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Effects of sex, morphological characteristics and haemoglobin type on the growth traits of red sokoto goats in semi-arid region of Nigeria

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***Target audience:** Animal Scientists, Breeders, Goat Farmers*

Abstract

The experiment was conducted to determine effects of sex, morphological characteristics and haemoglobin type on the growth traits of Red Sokoto goat. A total of 321 Red Sokoto goats were used for the study. The population of Red Sokoto goats was studied in Hardy-Weinberg equilibrium. The frequencies of observed morphological characteristics such as coat type, hair type, tail shape, tassels and sex were recorded. The body mensuration characteristics of the goats were identified and their effects on the performance were also assessed. Four haemoglobin types were discovered, namely; HbAA, HbAB, HbBB and HbAC. Only two (2) animals sampled had the rare pre-adult haemoglobin type (HbAC). The distribution of all the parameters were determined using Chi-square analysis and the Haemoglobin types were expressed as homozygous (HbAA and HbBB) and heterozygous (HbAB and HbAC). Data collected were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of SAS. The Red Sokoto goats within 8 months of age had the highest frequencies (24.61 %) while the least (3.12 %) was obtained in those that are within 48 months. The highest coat type, hair type and tail shape were found in Brown (B), Short-smooth (SS) and Curled up (CU) respectively. The Red Sokoto goats without tassels (308) were more than those with tassel (13). Sex significantly ($P<0.05$; $P<0.01$) affected the body mensuration traits except body length with the does having superior performance compared to the bucks. Tassel had no significant ($P>0.05$) effect on all body mensuration traits. Hair type significantly ($P<0.05$; $P<0.01$) influenced body mensuration traits of Red Sokoto goats. The long-curly and short-smooth were superior to short-rough hair typed goats in all the body mensuration traits. Tail shape had no significant ($P>0.05$) effect on body mensuration traits in Red Sokoto goats except on body length ($P<0.01$). Goats with curled up tails were superior to those with curled down and straight tails. Hb type significantly ($P<0.05$; $P<0.01$) influenced the body mensuration characteristics except body depth. The HbBB typed goats were superior in performance compared to HbAA typed goats; while the HbAB typed goats were the intermediates. The HbAC typed goats were the least in performance compared to HbBB, HbAA and HbAB variants in Red Sokoto goats. In essence, the haemoglobin genotype HbAB in Red Sokoto goats seems to be favoured by natural selection with preponderance for the HbAA allele. Goats with the SS and LC hair type and BWS coat type recorded greater production performance in terms of the mensuration traits. In conclusion, the significant effect of Hb type and all other physical indicators for production show that with careful genetic studies and proper documentation of records, variation in our goat herd could be drastically improved within a short time.

***Keywords:** Goat, Red Sokoto, Semi-arid, Haemoglobin types, Morphological Characteristics*

Description of Problem

The livestock sector is essential to the livelihood of the populace the sub-Saharan Africa than in any other part of the world, as it contributes significantly not only to food security and nutritional quality of the diet but also to the sustenance of national economies. Adding to this is the increased demand for livestock products in this region coupled with combination of population growth, rising incomes and urbanization (1). Therefore, there is the need for increased livestock production which has been estimated at 23,836 million tonnes for milk, beef buffalo, sheep, goat, chicken meats (white meat) and eggs in Sub-Saharan Africa (2). However, output of both mutton and chevon in Nigeria was estimated at 163,000 tonnes (3).

The animal protein intakes by Nigeria populace at present is 4.82g/caput/day (4) as against a minimum required of 35g recommended by the FAO and also a stark contrast to the 58g per day consumed in developed countries such as the United States of America.

Small ruminants are increasingly becoming a major source of animal protein in Nigeria; they are almost as ubiquitous as poultry, though not as numerous. They have a total estimate of 56.6 million throughout the country, with goats outnumbering sheep by three to two (5). The Red Sokoto goat (RSG) or Maradi is the most predominant goat and accounts for about 70% of Nigeria's total goat population which has been estimated at 34.45 million (6). The breed is predominantly reddish brown in colour and is found in the Savanna zone of Nigeria (8°N-11°N) where it constitutes more than 90% of the goat population in that area. The breed weighs about 1.5-2.0kg at birth and reaches about 12.0kg when weaned at 3 months under good management (7). Weights of adult does and bucks are 20-35kg and 25-40kg, respectively (7).

