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CHARACTERISATION OF SOME NIGERIAN BREEDS OF CATTLE USING MULTIVARIATE ANALYSISON PRODUCTIVE TRAITS AND THEIR RELATIONSHIP

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ABSTRACT

The objective of the study is to establish the existing relationship between Nigerian breeds of cattle using Multivariate analysis of Morphometric and milk trait. A total of 150 animals, 50 per each breed of the Bunaji, Friesian X Bunaji and Gudali were used to study the relationship between breeds sourced from National Animal Production Research Institute (NAPRI). Variables measured were BW: Body Weight (Kg); BL: Body Length (cm); HW: Height at Withers (cm); CW: Chest Width (cm); HG: Heart Girth (cm); RW: Rump Width (cm); TL: Teat Length (cm); RUH: Rear Udder Height (cm); UC: Udder Circumference (cm); TY: Total Yield (Litres); ADY: Average Daily Yield (Litres/day) and LL: Lactation Length (days).Principal component analysis of these variables and multivariate analysis involving genetic distance and classification components between breeds were all computed. From the results, Principal component analysis observed to show factors ranging from 3 in the pooled data to 5 in Bunaji, 6 in Friesian X Bunaji and Gudali breeds. Generally, communalities ranged from 0.30 to 0.99 while proportion of variance accounted for by factors were 47% in the pooled, 48% in Bunaji and 58% in the cross bred and Gudali. Multivariate analysis indicated TY, CW, ADY, RUH, LL, RW, UC, TL and HG as the most discriminating variables among the breeds. The Highest proper classification (84%) was in the Gudali and it indicated greater breed homogeneity. However, multivariate studies clearly indicated manifestation of gene introgression across breeds, as evidenced by the high levels of misclassification in the Bunaji, Friesian X Bunaji and Gudali. There is a need for a genetic study at DNA level to compliment the results arisen from morphometric differentiation of the two most populous Nigerian breeds of cattle in the NAPRI herd.

Keywords: Characterisation**,** Multivariate Analysis, Principal Component Analysis**.**

INTRODUCTION

Genetic characterization of indigenous breeds and their economic traits form one important component as a strategy to expand food production. Several studies have been published on various livestock species in Nigeria (Das and Deeb, 2008). The local indigenous breeds have received less attention due to low performance in productivity which has shifted the interest of the breeders towards temperate cattle breeds to upgrade their local genetic resources. 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 is high and on the increase. Recently, loss of genetic diversity within indigenous livestock breeds has been a major concern (Kastelic*et al*., 2005).

The classical approach to the breeding of superior animals is based on phenotypic variations observed among and between related groups of individuals, but these are only partly due to genetic variations and partly due to environmental influences. There may be however a great variety of genetic variations of a completely different nature that may reflect more accurately the genetic differences and productive efficiency between individuals (Desmaris and Pare, 1974; Vicovan and Rascu, 1989; Charon *et al.,* 1996, Akpa*et al.,* 2010).

Rako*et al.* (1964) observed that higher productivity may be a result of special traits arising from certain processes in the organism and suggested the introduction of selection tests based on markers. Principal components analysis (PCA) is a multivariate technique used mainly to reduce the dimensionality of data by transforming an original group of variables into another group called principal components (Morrison, 1976; Hair *et al.,* 2009). The direct purpose is to reduce a set of data so that it may be described and used easily (Yakubu *et al.*, 2009).A small number of these new variables are usually sufficient to describe the individual without losing too much information. However, principal component analysis (PCA) is a refinement and can explain relationships between biometric traits in a better way when the recorded traits are correlated. It provides information about the relative importance of each variable in characterizing the individuals (Tolenkhomba*et al.*, 2012).Multivariate analysis used to study the different biometric traits in Japanese black cattle, Swiss Dairy Cattle and White Fulani cattle (Fumio *et al*., 1982; Hammock *et al*., 1986; Karacaroen*et al*., 2008). Tolenkhomba*et al.* (2012) measure 18 different biometric traits in Manipuri local cattle in India. Edouard (2018) characterized N'dama cattle breed in two ecological zones of Cote d'Ivoire using linear body measurements through principal component analysis and discriminant analysis. The objective of the study is to establish the existing relationship between Nigerian breeds of cattle using Multivariate analysis of Morphometric and milk trait. A

MATERIALS AND METHODS

Location of the study

The research was conducted at the Dairy Breeding Unit of National Animal Production Research Institute (NAPRI), Shika, Zaria, Kaduna State. NAPRI is geographically located between latitude 11^0 and 12^0N and longitude 7^0 and 8^0E at an altitude of 640m above sea level (Ovimaps, 2013).

