Multivariate Analysis of Phenotypic Differentiation in Yankasa and Balami Sheep

***Ali, Y., and Adedibu, I. I.**
Department of Animal Science,
Ahmadu Bello University,
Zaria, Kaduna State, Nigeria.

Ojo, O. A.
Department of Livestock and Fisheries,
National Agricultural Extension and Research Liason Services,
Zaria, Kaduna State, Nigeria

Abstract
Animal genetic resources are components of biological diversity and are important in meeting the food requirement of countries of the world. The present study is aimed at examining morphometric differentiation in two Nigerian indigenous sheep (Yankasa and Balami) using canonical discriminant analysis. Body weight and ten (10) body measurements (Head width, length, and depth, Ear length, Wither height, Chest girth, Body Length, Rump height and width, and Tail length) were utilized to discriminate between sixty (60) randomly selected Yankasa and sixty (60) randomly selected Balami sheep. The animals, which were aged 2−3 years, were reared extensively. The Balami had significantly ($P < 0.05$) higher values for all morphometric traits than Yankasa sheep. The stepwise discriminant analysis gave a better resolution as only six traits, ear length, rump width, head width, body length, head depth and head length were more discriminating in separating the two sheep breeds. The Mahalanobis distance between the two sheep breeds was high (12.82) 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 90% of Yankasa sheep were classified into their source population and 95% of Balami sheep were correctly assigned into their source genetic group. The present phenotypic information can serve as the basis for the establishment of further characterization, conservation and selection strategies for the two Nigerian indigenous Sheep. Thus, multivariate analysis using canonical approach has proved useful and informative in differentiating between the two breeds.

Key words: *Yankasa sheep; Balami sheep; morphometric traits; canonical discriminant analysis.*

INTRODUCTION

Domestic animals have been part of the living world since the beginning of human history (Epstein, 1971). Over the years they have developed unique combinations of traits through adaptation to best respond to specific pressures presented by different ecological and cultural environments (Köhler-Rollefson, 2000; Hall, 2004). This has brought about a great genetic diversity which has birthed different breeds of domestic animals. These breeds contribute greatly to the world's genetic diversity, and are particularly well adapted to specific local conditions where exotic breeds would not survive. 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 centuries, with unique genotypes and aesthetic and cultural value are being lost (Macijauskiene and Juras, 2003; Adamczyk *et al*., 2008). Hence, the 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). Sheep biodiversity have been described using morphological measurements (Gizaw *et al*., 2007; Carneiro *et al*., 2010). The phenotypic variation in a population arises due to genotypic and environmental effects and the magnitude of phenotypic variability differs under different environmental conditions. Morphometric characters are continuous characters describing aspects of body shape (Riva *et al*., 2004; Cervantes *et al*., 2009). Morphometric variation between populations can provide a basis for understanding flock structure and may be more applicable for studying short-term, environmentally induced variations and thus, more applicable to livestock management. According to Gizaw *et al*. (2007) morphological description is an essential component of breed characterization that can be used to physically identify, describe, and recognize a breed, as well as classify them into broad categories.

Canonical discriminant analysis (CDA) is a multivariate statistical technique used to discriminate two or more naturally occurring groups based on a suite of continuous or discriminating variables. The technique consists of two closely related procedures that allow determining underlying, dominant gradients of variation among groups of sample entities from a set of multivariate observations, to elucidate how variation among groups is maximized and variation within groups is minimized along a gradient (McGarigal *et al*., 2000).

In this study, two Nigerian sheep breeds were considered for investigation. They represent an important genetic resource in their environment and make up an integral part of the livestock population in the country. The current trend in livestock classification using multivariate statistical tools (Herrera, 1996; Zaitoun *et al*., 2005; Dossa *et al*., 2007; Traoré *et al*., 2008; Yakubu *et al*., 2011) has not yet found place in the morphometric differentiation of Nigerian sheep breeds. In all these cases, the classical discriminant function analysis method was found to be relatively efficient and allowed differences between breeds and subpopulations to be detected, as well as the relative distance between them.

Therefore, the objective of this study was to differentiation two breeds of sheep based on some morphological characteristics, using canonical discriminant analysis.