The small ruminants of Nigeria have been variously evaluated for genetic variation based on morphological and productive characters/data. However, morphological variations have been documented to underestimate true levels of genetic variations (8).

Studies of biochemical polymorphism and their association with reproductive performances and production characteristics in animals have also been successfully utilized in selecting superior performers in the recent past, (9; 10). Morphological traits have long been used in selecting animals for parents of the next generation. However, few experiments have likened various body features or morphological characteristics to haemoglobin type and production traits viz characters such as hair type and coat colour variations.

Knowledge of the haemoglobin types, body measurements and production characteristics of Red Sokoto goats will go a long way to improving the genetic background of our indigenous herd. With this study, by simply knowing effects of sex, qualitative and quantitative traits of Red Sokoto goat and haemoglobin type, prediction is possible for production performance of Red Sokoto goat. Therefore, the aims of this study were to identify morphological characteristics that may serve as indicators for improving production performance and existing association of haemoglobin types with body mensuration characteristics.

Materials and Methods

Experimental Location

The field research was conducted in the semi-arid zone of Nigeria. The semi-arid zone of Nigeria starts from about 11^{o}N latitude and ends at the Nigeria-Niger frontier. It encompasses the Sudan and Sahel Savanna and part of the Northern Guinea Savanna. The

mean annual temperature runs between 26 and 28ºC. There is a single rainy season from May to October, with mean annual rainfall ranging from 1016mm in the wettest parts to less than 508mm in the driest parts. The length of growing period is about 100-150 days which makes it possible to cultivate a wide variety of crops (11). The semi-arid zone has a land mass of 113,530km2 and a population of over 35 million people (12). The major inhabitants of this area are Hausa and Fulani who are predominantly mixed crop-livestock farmers and livestock herders respectively.

Sampling Size, Sampling Structure and their Characterization

The Red Sokoto goats were sampled using a random sampling method to determine their body morphological traits. A total of three hundred and twenty one (321) Red Sokoto goats were used for this study while two hundred and thirteen (213) of them were evaluated for haemoglobin type or polymorphism. Thirty-four (34) of the goats sampled were male while two hundred and eighty-seven (287) were female.

Each of the goat were then categorized for age, coat type, hair type, tail shape, presence or absence of tassels, sex and haemoglobin type.

The age of the goats was determined using teeth count (2) in combination with the information provided by the goat owners.

Measurements/Observations of Morphological Parameters

1. **Body weight**- The body weight was taken for each goat using a hanging scale. Weight was taken in Kilogram (Kg).
2. **Height at withers**- This was measured in centimetres (cm) from the highest point on the dorsum of the animal to the ground surface at the level of the front legs using a measuring stick.
3. **Body length**- Body length was taken from the point of shoulder to the ischium using a tape rule in centimetres (cm).
4. **Stature**- This was measured from the top of the spine in between the hips to the ground using a measuring stick in centimetres (cm).
5. **Body depth**- This is the distance between the top of the spine and the bottom of barrel at the last rib, the deepest point independent of stature. It was measured in cm using a tape rule.
6. **Chest girth**- This was measured as a circumference of the body at a point immediately behind the fore-legs, perpendicular to the body axis or simply as the smallest circumference around the belly. This was also measured with a tape rule in centimetres (cm).
7. **Tassels/ Wattles**- The presence or absence of the loose fold of bare skin hanging from the throat of goats, called 'tassels' was noted.
8. **Tail shape**- The orientation of the tail shape of the goat; whether straight, curling upwards or curling downwards was noted.
9. **Coat type**- This was observed as the colour pigmentation of the goat.
10. **Hair type**- The types of hair observed was also documented and this was categorized into smooth, rough, and curly (woolly) hair type.
11. **Age**- The pairs of permanent incisors in the dentition of the goat was used to determine age.
12. **Sex**- The sex of the animal was also noted.

The tassels, tail shape, coat type and hair type served as morphological characteristics served as indices for production performance.

Blood Sampling and Analysis for Hb Types

Blood samples were obtained via jugular venipuncture; about 5ml of blood was drawn by using a syringe into heparinized vacutainer

tubes containing ethylene diamine tetra-acetic acid (EDTA) as blood anti-coagulant. The test tubes were then labelled according to ascribed numbers given to each goat sampled for body mensuration characteristics. The blood samples were then taken to the laboratory, washed with normal saline and then haemolysed with distilled water to release the haemoglobin. The supernatant was removed after centrifuging at 3000 rpm for 5 min and the sample haemoglobin stored until ready for electrophoresis.

