Full Length Research

Effect of interaction of haemoglobin genotype with locations on morphometric traits of West African Dwarf goats raised in Akwa Ibom State, Nigeria

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ABSTRACT: Haemoglobin type, a useful marker for genomic selection, has influenced the adaptability of animals to a particular environment. The effect of the interaction of haemoglobin types with various locations on morphometric traits of West African Dwarf goats in Akwa Ibom State, Nigeria, was studied. Three hundred and eighty-four goats of both sexes were sampled from three senatorial districts (Eket, Ikot Ekpene and Uyo) of Akwa Ibom State. Morphometric traits measured were body length (BL), height at wither (HW), heart girth (HG), rump height (RH), body depth (BD) and body weight (BWT). Five millilitres of blood samples from each goat were collected through the jugular vein for electrophoretic analysis. The data obtained were subjected to a 2x3 factorial in a completely randomised design. Gene and genotypic frequencies were estimated, and chi chi-square test was used to assess the conformation mode of the goat population to Hardy-Weinberg genetic equilibrium. Two haemoglobin genotypes, HbAA and HbAB, were identified. Genotypic and allelic frequencies for HbAA are higher in all locations than HbAB. BL (50.75±0.52), HW (45.11±0.29), and RH (45.80±0.36) for HbAA were superior to HbAB. However, HbAB was superior to HbAA for TL (11.00±0.29) and NC (33.43±0.82) in the main effect. The interaction of haemoglobin types with locations had a significant influence on all the morphometric traits, with HbAA being superior to HbAB, but both HbAA and HbAB favoured body weight in Ikot Ekpene.

Keywords: West African Dwarf goats, haemoglobin types, interaction and morphometric traits.

INTRODUCTION

In the present economic woes and food shortage in Nigeria, goat breeding and its improvement have become necessary. Interestingly, goats do not compete with humans for food but can survive only on renewable forage materials and crop residues, converting them into food and thus contributing immensely to the livelihood of farmers. Shettima *et al.* (2019) noted that disposal of agro by-products, which could have constituted an environmental problem, is consumed by ruminants and converted into high-quality food for humans.

However, Sam *et al.* (2017) asserted that there are hidden potentials of goat which are yet to be unlocked. In order to gainfully utilise the full potential of goats, breeders have to focus on the variations existing within the population as the raw materials for their improvement. Studies by Odubote (1996) showed that optimal genetic gain of animals could be achieved by continuous appraisal of genetic parameters for quantitative traits which are under the influence of the environment.

West African Dwarf goat, the predominant breed in the humid tropics, has been reported to have various coat colours (Okon *et al.*, 2023; Shoyombo *et al.*, 2018). This may confer adaptive ability to a stressful tropical humid environment.

Haemoglobin genotypes, one of the useful markers for genomic selection, have been reported to influence the environmental adaptability of animals (Peters *et al.*, 2004). Three types of haemoglobin variants have been identified by electrophoretic analysis, HbAA, HbAB and HbBB in goats (Sam *et al.*, 2016., Shoyombo *et al.*, 2018). Alphonsus *et al.* (2012), however, reported the presence of four haemoglobin types (HbAA, HbAB, HbBB and HbAC) in Red Sokoto goats. They further noted that HbAC is also known as foetal haemoglobin and is mostly associated with very young animals. Gurcan *et al.* (2010) observed that haemoglobin types can be determined easily during the postnatal period of young animals, and these components are not affected by environmental factors.

A report by Hrinca (2008) explained that the polymorphism degree of the haemoglobin system of goat breed is defined by the number of alleles, the ratio between them, the interallelic combinatory capacity, the number of genotypes expressed, their distributions, the grouping mode, variability ranges and dispersion degree. Many studies have been conducted using different breeds of sheep, goat and cattle to determine the relationship between blood biochemical polymorphism and production traits (Shoyombo *et al.*, 2018; Gurcan *et al.*, 2010; Akinyemi and Salako, 2010).

Several studies have shown that haemoglobin genotype could be used to improve many economic traits that are associated with it (Sam *et al.*, 2016; Yakubu *et al.*, 2014; Akinyemi and Salako, 2010).

