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Multivariate Morphological Characterization and Analysis of the Endangered Sheko Cattle Breed in South-western Ethiopia

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Abstract

The current study made use of multivariate statistical analysis of morphological characteristics of the Sheko cattle breed in 14 districts in Southern Western Ethiopia. In total, 7252 Sheko cattle were analysed with regard to 11 body measurements and 7 qualitative morphological characteristics. The selection of samples was made on the basis of the presence of high, medium, and low numbers of Sheko cattle breeds in various regions. It has been found that there is little difference in body measurements of different Sheko cattle breeds, with higher average values being recorded in Shi Bench Sheko breed. The first canonical variable accounted for 83.1% of the variation, whereas the second canonical variable contributed 16.9% to the variation. The lowest Mahalanob is distance was found between Shi Bench and Sheko district Sheko cattle breeds, while the highest distance was between Shi Bench and Biro Sheko cattle breeds. It appears that Face length was the most significant discriminating variable, followed by Cannon bone circumference, Horn length, and Body length. The discrimination model accurately categorized Biro, Sheko, and Shi Bench breeds in to the correct groups, representing around 88.57%, 79.63%, and 77.57% of the initial Sheko cattle population. Regarding morphology, the morphologically distinct features of the Sheko cattle breed in the Shi Bench region include a wide mouth, humpless back, polled, and short horns; all of these may be the result of the particular environment in which the breed lives and its conservation practices. From a genetic stand point, there is considerable genetic distance between Sheko and Bero districts. The results obtained from the current study will help future studies on this subject to gain more information about Sheko cattle breed populations.

Keywords: Conservation strategy, Genetic distance, Morphological traits, Sheko cattle breed, Southwestern Ethiopia

Introduction

Sheko cattle are considered important livestock breeds owing to their trypanotolerance in the south-western part of Ethiopia (DADI, 2009). At present, Sheko cattle have relatively small and medium-sized humps inherited from zebu cattle. In terms of geographical location, most of these cattle can be seen in Bench Maji Zone, while some are scattered in nearby places in Kaffa,West Omo and Shaka Zones in south-western Ethiopia (Taye, 2007). Unfortunately, the Sheko cattle breed is threatened by the constant crossbreeding with zebu cattle in their respective locations (DAGRIS, 2004). It should be noted that the need for characterization and conservation of genetic resources in Ethiopia, including the Sheko breed, is high. Phenotypic characterization forms the basis for distinguishing among different groups/breeds and contributes to efforts in conservation. The process is extensively applied in the characterization of genetic materials across the globe (Aziz & AlHur, 2013; Carneiro et al., 2010; Jimcy et al., 2011; Revidatti et al., 2007; Zaitoun et al., 2005; Zepeda et al., 2002). Several means can be utilized in assessing the

discriminating ability of certain variables in describing the characteristics of the breeds in consideration, with the aim of determining their importance and efficient use of resources. Multivariate analysis has played an important role in breed characterization through methods such as cluster analysis, principal component analysis, canonical analysis, discriminant analysis, and classification analysis. The population of Sheko cattle breed needs to be characterized in various locations and assessed whether they are similar or dissimilar to other populations. With the identification of different populations, this study will lay down ways of conserving the population and researches that need to be done in the future. Earlier studies on Sheko cattle breeds have not investigated the multivariate analysis of the population. The study will help in analysing data, remove redundancy, and identify similarities with the help of multivariate analysis.

Objectives

The objectives of this study are as follows:

To conduct a multivariate characterization of morphological traits in the Sheko cattle breed in southwest Ethiopia. To compare body dimensions and morphological features among the Sheko cattle populations of different districts. To identify the most important morphological features that distinguishes different populations of Sheko cattle. To calculate the Mahalanobis distance between the different Sheko cattle populations to establish the level of genetic relationship between them. To construct a discriminant function model for classifying the individual cattle to their respective Sheko cattle populations.