Materials and Methods

Study area and agro-climatic conditions

Sampling of sheep was done in Kaduna and Gombe States for Yankasa and Balami sheep, respectively. Kaduna State falls within the guinea savanna agro-ecological zone and is located between Latitudes 10º20'N and 10.333ºN and Longitudes 7º45'E and 7.750ºE at an altitude of 634 m above sea level. The average annual rainfall is 1211 mm and this spreads from April to October. The average annual temperature is 25.2ºC depending on the season while the average humidity during the wet season is between 70 and 80% and 15 and 21% during the dry season of November to January (World Meteorological Organization, 2017). Gombe State is located between Latitudes 10º15'N and 10.250ºN and Longitudes 11º10'E and 11.167ºE at an altitude of 493 m above sea level. It has two distinct seasons, the dry season (November – March) and the rainy (April – October) with an average rainfall of 850 mm and the average annual temperature of 25.4ºC (World Meteorological Organization, 2017).

Experimental animals

Morphometric measurements were taken on 120 randomly selected Sheep comprising 60 Yankasa (30 females and 30 males) and 60 Balami (30 females and 30 males) sheep. They were 2-3 years of age as determined by dentition (presence of 3 permanent incisors). All sheep breeds under study were reared under extensive management with little or no supplementary feeding. They grazed during the day on natural pasture containing forages such as northern gamba grass (*Andropogon gayanus*), stylo (*Stylosanthes gracilis*) and leucaena (*Leucaena leucocephala*).

Data collection

Measured traits

Body weight and ten morphometric traits were measured on each animal. The body parameters were Head width (HW), Head length (HL), Head depth (HD), Ear length (EL), Wither height (WH), Chest girth (CG), Body Length (BL), Rump height (RH), Rump width (RW) and Tail length (TL). Anatomic reference points for the measurements are as described by Salako and Ngere, 2002; Sarma, 2006 and Pares, 2009. Measurements were taken when the animals were standing still with head raised and weight on all four feet (Salako and Ngere, 2002). Physical restraint was sometimes applied to limit movement (Yunusa *et. al.*, 2013). Measurements were restricted to apparently healthy animals that conform to the classification descriptors of each breed (Salako and Ngere, 2002). Measurements were taken as described by FAO (2012) using a measuring tape calibrated in centimeters (WEBO MALEBAND®).

Data analysis

Analysis of variance (ANOVA) of morphometric traits

The measured traits were subjected to analysis of variance to determine breed effect using the MEAN procedure of SAS JMP (2019). Means were separated using the t-test of the same statistical package.

$Y_{ijk} = \mu + B_i + E_{ijk}$

Where; Y_{ij} = observation of growth trait; μ = overall mean; B_i = fixed effect of the i^{th} breed (i=Yankasa and Balami); and E_{ijk} = random error, assumed to be independently, identically and normally distributed, with zero mean and constant variance.

Discriminant analysis of morphometric traits

Stepwise discriminant procedure (SAS JMP, 2019) was applied using PROC STEPDISC to determine which morphometric traits have more discriminant power than others. The relative importance of the morphometric variables in discriminating between the two sheep breeds was assessed using the level of significance, Wilk's Lambda, partial R2, ASCC and F-statistics. The CANDISC procedure was used to perform univariate and multivariate one-way analysis that calculated the Mahalanobis distance between the two sheep 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).

$D = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + \ldots + b_nx_n$

Where; D = discriminant score; a = a constant; b = discriminant coefficient; x = respondent score for a variable; and i = number of predictor variable.