Although researchers have made attempts to investigate the influence exerted by haemoglobin genotypes on morphological traits in other locations, there is a dearth of this information on the interaction of haemoglobin type and location in the humid tropic zone of Nigeria.

MATERIALS AND METHODS

Study area

The study was conducted across the three senatorial districts of Akwa Ibom State, namely Eket, Ikot Ekpene and Uyo. Eket is located between longitude 7°52' East and latitude 4°45' North. The Eket senatorial district is identified with fresh water and mangrove swamp forest ecological structure. The mean yearly temperature is 25 and 28°C throughout the year. The average annual rainfall amounts to 3731 mm. The area experiences two main seasons, the dry and wet seasons. The people of Eket senatorial district are notably small farmers, fishermen and hunters. Ikot Ekpene senatorial district is located between longitude 7°33' East and latitude 5°35'North. The location falls within the humid tropic characterised by bimodal rainfall. Average rainfall is about 366.47mm, and average annual temperature is 30.46°C. Vegetation is of a heavy

rainforest type. The people of Ikot Ekpene are notably small-scale livestock and crop farmers. Uyo senatorial district is located between latitude 04°56'N and longitude 07°56'E. The climate is tropical, and it belongs to the swamp forest agro-ecological zone of Nigeria. The annual rainfall is about 339.79 mm, and the average temperature is 28.24°C (AKSG, 2012).

Animals and their management

A total of three hundred and eighty-four (384) goats between the ages of 1- 3 years for males and 2- 5 years and above for females were sampled. They were intensively managed in mud houses or tethered outside in pasture areas to avoid damage that could be caused by goats to crops. They were fed on browses/grasses/legumes mixtures Sometimes, supplementary feed in the form of cassava peel, yam peel and kitchen wastes were also given to them.

Sample size and sampling techniques

One hundred and twenty-eight (128) goats were sampled from each of the three senatorial districts, making it a total of three hundred and eighty-four (384) goats. Sample size was determined using the formula for calculating sample size $n = N \times [Z^2 \times p \ (1\text{-}p)/e^2] / [N - 1+(Z^2 \times p \times (1\text{-}p)/e^2]$ (Srivastav and Vaidya, 2023) from a population of 1,826,780 goats in Akwa Ibom State reported by NBS/FMARD (2011). A maximum of two goats was sampled from each household using a random sampling technique.

Measurement of morphometric traits

Animals selected for measurement were brought out with acceptance from the owner and restrained before measurement. The following measurements were taken using tailor's tape in centimetres (cm), except body weight in kilograms (kg), on each of the animals using the methods as described by Sam (2012).

Body length (BL): Body length was measured using tailor's tape as the distance from the occipital protuberance to the base of the tail.

Height at withers (HW): The height was measured as the distance from the ground to the withers using tailor's tape.

Heart girth (HG): The heart girth was measured by measuring the circumference of the chest using tailor's tape.

Rump height (RH): The rump height was measured as

the distance from the ground to the rump using tailor's tape.

Body depth (BD): This was measured using tailor's tape as the circumference of the region immediately after the hind leg towards the abdomen.

Body weight (BW): This was measured using a hanging scale in kilograms.

Ear length (EL): ear length was measured from the base of the ear to the tip of the pinna.

Tail length (TL): Tail length was measured from the base of the tail to the pinpoint of the tail.

Neck circumference (NC): This was measured as the distance around the neck.

Blood collection and preparation for analysis

Five millilitres (5ml) of blood were collected from each of the sampled animals by jugular venipuncture, using a sterile needle and syringe into a test tube containing Ethylene Diamine Tetra Acetic acid (EDTA) as anticoagulant. The samples were properly labelled and sent to the Haematology Laboratory, University of Uyo Teaching Hospital, Uyo, Akwa Ibom State, for electrophoresis. The blood samples were washed with normal saline and haemolysed with distilled water to release the haemoglobin. The supernatant was removed after centrifugation at 3000 rpm for five minutes, and the sample haemoglobin was stored until ready for electrophoresis. A cellulose acetate paper strip was used to separate the haemoglobin fractions. Electrophoresis was carried out in a Shandon electrophoresis tank on cellulose acetate strips 34.5 x 150 with 0.26MTris buffer (pH 9.1) at the anode and cathode. The strips were run for five minutes at a constant voltage of 250 V until a clear separation was observed. Interpretations were made based on the relative mobility of the haemoglobin bands toward the anode. The genotype that migrated faster was labelled HbAA, while the double band, consisting of both fast and slow bands, was labelled HbAB as described by Tella *et al.* (2000) and Das *et al.* (2004).