Methods

Areas of study

The experiment was conducted in Bench-Sheko, South West Omo, Sheka, and Kaffa zone in South west Ethiopia. The scope of the study according to the research papers is the multivariate analysis of morphological traits in the endangered indigenous Sheko cattle breed in South Western Ethiopia. The aim of the study is to characterize the morphological traits of Sheko cattle, to compare the body measurements and qualitative traits of the Sheko cattle populations, to determine the critical traits useful for distinguishing between populations, to assess Mahalanobis distance between populations, and to classify individual cattle into their specific breeds using discriminant analysis. Moreover, the study will help in providing useful information for future characterization, conservation, and selection of Sheko cattle breeds in south-western Ethiopia.

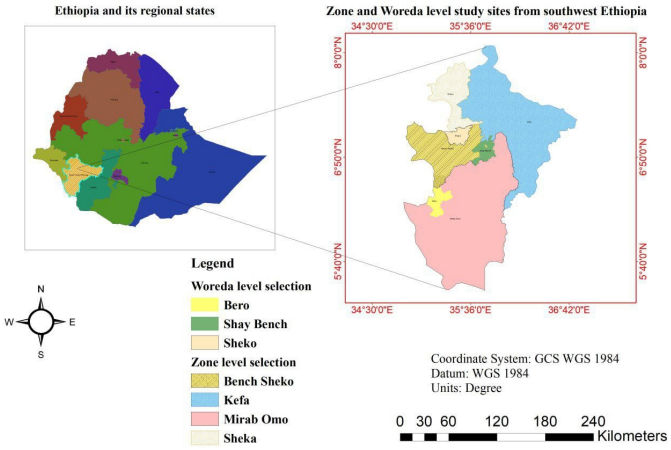


Fig. 1. Map of The Study areas

Data Collection and Study Location

The data used in this research paper was collected through a survey among 7252 indigenous Sheko cattle in different places in South West Ethiopia such as Bench-Sheko, South West Omo, Sheka and Kaffa zones. Eleven quantitative and seven qualitative traits of the cattle were studied. In order to avoid inconsistency in results, all measurements were done by a single recorder. Data collection was conducted at the left side of the cows. Prior to conducting the major survey, a preliminary field survey was carried out in order to find out about the geographical distribution and concentration of the Sheko breed. Survey sites were classified according to the level of concentration into high, medium and low density. Using a standard form, it was noted whether the cattle met the requirements. In the survey process, the circumference was measured using a tape while other measures were recorded using a measuring stick.

Measured traits

The morphometric measurements taken include body length, which is the length from the point of the shoulder joint to the point of the pin bone; height at withers, which is the height from the highest point of the withers to the ground; heart girth, which is the circumference of the chest behind the elbow joint; paunch girth, which is the circumference of the paunch region, anterior to the hip joint; ear length, which is the length from the base to the tip of the ear; face length, which is the length

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from between the horn site to the lower lip; horn length, which is the length from the part of horn attachment to the tip of the horn; and tail length without switch, which is the length from the root of the tail droop to the tip of the tail minus the switch.



Fig. 2. Picture of Sheko Cattle Breed Cooperative Society in Sheybench District, Maha Kebele

Sampling Method

The sample size included the collection of samples from 14 districts in Southern Western Ethiopia where the Sheko cattle breed occurs. The total number of Sheko cattle sampled included 7252 cows on which eleven morphological body measurements and seven qualitative morphological characteristics were measured. Sampling included selection from areas with high, moderate, and low Sheko cattle density. All measurements were measured by one recorder to minimize any possible variations due to the between recorder effect. The geographical distribution and population density were established via a quick field survey. For the circumferences, the measurement was done by a tape measure, whereas other measurements were done by a measuring stick.

Statistical analysis

Statistical analyses were performed for morphometric measurements of the cattle populations using General Linear Model PROC GLM in SAS (2009). Mean, Standard Error, and Coefficients of Variation were determined, considering the effect of state. Discrimination by a stepwise procedure was performed using PROC STEPDISC in order to determine which morphometric traits had greater discriminant capability. Significance levels, Partial R2 and F-statistic values were considered to identify the relative discriminant ability of each morphometric trait. The CANDISC procedure in SAS (2009) was used for a multivariate one-way analysis to determine Mahalanobis distance among sheko cattle populations in the three districts. Canonical variables were used to classify each individual observation into appropriate groups; the percent of individuals classified into the correct groups was taken as a measure of the efficiency of the canonical procedure. DISCRIM procedure of SAS (2009) was used for an unbiased determination of error rate and morphological discrimination among cattle populations through the proportion of correct reallocation of individuals.

