this measure not explaining the body shape variation of goat landim in relation to other factors.

Multivariate analysis of morphological characteristics has been successfully applied in estimating genetic variation within and between local caprine breeds and in different species (Dossa et al., 2007; Verma et al., 2015; Vohra et al., 2015). However, molecular analysis along with participatory breeding programs involving local breeders is essential for the validation of the present results. This may allow better attention in the field and subsequent conservation of genetic resources for sustainable production of goats, especially in tropical environments.

Table 4. Varimax rotated loading matrix and communality estimate for different morphometric traits of landim goats.

Traits	Principal components			Communality
	1	2	3	
HL	0.395	0.640	0.295	0.653
HW	0.007	0.796	0.058	0.637
EL	0.069	-0.143	0.645	0.441
TC	0.770	0.433	0.218	0.828
BL	0.746	0.231	0.183	0.643
HT	0.246	0.270	0.740	0.681
TD	0.765	-0.180	0.309	0.713
LC	0.756	0.026	0.158	0.597
AC	0.752	0.264	0.201	0.676
RW	0.755	0.291	-0.042	0.656
RL	0.680	0.297	0.131	0.567
HR	0.180	0.484	0.571	0.592
CC	0.366	0.608	-0.081	0.511

HL- Head length; HW- Head width; EL- Ears length; BL- Body length; TC- Thoracic circumference; HT- Height at wither; TD- Thoracic depth; LC- Thoracic length; AC- Abdominal circumference; RW- Rump width; RL- Rump length; HR- Rump height and CC- Cannon bone circumference.

CONCLUSION

The phenotypic and multivariate statistical characterization by the main component analysis technique proved to be effective to explain the corporal conformation of landim goat. The results of the extracted components provide ways to reduce the number of biometric features collected in goat landim, which may explain body conformation. Principal component 1 can be applied in phenotypic selection programs as a way of explaining body shape adult goats to be used in breeding programs.

ACKNOWLEDGMENT

Authors wish to thank, Silvio Magaço, Belmiro Zalimba to provide logistic support to carry out the work and sincere gratitude to all the livestock keepers who allowed measurements of their goats.

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