MULTIFACTORIAL DISCRIMINANT ANALYSIS OF CEPHALIC MORPHOLOGY OF INDIGENOUS BREEDS OF RAMS IN NIGERIA

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ABSTRACT
The study aimed at classifying Nigerian indigenous rams on the basis of their head conformation using multivariate analyses. Twelve cephalic traits of 1,200 rams belonging to four breeds (Balami, Yankasa, Uda and WAD) were measured. The traits were subjected to principal component analysis to reduce data dimensionality. A discriminant canonical analysis was also applied to differentiate between the breeds. The cephalic index reveals that the ram breeds are brachyprosopic except Uda which is mesocephalic breed. The first principal component (PC) had variables related to length and diameter amplitudes and explained 37.5 percent of the variance. The second PC gave major relevance to skull, face and neck lengths of the rams and contributed to 21.30 percent of the total variance, while the third PC loaded highly for skull length, head depth and neck length and contributed 17.35 percent of the total variance. The stepwise discriminant analysis revealed that skull width, head width, head length and head depth were the most discriminating variables to separate the four breeds of rams.
Keywords: Breeds, cephalic, discriminant analysis, traits.

INTRODUCTION
In Nigeria, sheep are meat producing animals adapted to all ecological zones of the country. They play agricultural, economic, cultural, and religious roles. There are generally considered to be four breeds of sheep native to Nigeria. These are Balami, Uda, Yankasa and West African Dwarf (Ngere *et al.*, 1979). Indigenous sheep breeds are an important storehouse of genetic materials because of their ability to acclimatize to local, sometimes harsh environmental conditions, nutritional fluctuations and resistance to diseases and parasites (Kosgey and Okeyo, 2007). The Global Plan of Action for Animal Genetic Resources recognizes that a better understanding of the characteristics of livestock breeds is necessary for guiding decision making in the development of breeding programs (FAO, 2007). Sheep biodiversity have been described using morphological measurements or characterized using molecular data (Paiva *et al.*, 2011). According to Solomon *et al.* (2007), morphological description is an essential component of breed characterization that can be used to physically identify, describe, and recognize a breed, and also to classify livestock breeds into broad categories. Historically, morphological studies, especially of the skull, were the major source of data used to characterize breeds (Kidd and Pirchner, 1971). Given their biometric nature, cephalic measurements and indices allow comparisons between breeds from very distant geographical areas, and permit research into breeds (Pares and Jordan, 2008). According to Yunusa *et al.* (2013) incorporating more cephalic measurements in principal component analysis (PCA) models combine with biometry of cephalic anatomy will shed more light on the suitability of head measurement for breed classification. Skull morphometric studies within and across sheep breeds based on a relatively large number of specimens and employing multivariate analysis techniques are limited. Thus, this study sought to examine the skull differences among indigenous breeds of rams in Nigeria using their intraspecific variability by means of multivariate analyses via principal component and discriminant analyses.

MATERIALS AND METHODS
The study was conducted in Ibadan, Oyo State, Nigeria. The city is the largest metropolitan geographical area in the country. The 2006 census put the total population of Ibadan to 2,550,593 while the average population density was 828 persons per km2 (NPC, 2006). It is a strategic location where appreciable number of livestock such as cattle, sheep and goat can be found. Thus, all the breeds of sheep are found in

Ibadan as representation of sampling frame for the study. A total of 1,200 individual rams consisting of 300 rams from each breed were sampled from major small ruminant markets in Ibadan and households where ram are raised. Twelve morphostructural traits were measured. These are head width, head length, head depth, face width, face length, skull width, neck length, neck width, horn length, horn circumference, horn space and skull length. The measurements were taken following standard procedure and anatomical reference points described by Parés *et al.* (2012 and FAO (2012).

Data were subjected to multivariate analyses. The data were submitted to preliminary univariate analyses using the procedures UNIVARIATE and FREQ from SAS statistical package SAS 9.13 (2004). The data were then submitted to PCA in order to reduce data dimensionality. Stepwise discriminant procedure was applied using PROC STEPDISC. The CANDISC procedure was used to enable differentiation between the breeds and to derive canonical functions.

RESULTS AND DISCUSSION

Table 1 shows the effect of breeds on the cephalic traits of the rams. Breeds of rams differed significantly in the cephalic traits considered. Results revealed significant differences between breeds in all variables. Uda and Balami had significantly ($P<0.05$) higher mean values of the traits than Yankasa and WAD with the exception of skull length and horn space which were significantly higher in WAD. Highest cephalic index was obtained in Balami (82.66 ± 11.98) followed by Yankasa (82.28 ± 11.65), WAD (82.16 ± 13.02) and Uda (78.35 ± 9.41). On average, the cephalic index reveals that Balami, WAD and Yankasa are brachycephalic (short-headed) breeds having cephalic index values of 82%. A ram is said to be brachycephalic or brachycranial when its cephalic index is greater than 81.1%. A brachycephalic individual is characterized with short and broad skull, flattened and widened occiput. Uda ram is mesocephalic with cephalic index of 78%; this implies that the breed possess narrow or nearly oval skull. Different cephalic index have been reported in previous studies for different animals, cephalic index of 41.95 was reported in goat (Sarma, 2006), 58.45 in 45-60 days old puppies and 51.73 in 61-105 days old puppies (Onar, 1999) and in Mehraban sheep 53.57 was recorded (Karimi *et al.*, 2011).