Animals and Management

Animals used for this research were sourced in National Animal Production Research Institute (NAPRI). They were raised under semi intensive system of management.

Sampling size and Sampling structure

A total of 150 cattle comprising of equal number of FriesianXBunaji (50) cross, Sokoto Gudali (50) and White Fulani (50) were used for the study.

Breed Recognition

Documented morphological features described by Adu and Ngere (1979) were used as base line markers to ascribe sampled animals to a breed. Individuals that do not strictly conform to primary breed characters and visibly pregnant animals were excluded.

Age Determination

Bio-information of birth date of all the animals used in this study was collected from NAPRI records.

Quantitative Characters

Nine metric characters including body weight and ten linear measurements were taken on each sampled animal. They include: BW: Body weight (kg), BL: Body length (cm), HW= Height at withers (cm), CW: Chest width (cm), HG: Heart girth (cm), RW: Rump width (cm), TL: Teat Length (cm), RUH: Rear udder height (cm), UC: Udder circumference (cm).

Metric Variables

Weights of the animals were taken using a spring balance and walk-in weighing scale (kg). Flexible tape rule was used to take the body measurement. During body measurement animals were made to stand upright and restrained by two assistants in such a way that their heads, necks, and chest were stretched almost in a straight line, each measurement were taken at least three times and the mean recorded to the nearest cm. Reference marks were used for body measurement according to the method of Riva *et al.* (2004) and Salako*et al.* (2007).

Udder Measurements

The Udder and teat measurements were done using flexible tape (cm) as follows:

Udder Circumference (cm): Measured at the widest point of the Udder round it.

Udder height (cm): Measured from the rear attachment of the Udder to the front of it where it blends with the body.

Teat length (cm): measured as the distance from the upper part of the teat, where it hangs perpendicularly from the Udder to the tip of the teat.

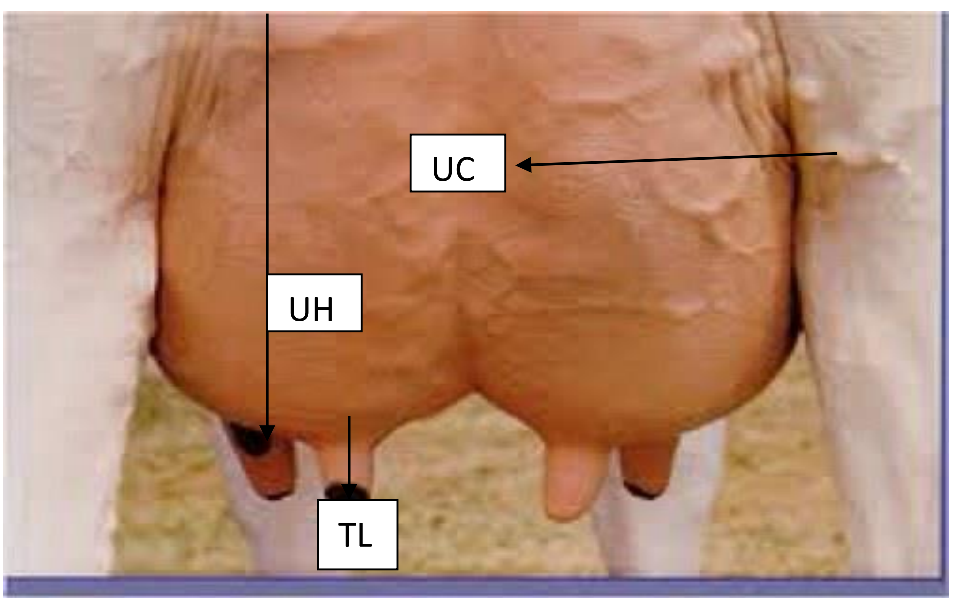

Plate A: Showing Udder Measurement

Key: UC: Udder Circumference, UH: Udder Height, TL: Teat Length

Milk Yield Characteristics

Milk yield characteristics were measured as follows:
Average Daily Yield (ADY): - As average of all test day yields within the milking period.
Total Yield (TY): - As milk production during the lactation period up to the point where the production of the cow dropped below 100ml.
Lactation Length (LL): - As the period from calving to the point when the milk yield of the cow falls below 100ml

