Morphological characteristics of goat breeds in Nigeria using discriminant analysis approach

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Abstract

Information on morphological characteristics is a prerequisite to sustainable breed classification and conservation for proper management and utilization. The present study aimed to identify morphological characteristics that best classify the Sahel, Sokoto Red and West African Dwarf goats of Nigeria. A total of 584 goats of both sexes; Sahel (N = 163), Sokoto Red (N = 171) and West African Dwarf (N = 250) were randomly sampled and used for this study. The body parameters measured included body weight (BWT), height at wither (HW), body length (BL), paunch girth (PG), heart girth (HG) and ear length (EL). Multivariate technique of discriminant analysis procedure of SPSS 20.0 statistical package was used to classify the Sahel, Sokoto Red and West African Dwarf goats into their original breed. Accuracy of the classification was checked using cross-validation (leave-one-out, jack-knife or split-sample) procedure. Results showed that the mean body weight (kg) of Sokoto Red was significantly ($P < 0.05$) higher than those of Sahel and West African Dwarf goats (23.596, 17.117 and 14.800 respectively). Highest correlation values were recorded between body weight and height at withers (0.777) in Sahel, body weight and paunch girth (0.707) in Sokoto Red and body weight and heart girth (0.797) in West African Dwarf goats. The discriminant analysis on body weight and the linear body measurements revealed that paunch girth and height at withers were the most discriminating variables and clearly separated and classified the three goat breeds into their breeds of origin. The discriminant function obtained correctly classified 99.0% of individuals from the sample of known goat populations. The classification accuracy of the function was cross-validated using the split-sample method, and indicated a 99.0% success rate (97.5%, 100.0% and 99.2% of Sahel, Sokoto Red and West African Dwarf goats respectively). It was concluded that there was a clear separation between Barcha and Atlas goats. It was concluded that discriminant tool may be used successfully in the field to classify Sahel, Sokoto Red and West African Dwarf in the field, however there is need to complement this with molecular characterization using DNA marker for better conservation and improvement programme of indigenous goat genetic resources.

Keywords: Breeds, discriminant analysis, morphological traits, multivariate

Caractéristiques morphologiques des races caprines au Nigeria en utilisant l'approche d'analyse discriminante

Résumé

L'information sur les caractéristiques morphologiques est une condition préalable à la classification et à la conservation durables des races pour une gestion et une utilisation appropriées. Cet étude visait à identifier les caractéristiques morphologiques qui classent le mieux les chèvres sahéliennes, rouges de Sokoto et naines d'Afrique de l'Ouest du Nigeria. Un total de 584 chèvres des deux sexes ; Sahel (N = 163), Sokoto Red (N = 171) et West African Dwarf (N = 250) ont été échantillonnés au hasard et utilisés pour cette étude. Les paramètres corporels mesurés comprenaient le poids corporel (PC), la hauteur au garrot (HG), la

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longueur du corps (BL), la circonférence de la panse (CP), la circonférence du cœur (CC) et la longueur des oreilles (LO). La technique multivariée de la procédure d'analyse discriminante du progiciel statistique SPSS 20.0 a été utilisée pour classer les chèvres sahéliennes, rouges de Sokoto et naines d'Afrique de l'Ouest dans leur race d'origine. L'exactitude de la classification a été vérifiée à l'aide d'une procédure de validation croisée (en laisser un, un couteau ou un échantillon divisé). Les résultats ont montré que le poids corporel moyen (kg) de Sokoto Red était significativement ($P < 0,05$) supérieur à celui des chèvres naines du Sahel et d'Afrique de l'Ouest (23,596, 17,117 et 14,800 respectivement). Les valeurs de corrélation les plus élevées ont été enregistrées entre le poids corporel et la hauteur au garrot (0,777) au Sahel, le poids corporel et la circonférence de la panse (0,707) chez le Sokoto Red et le poids corporel et la circonférence cardiaque (0,797) chez les chèvres naines d'Afrique de l'Ouest. L'analyse discriminante sur le poids corporel et les mesures corporelles linéaires ont révélé que la circonférence de la panse et la hauteur au garrot étaient les variables les plus discriminantes et ont clairement séparé et classé les trois races caprines dans leurs races d'origine. La fonction discriminante obtenue a correctement classé 99,0 % des individus de l'échantillon de populations caprines connues. La précision de la classification de la fonction a été contre-validée à l'aide de la méthode de l'échantillon divisé et a indiqué un taux de réussite de 99,0 % (respectivement 97,5 %, 100,0 % et 99,2 % des chèvres sahéliennes, rouges de Sokoto et naines d'Afrique de l'Ouest). Il a été conclu qu'il y avait une nette séparation entre les chèvres Barcha et Atlas. Il a été conclu que l'outil discriminant peut être utilisé avec succès sur le terrain pour classer le Sahel, le rouge de Sokoto et le nain d'Afrique de l'Ouest sur le terrain, mais il est nécessaire de le compléter par une caractérisation moléculaire à l'aide d'un marqueur ADN pour une meilleure conservation et un programme d'amélioration de la génétique caprine indigène. Ressources.