Results and Discussion

Effect of breed on morphometric traits of indigenous Sheep

The least square means (±se) and coefficient of variation for effect of breed on morphometric traits of Yankasa and Balami sheep are presented in Table 1. Balami sheep had significantly higher values for all the measured traits as compared with Yankasa. The morphometric traits of the Balami breed in this study revealed that the Balami sheep is larger than the Yankasa sheep. Sheep breeds exhibit an unusual intra-species polymorphism (Alpak *et al*., 2009). The difference observed are an inkling to the innate genetic constitution of each sheep breed. The values reported in this study are similar to that of Raji *et al.* (2017) who reported withers height, rump height, ear length, tail length, chest girth and rump width as 71.99±0.42cm, 67.75±1.00cm, 14.01±0.55cm, 35.50±0.99cm, 73.09±1.00cm and 13.52±0.53cm respectively in Yankasa sheep and withers height, rump height, ear length, tail length, chest girth and rump width as 76.01±0.38cm, 73.57±0.53cm, 16.47±0.24cm, 42.05±0.94cm, 79.19±1.24cm and 14.52±0.30 cm respectively in Balami sheep. Agaviezor *et al.* (2012) obtained body weight, wither height, chest girth, body length, rump height and rump width as 32.62 ± 1.59cm, 67.39 ± 1.26cm, 73.07 ± 1.30cm, 92.58±3.46cm, 67.75±1.00cm and 13.92±0.31cm respectively in 2-3 years old Yankasa sheep and body weight, wither height, chest girth, body length, rump height and rump width as 37.53±1.52cm, 72.25±1.20cm, 79.19±1.24cm, 77.11±3.30cm, 74.50±0.95cm and 14.62±0.30cm respectively in 2-3 years old Balami sheep. Agaviezor *et al.* (2012) reported a higher value for body length in Yankasa sheep (92.58±3.46cm) than for Balami sheep (77.11±3.30cm) contradicting the result of this study and the reports of Raji *et al* (2017).

The coefficient of variation for the measured traits in Yankasa sheep range from 3.28% - 11.62% with body weight (11.62%) and head length (3.28%) having the highest and lowest values respectively. While, the coefficient of variation for the measured traits in Balami sheep range from 1.58% - 4.70% with head depth (4.70%) and chest girth (1.58%) having the highest and lowest values respectively. The coefficient of variation (CV) for Yankasa sheep were higher than that of Balami sheep in each measured trait. This implies heterogeneity in Yankasa sheep and homogeneity in Balami sheep. Traits having high CV suggest that the traits are heterogeneous in nature hence possessing more room for genetic improvement through selection while traits having lower CV suggest that those traits are homogenous and possesses less room for improvement (Abbaya and Dauda, 2018). Therefore, the variations that exists in the measured traits shows a more possibility of genetic improvement through selection and mating in Yankasa sheep than Balami sheep due to high values of coefficient of variation of Yankasa sheep for the measured traits since the characterisation of local genetic resources depends on the knowledge of the variation of morphological traits, which have played a very fundamental role in classification of livestock based on size and shape (Yakubu *et al*., 2010). This result is similar with the report of Yakubu, (2010) who reported a CV of between 6.43 – 12.90 for body weight, wither height, tail length and chest girth in Yankasa sheep. Shuaibu *et al.* (2018) and Afolayan *et al.* (2006) reported higher CV between (9.31 - 45.54) for heart girth (HG), wither height (WH), body length (BL), shoulder width (SW), ear length (EL), horn length (HL), tail length (TL), hip width (HP) head width (HW) and ear width (EW) in Yankasa sheep. On the contrary to higher CV values, Salako, (2006) reported lower CV of 0.24 % (rump length) and 0.06 % (live weight) among Nigerian indigenous sheep (Yankasa, Uda, WAD and Balami).

Discriminant Analysis of Morphometric traits for Yankasa and Balami sheep

The stepwise discriminant analysis to separate Yankasa and Balami sheep (Table 2) showed that six traits were selected using the forward selection, they include: ear length, rump width, head width, body length, head depth, head length in that order. Ear length had the highest value for Wilk's Lambda, partial R^2, F value and least value for ASCC (0.452, 0.548, 142.90 and 0.548 respectively) while head length had the least value for Wilk's Lambda, partial R^2, F value and highest value for ASCC (0.235, 0.038, 4.51 and 0.765 respectively). 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). These six morphometric traits (ear length, rump width, head width, body length, head depth and head length) are more important in differentiating between Yankasa and Balami sheep than acquiring numerous additional measurements.

The morphometric traits obtained in this study are similar to those reported by other researchers who studied morpho-structural differences of Nigerian indigenous sheep such as Yunusa *et al.* (2013) and Agaviezor *et al.* (2012) but both authors reported tail length as the most discriminating trait followed by ear length and rump width while Yakubu and Ibrahim, (2011) reported wither height as the most discriminating trait in Yankasa, Uda and Balami breeds of sheep. The variation in the result of Yunusa *et al* (2013) and Agaviezor *et al.* (2012) can be attributed to the inclusion of the West African dwarf (WAD) sheep in the discriminant model as the WAD sheep is known to have a short tail and low wither height compared to other indigenous sheep.

