# Multivariate Analysis of Spatial Patterns of Morphological Traits in West African Dwarf Goats in Three Agro-ecological Zones of Nigeria

**A. Yakubu[ab*], A.E. Salako[b], I.G. Imumorin[c]**

[a]Department of Animal Science
Faculty of Agriculture
Nasarawa State University, Keffi, Shabu-Lafia Campus
PMB 135, Lafia, Nigeria

[b]Animal Breeding and Genetics Laboratory
Department of Animal Science
University of Ibadan
Ibadan, Nigeria

[c]Department of Animal Science
B267 Morrison Hall, Cornell University
Ithaca, NY. 14853. USA

(Received March 21, 2010; accepted August 30, 2010)

## *Abstract*

Yakubu, A., Salako, A.E. and Imumorin, I.G. 2010. Multivariate analysis of spatial patterns of morphological traits in West African dwarf goats in three agro-ecological zones of Nigeria. J. Appl. Anim. Res., 38: 257-260.

*A multivariate analysis of phenotypic trait distribution across agro-ecological zones (tropical rainforest, guinea savanna and sudan savanna zones) in Nigeria was carried out on 302 West African Dwarf (WAD) goats. Most of the morphometric traits of rainforest and guinea savanna goats were higher (P<0.05) than those of the sudan savanna zone. Abdominal circumference, rump width, ear length, chest depth and cannon circumference were the most discriminating variables among the goats of the three zones. Based on Mahalanobis distances, the least differentiation was observed between rainforest and guinea savanna goats. Only 24.38% of rainforest and 22.86% of guinea savanna goats were classified into their source population. The relatively low morphometric distances as well as intermingling between the three goat populations indicate that they are homogenous and share similar genetic identities. This could aid in their conservation and formulation of appropriate breeding and selection strategies.*

Key words: Body measurements, discriminant analysis, goats, agroecological zones, Nigeria.

## *Introduction*

The conservation of West African Dwarf (WAD) goats is of increasing concern because of their historical and genetic value. This is more so important because livestock diversity is shrinking rapidly and there is an urgent need to prioritize breed conservation. Morphometric traits have been used to describe and classify breeds of farm animals (Kastelic *et al*., 2005; Yakubu, 2009).

*For correspondence: Tel. +234-8065644748;
E-mail: abdul_mojeedy@yahoo.com

Although the WAD goats are largely concentrated in Southern Nigeria; they are found in large number in Nasarawa State in north-central Nigeria. Previous efforts on the phenotypic characterization of this breed have been restricted to the use of analysis of variance, whereas the current trend in livestock classification involves the use of multivariate statistical tools (Dossa *et al*., 2007; Pinto *et al*., 2008; Yakubu *et al*., 2009). This is because univariate statistical techniques analyze each variable separately and do not explain how the populations under investigation differ when all measured morphological variables are considered jointly. To date, there is no documented evidence in the literature on the multivariate analysis of the conformation traits of WAD goats in Nigeria. Attempts have also not been made at examining spatial variation in their morphological traits.

In this paper, we report the quantitative examination of three populations of West African Dwarf goats drawn from the agro-ecological zones of rainforest, guinea savanna and sudan savanna for inter-population differences in morphology.

## *Materials and Methods*

The study was conducted in Oyo, Nasarawa and Kano States. Oyo state is located in the tropical rainforest zone of South-western Nigeria. Nasarawa state falls within the guinea savanna agro-ecological zone of north central Nigeria. Kano state is located in the sudan savanna zone of north western Nigeria.

Sampling of goats was carried out in randomly selected villages in the three study areas from August 2008 to March 2009. Morphological measurements were taken on 302 WAD goats of both sexes [160 (113 females and 47 males), 105 (83 females and 22 males) and 37 (22 females and 15 males) goats in tropical rainforest, guinea savanna and sudan savanna zones, respectively].

The nineteen morphometric traits measured were body weight (BW), withers height (WH), rump height (RH), foreleg length (FRL), hindleg length (HDL), body length (BL), face length (FAL), ear length (EL), horn length (HL), rump length (RL), tail length (TL), neck circumference (NC), abdominal circumference (AC), cannon circumference (CC), chest girth (CG), chest depth (CD), head width (HW), shoulder width (SW) and rump width (RW). Anatomical reference points were as described earlier (Yakubu, 2009; Adebayo, 2009).