Mots-clés : Races, analyse discriminante, traits morphologiques, multivarié.

Introduction

Goats are the most numerous of all domesticated ruminants in Nigeria with an estimated population of 79.38 million, representing about 6.56% of the world's goat population (FAOSTAT, 2018). Goats play very significant role in the social and economic livelihoods of rural dwellers, they constitute significant source of milk, meat and skin; goats also serve as a source of income (Adebambo *et al.*, 2011). Information on morphological characteristics is a prerequisite to sustainable breed improvement, utilization and conservation (FAO, 2012). Multivariate analyses using morphological traits have been proved to be suitable in assessing the variation within a population and can discriminate different population (Dossa *et al.*, 2007). Breeds are a homogenous, sub-specific groups of domestic livestock with

definable and identifiable external characteristics that enable it to be classified, using visual appraisal, from other similarly defined groups within the same species (FAO 2000). Discriminant analysis is a statistical procedure to visually classify species or breeds that are morphologically distinct (Setiaji *et al.*, 2012). Discriminant analysis uses a set of prediction equations based on independent variables that are used to classify individuals into groups, thereby reducing errors of selection for future improvement programmes (Yakubu *et al.*, 2010).

Some researchers have used discriminant analysis procedures to classify various farm animals into groups using; morphometric parameters on West African Dwarf and Red Sokoto goats (Yakubu *et al.*, 2010), body weight and linear body measurements on three Saudi goat types (Aziz and Al-Hur,

2013), morphometric on West African Dwarf Goats in south-eastern Nigeria (Ebegbulem *et al.*, 2011) and morphometric characterization of Nigerian indigenous sheep (Yunusa *et al.*, 2013). Discriminant analysis allows us to understand the differences between populations and predict the class or group which individuals belong to. The objective of the present study was to evaluate morphological characteristics of the three Nigerian indigenous goat breeds using discriminant analysis approach. The information obtained from this study will provide basis for effective identification, conservation, management and utilization of the goat genetic resources in Nigeria.

Materials and methods

Description of the study location

The study was carried out across locations in three States (Benue, Katsina and Sokoto states) of Nigeria. Locations were selected based on the preponderance of the breed in the area.

Experimental animals and management

Three Nigerian indigenous goat breeds, namely: Sahel (SAH), Sokoto Red (SOR) and West African Dwarf (WAD) were used for this study. A total of 584 goats; Sahel (N = 163), Sokoto Red (N = 171) and West African Dwarf (N = 250) were randomly sampled for this study. Both sexes were included in the study. The goats were managed under extensive system where they grazed during the day on natural pasture containing forages and scavenged on farm residues and kitchen wastes when and as available.