Human haemoglobin AA and AS were used as controls for the first 100 samples. This was to develop a control for the caprine samples. On development of caprine control, the procedure was then repeated for all the samples using caprine haemoglobin AA and BB as controls.

Fig. 1: Showing haemoglobin bands using Electrophoresis.

Cellulose acetate paper strip electrophoresis was employed to separate the globin fractions. Electrophoresis was carried out in a Shandon electrophoresis tank on cellulose acetate strips 34.5x 150mm with 0.26MTris buffer (pH 9.1) at both the anode and cathode. The strips were run for 5 minutes at a constant voltage of 250v until a clear separation is observed. On separation, the strips were stained with ponceau-s stain, later washed with 5% glacial acetic acid, and dried using filter paper. Interpretations were made based on the relative mobility of the haemoglobin bands towards the anode. The genotype that migrated faster was labeled HbAA, the slow moving fraction was identified as HbBB while the heterozygote (consisting of both slow and fast bands) was HbAB (13; 10).

Fig 2- An electrophoresis tank showing acetate strips and band separations as a result of current flowing from a galvanometer.

Fig 3- An electrophoresis tank with galvanometer

Strip 1: Haemoglobin types of Nigerian Red Sokoto goats using caprine HbAA and HbBB as controls

a'- Caprine HbBB (Control)
n'- Caprine HbAA (Control)
a,b,d,- Bovine HbBB
c,e,f,g,h,i,j,k,l,m,n- Caprine HbAB
+ - Anode

Strip 2: Haemoglobin types of Nigerian Red Sokoto goats using Human HbAA and HbAS as controls.

a'- Human HbAA (Control)
n'- Human HbAS (Control)
a, b- Caprine HbAA
c, d, h, j, k- Caprine HbBB

e, f, g, i, l, m, n- Caprine HbAB
+ - Anode

Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of SAS (14). Significant means were separated using Duncan Multiple Range Test. The distribution of the goats across classes based on morphological traits and the measured qualitative traits were assessed for significance using Chi-square analysis and computed based on pooled data among strains and age categories using the Frequency procedure of SAS (14) package and haemoglobin types were determined as earlier stated above.

Chi-square (χ^2) =

$$\frac{(\text{Observed freq} - \text{Expected frequency})^2}{\text{Expected frequency}}$$

The relationship between body measurements with age, coat type, hair type, tail shape and tassels was determined using the equation:

$Y_{ijklm} = \mu + C_i + H_j + S_k + T_l + e_{ijkl}$

Where;

Y_{ijklm}=Measured variable or value of any observation

μ=Overall mean

C_i=Effect of i^{th} Coat type

H_j=Effect of j^{th} hair type

S_k=Effect of k^{th} tail shape

T_l=Effect of l^{th} tassel

e_{ijkl}=Residual effect/error term

Results and Discussion

Table 1 shows the age distribution of Red Sokoto goats that were studied. With a total number of 321 goats sampled from different herds at age of 6 months and above.The maximum age observed from the different herds was 48 months. Goats that aged 8 months (24.61%) constituted the majority herds. This was followed by goats that aged 36 months (17.13%), 30 months (16.51%) and 24 months (12.46%), respectively. The rest of the age categories were less than 10% with the least distribution was from goats that aged 48 months (3.12%). The distribution further revealed that goats that aged between 6 and 12 months (36.76%) constituted the majority in the herds; followed by 24-36 months (33.64%) and 12-24 months (20.87%), respectively. The least was for goats that aged greater than 36 months (8.73%). This is similar with the trend observed in the study of (15). However, this may be attributed to the genetic factors.

Table 1: Age distribution of red sokoto goats of 6 months and above in the studied herds

Age (months)	Observed	Frequency (%)
6	12	3.74
8	79	24.61
12	27	8.41
18	27	8.41
24	40	12.46
30	53	16.51
36	55	17.13
42	18	5.61
48	10	3.12
Total	321	100

Table 2: The effect of sex on body mensuration characteristics of Red Sokoto goats

Sex	N	BW	HAW	BL	S	BD	CG
Total/ LOS	321	**	*	NS	*	*	**
Male	34	12.5 ± 0.82^{b}	52.6 ± 0.80^{b}	36.6 ± 0.63^{b}	53.7 ± 0.79^{b}	19.5 ± 0.29^{b}	56.0 ± 0.72^{a}
Female	287	22.6 ± 0.57^{a}	58.3 ± 0.35^{a}	40.6 ± 0.23^{a}	60.1 ± 0.35^{a}	21.3 ± 0.15^{a}	66.1 ± 0.49^{a}

a,b = means within the same column with different superscripts differ significantly (P<0.05); *=P<0.05; **=P<0.01; N= number of observations; BW= body weight; HAW= height at withers; BL= body length; S= stature; BD= body depth; CG= chest girth.; NS= not significant.