Statistical analysis was carried out using PROC GLM procedure of SAS (1999), with means separation done using Duncan's Multiple Range Test. Stepwise discriminant procedure was applied using PROC STEPDISC to determine which morphological traits have more discriminant power. The relative importance of the morphometric variables in discriminating the three goat populations was assessed using the level of significance, partial $R^2$ and F-statistic. The CANDISC procedure was used for univariate and multivariate one-way analysis that calculated the Mahalanobis distances, and derived canonical functions (linear combinations of the continuous variables that summarize variation between the agro-ecological zones). The ability of these canonical functions to assign each individual goat to its sampling area was calculated as the percentage of correct assignment of each agro-ecological zone using the DISCRIM procedure (Nearest Neighbour Discriminant Analysis).

## *Results and Discussion*

Our value of 44.09 cm for withers height of rainforest goats (Table 1) is consistent with earlier reports (Ozoje, 2002), although higher than the 41.82 cm recorded for goats from the southern most vegetation zone of Benin (Dossa *et al*., 2007). The present results indicate that even within a breed, there could be substantial inherent differences in size. The relatively harsher environment in terms of nutrition and environmental temperature under which WAD goats in sudan savanna are raised could have

Table 1
Body weight (kg) and morphological traits (cm) of West African Dwarf goats according to agro-ecological zone (mean±SE)

| Trait | Rainforest | Guinea savanna | Sudan savanna |
|---|---|---|---|
| BW | 17.14[a]±0.30 | 16.46[a]±0.33 | 13.78[b]±0.19 |
| WH | 44.09[a]±0.33 | 43.56[a]±0.39 | 40.85[b]±0.33 |
| RH | 45.96[a]±0.32 | 45.42[a]±0.39 | 42.95[b]±0.30 |
| FRL | 33.78[a]±0.29 | 33.32[a]±0.37 | 31.90[b]±0.46 |
| HDL | 35.00[a]±0.31 | 34.56[a]±0.38 | 33.14[b]±0.46 |
| BL | 45.10[a]±0.38 | 44.13[a]±0.43 | 40.24[b]±0.31 |
| FAL | 15.02[a]±0.26 | 14.85[a]±0.29 | 13.65[b]±0.35 |
| EL | 10.85[a]±0.13 | 10.83[a]±0.12 | 9.34[b]±0.24 |
| HL | 7.03[a]±0.15 | 6.96[a]±0.19 | 6.38[b]±0.17 |
| RL | 11.44[a]±0.11 | 11.27[a]±1.14 | 10.23[b]±0.20 |
| TL | 11.22[a]±0.09 | 11.13[a]±0.11 | 10.59[b]±0.20 |
| NC | 21.96[a]±0.18 | 21.14[b]±0.26 | 20.03[c]±0.31 |
| AC | 71.37[a]±0.59 | 70.27[a]±0.68 | 62.52[b]±0.65 |
| CC | 6.97[a]±0.08 | 6.66[b]±0.09 | 6.81[b]±0.05 |
| CG | 60.09[a]±0.49 | 59.39[a]±0.52 | 55.78[b]±0.75 |
| CD | 26.43[a]±0.31 | 26.24[a]±0.34 | 24.17[b]±0.52 |
| HW | 9.41[a]±0.12 | 9.21[a]±0.14 | 8.33[b]±0.11 |
| SW | 10.81[a]±0.15 | 10.39[a]±0.17 | 9.32[b]±0.14 |
| RW | 9.69[a]±0.12 | 9.11[b]±0.17 | 8.49[b]±0.13 |

BW: body weight, WH: withers height, RH: rump height, FRL: foreleg length, HDL: hindleg length, BL: body length, FAL: face length, EL: ear length, HL: horn length, RL: rump length, TL: tail length, NC: neck circumference, AC: abdominal circumference, CC: cannon circumference, CG: chest girth, CD: chest depth, HW: head width, SW: shoulder width, rump width (RW).

[abc]Means in the same row with different superscripts are significantly different ($p<0.05$).

Table 2
Summary of stepwise selection of traits

| Step | Traits entered | Partial $R^2$ | Pr> F | Pr< lambda | P> ASCC |
|---|---|---|---|---|---|
| 1 | AC | 0.1408 | <0.0001 | <0.0001 | <0.0001 |
| 2 | EL | 0.0412 | 0.0019 | <0.0001 | <0.0001 |
| 3 | RW | 0.0456 | 0.0010 | <0.0001 | <0.0001 |
| 4 | CD | 0.0280 | 0.0149 | <0.0001 | <0.0001 |
| 5 | CC | 0.0235 | 0.0301 | <0.0001 | <0.0001 |

AC: abdominal circumference, EL: ear length, RW: rump width, CD: chest depth, CC: cannon circumference.