Data analysis

Data collected on morphometric traits were subjected to a 2 x 3 factorial in a Completely Randomised Design using the General Linear Model procedure of Statistical Package for Social Science (SPSS). The significant differences between means were separated using the Duncan Multiple Range Test of the same package. The statistical model used was:

$$Y_{ij} + \mu + H_i + L_j + (H \times L)_{ij} + E_{ij}$$

Where: Y_{ij} = Single observation, μ = Population mean, H_i = Effect of haemoglobin type (HbAA, HbAB), L_j = Effect of locations (Eket, Ikot Ekpene and Uyo), $(H \times L)_{ij}$ = Interaction effect of haemoglobin type and location, E_{ij} = Random error that occurred during measurement.

Genotype and allele frequencies were analysed using Chi-square to test for goodness-of-fit for observed and expected frequencies under Hardy-Weinberg genetic equilibrium.

RESULTS AND DISCUSSION

The genotypic and allelic frequencies of West African Dwarf goats according to location is presented in Table 1. The results indicated that the allele frequency of Hb A alleles was higher in Eket (0.777), Ikot Ekpene (0.797) and Uyo (0.773) than Hb B alleles, 0.223, 0.203 and 0.227, respectively. This result strengthened the study of Dafur *et al.* (2019), who reported gene frequencies of 0.705 for Hb A and 0.295 for Hb B in male West African Dwarf goats. However, gene frequency obtained in this study was higher than the values reported by Yakubu *et al* (2014) for West African Dwarf goats and Sam (2012) for Agropastoral goats. The predominance of Hb A over Hb B and the absence of Hb BB in this present study had been earlier reported by Yakubu *et al.* (2014) in West African Dwarf goats in north central Nigeria, Bindu and Raghavan (2010) in Malabari goats, and Canatan and Boztepe (2000) in Turkish Hair goats.

The high frequency of HbAA in the goat population studied suggested that the genotype is favoured by natural selection in the study area. Sam *et al.* (2016) noted that expression of Hb genotypes and adaptability of animals to a particular environmental condition are related. Guney *et al.* (2003) found that gene frequency of haemoglobin types is related to breed and geographical location and may influence the performance of sheep and goats. The result of this study suggested that the predominance of HbAA and absence of HbBB might be an adaptive superiority of HbAA and its selective advantage over Hb BB.

Chi-square test (Table 2) showed that there were no significant (p>0.05) differences between the observed and expected frequencies of haemoglobin and alleles. Therefore, the population as a whole was in Hardy-Weinberg equilibrium. This suggested that there was no significant change in the gene frequency. This same observation had been reported by Sam (2012) for agro pastoral goats. However, Yakubu *et al.* (2014) observed deviation in West African Dwarf goats population in north central of Nigeria.

The main effect of haemoglobin type on morphometric traits of West African Dwarf goats, as presented in Table

Table 1. Gene and genotypic frequency of haemoglobin type based on location.

Location	Obs	Genotypic frequencies		Allelic frequencies	
		AA	AB	A	B
Eket	128	(71) 0.555	(57) 0.445	0.777	0.223
Ikot Ekpene	128	(76) 0.594	(52) 0.406	0.797	0.203
Uyo	128	(70) 0.547	(58) 0.453	0.773	0.227

Figures in parentheses indicate the number of animals.

Table 2. Observed and expected number of haemoglobin genotypes of West African Dwarf goats based on location.

Location	Obs	Hb	Observed (O)	Expected (E)	($\chi 2$) df = 1
Eket	128	AA	71	72.33	0.0563
		AB	57	55.67	
Ikot Ekpene	128	AB	76	72.33	0.1726
		AB	52	55.67	
Uyo	128	AA	70	72.33	0.1726
		AB	58	55.67	
Overall	384	AA	217	216.99	0.657
		AB	167	167.01	

Table 3. Main effect of haemoglobin genotype on morphometric traits (Mean ± SD) of West African Dwarf goats.