Table 2 shows the PCA of cephalic traits of ram breeds. The percentage of total variance that best explained the data was summarized in the first three components. The three PCAs jointly explained 76.2 percent of the total variance formed by the traits. PC 1 axis could be linked to variables related to length and diameter amplitudes; PC2 gave a major relevance to skull, face and neck lengths of the ram; whereas PC 3 axis gave a major relevance to skull length, head depth and neck length (Table 3). Yunusa *et al.*, (2013) reported that measurements that were associated with cranial development (head length and head width) tend to load on first component for Uda and Balami which suggested them as classification traits for these sheep. Similar result was reported by Salako (2006) on immature Uda sheep where all parameters considered but skull width, rump length and rump width loaded on the first component.

The canonical (CAN) discriminant analysis identified three statistically significant ($P<0.001$) canonical variables that accounted for 83.04, 3.42 and 13.54 percent of the total variation (Table 4). CAN 1 was dominated by head width and skull width. Skull width, head length and head width were highly correlated with CAN 2. Skull width and head width were highly correlated with CAN 3. Parés *et al.*, (2012) reported on similar study conducted on pyrean cattle and reported that variables that most contributed to the discrimination between breeds were face width and head depth.

CONCLUSION

There are differences in the cephalic traits of these ram populations. On the basis of the cephalic index, the ram breeds are brachyprosopic (short-headed) except Uda which is mesocephalic (medium headed). Traits such as head width, skull width, head length and head depth mostly contributed to the discrimination between the breeds of ram. Large scale sampling is needed to validate the cephalic indices of these ram breeds.

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Table 1: Effect of breeds on cephalic traits of indigenous rams

Traits (cm)	Balami	Uda	WAD	Yankasa
Skull width	10.05 ± 1.37^{b}	10.74 ± 1.42^{a}	9.02 ± 1.62^{c}	9.97 ± 1.52^{b}
Head width	17.60 ± 3.10^{a}	17.53 ± 2.76^{a}	13.53 ± 2.78^{c}	16.39 ± 2.55^{b}
Face width	14.65 ± 2.15^{b}	15.53 ± 3.21^{a}	10.98 ± 2.44^{c}	13.89 ± 2.32^{b}
Skull length	3.63 ± 0.65^{b}	4.17 ± 1.89^{ab}	4.29 ± 1.99^{a}	3.96 ± 2.06^{ab}
Head length	21.35 ± 2.11^{b}	22.41 ± 2.77^{a}	16.27 ± 2.76^{d}	20.03 ± 2.45^{c}
Cephalic index	82.66 ± 11.98^{a}	78.35 ± 9.41^{b}	82.16 ± 13.02^{ab}	82.28 ± 11.65^{ab}
Face length	18.27 ± 2.51^{b}	19.70 ± 3.32^{a}	15.27 ± 2.65^{c}	17.86 ± 3.34^{b}
Head depth	16.38 ± 2.49^{a}	16.27 ± 2.32^{a}	13.91 ± 1.84^{c}	15.55 ± 2.37^{b}
Neck length	25.36 ± 5.49^{ab}	26.86 ± 5.50^{a}	18.96 ± 5.01^{c}	23.90 ± 5.20^{b}
Neck width	39.29 ± 8.85^{a}	39.71 ± 9.34^{a}	30.22 ± 8.15^{c}	36.62 ± 7.80^{b}
Horn length	32.59 ± 9.19^{a}	30.20 ± 10.90^{a}	13.93 ± 6.42^{c}	8.41 ± 14.68^{b}
Horn width	15.78 ± 3.47^{a}	16.11 ± 3.62^{a}	10.21 ± 2.60^{c}	14.68 ± 3.31^{b}
Horn space	3.51 ± 2.54^{ab}	3.34 ± 1.55^{ab}	3.92 ± 1.65^{a}	3.18 ± 1.46^{b}

[abc] Means within the same row having different superscripts differ significantly ($P<0.05$)

Table 2: Extraction of the three first principal components

Principal component	Eigenvalue	Fraction of variance	Cumulative variance
1	5.7251	0.3752	0.3752
2	1.3499	0.2130	0.5882
3	1.1368	0.1735	0.7617

Table 3: Component loading matrix after varimax rotation

Traits (cm)	PC1	PC2	PC3
Skull width	0.238	0.013	**0.524**
Head width	**0.301**	0.153	-0.066
Face width	**0.343**	0.059	-0.104
Skull length	0.041	**0.727**	0.235
Head length	**0.356**	-0.096	-0.066
Face length	**0.323**	**0.443**	0.225
Head depth	0.266	-0.081	**-0.481**
Neck length	0.184	**-0.410**	**0.631**
Neck width	**0.325**	-0.056	-0.147
Horn length	**0.360**	-0.175	0.030
Horn width	**0.360**	-0.135	0.093
Horn space	-0.171	-0.106	-0.173

Table 4: Canonical correspondence analysis of breeds of ram

Traits	Discriminant variates		
	CAN 1	CAN 2	CAN 3
Skull width	0.630	1.000	1.000
Head width	1.000	0.717	1.000
Head length	0.305	0.784	-0.046
Head depth	0.408	0.360	-0.033
Adjusted canonical correlation	0.512	0.713	0.782
Eigenvalue	0.370	1.057	1.596
Variance accounted for (%)	83.04	13.54	3.42
CUMULATIVE VARIANCE (%)	83.04	86.46	100