Table 3
Standardized canonical coefficients for the canonical discriminant function, the canonical correlation, the eigen value and the percentage total variance accounted for

| Variables | CAN 1 | CAN 2 |
|---|---|---|
| Abdominal circumference | 0.982 | -0.184 |
| Ear length | 0.595 | -0.309 |
| Rump width | -0.298 | 0.975 |
| Chest depth | -0.497 | -0.487 |
| Cannon circumference | -0.199 | 0.634 |
| Adjusted canonical correlation | 0.443 | 0.219 |
| Approximate standard error | 0.045 | 0.054 |
| Eigen value | 0.266 | 0.058 |
| Variance accounted for (%) | 82.04 | 17.96 |

been largely responsible for their lower body dimensions (Table 1). This is probably to enable them to cope with low water and low quantity and quality of available feed. These stress factors could have prevented the goats from expressing their genetic potential.

The two canonical functions obtained in the present study (Table 3) could be used for the selection of WAD goats and could equally serve as criteria for establishing phenotypic standards for the breed. The low differentiation between the three goat populations as revealed by the Mahalanobis distances (Table 4) did not provide sufficient statistical support to separate the populations into different genetically distinct groups or breeds. Moreover, the extremely high assignment errors (Table 5) for goats in the three zones affirms the homogeneity of the genetic identity of the goats.

Persistence of the observed morphological differences between goats in the three agro-ecological zones under controlled environmental conditions will support the hypothesis that much of the morphological variation is under genetic control and according to Dossa *et al.* (2007), can respond to improved

Table 4
Mahalanobis distances between goat populations according to agro-ecological zone

| Agro-ecological zone | Rainforest | Guinea savanna | Sudan savanna |
|---|---|---|---|
| Rainforest | | 0.27 | 2.50 |
| Guinea savanna | | | 2.54 |
| Sudan savanna | | | |

Table 5
Per cent (%) of individual goats classified into agro-ecological zone

| Agro-ecological zone | Rainforest | Guinea savanna | Sudan savanna |
|---|---|---|---|
| Rainforest | 24.38 | 64.37 | 11.25 |
| Guinea savanna | 63.81 | 22.86 | 13.33 |
| Sudan savanna | 24.32 | 29.73 | 45.95 |
| Error level | 0.76 | 0.77 | 0.54 |
| Priors | 0.33 | 0.33 | 0.33 |

management practices. The WAD goat has the inherent ability to resist trypanosomiasis. Since the genetic resources required for the future are difficult to predict, selection for conserving these populations with unique evolutionary history has to be taken into account and breeds should be chosen in order to cover the widest range of genetic variability.

It is concluded that West African Dwarf goats from the rainforest, guinea savanna and sudan savanna zones of Nigeria could best be separated using morphometric traits such as abdominal circumference, rump width, ear length, chest depth and cannon circumference. The information reported in this study will along with molecular information enable high resolution characterization, conservation and formulation of breeding and selection strategies for Nigerian WAD goats.

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ए. याकुबू, ए.ई. सालाको, आई.जी. ईमुमोरिन। नाईजीरिया के तीन कृषि–पारिस्थिक क्षेत्रों में पश्चिमी अफ्रीकी बौनी बकरियों के आकृतिक गुणों के स्थानिक पैटर्न का बहुचर विश्लेषण।

नाईजीरिया के तीन क्षेत्रों (समशीतोष्ण वर्षावन, गिनी घास का चारागाह और सूडान घास का चारागाह) में फैली 302 पश्चिमी अफ्रीकी बौनी बकरियों (पअबौब) के आकृतिक गुणों का बहुचर विश्लेषण किया गया। वर्षावन और गिनी सवान्ना की बकरियों के आकृतिकमाप सार्थकत: अधिक थे। अल्प आकृतिमापी दूरी और बकरियों के तीनों समुदायों में मिलन से पता चलता है कि वे समांगी है और उनकी आनुवंशिक पहिचान में साझेदारी है। यह उनके संरक्षण और उचित संवर्धन एवं चयन क्रिया के बनाने में सहायक हो सकता है।

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