Parameters	Haemoglobin type		P-Value	LOS
	AA	AB		
Body weight (kg)	19.78±0.42	18.85±0.39	0.188	NS
Body length (cm)	50.75±0.52[a]	44.73±0.99[b]	0.000	*
Height at wither (cm)	43.11±0.29[a]	41.33±0.37[b]	0.003	*
Heart girth (cm)	59.34±0.47	60.16±0.45	0.289	NS
Rump height (cm)	45.80±0.36[a]	42.61±0.43[b]	0.000	*
Body depth (cm)	66.69±0.57	65.61±0.66	0.070	NS
Tail length (cm)	10.02±0.15[b]	11.00±0.29[a]	0.005	*
Ear length (cm)	9.72±0.11	9.69±0.20	0.516	NS
Neck circumference (cm)	28.15±0.39[b]	33.43±0.82[a]	0.000	*

*=p<0.05; LOS=level of significant.

3, showed that two haemoglobin genotypes were found in this present study. This finding corroborates the report of Yakubu *et al.* (2014), who also reported two haemoglobin genotypes (HbAA and HbAB) in West African Dwarf goat raised in north central. Body length (50.75±0.52 cm), height at wither (43.11±0.29) and rump height (45.80±0.36 cm) were significantly (p<0.05) higher in goats with HbAA than HbAB.

In the main effect, location significantly (p<0.05) affect all the morphometric traits studied except height at wither. Goats in Ikot Ekpene and Uyo had significantly (p<0.05) superior body weight compared to Eket (Table 4). Similar effect of location on morphometric traits has been reported by Aluko *et al.* (2013) and Sam *et al.* (2016) for West African Dwarf goats in Ogun State and Obio Akpa respectfully.

The interaction of HbAA with locations showed significantly (p<0.05) higher body length (BL) in UYAA (52.06 ±5.89) and IKAA (51.65±4.86), while the least body length was observed for UYAB (38.22±5.73). Height at wither (HW) for EKAA (42.31±2.53), IKAA (43.22±3.10) and UYAA (43.78±3.05) were significantly higher than IKAB (40.54±0.88) and UYAB (40.17±2.55), suggesting that Hb AA favours increased body size and height of West African Dwarf goats in all the locations. Body weight (BW), heart girth (HG), body depth (BD) and ear length (EL) were not significantly (p>0.05) influenced by haemoglobin genotype in the main effect. However, interaction of HbAA with locations (Table 5) indicated significantly higher body weight (BWT) for IKAA (21.19±4.91), UYAA (20.58±3.48), EKAA (19.89±3.56) and IKAB (19.34±2.25) than UYAB (17.44±1.04 and EKAB (17.34±2.73), suggesting that

Table 4. Main effect of location on morphometric traits (Mean ± SD) of West African Dwarf goats.

Parameters	Location			p-value
	Eket (±sd)	Ikot Ekpene (±sd)	Uyo (±sd)	
BW (kg)	18.26±3.26[b]	20.71±4.43[a]	19.45±3.22[ab]	0.047
BL (cm)	48.54±4.39[ab]	50.74±4.94[a]	47.08±8.86[b]	0.000
HW (cm)	42.58±2.59	42.52±2.94	42.48±3.34	0.321
HG (cm)	57.88±3.61[b]	59.08±4.75[b]	61.86±3.47[a]	0.000
RH (cm)	43.92±2.56[b]	44.64±4.32[ab]	45.72±3.91[a]	0.049
BD (cm)	65.34±4.26[b]	64.86±6.63[b]	68.82±4.09[a]	0.000
TL (cm)	10.42±1.62[b]	9.50±1.14[c]	11.10±2.08[a]	0.000
EL (cm)	9.24±1.04[b]	9.50±1.26[b]	10.40±1.12[a]	0.000
NC	28.64±3.37[b]	28.44±3.68[b]	32.54±6.91[a]	0.000

[abc] means on the same row bearing various superscripts differed significantly ($p<0.05$); BW=body weight; BL= body length; HW= height at wither; HG= heart girth; RH= rump height; BD= body depth; TL= tail length; EL= ear length; NC= neck circumference; SD=standard deviation.