Results

Canonical discriminant analysis

Canonical discriminant analysis is a statistical tool applied to explain the relationships between predictor variables and criterion variable. In this case, the Sheko cattle breed population was analyzed using canonical discriminant analysis to establish relationships between predictor variables and criterion variable. From Table 1 below, the results show the standardized canonical coefficients and canonical correlations with total variations explained for each canonical variable. The first canonical variable explains 83.1% of total variation while the second canonical variable explains 16.9% of total variation. Thus, two canonical variables explain 100% of total variation. However, when looking at predictor variables that explain each canonical variable, it emerged that Cannon bone circumference and Cannon bone length played key roles in the extraction of the first canonical variable. On the other hand, the extraction of the second canonical variable was influenced by Ear length and Face length. Particularly, Cannon bone circumference and Face length are highly weighted predictor variables in the first and second canonical variables, respectively. The high canonical correlations found between the Sheko cattle populations and the first canonical variable (rc = 0.83) and the second canonical variable (rc = 0.56) indicate that the canonical variables satisfactorily account for the variation among the Sheko cattle breeds populations. In particular, the importance of the first canonical variable (Can1) was more prominent as far as accounting for the majority of variation is concerned. Thus, from the results obtained from the analysis, it can be concluded that the two important variables used in the discrimination of the Sheko cattle breed population are the Cannon bone circumference and Face length.

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TABLE 1
TOTAL CANONICAL STRUCTURE BASED ON MORPHOMETRIC AND MORPHOLOGICAL FEATURES OF SHEKO CATTLE BREED

Variable	Can 1	Can 2
Variation (%)	83.1	16.9
Canonical Correlation	0.83	0.56
Total Standardized Canonical Coefficients		
BL	0.0481	0.0053
CBC	0.3556	-0.9735
CBL	0.2064	-1.0066
EL	0.0050	0.0500
FL	0.1531	0.1207
HG	0.0020	-0.0081
HW	-0.0172	0.0091
HL	-0.7143	0.0052
HC	0.0240	-1.2632
RH	0.0253	0.0079
DW	0.1584	-0.5700
MC	-0.0193	-0.0655
NFW	-0.8199	0.0918
TL	-0.1528	-0.4587
PW	0.0613	0.0870
NL	0.0107	0.0727
PSWP	-0.7182	0.0799

BL = Body Length; CBC = Cannon Bone Circumference; CBL = Cannon Bone Length; EL = Ear Length; FL = Face Length; HG = Heart Girth; HW = Height at Withers; HL = Horn Length; HC = Horn Circumference; RH = Rump Height; DW = Dewlap Width; MC = Muzzle Circumference; NFW = Neck Fold Width; TL = Tail Length; PW = Pelvic Width; NL = Neck Length; PSWP = Pin-to-Shoulder Width Projection.

TABLE 2
MAHALANOBIS DISTANCES AMONG SHEKO CATTLE POPULATIONS BASED ON MORPHOMETRIC AND MORPHOLOGICAL CHARACTERISTICS

From Population	Pairwise Squared Mahalanobis Distance		
	Biro	**Sheko**	**Shi Bench**
Biro	0.00000	10.37825	20.50619
Sheko	10.37825	0.00000	4.56347
Shi Bench	20.50619	4.56347	0.00000
Probability ($P >$ Mahalanobis Distance)			
	Biro	**Sheko**	**Shi Bench**
Biro	1.0000	< 0.0001	< 0.0001
Sheko	< 0.0001	1.0000	< 0.0001
Shi Bench	< 0.0001	< 0.0001	1.0000

Mahalanobis distance

Mahalanobis distance among all pairs of Sheko cattle breeds populations was found to be very significantly $P < 0.001$. As depicted in Table 2, a high distance value of 20.5 was noted between the Biro and Shi Bench populations which could be explained by the geographical separation of these herds resulting in the disruption of gene flow. On the other hand, the distance value of 4.5 was noted between Sheko and Shi Bench populations probably because of their closer geographical location. These two populations have common feeding practices and possess similarity in body size and length as shown in Table 2. In addition, the Sheko cattle breed's populations have phenotypically homogenous populations.