Table 2 indicated the effect of sex on body mensuration characteristics of Red Sokoto goats. Sex had significant (P<0.05; P<0.01) effect on all the body mensuration traits except body length. Females differed significantly (P<0.01, P<0.05) from male with the female having higher values in all the measured traits; body weight (BW), height at withers (HAW), body length (BL), stature (S), body depth (BD) and chest girth (CG).

The results obtained in this study agreed with the findings of (16) and (17) who reported higher body weights for does (female) in West African Dwarf breed than its counterparts. However, the results contradicted the report of (7) who noted heavier weights for adult bucks. Earlier reports by (18) also concluded that male goats of similar age to females had improved linear body measurements. This might be as a result of the small population of bucks (males) sampled; the owners disposes majority of their bucks at yearling leaving just one or two bucks to service the females. Moreover, 23 out of 34 bucks were 8 months of age with only a few (5 bucks) over 1 year.

The effect of tassel on body mensuration characteristics of Red Sokoto goats is presented in Table 3. Tassel had no significant (P>0.05) effect on body mensuration traits. Also, 'presence' or 'absence' of tassels on the goats. Tasseling was to be examined as a marker for production traits, though only very few animals (13 animals) had this external protruding loose skin. The non- significant influence of tassel was in line with observation of (16) who concluded that tasseling is not a good index for production.

Table 4 shows the effect of hair type on body mensuration characteristics of Red Sokoto goat. Hair type significantly (P<0.05; P< 0.01) influenced body mensuration characteristics of Red Sokoto goats. The long-curly and short-smooth were superior to short-rough hair typed goats in all the body mensuration traits.

Table 3: Effect of tassel on body mensuration characteristics of Red Sokoto goats

Tassels	N	BW	HAW	BL	S	BD	CG
Total/ LOS	321	NS	NS	NS	NS	NS	NS
Absent	308	21.7 ± 0.55	57.7 ± 0.35	40.2 ± 0.23	59.5 ± 0.35	21.1 ± 0.14	65.1 ± 0.49
Present	13	18.2 ± 2.76	57.2 ± 1.36	39.9 ± 0.85	58.9 ± 1.42	20.6 ± 0.57	62.5 ± 2.34

N= number of observations; NS = not significant (P>0.05), LOS= Level of significant, BW= body weight; HAW= height at withers; BL= body length; S= stature; BD= body depth; CG= chest girth; NS= not significant.

Table 4: Effect of hair type on body mensuration characteristics of Red Sokoto goat

Hair type	N	BW	HAW	BL	S	BD	CG
Total/LOS	321	**	**	**	**	*	**
SS	224	22.2 ± 0.65[a]	58.5 ± 0.38[a]	40.6 ± 0.26[a]	60.2 ± 0.40[a]	21.3 ± 0.17[a]	65.8 ± 0.56[a]
SR	59	17.9 ± 1.15[b]	54.0 ± 0.80[b]	38.0 ± 0.52[b]	56.1 ± 0.78[b]	20.4 ± 0.33[b]	60.8 ± 1.12[b]
LC	38	23.7 ± 1.52[a]	58.32 ± 0.94[a]	40.9 ± 0.62[a]	60.3 ± 0.92[a]	21.2 ± 0.35[a]	66.6 ± 1.25[a]

a,b = means within the same column with different superscripts differ significantly, N= number of observations, SS= Short-smooth, SR= Short-rough, LC= Long-curly, LOS= Level of significant, *=P<0.05; **=P<0.01; BW= body weight; HAW= height at withers; BL= body length; S= stature; BD= body depth; CG= chest girth.

