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MULTIVARIATE ANALYSIS OF PHENOTYPIC DIFFERENTIATION IN BUNAJI AND SOKOTO GUDALI CATTLE

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Multivariate analysis of phenotypic differentiation in Bunaji and Sokoto Gudali cattle

The study aimed at examining morphometric differentiation in two Nigerian breeds of cattle using multifactorial discriminant analyses. Ten morphological traits (withers height, rump height,chest circumference, body length, face length, tail length, rump length, head width, rump width and shoulder width) of 224 Bunaji and 87 Sokoto Gudali cattle were measured. The animals, which were aged 2.5–3.6 years, were subjected to extensive management system. The linear type traits of Sokoto Gudali cattle were significantly ($P < 0.05$) higher than those of their Bunaji counterparts, with the exception of body length and face length respectively. The stepwise discriminant analysis gave a better resolution as only three variables, rump width, withers height and face length were more discriminating in separating the two cattle breeds. The Mahalanobis distance (7.19) between the two cattle populations was high and significant, which is an indication that they belong to genetically different groups. This was complemented by the result of the Nearest Neighbour Discriminant Analysis, where 85.48% of Bunaji cattle were classified into their source population while 96.55% of their Sokoto Gudali counterparts were correctly assigned into their source genetic group. The present phenotypic information will be the basis for the establishment of further characterization, conservation and selection strategies for the two Nigerian breeds of cattle.

Key words: cattle / breeds / morphological traits / discriminant analysis / characterization / Nigeria

Multivariatna analiza fenotipskih razlik med "Bunaji" in "Sokoto Gudali" govedom

V študiji smo z multivariatno diskriminantno analizo proučevali morfometrične razlike med dvema nigerijskima pasmama goveda. Merili smo deset morfoloških lastnosti (višina vihra, višina trupa, obseg prsi, dolžina telesa, dolžina glave, dolžina repa, dolžina trupa, širina glave, širina trupa in širina pleč) pri 224 živalih pasme "Bunaji" in 87 živalih pasme "Sokoto Gudali". Živali so bile v ekstenzivni reji, stare med 2,5 ter 3,6 leti. Izmerjene vrednosti za linearne lastnosti živali pasme "Sokoto Gudali" so bile statistično značilno večje ($P < 0,05$) kot pri živalih pasme "Bunaji", izjema sta bila le dolžina telesa in dolžina glave. Za doseganje boljše resolucije smo uporabili postopno diskriminantno analizo, ker so le tri spremenljivke, širina telesa, višina vihra in dolžina glave, omogočile zanesljivo ločevanje obeh pasem. Mahalanobijeva distanca (7,19) med obema pasmama je bila visoko statistično značilna, kar nakazuje, da populaciji pripadata različnim pasemskim skupinam. Te rezultate potrjuje tudi diskriminantna analiza najbližjih sosedov, kjer je bilo 85,48% "Bunaji" goveda razvrščenega v izvorno populacijo, medtem, ko je bil ta odstotek pri "Sokoto Gudali" pasmi še višji (96,55). Tako pridobljene fenotipske informacije bomo uporabili za še natančnejši opis , zaščito in oblikovanje rejske strategije obeh nigerijskih pasem goveda.

Ključne besede: govedo / pasme / morfološke lastnosti / diskriminantna analiza / karakterizacija / Nigerija

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1 INTRODUCTION

The wide range of breeds and species that have evolved in various environments represent unique sets of genetic diversity. Genetic diversity has been defined as the variety of alleles and genotypes present in a population, and this is reflected in morphological, physiological and behavioural differences between individuals and populations (Frankham *et al*., 2002). It is generally accepted that the highest amount of genetic diversity in the populations of livestock is found in the developing world where record keeping is poor, and the risk of extinction high and on the increase. Recently, loss of genetic diversity within indigenous livestock breeds has been a major concern (Kastelic *et al*., 2005). Every year many species and breeds of animals become extinct thereby decreasing the biodiversity and genetic variation of populations. Thus, breeds and species that have a tradition of breeding for many a centuries, a unique genotype and aesthetic and cultural value are being lost (Macijauskiene and Juras, 2003; Adamczyk *et al*., 2008). Hence, need for sustainable management and conservation strategies for these animal genetic resources. Since the breed is the operational unit for the assessment of livestock diversity all over the world (Duchev and Groeneveld, 2006), contributions to characterization of local domestic animal populations are of major importance in developing countries.