Statistical Analysis

Multivariate Principal Component Analysis.
In order to have precise level of variation and more reliable estimates, data for the principal component factor analysis was generated which was the primary data required for PCA.Bartletts test of sphericity was used to test if the correlation matrix will be an identity matrix (each variable correlated with itself). The suitability of the data set to PCA was further be tested by Kaiser-Mayer-Olkin (KMO) measure of sampling adequacy.

The principal component analysis was used to transform variables in a multivariate data format, $x_{1,}$ x_2…..... x_p into newly uncorrelated variables y_1, y_2…….y_p. This accounted for decreasing proportions of the total variance in the original variables that was defined as follows (Everitt*et al*., 2001):

$$y_1 = a_{11}X_1 + a_{12}X_2 + \cdots ... + a_{1p}X_p$$
$$y_2 = a_{21}X_1 + a_{22}X_2 + \cdots ... + a_{2p}X_p$$
$$y_p = a_{p1}X_1 + a_{p2}X_2 + \cdots ... + a_{pp}X_p$$

The principal components y_1, y_2…. y_p account for decreasing proportions of the total variance in the original variables x_1, x_2….x_p. Variance maximizing orthogonal rotation was used in the linear transformation of the factor pattern matrix in order to make the interpretation of the extracted principal components easier and was executed using SAS 9.2 (2003).

Discriminant Analysis
The ability of these canonical functions to assign each individual animal to its breed was judged as the percentage of correct assignment to each genetic group using the DISCRIM procedure (Nearest Neighbour Discriminant Analysis) as applied using SAS 9.2 (2003).

RESULTS.

Multivariate Principal Component Analysis.
Principal Component Analysis of Morphometric Traits for all Breeds
Table 1. Presents the share of total variance, factor loading and Eigen value of principal components of morphometric and milk traits pooled for all the breeds of cattle. The factor pattern coefficients were used to assess the relative contributions of the various body measurements in determining the numerical value of the corresponding factor (principal component). Three components were extracted from the original 12; PC1 with Eigenvalue of 2.73 accounted for 23% of total variation observed with loadings for Total Yield (TY) and Average Daily Yield (ADY). PC2 (1.78) and PC3 (1.07) accounted for 15 and 9 % respectively and loaded for Chest Width (CW) and Rump Width (RW); and Body weight (BW) and Teat Length (TL) respectively. Communality estimates ranged from 0.06 to 0.99.

Table 1: Principal Component Analysis of Studied Traits for all Breeds

Traits	PC1	PC2	PC3	Communality
BW	0.19	0.11	-0.54	0.53
BL	0.19	0.09	0.04	0.34
HW	0.06	0.32	0.27	0.73
CW	0.02	0.60	-0.04	0.53
HG	-0.09	0.21	0.41	0.36
RW	-0.12	0.49	-0.04	0.49
TL	0.18	-0.17	0.59	0.99
RUH	0.38	-0.30	0.07	0.99
UC	0.12	-0.11	-0.34	0.29
TY	0.54	0.08	0.00	0.06
ADY	0.51	0.02	0.01	0.47
LL	0.40	0.30	0.03	0.71
Eigenvalue	2.73	1.78	1.07	
% Variance	23	15	9	

Keys: BW: Body weight (Kg); BL: Body Length (Cm); HW: Height at withers (cm); CW: Chest width (cm); HG: Heart Girth (cm); RW: Rump width (cm); TL: Teat Length (cm); RUH: Rear Udder Height (cm); UC: Udder Circumference (cm); TY: Total Yield (Litres); ADY: Average Daily Yield (Litres/day) and LL: Lactation Length (days).