The total canonical structure (Table 3) of the traits selected by the stepwise discriminant analysis. Ear length had the highest coefficient of 0.846 while head length has the least 0.310. The Mahalanobi's distance and percentage misclassification is given in Table 4. The Mahalanobi's distance (12.82) between the two sheep breeds was highly significant ($P < 0.001$). This was substantiated by the classification result (posterior probability of membership in each population) between the two breeds which showed that 90% of Yankasa and 95% of Balami sheep were classified into their actual breed, while 10% of Yankasa sheep were misclassified into Balami sheep and 5% of Balami sheep were misclassified into Yankasa sheep, 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 canonical discriminant analyses therefore could be successfully used in morphometric differentiation. Yunusa *et al.* (2013) reported similar value of 12.82 for genetic distance between Yankasa and Balami sheep while Yakubu, (2011) reported a mahalanobi's distance of 4.83.

Conclusions

This study has shown that significant variation exists between the two breeds for the morphometric traits measured Balami breed expressed superior genetic potential in all morphometric traits than Yankasa. Six morphometric traits; ear length, rump width, head width, body length, head depth and head length were the most discriminating between Yankasa and Balami sheep. Multivariate analysis successfully differentiated the Yankasa and Balami sheep breeds.

REFERENCE

Abbaya, H.Y. and Dauda, A. (2018). Morphormetric Differentiation of Yankasa Sheep in Maiduguri, North-Eastern Nigeria. *Journal of Genetics and Genetic Engineering*, 2(3): 1-6.

Abdalhag, M.A., Zhang, T., Fan, Q.C, Zhang, X.Q. and Zhang, G.X. (2015). Single nucleotide polymorphisms associated with growth traits in Jinghai yellow chickens. *Genetics and Molecular Research*, 14: 16169-16177.

Adamczyk, K., Felenczak, A., Jamrozy, J., Szarek J. and Bulla, J. (2008). Conservation of Polish Red cattle. *Slovak Journal of Animal Science*, 41: 72–76.

Afolayan, R.A., Adeyinka, I.A. and Lakpini, C.A.M. (2006). The estimation of live weight from body measurements in Yankasa sheep. *Czech Journal of Animal Science*, 51(8): 343-348.

Agaviezor, B.O., Peters, S.O., Adefenwa, M.A., Yakubu, A., Adebambo, O.A., Ozoje, M.O. and Imumorin, I.G. (2012). Morphological and microsatellite DNA diversity of Nigerian indigenous sheep. *Journal of Animal Science and Biotechnology*. 3 :38 https://doi.org/10.1186/2049-1891-3-38.

Alpak, H., Onar, V. and Mutus, R. (2009). The relationship between morphometric and long bone measurements of the Morkaraman sheep. *Turkish Journal of Veterinary and Animal Science*. 33:199- 207.

Carneiro, H., Louvandini, H., Paiva, S.R., Macedo, F., Mernies, B. and McManus, C. (2010). Morphological characterization of sheep breeds in Brazil. Uruguay and Colombia. *Small Ruminant Research*, 94: 58-65.

Cervantes, I., Baumung, R., Molina, A., Druml, T., Gutierrez, J.P., Solkner, J. and Valera, M. (2009). Size and shape analysis of morphofunctional traits in the Spanish Arab horse. *Livestock Science*, 125:43–49.

Delgado, J.V., Barba, C., Camacho. M.E., Sereno, F.T.P.S., Mar- tinez, A. and Vega-Pla, J.L. (2001). Livestock characterisation in Spain. *Animal Genetic ResourcesInformation*, 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.

Duchev, Z., Groeneveld, E. (2006). Improving the monitoring of animal genetic resources on national and international level. *Arch. Tierz. Dummerstorf*, 49: 532–544.

Duchev, Z., Distl, O. and Groeneveld, E. (2006). Early warning system for loss diversity in European livestock breeds. *Arch. Für Tierzucht, Dummerstorf*, 49:521-531.

Epstein, H. (1971). The origin of the domestic animals of Africa. African Publishing Corporation (APC). Volume I. 101 Fifth Avenue, New York, N.Y. 10003, U.S.A.

FAO (2012). Phenotypic characterization of animal genetic resources. FAO Animal Production and Health Guidelines. pp. 91-105.