Characterization of livestock breeds is the first approach to a sustainable use of its animal genetic resources (Lanari *et al*., 2003). The first step of the characterization of local genetic resources is based on the knowledge of variation in the morphological traits (Delgado *et al*., 2001). Morphometric measurements have been used to evaluate the characteristics of various breeds of animals, and could provide useful information on the suitability of animals for selection (Nesamvuni *et al*., 2000; Rastija *et al*., 2004; Araujo *et al*., 2006; Mwacharo *et al*., 2006; Martins *et al*., 2009; Yakubu, 2010). The outcome of genetic improvement programmes could also be evaluated on morphological basis (Riva *et al*., 2004). Although recent analyses have focused on molecular techniques, most mammalian species and subspecies originally were described on the basis of morphological characteristics (Feldhamer *et al*., 2004). Previous efforts on the phenotypic characterization of breeds of livestock have been restricted to the use of analysis of variance, whereas the current trend in livestock classification involves the use of multivariate statistical tools (Traore *et al*., 2008; Yakubu and Akinyemi, 2010). This is because univariate statistical analysis, according to Dossa *et al*. (2007), analyze each variable separately and do not explain how the populations under investigations differ when all measured morphological variables are considered jointly. Multifactorial discriminant analyses have been found to be more suitable in assessing variation within a population and can discriminate different population types when all measured morphological variables are considered jointly.

Cattle are the single most important livestock species in Nigeria in terms of animal protein, value and biomass (Tewe, 1998). However, information is scanty on the morphological characteristics of indigenous cattle especially the Bunaji and Sokoto Gudali which constitute 37.2 and 31.6% of the Nigerian cattle herd of 13,770,641 (RIM, 1992). The research questions are: How morphologically heterogeneous are Nigerian breeds of cattle? And has the classification of Nigerian cattle into different breeds any scientific support? The general objective of the study is to characterize two indigenous cattle breeds of Nigeria based on morphological variation using multivariate discriminant analyses, which could help in proper management, conservation and genetic improvement of the local stock.

2 MATERIALS AND METHODS

2.1 EXPERIMENTAL ANIMALS AND LOCATION OF STUDY

The experiment made use of a random sample of 211cattle of both sexes, comprising 124 Bunaji and 87 Sokoto Gudali, respectively. The animals were 2.5–3.6 years old as determined by dentition. They were reared through the extensive management system and originated from different herds sampled in Nasarawa state, north central Nigeria. Efforts were made to restrict sampling to phenotipically pure Bunaji and Sokoto Gudali cattle respectively by measuring only those that conformed to the classification descriptors of both breeds.

2.2 MEASURED TRAITS

Ten morphometric traits were measured on each animal. The body parameters were withers height (WH), rump height (RH), chest circumference (CC), body length (BL), face length (FL), tail length, rump length (RL), head width (HW), rump width (RW) and shoulder width (SW). Anatomical reference points were as earlier described (Yakubu *et al*., 2009). The height measurement (cm) was done using a graduated measuring stick. To achieve this, animals were placed on a flat ground and held by two field assistants. The length and circumference measurements (cm) were effected using a tape rule while the width measurements (cm) were taken using a calibrated wooden calliper. All measurements were car-

Table 1: *Descriptive statistics of morphological traits of Bunaji and Sokoto Gudali cattle*
Preglednica 1: *Opisna statistika morfoloških lastnosti "Bunaji" in "Sokoto Gudali" goveda*

