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Phenotypic Characterization of Cattle Based on Coat Colour in Obudu Grass Plateau, South-South Nigeria: A Discriminant Approach

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Target Audience: Animal Breeders, Academia, cattle industries

Abstract

A total of 311 cattle comprised 145 mixed coat coloured, 100 white coat coloured and 66 brown coat coloured were used to investigate the phenotypic characterization of cattle based on coat colour using multivariate discriminant analysis approach. A total of nineteen morphological traits where measured. Theses includes: body weight (BW), body length (BL), ear length (EL), horn length (HNL), head length (HDL), head width (HDW), rump length (RL), rump width (RW), horn circumference (HNC), heart girth (HG), cannon circumference (CC), cannon length (LC), scrotal circumference (SC), foreleg length (FLT), hind leg length (HLT), rump wide (RW), rump length (RL), dewlap wide (DWW) and number of teat (NTT) were collected on each animal. The data was analyzed by SPSS and the mean was separated using Duncan multiple test. The multivariate analysis revealed that the phenotypic trait measured of brown coat coloured cattle were significantly larger ($P<0.05$) than white and mixed coat coloured with the exception of HNL in white. However, the stepwise discriminant analysis revealed that HNC, CL, UDC and HDW were more discriminating in separating the three coat colour populations. The Mahalanobis distance of the morphological traits between brown and mixed coat coloured cattle was the largest (14.16) while the least genetic distance was observed between white and brown coat coloured cattle (7.43). The eigenvalues and Wilk's lambda test revealed the function 1 with percent (%) variance of 67.8 and Wilk's lambda of 0.166 showed a good function to discriminant and grouping. The study concluded that the high value of genetic distance (D^2) between brown and mixed coat colours indicates that if mated, it will give rise to hybrid vigour.

Keywords: Cattle, Coat Colour, Discriminant, Phenotypic

Description of Problem

Cattle are the single most important livestock species in Nigeria in terms of animal protein, value and biomass (16). Increasing these protein value and biomass requires the conservation of genetic distance among indigenous cattle breeds. In order to cope with an unpredictable future in the face of climate change, genetic reserves that are capable of readily responding to directional forces imposed by a broad spectrum of environments must be maintained (5). Sub-Saharan Africa is an important source of farm animalgenetic resources as most of the alleles coding for traitswhich are implicated for resistance to stress, resistanceto diseases and ability to thrive on low quality feed can befound in this region (20). The need for the conservation of this enormous genetic diversity to accommodate changes is of great concern (4).

The wide range of breeds and species that have evolved in various environments represent unique sets of genetic diversity. Genetic diversity has been defined as the variety of alleles and genotypes present in a population, and this is reflected in morphological, physiological and behavioral differences between individuals and populations (10). 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 high and on the increase. Recently, loss of genetic diversity within indigenous livestock breeds has been a major concern (12). 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, a unique genotype, aesthetic and cultural values are being lost (14, 1). Characterization of animal genetic resource (AnGR) encompasses all activities associated with the identification, quantitative and qualitative description of breed populations and the natural habitat and production systems to which they are or not adapted (6). The characterization of domestic animal diversity is essential to meet future needs in Nigeria and sub-Saharan Africa in general. Comparison orcharacterization based on morphological properties canprovide to some extent a reasonable representation ofthe differences among the breeds, though not exhaustive,it serves as the foundation upon which DNA analysis canbe built. Domestic animal diversity is critical for foodsecurity and essential to meet unpredictable futuredemand of population increase, climate change and morevirulent disease pathogens, thus, a reservoir not onlydepends on the number of breeds but also on the geneticdiversity within and between these breeds (7). The objective of the study is to characterize indigenous cattle breeds in Obudu Grass Plateau, South-South Nigeria based on their colour due to indiscriminant mating over the years, in order to determine the genetic distance between the coat colours, which could help in proper genetic improvement of the local stock.