Data collection

Data were collected on five hundred and eighty-four (584) goats. Data were taken on individual goats. All measurements were taken on goats that are apparently healthy and phenotypically conformed to the classification description of each breed. Before measuring various parameters, the

goats were restrained and calmed properly. Measurements were done early in the morning to avoid the effect of feeding and watering on the goats' size and conformation. Measurements on body lengths and circumferences (in cm) were obtained using flexible measuring tape, while the height measurements (in cm) were taken using graduated meter ruler. All the linear, girth and height measurements were taken to the nearest 0.5 cm. The reference points and procedure for the body measurements were in accordance with the methods described by FAO (2012), Akpa *et al.* (2014) and Rotimi *et al.* (2020).

Traits measured

The morphological traits measured were;

1. Body weight (BWT): The live body weight (in kg) was obtained by using a top-loader weighing scale.
2. Height at Wither (HW): The vertical distance from the top of the shoulder to the ground (in cm).
3. Body Length (BL): This was taken as the horizontal length from the point of shoulder to the pin bone (in cm).
4. Paunch girth (PG): This is the body circumference taken around the umbilicus (in cm).
5. Heart girth (HG): The circumference of the chest posterior to the forelegs at right angles to the body axis. This is also called Chest Girth (in cm).
6. Ear Length (EL): This is the length of the external ear from its root to the tip (in cm).

Data analysis

Morphological data

Data generated on the morphological traits were subjected to Analysis of Variance (ANOVA) using the SPSS 20.0 (2011) statistical package to test the effects of breed on the measured parameters. Mean separation was done using Duncan Multiple Range Test (DMRT) statistical procedures. The model employed was;

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$$Y_{ij} = \mu + B_i + e_{ij}$$

Where;

Y_{ij} = Single observation on body weight or linear body measurements.

μ = Overall mean

B_i = Fixed effect of breed ($i = 1, 2, 3$)

e_{ij} = Random error effect associated to the observation

Phenotypic correlation

Pearson's correlation coefficient was computed between the body weight and morphological traits using SPSS 20.0 (2011) statistical package.

Discriminant analysis

The discriminant analysis procedure was employed to estimate the proportion of goats that were properly classified into their original breed using SPSS 20.0 (2011) statistical package. Accuracy of the classification was checked using cross-validation (leave-one-out, jack-knife or split-sample) procedure. The percentage of mis-classified goats indicates the degree of admixture between the breeds.

Results and discussion

Morphological traits

Table 1 shows the descriptive statistics of the body weight and linear measurements of the three Nigerian goat breeds. Body weight (kg) was significantly ($P < 0.05$) higher in SOR than in SAH and WAD (23.596, 17.117 and 14.375 respectively). There were significant ($P < 0.05$) difference in the linear body measurements, with SAH having higher values. Results showed more variability for body weight among the breeds (35.485%, 34.375% and 33.541% for SAH, SOR and WAD respectively). The results of this study were slightly higher than the report of Popoola and Oseni (2017) on sheep. The varying coefficients of variation obtained in this study could be

attributed to breed differences or influence of the environment on the parameters.

Correlation coefficients for the morphological traits of the three goat breeds

Tables 2-4 show the correlation coefficients among the morphological traits for West African Dwarf, Sokoto Red and Sahel goat breeds. The phenotypic correlation values (r) were all positive and significant ($P < 0.01$) in West African Dwarf, Sokoto Red and Sahel goat breeds. High correlation values were also recorded across the breeds. The highest values recorded were; 0.777 between BWT and HW in Sahel goats, 0.739 between HG and HW in Sokoto Red goats and 0.797 between BWT and HG in West African Dwarf goats. The high, positive and significant ($P < 0.01$) relationships between the body weight and other traits in West African Dwarf, Sokoto Red and Sahel goat breeds observed in the present study indicated that an increase in any one of these traits would result in an increase in the body weight. This indicates that HW, BL, PG and HG may be effective in predicting body weight, and their selection can lead to the improvement of body weight. This result is similar to the report of Ogah *et al.* (2013) for West African Dwarf goat breeds, Adeyinka and Mohammed (2006) for Sokoto Red and Sahel goat breeds. Okpeku *et al.* (2011) also reported similar results for West African Dwarf and Sokoto Red goat breeds. The relationships existing among linear body traits provide useful information on performance, productivity and carcass characteristics of farm animals (Ngere, 2006) and have been found useful in quantifying body size (Ibe and Ezekwe, 1994). The quantitative measurements for size and shape are necessary for estimating genetic parameters in animal breeding programmes (Chineke, 2000).