Stepwise discriminate analysis

Table 3 shows the results of the stepwise discriminate analysis in relation to the Sheko cattle breed population. Stepwise discriminate analysis performed to determine the level of significance of each trait with regard to their discrimination capacity indicated face length as the most significant variable (partial R2=0.43). Other variables were cannon bone circumference, horn length, and body length, having partial R2 values of 0.23, 0.12, and 0.13 respectively. These findings are in agreement with previous studies (Albero, 1981), which indicated that the Sheko cattle breed usually displays an elongated face of a rectangular shape with a wide muzzle. These six morphological variables have great significance and can be used as classification indicators in order to differentiate between the three different cattle populations. The use of such morphological variables in selection and breeding programs will contribute to increasing the effectiveness of breeding efforts.

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TABLE 3
STEPWISE SELECTION SUMMARY FOR SHEKO CATTLE BREED POPULATION

Step	Variable entered	Partial-R^2	F-value	Pr > F	Wilk lambda	Pr < lambda	Average squared canonical correlation	Pr > ASCC
1	FL	0.4337	94.60	< 0.0001	0.56625307	< 0.0001	0.21687346	< 0.0001
2	CBC	0.2300	36.74	< 0.0001	0.43601401	< 0.0001	0.30948184	< 0.0001
3	HL	0.1253	17.54	< 0.0001	0.38140027	< 0.0001	0.34165759	< 0.0001
4	BL	0.1300	18.22	< 0.0001	0.31183629	< 0.0001	0.37149117	< 0.0001
5	PW	0.0792	10.46	< 0.0001	0.30554370	< 0.0001	0.39536068	< 0.0001
6	TL	0.0783	10.28	< 0.0001	0.28162723	< 0.0001	0.42294671	< 0.0001
7	CBC	0.0704	9.13	0.0002	0.26178719	< 0.0001	0.43941828	< 0.0001
8	HC	0.0451	5.67	0.0039	0.24998035	< 0.0001	0.45685437	< 0.0001
9	NL	0.0502	6.31	0.0021	0.23743866	< 0.0001	0.47572709	< 0.0001
10	PSWP	0.0300	3.68	0.0267	0.23031987	< 0.0001	0.48210040	< 0.0001
11	NFB	0.0560	7.03	0.0011	0.21741813	< 0.0001	0.49584638	< 0.0001
12	RH	0.0176	2.11	0.1229	0.21359027	< 0.0001	0.49884697	< 0.0001

Body Length; CG = Chest Girth; HW = Height at Wither; EL=Ear Length; PW=Pelvic Width ;HL=Horn Length; HL = Heart girth; FC=Face Length; DW=Dewlap Width; NL=Neck Length; MC=Muzzle Circumference; TL=Teal Length; CBN=Canon Bone Circumference; CBC=Canon Bone Length; EL=Ear Length.

Discriminate analysis

The discriminant function analysis was used to properly classify the individuals of Sheko cattle breeds based on their specific breeds. As presented in Table 4, Biro, Sheko, and Shi Bench were properly classified based on their specific breeds with an accuracy rate of 88.57%, 79.63%, and 77.57%, respectively. On the average, there were 18.1% of individuals misclassified in other breeds. The largest amount of misclassification was observed in the comparison between Biro and Shi Bench breeds. This indicates that the genetic difference between the two breeds is high compared to the Sheko and Shi Bench breeds. This suggests that there is a higher breed homogeneity in the Sheko breed than the Shi Bench breed.

TABLE 4
PERCENTAGE OF INDIVIDUAL COWS CLASSIFIED INTO DIFFERENT POPULATIONS

From Woredas	Biro	Sheko	Shi Bench	Total
Biro	31 (88.57)	4 (11.43)	0 (0.00)	35 (100)
Sheko	3 (2.78)	86 (79.63)	19 (17.59)	108 (100)
Shi Bench	0 (0.00)	24 (22.43)	83 (77.57)	107 (100)
Total	34 (13.60)	114 (45.60)	102 (40.80)	250 (100)
Prior	0.140	0.432	0.428	–

Genetic Diversity and Correspondence Analysis

Results of the current study concerning the distribution of Sheko cattle populations, obtained through the application of correspondence analysis, corroborate findings from earlier studies performed on native Ethiopian cattle (Alemu et al., 2017; Tadesse et al., 2014). Like these earlier studies, genetic and phenotypic differences were found to exist between cattle populations of diverse geographical origins.