Principal Component Analysis of Morphometric Traits in the Bunaji

Table 2 presents the PC for the Bunaji indicating share of total variation, Eigenvalues and factor loadings. Five components were extracted from the initial 12. PC1 showed Eigenvalue of 1.36 and 11% of total variation, it loaded for Heart Girth (HG), RWi and negatively for TY, PC2 had 10% of the total variation and 1.22 Eigenvalue and loaded for TL negatively and positively for Udder circumference (UC). PC3, PC4 and PC5 accounted for 9% of total variation each with Eigenvalues of 1.13, 1.12 and 1.03 respectively. PC3 loaded for Body length negatively, PC4 loaded negatively for CW and positively for ADY and PC5 loaded for CW and negatively for Lactation Length (LL). Communality estimates ranged from 0.32 to 0.89.

Principal Component Analysis of Morphometric Traits in the Friesian X Bunaji

Principal component analysis of morphometric and milk traits in the Friesian X Bunaji cross is presented in Table 4.17. Six factors were extracted, share of total variance and Eigenvalue were (11%, 10%, 10%, 9%, 9% and 9%) and (1.34, 1.18, 1.14, 1.13, 1.07 and 1.03) respectively. PC1 loaded for TL and RUH, PC2 loaded BL and RUH, PC3 loaded HW and CW, PC4 loaded for RW, TL and ADY, PC5 loaded for HW, HG and UC and PC6 loaded negatively for Communality ranged from 0.30 to 0.97. Principal

Component Analysis of Morphometric Traits in the Gudali

Principal component analysis of morphometric and milk traits in the Gudali is presented in Table 4. Six factors were extracted similar to that of the Friesian X Bunaji cross, share of total variance and Eigenvalue were (11%, 10%, 10%, 9%, 9% and 9%) and (1.27, 1.24, 1.20, 1.10, 1.09 and 1.04) respectively. PC1 loaded for TL, Rear Udder height (RUH) and TY
PC2 loaded CW and negatively for HG, PC3 loaded BW, BL and negatively for LL, PC4 loaded for HG, PC5 loaded for RW and UC and PC6 loaded positively for CW and ADY. Communality ranged from 0.31 to 0.99.

Discriminant analysis of Selection Traits

Individual Cattle classified into breed
The posterior probability of membership of individual cattle in each population is presented in Table 5. The proportion of Bunaji classified as Bunaji was 63.33%, while 36.67% were classified as FriesianXBunaji cross and 0% as Gudali. 26% of Friesian X Bunaji cross were classified as Bunaji, 66% as FriesianXBunaji and 8% as Gudali. 16% of Gudali were classified as Bunaji, 0% as FriesianXBunaji and 84% were correctly assigned as Gudali. Error level of classification was lowest for the Gudali (0.16), while it was similar and higher for the Bunaji (0.37) and Friesian X Bunaji (0.34).

Table 2: Principal Component Analysis of Studied Traits for the Bunaji

Traits	PC1	PC2	PC3	PC4	PC5	Communality
BW	-0.32	-0.17	-0.34	0.02	0.13	0.48
BL	0.25	0.19	-0.48	0.13	-0.11	0.56
HW	0.21	-0.37	0.08	0.37	-0.27	0.74
CW	0.08	0.07	0.24	-0.42	0.59	0.32
HG	0.53	-0.25	0.08	0.14	0.20	0.44
RW	0.49	-0.05	0.19	-0.31	-0.04	0.58
TL	-0.06	-0.45	0.36	0.30	-0.03	0.91
RUH	0.20	0.23	-0.18	0.30	0.02	0.88
UC	0.19	0.56	0.07	0.19	-0.12	0.52
TY	-0.42	0.17	0.34	0.19	-0.05	0.64
ADY	0.04	0.33	0.37	0.45	0.34	0.89
LL	0.05	0.16	0.35	-0.33	-0.62	0.59
Eigenvalue	1.36	1.22	1.13	1.12	1.03	
% Variance	11	10	9	9	9	

Keys: BW: Body weight (Kg); BL: Body Length (Cm); HW: Height at withers (cm); CW: Chest width (cm); HG: Heart Girth (cm); RW: Rump width (cm); TL: Teat Length (cm); RUH: Rear Udder Height (cm); UC: Udder Circumference (cm); TY: Total Yield (Litres); ADY: Average Daily Yield (Litres/day) and LL: Lactation Length (days).