Materials and Method

Study Area

The study area is the Obudu Grass Plateau located in the Obanliku Local Government Area of Cross River State, Southeastern Nigeria. It lies between longitude 90 22’ 00” and 90 22’ 45” E, and latitude 60 21’ 30” and 60 22’ 30” N, with an approximate area of 104sqm^2, and a height of about 1576m above sea level (9). Obudu Grass Plateau is bounded in the north by Benue State, northeast by the Republic of Cameroon, to the southeast by Boki Local Government Area in Cross River State of Nigeria. The area is situated within the tropics but it has a climate that is likened to temperate region with mean daily temperatures range between 15^{0}C and 22^{0}C. It has a mean annual rainfall of about 4300mm with highest rainfall of about 76.2cm usually recorded in August while the lowest of 0.76cm is usually recorded in December (13). The Obudu Grass Plateau is part of the Precambrian Basement Complex of Nigeria (9)

Management system of the experimental Animals

The animals were managed under extensive system with little or no provision of shelter in the day and night. The animals are kept in lots in the night and the lots are fence with stick or barb wires. The calves were separated from the cows in the night. They grazed during the day time on natural pasture. No Adequate veterinary care was in existent and uncontrolled breeding was also practice.

Other management practice such as hand picking of ticks, castration of mature bulls that have used for service over the years and mineral salt were given as supplement.

Experimental Animals and Phenotypic Data Measured

A total of 333 animals were used for the experiment of which 145 were (mixed coat colour), 100 (white coat colour), 66 (Brown coat colour) and 22 (Black coat colour). Body measurements were taken when the animals were in standing position with head raised and weight on all four feet without body movement. Physical restraint was applied to limit movement by use of crusher sometime rope was used. Seventeen phenotypic traits were measured on each animal. Linear body measurements were taken with a measuring tape while body weight was taken using glass fiber band with model number WJ515. The phenotypic traits measured are;

Head length (HL): This is the distance from the base of the head to the muzzle.

Head Width (HW): It is the distance between extreme lateral edges of forehead at narrowest point, midway between the eyes.

Ear length (EL): The distance from the tip of the ear to the base of the ear.

Horn length (HNL): The distance from the tip of the horn to the base of the horn

Horn circumference: It's the narrowest distance at the base of the horn.

Height at withers (HW): This is the vertical distance from the floor beneath the animal to the point of the withers. It was measured with a measuring stick with a sliding arm.

Heart girth (HG): This is the narrowest circumference immediately posterior to the front legs.

Cannon circumference (CC): This is the narrowest circumference of the canon bone.

Body length (BL): It's the length from the shoulder point to pin bone

Tail length (TL): The distance from the pin bones of the sacrum to the base of the tail switch.

Cannon length (CL): It's the vertical distance from the floor beneath the hind limp to the rear flank.

Scrotal circumference (SC): This is the narrowest circumference of the scrotal sac. **Udder circumference:** This is the narrowest circumference of the animal udder.

Fore limp length (FLT): It's the vertical distance from the floor beneath the fore limp to the point of shoulder.

Hind limp length (HLT): It's the vertical distance from the floor beneath the hind limp to the pin bone.

Rump with (RW): Measured with tapeline from a point on spine midway between tops of hip points to posterior tip of pin bone.

Rump length (RL): This the distance from the hipbone to the head of the tail.

Data Analysis

Statistical Analysis

The morphological traits were subjected to analysis of variance to determine genotype effect using the MEAN procedure of SPSS (2001). Means were separated using the Duncan Multiple Range Test (DMRT) (Duncan, 1955). The fixed effects of breed on linear body measurements were tested using linear model given as follows:

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

Where Y_{ij}= individual observation of each body traits;

μ = overall mean;

B_i = fixed effect of i^{th} on Breed

e_{ij}=random residual error associated with record of each animal

Estimation of Mahalanobis squared distance (D2) between cattle of different coat colour in same location was estimated based on the phenotypic trait measured. The data phenotypic traits were subjected to the Candisc

procedure to estimate the Mahalanobis. The Mahalanobis squared distance (D2) between the coat colours was estimated by following relationship between breeds was estimated by the following model: D2 (i/j) = (xi – xj) cov-1 (xi - xj).
Where D2 = genetic distance between populations in an m- dimensional space. I/j = the element of the i^{th} row and the j^{th} column of the inverse matrix. xi – xj = mean sets of original variables Cov = covariance of the original data set.