Table 5. Interaction effect of location and haemoglobin type on morphometric traits of West African dwarf goats in Akwa Ibom State.

Parameters	Location						p-value
	Eket		Ikot Ekpene		Uyo		
	EKAA	EKAB	IKAA	IKAB	UYAA	UYAB	
BW (kg)	19.89±3.56[a]	17.34±2.73[b]	21.19±4.91[a]	19.34±2.25[a]	20.58±3.48[a]	17.44±1.04[b]	0.000
BL (cm)	48.41±4.26[c]	48.78±4.71[b]	51.65±4.86[ab]	48.15±3.86[c]	52.06±5.89[a]	38.22±5.73[d]	0.000
HW (cm)	42.31±2.53[a]	43.05±2.71[a]	43.22±3.10[a]	40.54±0.88[b]	43.78±3.05[a]	40.17±2.55[b]	0.001
HG (cm)	59.00±3.37[ab]	57.25±3.65[b]	59.34±2.44[ab]	58.92±5.35[b]	61.91±3.81[a]	61.78±2.88[a]	0.042
RH (cm)	43.63±2.56[bc]	44.44±3.23[b]	46.08±3.93[ab]	43.54±1.27[bc]	47.66±3.08[a]	42.28±2.65[c]	0.000
BD (cm)	67.22±4.88[a]	64.28±3.52[b]	66.35±7.05[a]	60.62±2.10[c]	69.50±4.55[a]	67.61±2.87[a]	0.000
TL (cm)	10.09±1.46[bc]	11.00±1.74[b]	9.73±1.15[cd]	8.85±0.89[d]	10.28±1.93[bc]	12.56±1.46[a]	0.000
EL (cm)	9.28±1.05[c]	9.17±1.04[c]	9.81±1.24[bc]	8.62±0.86[d]	10.06±1.10[b]	11.00±0.91[a]	0.000
NC (cm)	28.16±5.23[c]	29.50±3.55[bc]	27.32±3.56[c]	31.61±1.61[b]	29.09±4.90[bc]	38.67±5.64[a]	0.000

[abcd] means on the same row bearing different superscripts are significantly different ($p<0.05$); EKAA=Eket x HbAA; EKAB=Eket x HbAB; IKAA=Ikot Ekpene x HbAA; IKAB=Ikot Ekpene x HbAB; UYAA=Uyo xHbAA; UYAB=Uyo x HbAB; BW= body weight; BL=body length; HW=height at wither; HG=heart girth; RH=rump height; BD=body depth; TL=tail length; EL=ear length; NC=neck circumference.

HbAA favours body weight in all the locations. Similarly, heart girth (HG) and body depth (BD) for HbAA across the three locations were significantly ($p<0.05$) higher than HbAB, suggesting that HbAA favours heart circumference. Tail length (TL), ear length (EL) and neck circumference (NC) were significantly ($p<0.05$) higher for UYAB than in EKAA and IKAA. This is contrary to the report of Yakubu et al. (2014), who observed that RH, EL, BL and HW were not significantly ($p>0.05$) influenced by haemoglobin types. However, Shettima et al. (2019) reported that heart girth, neck circumference, and shoulder width were significantly ($p<0.05$) influenced by haemoglobin type in Red Sokoto goat. Shoyombo et al. (2018) observed significantly ($p<0.01$) higher BL, HG and BD in goat with Hb BB than Hb AA and Hb AB. Das et al. (2004) found no significant relationship between Hb type and body weight, body length, heart girth and height at withers in Garole sheep.

Conclusion

Two haemoglobin types, HbAA and HbAB, were found in the studied location. This may be due to the adaptive superiority of HbAA over HbBB in the studied area. Goats with HbAA had superior body length, height at wither and rump height. The interaction of haemoglobin types with locations had a significant influence on all the morphometric traits, with HbAA being superior to HbAB, but both HbAA and HbAB favoured body weight in Ikot Ekpene.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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