The values obtained were similar to the findings of (19) and (16). The significant effect of hair type showed that animals with SR and LC were statistically improved in all the measured parameters. These animals weighed more, taller in stature, longer body lengths, body depths, and better circumference at the chest (chest girth): Goats with the SS hair type however, weighed less, shorter in stature, body lengths, less body depth and chest girths. The significant difference means selecting animals with the SR and LC hair type increases the possibility for better production parameters (BW, HAW, BL, S, BD and HG) in ones herd.

The effect of tail shape on body mensuration characteristics of Red Sokoto goat is presented in Table 5. Tail shape had no significant (P>0.05) influence on BW, HAW, S, BD and HG except on the body length (BL). Animals with tails curled up (CU) and curled down (CD) were similar and are significantly (P<0.05) higher than straight (S) tail shape.

The result obtained on tail shape was in line with documentation of (19) who reported a high and positive correlation between body length and body weight in adult Beetal goats. This is very important in selection and breeding as longer body length results in bigger animals with heavier weights. (16) also reported similar associations for body length and body weight in West African Dwarf (WAD) goats.

The effect of coat type on body mensuration traits is shown on Table 6. Coat type had significant (P<0.05) influence on the body mensuration characteristics except height at withers (HAW) and stature (S). The effect of the different coat types on the mensuration parameters varied slightly with coat type having a significant effect on BW, BL, BD and HG, while it had no significant (P>0.05) effect on HAW and S. The brown goats with white spots were superior in performance compared to others; these were followed by the white and brown, brown and dark red coat color goats.

This formed a peculiar association because HAW and S are the only two parameters used to determine height (tallness or shortness) of the animal. This implies that coat color was not a good indicator for these two productive traits, however goats with BWS as their coat type weighed more and excelled in all other measured parameters; they were taller (HAW and S), and had longer body length (BL) and chest girths (CG).

Animals with DR, B and BW had similar weight averages and were statistically improved with each other. This means that the WBKS pigmentation recorded were the least figures for production parameters, having the lowest BW, HAW and CG. Thus, animals with this coat pigmentation should not be selected for improvement for production traits. Goats with this WBKS pigmentation were however

at par in body length (BL) with other animals with the BWS, BW, W and B coat type. In essence, Brown goats with white spots weighed heavier, grew taller, longer and had higher depth and girth.

Table 5: Effect of tail shape on body mensuration characteristics of Red Sokoto goat

Tail Shape	N	BW	HAW	BL	S	BD	CG
Total/ LOS	321	NS	NS	**	NS	NS	NS
CU	305	21.6 ± 0.56	57.8 ± 3.43	40.3 ± 0.23^{a}	59.6 ± 0.35	21.2 ± 0.14	65.2 ± 0.50^{a}
CD	13	19.5 ± 0.56	54.5 ± 1.61	37.4 ± 1.21^{a}	56.6 ± 1.63	20.2 ± 0.64	61.3 ± 1.86^{b}
S	3	21.3 ± 4.84	55.0 ± 4.40	36.7 ± 3.71^{b}	58.0 ± 4.04	19.7 ± 1.20	66.0 ± 2.08^{a}

a,b = means within the same column with different superscripts differ significantly (P<0.01), NS= not significant, CU= Curled up, CD= Curled down, S=Straight, N= number of observations; BW= body weight; HAW= height at withers; BL= body length; S= Stature (the S on the horizontal); BD= body depth; CG= chest girth.

Table 6: Effect of coat type on body mensuration characteristics of Red Sokoto goat

Coat type	N	BW	HAW	BL	S	BD	CG
Total/ LOS	321	**	NS	**	NS	**	**
DR	24	22.4 ± 2.40^{ab}	57.3 ± 1.57^{b}	39.4 ± 0.91^{b}	59.3 ± 1.54^{b}	21.7 ± 0.60^{a}	65.8 ± 2.03^{bc}
B	142	22.7 ± 0.80^{ab}	58.2 ± 0.49^{ab}	40.7 ± 0.33^{a}	59.9 ± 0.48^{b}	21.4 ± 0.20^{ab}	66.4 ± 0.74^{b}
W	22	11.5 ± 0.51^{c}	56.6 ± 0.49^{b}	41.1 ± 0.51^{a}	58.4 ± 0.59^{b}	19.5 ± 0.31^{d}	56.9 ± 0.88^{d}
LB	22	20.7 ± 1.00^{b}	56.7 ± 0.72^{b}	38.7 ± 0.51^{b}	58.2 ± 0.78^{b}	20.4 ± 0.27^{c}	63.1 ± 0.84^{c}
BW	25	23.6 ± 1.71^{ab}	57.7 ± 1.23^{b}	40.8 ± 0.69^{a}	60.0 ± 1.22^{ab}	22.0 ± 0.54^{a}	66.8 ± 1.68^{b}
BWS	21	26.1 ± 2.13^{a}	59.8 ± 1.16^{a}	41.5 ± 0.74^{a}	62.0 ± 1.17^{a}	22.1 ± 0.54^{a}	70.0 ± 1.41^{a}
WBKS	5	14.0 ± 4.73^{c}	56.2 ± 0.97^{c}	41.0 ± 0.32 ^{a}	58.4 ± 1.40^{b}	20.8 ± 0.37^{b}	59.8 ± 2.60^{d}