FAOSTAT (2011). Food and Agriculture Organization of the United Nations. FAOSTAT Database on Agriculture. Italy: Rome.

Gizaw, S., van Arendonk J.A.M., Komen, H., Windig, J.J. and Hanotte, O. (2007). Population structure, genetic variation and morphological diversity in indigenous sheep of Ethiopia. *Animal Genetics*, 38:621–628.

Hall, S. J. G. (2004). Livestock Biodiversity. Genetic Resources for the Farming of the Future. Blackwell Publishing, Oxford.

Herrera, M., Rodero, E., Gutierrez, M.J., Pena, F., Rodero, J.M. (1996) Application of multifactorial discriminant analysis in the morphostructural differentiation of Andalusian caprine breeds.*Small Ruminan Research*, 22:39–47.

Kastelic, M., Zanotric, M. and Kompan, D. (2005). Linear body mea- surements of Cika cattle in comparison to Pinzgauer cattle. Acta Agriculturae Slovenica, 86, 2: 85– 91.

Köhler-Rollefson, I., (2000). Management of Animal Genetic Diversity at Community Level. GTZ Programme Agrobiodiversity in Rural Areas. GTZ, Eschborn, Germany.

Lanari, M.R., Taddeo, H., Domingo, E., Centeno, M.P. and Gallo L. (2003). Phenotypic differentiation of exterior traits in local Criollo goat population in

Patagonia (Argentina). *Arch. Tierz. Dummerstorf*, 46: 347–356.

Macijauskiene, V. and Juras, R. (2003). An Attempt at analyzing the selected traits of body conformation, growth, performance and genetic structure of Lithuanian native Zemaitukai horse, the breed being preserved from extinction. *Animal Science Papers and Reports*, 21:35–46.

McGarigal, K., S. Cushman and S. Stafford. (2000). Multivariate Statistics for Wildlife and Ecology Research. Springer Verlag, New York.

Pares, C.P.M. (2009). Zoometría. In: Sañudo AC (ed). ValoraciónMorfológica de losAnimales Domésticos. Madrid, España: Ministerio de Medio Ambiente y Medio Rural y Marino.

Raji, A. O., Mohammed, A., Igwebuike, J. U. and Alphonsus, C. (2017). Association of IGF 1 gene polymorphisms with some morphometric traits of Nigerian indigenous sheep breeds. *Nigerian Journal of Biotechnology*, Vol. 34: 97- 104.

Riva, J., Rizzi, R., Marelli, S., Cavalchini, L.G. (2004). Body measurements in Bergamasca sheep. *Small Ruminan Research*, 55:221-227.

Salako A.E. (2006). Application of morphological indices in the assessment of Type and Function in Sheep. *International Journal of Morphology*, 24: 13-18.

Salako, A.E and Ngere, L.O. (2002). Application of multifactorial discriminant analysis in the Morphometric structural differentiation of the WAD and Yankasa sheep in the humid Southwest Nigeria. *Nigerian Journal of Animal Production,* 29(2):163-167.

SAS JMP 15. (2019). SAT/STAT user's Guide, Version 15: Statistics, SAS Institute Incorporation, Cary, NC 27513, USA.

Sarma, K. (2006). Morphological and craniometrical studies on the skull of Kagani goat (*Capra hircus*) of Jammu region. *International Journal of Morphology*, 24:449-455.

Shuaibu, A., Aliyu, A., Ja'afar, A. M., Ma'aruf, B. S. and Mujitaba, M. A. (2018). Phenotypic Characterization of Yankasa Sheep in Northern Agricultural Zone of Bauchi State, Nigeria. *Nigerian Journal of Animal Science and Technology*, Vol. 1 (2):36 – 45.

Simon, D.L. (1999). European approaches to conservation of farm animal genetic resources. *Animal and Genenetic Resource Information*, 25:79–99.

Traoré A., Tamboura, H.H., Kabore, A., Royo, L.J., Fernández, I., Álvarez, I., Sangare, M., Bouchel, D., Poivey, J.P., Francois, D., Toguyeni, A., Sawadogo, L. and Goyache, F. (2008) Multivariate characterization of morphological traits in Burkina Faso sheep. *Small Ruminant Research*, 80:62–67.