Results and Discussion

The results of effect of coat colour on phenotypic traits of cattle are presented in Table 1. The result showed that BW, BL, EL, HNL, HNC, DWW, UDC, NTT, FLT, HLT, CC, RW and CL are significantly ($P<0.05$) different. Animal with brown coat colour showed superiority over the white and mixed coat colours except for HNL which showed superior in white coat. This could be that animal with brown coat have better adaptation to the environment than the other coat colours. The phenotypic comparison of phenotypic traits may provide facts about the breed relationships and size. This concurred with the report of (19) who opined that morphometric trait between breeds of cattle can served as basis for their genetic relationship. The variation in phenotypic traits of the three coat colour (white, brown and mixed colours) cattle might not be unconnected with individual breed's potential and peculiarities. Some of the reproductive traits like RW in the study showed superiority in brown coat colour cattle. This imply that brown coat colour could have easy of parturition. The superiority of RW in female could be as a result of their well-developed pelvic girdle, an adaptive feature of female animals for conception (8). Female animals require wide pelvic girdle to allow for easy pass of the fetus during parturition. The value of some traits measured for HW of 117.84cm (white), 129.23cm (brown) and 114.96cm (mixed) are equal and higher than the value 111.8cm4 (White Fulani) and 127.50cm (Sokoto Gudali) reported by (18). The value obtained in this study is also equal and higher than the Nandi (110–122 cm), Mongalla (100–110 cm) (15), Mexican Criollo Chinampo (101–117 cm) (21) and Sudan Baggara (115.9–148.80 cm) (3) cattle, respectively. The HG obtained in this study are 148.97cm (white), 166.08cm (brown) and 145.63cm (mixed) are higher than the range of 122–127 cm reported for North Bengal Grey cattle in Bangladesh (2).

Table 1: Effect of Coat colour on phenotypic traits of cattle

	White Colour		Brown		Mixed	
Traits	X	SD	X	SD	X	SD
BW	288.85[b]	75.01	404.15[a]	96.85	276.60[b]	110.13
BL	95.35[b]	21.77	114.38[a]	10.46	91.50[b]	14.07
HW	117.84	8.95	129.23	7.60	114.96	12.80
HDL	44.60	4.26	47.55	5.01	42.05	6.53
HDW	18.40	3.17	17.35	1.87	17.55	3.32
EL	21.68[a]	2.64	23.28[b]	1.98	20.25[b]	3.64
HNL	26.50[a]	12.57	41.88[b]	15.15	21.85[c]	18.25
HNC	16.70[a]	3.57	23.65[c]	4.98	56.50[b]	19.61
DWW	13.75[a]	3.67	12.75[b]	18.42	16.55[c]	17.18
TL	86.40	1.98	98.85	26.09	90.85	24.50
UDC	40.65[a]	3.38	48.25[b]	6.30	46.45[b]	4.45
NTT	4.20[a]	9.62	4.00[b]	0.600	4.00[b]	0.00
FLT	84.25[a]	9.56	83.90[b]	12.80	79.95[b]	19.24
HLT	96.55[a]	8.22	107.52[b]	5.16	95.85[b]	11.30
CC	19.23[a]	9.93	19.50[a]	5.08	14.93[b]	5.25
RW	35.20[b]	4.61	41.60[a]	7.03	32.50[b]	6.95
RL	18.30	2.56	18.00	3.36	17.85	2.98
CL	66.85[a]	3.44	69.30[a]	5.15	27.00[b]	22.40
HG	148.97	14.30	166.08	16.07	145.63	21.43

SEM=Standard Error of Mean, Significant difference ($p<0.05$), abcd = Means in the same row bearing different superscripts differ significantly ($p<0.05$). BW=body weight, BL=body length, EL=ear length, HNL=horn length, HNC=horn circumference, HG=heart girth, CC=cannon circumference, CL=cannon length, SC=scrotal circumference, FLT =foreleg length, HLT=hind leg length, RW=rump wide, RL=rump length, DWW=dewlap wide, NTT=number of teat, HG=heart girth

The results of Malahonobis distance between white, brown and mixed colour coat cattle are presented in Table 2. The genetic distances between the coat colours were estimated by Malahonobis distance (D^2) methods from the cattle of different coat colour. The largest distance was found between mixed and brown coat colour cattle (14.16) and the least distance (7.43) was found between white and brown coat colours. This indicates that the genetic exchange that has taken place overtime between the latter has reduced the genetic distance that would have theoretically described their differences (18). This may be due to location proximity, whereby there was non-directional and un-control crossbreeding among local populations. It could also be due to ethnic farming communities arising from selection induced by differed ethnic cultural practices. Thus, this could be stated as from the preceding that a cross between brown and mixed coat colours cattle in Obudu Grass land may yield good hybrid vigour, while mating between brown and white coat colours cattle counter parts might not give desirable hybrid vigour gains with regard to most economic traits. This agreed with the report of (18) who opined that crossbreeding between animal with high value of genetics distance will yield to good heterosis while those with small value of genetic distance will yield poor heterosis. In a related study, (17) reported low genetic distance between the Sudan (Djallonke) and Sudan-Sahel (Mossi) sheep using Mahalanobis distance, and attributed this to sustained introgression.