Table 3. Principal Component Analysis of Studied Traits for the Friesian X Bunaji

Traits	PC1	PC2	PC3	PC4	PC5	PC6	Communality
BW	-0.32	0.30	-0.30	-0.13	0.04	0.22	0.6
BL	0.34	0.42	0.19	0.30	-0.14	0.39	0.37
HW	-0.23	0.27	0.41	0.14	0.41	-0.35	0.77
CW	-0.08	-0.29	0.56	-0.30	-0.03	0.15	0.47
HG	0.11	0.01	-0.30	0.01	0.63	0.22	0.41
RW	-0.16	-0.13	-0.20	0.46	-0.01	-0.58	0.47
TL	0.41	-0.13	0.31	0.43	0.23	-0.03	0.97
RUH	0.42	0.45	-0.19	-0.02	-0.23	-0.23	0.97
UC	-0.18	0.35	0.10	0.03	0.42	0.14	0.38
TY	-0.35	0.19	0.25	0.34	-0.36	0.18	0.32
ADY	-0.26	-0.27	-0.22	0.51	-0.03	0.38	0.30
LL	0.34	-0.32	-0.05	0.09	0.10	0.15	0.63
Eigenvalue		1.36	1.18	1.14	1.13	1.07	1.03
Proportion		11	10	10	9	9	9

Keys: BW: Body weight (Kg); BL: Body Length (Cm); HW: Height at withers (cm); CW: Chest width (cm); HG: Heart Girth (cm); RWi: Rump width (cm); TL: Teat Length (cm); RUH: Rear Udder Height (cm); UC: Udder Circumference (cm); TY: Total Yield (Litres); ADY: Average Daily Yield (Litres/day) and LL: Lactation Length (days).

Table 4. Principal Component Analysis of Studied Traits for the Gudali

Traits	PC1	PC2	PC3	PC4	PC5	PC6	Communality
BW	0.07	0.27	0.50	-0.33	-0.24	-0.20	0.54
BL	-0.01	0.03	0.61	0.18	0.00	-0.02	0.37
HW	-0.37	-0.19	0.21	0.24	0.30	-0.06	0.65
CW	-0.16	0.52	-0.13	0.22	0.07	0.47	0.49
HG	0.04	-0.55	-0.06	0.47	-0.20	0.23	0.31
RW	0.08	0.23	-0.06	0.30	0.51	-0.43	0.55
TL	0.45	-0.30	0.02	-0.20	-0.10	-0.18	0.99
RUH	0.57	-0.03	0.18	0.39	0.10	0.12	0.98
UC	0.28	-0.09	0.01	-0.25	0.64	0.06	0.35
TY	0.48	0.37	0.08	0.22	-0.20	0.19	0.52
ADY	0.04	-0.12	0.16	-0.39	0.26	0.63	0.54
LL	0.24	0.14	-0.50	-0.13	-0.08	-0.08	0.89
Eigenvalue	1.27	1.24	1.20	1.10	1.09	1.04	
Proportion	11	10	10	9	9	9	

Keys: BW: Body weight (Kg); BL: Body Length (Cm); HW: Height at withers (cm); CW: Chest width (cm); HG: Heart Girth (cm); RW: Rump width (cm); TL: Teat Length (cm); RUH: Rear Udder Height (cm); UC: Udder Circumference (cm); TY: Total Yield (Litres); ADY: Average Daily Yield (Litres/day) and LL: Lactation Length (days).

Table 4.22: Percent of individual Cattle classified into breed

Breed	Bunaji	Friesian X Bunaji	Gudali
Bunaji	63.33	36.67	0
Friesian X Bunaji	26	66	8
Gudali	16	0	84
Error Level	0.3667	0.34	0.16
Priors	0.3333	0.3333	0.3333

DISCUSSIONS

Principal Component Analysis of Morphometric Traits

The obtained total sum of variance (47%) accounted for by the three PC in the pooled analysis and the five PC in the Bunaji were lower than the percentage of variance reported by Okpekue*t al*. (2011), while the six PC in the Friesian X Bunaji and Gudali (58%) were within the range 55.3-95.2% reported by Yakubu *et al*. (2009) in the Bunaji but comparable to 52.48% in Red Sokoto and 54.49% in WAD goats (Shoyombo, 2014). The loading of PC1 for TYA and ADY across all breeds supports the assertion of positive relationship between milk yield and general body condition based on morphometric composition (Alphonsus *et al*., 2010). The variables associated with factor 2 CW and RW described general body volume and broadness. Ignoring the negative loading, the PC3 loaded for TL. All these loadings showed that most of the animals studied are good milk producer.