	Bunaji			Sokoto Gudali		
Traits	Mean ± SE	SD	CV	Mean ± SE	SD	CV
Withers height	111.84 ± 0.98[b]	10.87	9.72	127.50 ± 0.53[a]	4.97	3.90
Rump height	120.34 ± 1.01[b]	11.20	9.31	149.53 ± 1.55[a]	14.43	9.65
Chest circumference	141.94 ± 1.62[b]	18.07	12.73	181.15 ± 1.92[a]	17.89	9.88
Body length	175.29 ± 2.25[a]	25.04	14.28	179.02 ± 1.55[a]	14.41	8.05
Face length	52.88 ± 0.49[a]	5.48	10.36	53.28 ± 0.34[a]	3.19	5.99
Tail length	76.81 ± 0.97[b]	10.80	14.06	84.27 ± 0.41[a]	3.87	4.59
Rump length	39.06 ± 0.42[b]	4.73	12.11	42.17 ± 0.31[a]	2.91	6.90
Head width	15.54 ± 0.14[b]	1.60	10.30	21.15 ± 0.41[a]	3.80	17.97
Rump width	33.32 ± 0.44[b]	4.95	14.86	50.43 ± 1.02[a]	9.47	18.78
Shoulder width	28.94 ± 0.43[b]	4.77	16.48	31.79 ± 0.28[a]	2.58	8.12

SE – Standard error, SD – Standard deviation, CV – Coefficient of variation.
Means in the same row with different superscripts are significantly different ($P < 0.05$)

ried out by the same person in order to avoid between-individual variations.

2.3 STATISTICAL ANALYSIS

The morphological traits were subjected to analysis of variance to determine genotype effect using the MEAN procedure of SPSS (2001). Means were separated using the two-tailed, two-sample t-test of the same statistical package. Stepwise discriminant procedure (SAS, 1999) was applied using PROC STEPDISC to determine which morphological traits have more discriminant power than others. The relative importance of the morphometric variables in discriminating between the two cattle populations was assessed using the level of significance, partial R^2 and F-statistic. The CANDISC procedure was used to perform univariate and multivariate one-way analysis that calculated the Mahalanobis distance between the two cattle breeds. The ability of these canonical functions to assign each individual animal to its breed was calculated as the percentage of correct assignment to each genetic group using the DISCRIM procedure (Nearest Neighbour Discriminant Analysis).

3 RESULTS AND DISCUSSION

Descriptive statistics of the morphological traits of Bunaji and Sokoto Gudali cattle are presented in Table 1. Generally, the linear body measurements of Sokoto Gudali were significantly ($P < 0.05$) higher than those of the Bunaji cattle with the exception of body length and face length respectively. Comparative measurements of morphometric traits can provide evidence of breed relationships and size. The considerable variation in body dimensions of the two cattle breeds might not be unconnected with individual breed's potential and peculiarities. While the Bunaji cattle is noted for milk production, their Sokoto Gudali counterparts which rank second in milk production produce more meat and appear to have more draught power than the former. The estimates obtained for height at withers of adult cattle in this study are comparable to those of the Nandi (110–122 cm), Mongalla (100–110 cm) (Rege, 1999), Mexican Criollo Chinampo (101–117 cm) (Espinoza *et al.*, 2009) and Sudan Baggara (115.9–148.80 cm) (Alsiddig *et al.*, 2010) cattle, respectively. The chest circumference values are, however, higher than the range of 122–127 cm reported for North Bengal Grey cattle in Bangladesh (Al-Amin *et al.*, 2007).

Table 2: *Summary of stepwise selection of traits*
Preglednica 2: *Povzetek postopnega izbora lastnosti*

Step	Variables entered	Partial R^2	F-value	Pr > F	Wilk's Lambda	Pr < lambda	Average squared canonical correlation	Pr > ASCC
1	RW	0.5824	291.54	< 0.0001	0.417550	< 0.0001	0.582	< 0.0001
2	WH	0.0948	21.67	< 0.0001	0.362555	< 0.0001	0.637	< 0.0001
3	FL	0.0408	8.85	0.0033	0.400504	< 0.0001	0.599	< 0.0001

RW – rump width, WH – withers height, FL – face length.