Table 2: Malahonobis distance between white & brown and mixed colour cattle

	White colour	Brown colour
White colour	-	
Brown Colour	7.43	
Mixed	12.44	14.16

The results of summary of stepwise discriminant analysis are presented in Table 3. The results showed that four of the measured traits were found to be significant (P<0.01-P 1-P .0001), which are HNC, CCL, UDC and HDW had more discriminant power than the others as revealed by their higher R^2 and F-values. Therefore, all other variables were removed from the final model. It was done following the method of (22). This implies that taking these four basic measurements (HNC, CCL, UDU and HDW) consistently could be more important in differentiating between the white, brown and mixed coat colour cattle in Obudu grass land, Nigeria. Morphological variables are easy to monitor and may facilitate the use of ethnological characterization and at the same time institute reliable racial discriminants (11). The four morphological variables obtained in the present study are more important and informative, and could be used to assign the three white, brown and mixed coat colour cattle into group.

Table 3: Summary of stepwise selection of traits

Step	Variable entered	Partial R^2	F-value	Pr>F	Pr<F	Wiles Lambda	Pr<Lambda	Average squard	Pr>ASCE
1	HNC	0.6934	40.11	<0.0001	0.217	0.217	<0.0001	0.56	<0.0001
2	CL	0.687	37.45	<0.0001	0.118	0.118	<0.0001	0.85	<0.0001
3	UDC	0.3189	30.58	<0.0001	0.146	0.146	<0.0001	0.74	<0.0001
4	HDW	0.0260	25.72	0.4724	0.1307	0.307	<0.0001	0.73	<0.0001

HNC=horn circumference, CL=cannon length, UDC=udder circumference, HDW=head width

The results of estimated total shared variance between the optimally weighted discriminant varieties in the groups (Eigen values) are presented in in Table 4: The percentage of shared variance (67.8) of function 1 was higher than 32.2 of functions 2. The canonical correlation of function 1(0.854) was also higher than 0.749 of functions 2.The high percentage of shared variance (Eigen value) and total variability in the groupings of discriminant function I indicated that the model in function I was more efficient in explaining the variation that exist in the grouping variable than the model of function 2. The efficiency of the higher canonical correlation measures the strength of a model which explains the variations that exist in a population or group of animals. It was also reported that canonical correlation measure the strength explaining the variation in the grouping variables (23), the higher the value of canonical correlation the higher the strength of the canonical correlation. The results of Wilk's lambda test are presented in Table 5. The result is link with the evident in Tables 3 and 4 where the first function (function 1) explaining 67.8 % of the variance and has a small lambda (0.118) and it's significant with p value of 0.000. The second function explains only 32.2 % of the variance in the data, with a recorded p value of 0.000. Thus, the first function will contribute significant in discriminant process. The second function does not contribute much significantly in the discrimination process as compared to that of the first function. In other words, this factor does not help much in discriminating the groups. This result agreed with the (6) who opined that the derived discriminant functions provided maximum (canonical linear discriminant function) separation among breeds.

Table 4: Eigen values, canonical correlation, total and cumulative functions of discriminant variables

Function	Eigenvalue	% Variance	Cumulative (%)	Canonical Correlation
1	2.699	67.8	67.8	0.854
2	1.281	32.2	100.0	0.749

Table 5: Wilks lambda test

Function	Wilk's Lambda	Chi Square	DF	P-Value
1 through 2	0.118	118.37	8	0.000
2	0.436	45.78	3	0.000

Conclusion and Applications

1. Based on this study coat colour have effect on the phenotypic traits which could be a useful tool for selection.
2. The genetic distance (D^2) revealed in this study showed high value of 14.16 between brown and mixed coat colours cattle which imply that mating between the two coat colours will result to hybrid vigour. Beside the lower value 7.43 between white and brown coat colours imply mating between the two coat colour will not result to meaningful heterosis.
3. The discriminant traits among the cattle are horn circumference, cannon length, udder circumference and head width.
4. The eigenvalue and Wilk's lambda test showed that function 1 is significant to provide good discriminant function among the coat colours cattle which imply that the variations that exist among the cattle based on their coat colours will give room for improvement.
5. This study will be relevant in further crossbreeding and grouping of cattle in Obudu grassland, Nigeria.

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