Table 1: Descriptive statistics of the body weight and body linear measurements of the three Nigerian indigenous goat breeds

Traits	Breeds			Sokoto Red (171)			West African dwarf (250)			SEM
	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV	
BWT	17.117 ^b	6.074	35.485	23.596 ^a	8.111	34.375	14.800 ^c	4.964	33.541	0.303
HW	64.871 ^a	8.189	12.624	55.667 ^b	11.284	20.271	46.920 ^c	4.727	10.075	0.454
BL	70.307 ^a	9.684	13.774	48.246 ^c	9.515	19.722	53.496 ^b	6.482	12.117	0.503
PG	70.196 ^a	9.704	13.824	31.228 ^c	9.550	30.582	65.720 ^b	8.916	13.567	0.788
HG	57.601 ^{ab}	8.457	14.682	56.684 ^b	9.214	16.255	59.308 ^a	7.334	12.366	0.343
EL	17.350 ^a	2.463	14.196	5.936 ^c	1.828	30.795	11.796 ^b	1.407	11.928	0.195

BWT = Body weight, HW = Height at wither, BL = Body length, PG = Paunch girth, HG = Heart girth, EL = Ear length, SE = Standard Error, ^{abc}Mean in the same row with different superscripts are significantly different (P<0.05)

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Table 2: Correlation coefficients between body weight and linear body measurements in Sahel goats

Traits	BWT	HW	BL	PG	HG
HW	0.777**				
BL	0.723**	0.673**			
PG	0.754**	0.733**	0.718**		
HG	0.712**	0.768**	0.478**	0.752**	
EL	0.471**	0.484**	0.309**	0.452**	0.520**

BWT = Body weight, HW = Height at wither, BL = Body length, PG = Paunch girth, HG = Heart girth, EL = Ear length, **Correlation is significant at the 0.01 level (2-tailed).

Table 3: Correlation coefficients between body weight and linear body measurements in Sokoto Red goats

Traits	BWT	HW	BL	PG	HG
HW	0.465**				
BL	0.515**	0.512**			
PG	0.707**	0.490**	0.206**		
HG	0.407**	0.739**	0.612**	0.273**	
EL	0.578**	0.403**	0.308**	0.703**	0.480**

BWT = Body weight, HW = Height at wither, BL = Body length, PG = Paunch girth, HG = Heart girth, EL = Ear length, **Correlation is significant at the 0.01 level (2-tailed).

Table 4: Correlation coefficients between body weight and linear body measurements in West African Dwarf goats

Traits	BWT	HW	BL	PG	HG
HW	0.617**				
BL	0.736**	0.709**			
PG	0.742**	0.588**	0.705**		
HG	0.797**	0.637**	0.751**	0.767**	
EL	0.412**	0.552**	0.545**	0.410**	0.461**

BWT = Body weight, HW = Height at wither, BL = Body length, PG = Paunch girth, HG = Heart girth, EL = Ear length, **Correlation is significant at the 0.01 level (2-tailed).

Discriminant analysis

Table 5 shows the results of the tests for the Eigen values and Wilks' lambda. From the Table, the first function explained 83.2 % of the total variation and had a small lambda of 0.013 and significant ($P < 0.01$). The second function explained only 16.8 % of the variance in the data set and significant ($P < 0.01$) with lambda of 0.228. The two functions contributed significantly in the discrimination process, having high canonical correlation values of 0.971 and 0.879, respectively. Table 6 shows the single standardized canonical discriminant function extracted in this study. The standardized canonical correlation coefficients show the individual contribution of independent variables to the prediction of the dependent variable. The