Yakubu, A. (2010). Path coefficient and path analysis of body weight and biometric traits in Yankasa lambs. *Slovakian Journal of Animal Science*, 43(1): 17 – 25.

Yakubu, A., Raji, A. O. and Omeje, J. N. (2010). Genetic and Phenotypic Differentiation of Qualitative Traits in Nigerian Indigenous Goat and Sheep Populations. *Asian Research Publishing Network Journal of Agricultural and Biological Science,* Vol. 5(2).

Yakubu A, Salako, A.E. and Imumorin, I.G. (2011) Comparative multivariate analysis of biometric traits of West African Dwarf and Red Sokoto goats. *Tropical Animal Health and Production*, 43:561–566.

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 and Conservation*, 5(10): 661-665.

World Meteorological Organization. (2017). "World Weather Information Service". Retrieved 7 November 2017.

Zaitoun, I.S., Tabbaa, M.J. and Bdour, S. (2005) Differentiation of native goat breeds of Jordan on the basis of morphostructural characteristics. *Small Ruminan Research*, 56:173–182.

Table 1: Least Square Means (±SE) and Coefficient of variation for Effect of breed on morphometric traits of Yankasa and Balami Sheep

	Yankasa		Balami	
Traits	**Means(±SE)**	**CV (%)**	**Means(±SE)**	**CV (%)**
Body weight (Kg)	36.13 ± 0.54^{b}	11.62	41.52 ± 0.21^{a}	4.00
Head length (cm)	23.03 ± 0.10^{b}	3.28	26.06 ± 0.11^{a}	3.17
Head width (cm)	11.27 ± 0.08^{b}	5.12	11.37 ± 0.04^{a}	2.50
Head depth (cm)	13.70 ± 0.13^{b}	7.31	15.68 ± 0.10^{a}	4.70
Wither height (cm)	68.80 ± 0.45^{b}	5.07	75.18 ± 0.25^{a}	2.62
Chest girth (cm)	73.77 ± 0.44^{b}	4.65	78.20 ± 0.16^{a}	1.58
Body length (cm)	62.00 ± 0.45^{b}	5.63	68.90 ± 0.34^{a}	3.38
Ear length (cm)	14.52 ± 0.09^{b}	4.88	17.93 ± 0.05^{a}	2.00
Rump height (cm)	67.10 ± 0.48^{b}	5.59	73.62 ± 0.28^{a}	2.94
Rump width (cm)	13.74 ± 0.11^{b}	5.90	15.90 ± 0.08^{a}	3.83
Tail length (cm)	36.28 ± 0.33^{b}	7.03	45.21 ± 0.15^{a}	2.54

[ab] Means with different superscripts within the same row differ significantly (P<0.05); SE = Standard error; CV = Coefficient of variation; cm = Centimeter

Table 2: Morphometric traits selected by stepwise discriminant analysis to separate Yankasa and Balami Sheep

Traits	Wilk's lambda	Pr <Lambda	Partial R^2	ASCC	Pr >ASCC	F value	Pr >F
Ear length	0.452	<0.0001	0.548	0.548	<0.0001	142.90	<0.0001
Rump width	0.295	<0.0001	0.347	0.705	<0.0001	62.26	<0.0001
Head width	0.273	<0.0001	0.075	0.726	<0.0001	9.41	0.0027
Body length	0.257	<0.0001	0.570	0.743	<0.0001	6.95	0.0095
Head depth	0.244	<0.0001	0.052	0.756	<0.0001	6.27	0.0137
Head length	0.235	<0.0001	0.038	0.765	<0.0001	4.51	0.0360

Table 3: Matrix structure coefficients of the canonical discriminant analysis of Yankasa and Balami Sheep

Traits	CAN 1
Ear length	0.846
Rump width	0.790
Head width	0.669
Body length	0.549
Head depth	0.746
Head length	0.310

CAN: Canonical

Table 4: Mahalanobi's distance and percentage misclassification into breeds for Yankasa and Balami Sheep

	Mahalanobi's distance		Percentage (%) misclassification	
	Yankasa	**Balami**	**Yankasa**	**Balami**
Yankasa	0	12.82	90	10
Balami	12.82	0	5	95
Error rate	0.10	0.05		
Priori	0.50	0.50		

CAN = Canonical