The stepwise discriminant analysis showed that rump width, withers height and face length were the most discriminating variables between Bunaji and Sokoto Gudali cattle (Table 2). Their respective partial R^2 and F-values were 0.5824, 0.0948 and 0.0408; 291.54, 21.67 and 8.85 with high significant values ($P < 0.01$–$P < 0.0001$). Morphological variables are easy to monitor and may facilitate the use of ethnological characterization and at the same time institute reliable racial discriminants (Herrera *et al*., 1996). The three morphological variables obtained in the present study are more important and informative, and could be used to assign the two cattle breeds into distinct populations, thereby reducing the errors of selection in future breeding and selection programmes.

Table 3: *Mahalanobis distance between Bunaji and Sokoto Gudali cattle*
Preglednica 3: *Mahalanobijeve distance med "Bunaji" in "Sokoto Gudali" govedom*

Breed	Bunaji	Sokoto Gudali
Bunaji	0	7.19
Sokoto Gudali	7.19	0

The Mahalanobis distance matrix is given in Table 3. The pairwise distance (7.19) between the two cattle breeds was highly significant ($P < 0.001$). This was substantiated by the classification result (posterior probability of membership in each population). While 85.48% of Bunaji cattle were classified into their source population, 96.55% of their Sokoto Gudali counterparts were correctly assigned into their source genetic group (Table 4). The high morphological distance between the two cattle populations coupled with high correct assignment to source genetic groups is an indication that they belong to different breeds. This could have been facilitated by the fact that measurements were restricted to phenotypically pure animals. The use of multivariate discriminant analyses therefore could be successfully used in morphometric differentiation. This is similar to the reports of previous workers on goats (Dossa *et al*., 2007, Yakubu *et al*., 2010a,b and c), sheep (Traore *et al*. 2008; Yakubu and Akinyemi, 2010), cattle (Ndumu *et al*., 2008) and buffalo (Johari *et al*., 2009) respectively.

Table 4: *Percent (%) of individual cattle classified into breed*
Preglednica 4: *Odstotek (%) osebkov, razvrščenih v posamezno pasmo*

Breed	Bunaji	Sokoto Gudali
Bunaji	85.48	14.52
Sokoto Gudali	3.45	96.55
Error level	0.15	0.03
Priors	0.50	0.50

The general aim of genetic conservation is to maintain within and across breed diversity, where within breed diversity refers to the genetic management of one population and the across breed diversity implies the genetic management of many populations. Within breed diversity it is needed for the breed to genetically adapt to changes in the production and economic environment, and to avoid inbreeding problems. Across breed diversity is needed to provide alternatives if a breed happens to run into genetic problems due to genetic drift or changes in the production systems (Meuwissen, 2009). Population studies which elucidate the relationship existing between the different breeds of a given species may offer useful information for the conservation and management of animal genetic resources (AnGR) such as the evolution of the breeds, the development of gene pools and the magnitude of genetic differentiation. According to Mariante *et al*. (2008), national AnGR conservation programmes should use the association of phenotypic data, molecular polymorphisms and adequate statistical methods which reflect the real condition of a population. This was buttressed by Berthouly *et al*. (2010) who studied genetic diversity of Vietnamese H'mong cattle using multivariate analysis on morphometric and genetic data. The present information on the phenotypic differentiation of Bunaji and Sokoto Gudali could therefore be exploited in designing appropriate strategies for their management and conservation. However, there is a need for a genetic study using protein and DNA microsatellite markers to complement the results arisen from morphometric differentiation of the two most populous Nigerian breeds of cattle.

4 CONCLUSIONS

This study showed that Sokoto Gudali had higher mean values in withers height, rump height, chest circumference, tail length, rump length, head width, rump width and shoulder width compared to their Bunaji counterparts. The two cattle breeds were not significantly different in body length and face length respectively. However, rump width, withers height and face length were found to be the most discriminating variables to assign Bunaji and Sokoto Gudali cattle into distinct genetic groups. However, the present information on the morphometric differentiation of Bunaji and Sokoto Gudali breeds of cattle could be complemented with genetic characterization using biochemical and DNA markers.

This could aid field assessment, management and conservation of the two cattle populations, where the goal is to obtain phenotypically pure local genetic resources for future selection and breeding improvement strategies.

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