discriminating power of paunch girth in the standardized canonical discriminant function 1 was highest (0.954), while height at wither was the highest (0.976) in the second discriminating function. Table 7 shows the results of the discriminant analysis. The results showed that 99.0 % of the animals were correctly classified, leaving 1.0 % rate of misplacement. Cross-validation with the split-sample method also indicated 99.0 % success rate. The use of cross-validation option provided a better assessment of classification accuracy. About 97.5 % of Sahel goats, 100.0 % of Sokoto Red goats and 99.2 % of West African Dwarf goats were correctly classified into their distinct genetic groups (Figure 1). The use of cross-validation procedures provided a better assessment of

classification accuracy. Thus, every data point was reclassified as if it were a new unknown observation; this provided a more conservative accuracy assessment. The unstandardized canonical discriminant function was used for classification of the individual goats. The variables included in the discriminant (D) equations are; body weight (BWT), height at wither (HW), body length (BL), paunch girth (PG), heart girth (HG) and ear length (EL). The discriminating power of paunch girth and height at withers in the standardized canonical discriminant functions 1 and 2 (0.954 and 0.976, respectively) showed that these two variables are highly important variables in classifying the goat breeds. Ibelbachyr *et al.* (2015) reported that the most discriminating traits between the Moroccan goat populations were body length, heart girth, hair length, horn length, ear length and live body weight while Zaitoun *et al.* (2005) indicated that nose shape was the most discriminating variable among goat breeds of Jordan, followed by withers height then body weight and ear type. Yakubu *et al.* (2010) revealed that rump height, body length, horn length, face length, chest girth, neck circumference and head width were the most important morphometric traits permitting discrimination between West African Dwarf and Red Sokoto goats in Nigeria. Jimcy *et al.* (2011) reported that head width, height at withers, chest depth, rump length, rump width, shin circumference and body length, were the most discriminating traits among the goat populations from India. Aziz and Al-Hur (2013) reported that ear length and canon circumference were the most discriminating variables among the three Saudi goat breeds. The results obtained in this study showed that 97.5 % SAH, 100.0 % SOR and 99.2% WAD were correctly classified respectively. The results, after cross-validation, showed that

99.0% of the animals were correctly classified into their classes, leaving only 1.0% of the animals that were misclassified in this study. This is close to the values reported by Yakubu *et al.* (2010), who also correctly assigned 99.4% of WAD and 100% of RS goats into their distinct genetic groups. The high percentage of correct classification of the individual goats into their respective breeds indicated that the discriminant function is an appropriate tool for correct placement of breeds and hence may help in selective breeding in future breeding programmes. Only about 1.0% of the animals were misclassified in this study. Traore *et al.* (2008) correctly classified 79.3% of Sudan and 82.7% of Sudan-Sahel goat populations of Burkina Faso into their respective population. Dossa *et al.* (2007) also correctly classified more than 70% of goats from Benin into their distinct populations. However, Hirbo *et al.* (2006) obtained a low percentage in classification in their study and concluded that the low classification correctness obtained in their report may be an indication of either high gene flow or as low power to assign because of too few variables used in analysis. Kunene *et al.* (2007) also reported that information derived from linear body measurements could be used to complement genetic analyses to develop proper conservation and utilization programmes.

The two functions contributed significantly in the discrimination process, having high canonical correlation values of 0.971 and 0.879 respectively. The two derived canonical discriminant functions discriminating the three goat breeds are as follows:

$$\begin{aligned}\text{CAN1} &= -6.299 - 0.176 \text{ BWT} - 0.024 \text{ HW} + 0.058 \text{ BL} + 0.102 \text{ PG} - 0.044 \text{ HG} + 0.361 \text{ EL} \\ \text{CAN2} &= -1.871 + 0.034 \text{ BWT} + 0.11 \text{ HW} + 0.047 \text{ BL} - 0.085 \text{ PG} - 0.107 \text{ HG} + 0.263 \text{ EL}\end{aligned}$$

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Table 5: Results of the Eigenvalues and Wilks' Lambda Tests

Tests	Functions	
	1	2
Test of Eigen values		
Eigenvalue	16.763	3.392
Variance (%)	83.2	16.8
Cumulative variance (%)	83.2	100.0
Canonical Correlation	0.971	0.879
Wilks' Lambda Tests		
Wilks' Lambda	0.013	0.228
Chi-square	2520.426	856.026
Df	12	5
Sig.	0.000	0.000

Df = degree of freedom, Sig. = significant

Table 6: Canonical discriminant function coefficients

Variables	Functions	
	1	2
BWT	-1.116	0.217
HW	-0.192	0.976
BL	0.487	0.399
PG	0.954	-0.794
HG	-0.358	-0.882
EL	0.676	0.493

BWT = body weight, HW = height at wither, BL = body length, PG = paunch girth, HG = heart girth, EL = ear length.