Variations among Populations and Principal Dimensions

The results showed that the main factors contributing to variation are reflected in the first two dimensions, where the majority of total variability in the data set was explained. This is supported by the findings of previous research works (Getachew et al., 2018), according to which it is proven that the first two dimensions in correspondence analysis usually explain the bulk of genetic differences between cattle breeds in Ethiopia. The Sheko cattle breed was significantly represented within these two dimensions.

Distribution and Clustering of Sheko and Shi Bench Populations

The central tendency of the Sheko breed cattle population was characterized by being highly clustered around the axes, with medium level of variability among the individuals, which implies very close genetic affinity of this particular breed population. On the other hand, the Shi Bench cattle population was widely spread away from the axes, suggesting high levels of intra population variability, meaning that the Shi Bench breed represents another genetic breed altogether. This finding is akin to what (Tsegaye et al., 2016) found for the Shibench breed.

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Population Variability and Clustering Patterns

The result of the correspondence analysis clearly showed clustering patterns between the different populations. For instance, the Biro cluster had a wide spread pattern in the first dimension, suggesting high genetic diversity, and this was in line with observations made by (Yohannes et al., 2015). On the other hand, the Sheko and Shibench were found to be tightly clustered together, representing close associations, which is in agreement with the observation made by (Mekonen et al., 2019).

Population Structure and Implications

As indicated from the analysis, there is substantial genetic diversity within and between the populations of Ethiopian cattle. It has been clearly shown that the distribution pattern of Shi Bench makes it a distinctive breed as pointed out earlier by (Hailu et al., 2013). It is therefore important to maintain the genetic diversity of the local breeds of cattle in Ethiopia.

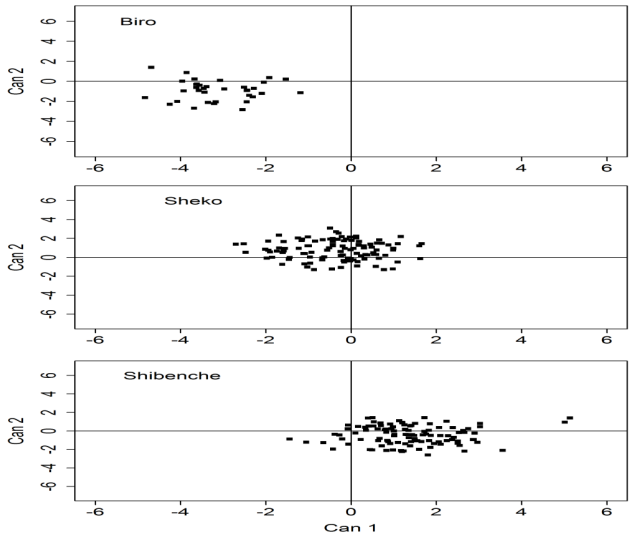


Fig. 3. A dimensional representation is depicted, showcasing the classification of individuals sampled from each concentration area of the Sheko cattle breed in the correspondence analysis

Conclusions

From the results obtained from the study, it can be concluded that there exist variations in the morphological and morphometric parameters of the Sheko cattle breed populations; however, the differences lie within the acceptable levels in relation to breed standards. Using discriminant analysis, the following parameters were identified as the most important parameters for the differentiation among Sheko cattle breed populations: face length, cannon bone circumference, horn length, and body length. The population of the Sheko cattle breed from the Shi Bench district showed a higher proportion of pure characteristic features than those from other districts. This result could be useful for future breeding programs. Remarkably, the highest genetic distance was observed in Biro district as compared with those from Shi Bench and Sheko districts. This implies that the risk of genetic erosion is relatively higher in this district than in other regions of Ethiopia. Accordingly, there is a need for immediate measures to develop suitable conservation programs for Sheko cattle breed populations in Biro district to preserve their genetic diversity. Thus, further studies involving molecular characterization should be performed in order to establish the genetic status of the Ethiopian Sheko cattle breed.

Acknowledgments

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