a,b,c,d = means within the same column with different superscripts differ significantly (P<0.01); N= number of observations; NS= not significant; BW= body weight; HAW= height at withers; BL= body length; S= stature, BD= body depth; CG= chest girth, DR= Dark Red, B= Brown, W= White, LB= Light brown ,BW= Brown and white , BWS= Brown with white spots/streaks, WBKS=White with black spots/streaks

Table 7: Effect of Hb type on body mensuration characteristics of Red Sokoto goat

Hb type	N	BW	HAW	BL	S	BD	CG
Total/LOS	321	**	**	**	**	NS	*
HbAA	65	22.0 ± 1.36^{b}	58.8 ± 0.71^{ab}	41.0 ± 0.50^{ab}	60.2 ± 0.74^{b}	20.9 ± 0.34	64.9 ± 1.10^{b}
HbAB	124	19.4 ± 0.83^{c}	56.4 ± 0.53^{b}	39.2 ± 0.58^{b}	58.2 ± 0.54^{c}	20.6 ± 0.20	63.0 ± 0.77^{c}
HbBB	22	26.9 ± 1.91^{a}	60.4 ± 0.79^{a}	41.5 ± 0.44^{a}	62.5 ± 0.83^{a}	22.0 ± 0.35	68.6 ± 1.30^{a}
HbAC	2	11.5 ± 0.50^{d}	61.0 ± 4.0^{a}	39.0 ± 2.00^{b}	58.5 ± 0.50^{c}	20.5 ± 0.50	57.5 ± 0.50^{d}

a,b,c,d = means within the same column with different superscripts differ significantly, *=P<0.05; **=P<0.01; NS= not significant; N= number of observations; BW= body weight; HAW= height at withers; BL= body length; S= stature; BD= body depth; CG= chest girth.

Table 7 shows the effect of haemoglobin (Hb) type on body mensuration characteristics of Red Sokoto goat. The Hb types significantly ($P<0.05$; $P<0.01$) influenced the body mensuration characteristics of Red Sokoto goat except body depth. The HbBB typed goats were superior in performance compared to HbAA typed goats; while the HbAB typed goats were the intermediates. The HbAC typed goats were the least in performance compared to HbBB, HbAA and HbAB variants in Red Sokoto goats.

The study of body weight, height art withers, body length, stature, and chest girth under different haemoglobin types showed significant variations except for depth.

The observed results were in agreement with the works of (20) who reported that haemoglobin type had influence on performance of sheep and goats.

The result obtained contradicted the findings of (10) who found no significant relationship between Hb type and body weight, body length, chest girth and height at withers in Garole sheep. (9) also found no significant effect of transferrin genotype on performance of Damascus goats.

Goats with the slow-banded homozygous haemoglobin type HbBB performed better in all the measured parameters. Therefore, selecting for goats with this genotype would mean bigger or fleshier goats with a high market appeal. The goats with HbAC had the least records for mensuration traits, being only greater in its HAW. The most important mensuration characteristic here which stands out is the body weights of goats with the HbBB genotype which was statistically not influenced the average body weights of all other haemoglobin types.

Conclusion and Applications

1. The long-curly and short-smooth were superior to short-rough hair typed goats in all the body mensuration traits
2. Goats with the SS and LC hair type and BWS coat type recorded greater production performance in terms of the mensuration traits
3. Knowledge of the haemoglobin types, body measurements and production characteristics of Red Sokoto goats will go a long way to improving the genetic background of our indigenous herd
4. The haemoglobin genotype HbAB in Red Sokoto goats seems to be favoured by natural selection with preponderance for the HbAA allele which suits the northern highlands of Nigeria, though goats with HbBB genotype showed greater promise for improved production.

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