Table 7: Results of the discriminant analysis of goat breeds

		Breed	Predicted Group Membership			Total
			SAH	SOR	WAD	
Original ^a	Count	SAH	159	0	4	163
		SOR	0	171	0	171
		WAD	1	1	248	250
	%	SAH	97.5	0.0	2.5	100.0
		SOR	0.0	100.0	0.0	100.0
		WAD	0.4	0.4	99.2	100.0
Cross-validated ^b	Count	SAH	159	0	4	163
		SOR	0	171	0	171
		WAD	1	1	248	250
	%	SAH	97.5	0.0	2.5	100.0
		SOR	0.0	100.0	0.0	100.0
		WAD	0.4	0.4	99.2	100.0

a. 99.0% of original grouped cases correctly classified.

b. 99.0 % of cross-validated grouped cases correctly classified.

SAH = Sahel goats, SOR = Sokoto Red goats, WAD = West African Dwarf goats.

Figure 1: Canonical allocation of the morphological traits associated with individuals by breeds

Conclusions

The study showed that paunch girth and height at withers were the most discriminating variables to classify the three goat breeds. This might be valuable in field assessment, management and conservation of these goat breeds. However, genetic marker is needed to complement the information obtained from this study.

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References

- Adebambo, A. O., Adebambo, O., Williams, J. L., Blott, S. and Urquart, B. 2011. Genetic distance between two popular Nigerian goat breeds used for milk production. *Livestock Research for Rural Development*, 23 (26).
- Adeyinka, I. A. and Mohammed, I. D. 2006. Accuracy of body weight prediction in Nigerian Red Sokoto goats raised in North Eastern Nigeria using linear body measurements. *Pakistan Journal of Biological Science*, 9, 2828-2830.
- Akpa, G. N., Ambali, A. L. and Suleiman, I. O. 2014. Body Conformation, Testicular and Semen Characteristics as Influenced by Age, Hair Type and Body Condition of Red Sokoto Goat. *New York Science Journal*, 6 (7), 44 -58.
- Aziz, M. M. A. and Al-Hur, F. S. 2013. Differentiation between three Saudi goat types using size-free canonical discriminant analysis. *Emir Journal of Food and Agriculture*, 25(9), 723-735.
- Chineke, C. A. 2000. Characterization of physical body traits of domestic rabbits in Humid Tropics.