Communalities, ranging from 0.31-0.99 for pooled and individual breed were wider than communality estimatesthat ranged from 0.79 to 0.93 asreported by Yakuba*et al*. (2009).Tolenkhomba*et al*.(2012) also reported a communality estimates that ranged from 0.493 (elbow length) to 0.782 (neck circumference) and unique factors ranged from 0.507 to 0.218 for 18 different biometric traits studied. This wideness lends moderate credence to the appropriateness of the factor analysis.It was observed that the components of the Gudali were closer to that of the pooled. However no clear pattern among breeds for corresponding principal components. This may lend credence to differences in breeds with regards to conformational and production traits and can also be attributed to low level of correlation coefficients among traits in this age, since in PCA, the extent to which a set of variables decomposes into fewer factors depends on the level of redundancy (correlations) in original variables (Mavule*et al*., 2013). Since principal components are uncorrelated by definition, the selection to improve body size which is an important target for beef production implies little or no variation in milk production across and within breeds.

Multivariate analysis of Selection Traits

The Observation of TY, CW, ADY, RUH, LL, RW, UC, TL and HG points to the fact that these breeds are different in all traits of interest most especially milk production traits as all traits pertaining to milk production were involved, only CW and HG were discriminating among growth related traits. The Presence of RW as a discriminating factor in this study was in agreement with similar observations of Yakubu *et al*. (2010) in the analysis of phenotypic differentiation in Bunaji and Sokoto Gudali cattle and in the report of Birteeb*et al*. (2012) in sheep, while the observation of CW and HG was contrary to their observation. The use of discriminant analysis for milk production traits scarcely exist in previous literatures, hence, basis of comparison weredifficult to found. According to Herrera *et al*. (1996) Morphological variables are easy to monitor and may facilitate the use of ethnological characterization and at the same time institute reliable racial discriminants. The three variables obtained in the present study are more important and informative and could be used to assign the cattle breeds into distinct populations, thereby reducing the errors of selection in future breeding and selection programmes especially in a research institute like NAPRI.

In the classification of studied animals into breeds it was observed that the considerable (37 and 34) erroneous classification of the Bunaji and FriesianXBunajias belonging to each other were comparable to those obtained (30.2-31.7) in classifying the Sahel as the Djallonke sheep (Birteeb*et al*., 2012) and implies gene introgression within the breeding stock probably due to attempt at cross breeding. Similar reason is adduced for the lower error rate (16) encountered in classifying the Gudali as either the Bunaji or the FriesianXBunaji, this error rate was similar to 15% in the Bunaji (Yakubu*et al*., 2010). The higher proper classification (84%) of Gudali compared to the Bunaji was comparable to the findings of Yakubu *et al*. (2010).Traoréet *al*. (2008)haveattributed the cause of large misclassifications to the manifestation of introgressions across breeds resulting from the actions of most stock breeders who intend to obtain productswith bigger conformation. The lower misclassification in the Gudali breed may be an indication ofmore uniformity as a result of more genetic homogeneity ofthis breed than the other two breeds. This inference is further supported by an error rate of 3% established in the Sokoto Gudali (Yakubu*et al*., 2010) compared to the Bunaji. The larger restriction of the Gudali to its ecological zone, and the wide dispersal of the Bunaji may account in part for this observations and inference. It therefore follows that, the gene pool of the Bunaji is been eroded at a faster rate than the Sokoto Gudali counterpart. And efforts should be made to curtail this alarming trend.

CONCLUSIONS

Multivariate studies clearly indicated manifestation of gene introgression across breeds through indiscriminate cross breeding perhaps, as evidenced by the high levels of misclassification in the Bunaji, FriesianXBunaji and Gudali. However, this was more pronounced in the Bunaji herd. Consequently, 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.

RECOMMENDATIONS

There is a need for a genetic study using protein and DNA markers to complement the results arisen from morphometric differentiation of the two most populous Nigerian breeds of cattle in the NAPRI herd.

Effort must be made to correct the erosion of the desired traits of the Bunaji that is building up within the institute's herd in order to conserve their uniqueness. A more detailed study using animals with uniform age of the different breed is further recommended in carrying out relationship analysis based on protein and DNA markers since principal components measures were not sufficient to delineate the relationship and differences among these breeds.

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