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- Proceedings 25th NSAP Conference. Michael Okpara University of Agriculture, Umudike, 19-23 March, 237-238.
- Delgado, J. V., Barba, C., Camacho, M. E., Sereno, F. T. P. S., Martinez, A. and Vega-Pla, J. L. 2001.** Livestock characterisation in Spain. *AGRI*, 29, 7-18.
- Dossa, L. H., Wollny, C. and Gauly, M. 2007.** Spatial variation in goat populations from Benin as revealed by multivariate analysis of morphological traits. *Small Ruminant Research*, 73, 150-159.
- Ebegbulem, V. N., Ibe, S. N. and Asuquo, B. O. 2011.** Morphometric differentiation of West African dwarf goats in Southeastern Nigeria using discriminant analysis. *Journal of Agriculture and Veterinary Science*, 3, 29-34.
- FAO 2000.** *World watch list for domestic animal diversity*, 3rd edn (edited by Scherf BD), Rome, Italy. Pp726.
- FAO 2012.** Phenotypic characterization of animal genetic resources. FAO Animal Production and Health Guidelines No.11. Rome, Italy.
- F A O S T A T 2 0 1 8 .** http://www.fao.org/faostat/en/#data/QA
- Hirbo, J., Muigai, A., Naqvi, A. N., Rege, E. D. and Hanotte, O. 2006.** The Genetic Diversity of Trans-caucasian Native Sheep Breeds. *Asian-Australian Journal Animal Science*, 19(7), 943-952.
- Ibe, S. N. and Ezekwe, A. G. 1994.** Quantifying size and shape difference between Muturu and N'dama breeds of cattle. *Nigerian Journal of Animal Production*, 21, 51-58.
- Ibnelbachyr, M., Boujenane, I. and Chikhi, A. 2015.** Morphometric differentiation of Moroccan indigenous Draa goat based on multivariate analysis. *Animal Genetic Resources*, 57, 81-87.
- Jimcy, J., Raghavan, K. C. and Sujatha, K. S. 2011.** Diversity of local goats in Kerala, India, based on morpho-biometric traits. *Livestock Research for Rural Development*, 23(5).
- Kunene, N., Nesamvuni, E. A. and Fossey, A. 2007.** Characterization of Zulu (Nguni) sheep using linear body measurements and some environmental factors affecting these measurements. *South African Journal of Animal Science*, 37, 11-20.
- Ngere, L. O. 2006.** A comparative study of structural variation between Red Sokoto and West African Dwarf goats in South West Nigeria. M.Sc Thesis. Department of Animal Science, University of Ibadan, Ibadan, Nigeria.
- Ogah, D. M., Musa, I. S. and Yusuf, N. D. 2013.** Prediction of Carcass weight from body measurements in West African Dwarf goat using canonical correlation analysis. *Egyptian Journal of Sheep and Goat Sciences*, 8(1), 75-79.
- Okpeku, M., Yakubu, A., Peters, S. O., Ozoje, M. O., Ikeobi, C. O. N., Adebambo, O. A. and Imumorin, I. G. 2011.** Application of multivariate principal component analysis to morphological characterization of indigenous goats in southern Nigeria. *Acta Argiculturae Slovenica*, 98(2), 101-109.
- Popoola, M. A. and Oseni, S. O. 2017.** Multifactorial discriminant analysis of cephalic morphology of indigenous breeds of rams in Nigeria. Proc. 42nd Conf. Nig. Soc. for Ani. Prod. 26th-30th March.

- Landmark University, Omu-Aran, Kwara state, Nigeria.
- Rotimi, E. A., Momoh, O. M. and Egahi, J. O. 2020.** Relationship between body weight and morphological traits in Sahelian goats of Nigeria using path analysis, *Mustafa Kemal University Journal of Agricultural Sciences*, 25(3), 455-460.
- SPSS 2011.** Statistical Package for the Social Sciences. User's Guide: Statistics, Version 15.0. Institute, Inc., Cary, NC, USA.
- Traore, A., Tambouraa, H. H., Kaborea Royob, L. J., Fernandezb, I., Alvarezb, I., Sangarec, M., Boucheld, D., Poiveye, J. P., Francoisf, D., Toguyenic, A., Sawadogog, L. and Goyache, F. 2008.** Multivariate characterization of morphological traits in Burkina Faso sheep. *Small Ruminant Research*, 80, 62-67.
- Yakubu, A., Salako, A. E., Imumorin, I. G., Ige, A. O. and Akinyemi, M. O. 2010.** Discriminant analysis of morphometric differentiation in the West African Dwarf and Red Sokoto goats. *South African Journal of Animal Science*, 40(4), 381-387.
- Yunusa, A. J., Salako, A. E. and Oladejo, O. A. 2013.** Morphometric characterization of Nigerian indigenous sheep using multifactorial discriminant analysis. *International Journal of Biodiversity Conservation*, 5(10), 661-665.
- Zaitoun, I. S., Tabbaa, M. J. and Bdour, S. 2005.** Differentiation of native goat breeds of Jordan on the basis of morphostructural characteristics. *Small Ruminant Research*, 56, 173-182.

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