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Original Article

Haemoglobin Polymorphism in Red Sokoto Goats of Nigeria

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Abstract

This study describes the genetic structure from the Hb locus in goats of the Red Sokoto type. The haemotypification of the individuals at the Hb locus was achieved by Cellulose acetate electrophoresis. The haemoglobin polymorphism in the Red Sokoto goat was identified in the electrophoretic field of three migration zones: the fast haemoglobin named Hb^A type, the intermediate migration labelled Hb^AHb^B type and the slow haemoglobin designated Hb^B type. These phenotypes were determined by the two co-dominant alleles, Hb^A and $Hb^{B.}$ The two alleles control three haemoglobin genotypes: two homozygotes, Hb^AHb^A and Hb^BHb^B, and one heterozygote, Hb^AHb^B. The allele Hb^A had a higher frequency (60.4%) than the allele Hb^B (39.6%). The Hb^AHb^B heterozygotes had a higher incidence in the population (64.15%) in comparison with the other two homozygous genotypes; the Hb^AHb^A had a middling frequency (28.30%) and Hb^BHb^B had the least occurrence (7.55%). The observed haemoglobin homozygotness (35.8%) was less than the haemoglobin heterozygotness (64.2%) in the current study. This indicates that environmental conditions, selection system or breeding methods has disturbed the Hardy-Weinberg genetic equilibrium at the Hb locus level in the population of Red Sokoto goats.

Keywords: Haemoglobin, polymorphism, goat, red sokoto.

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Introduction

Although goat breeding is a very old tradition among indigenous farmers, no purposeful breeding programme has ever been organized for the species in Nigeria. Red Sokoto (Maradi) goat is a major breed found in the Northern part of Nigeria. It is reputed for its high quality skin used in the leather industry locally and internationally (Akpa *et al*., 1998).

Goat breeds have been variously evaluated for genetic variation based on morphological, physiological, pathological, productive, reproductive and behavioural features (Pourlis and Christodoulous 2008; Salako *et al*., 2007). However, these characters underestimate the true level of genetic variation. Therefore, the polymorphic variants of different proteins, enzymes, and mineral element or blood group factors represent more accurate procedure for better measurement of genetic variation in goat species (Fesus *et al*., 1983; Menrad *et al*., 2002). One of the important blood proteins is haemoglobin because of its biochemical, biophysical and physiological properties, having relevance to selection phenomenon of animals (Raushenbach and Kamenek, 1978)

Analysis of genetic markers based on protein variants detected by electrophoretic method has been a tool for studying genetic differentiation among populations (Nyamsamba *et al*., 2003). Hence, if animals belonging to one population are kept under different environmental conditions, phenotypic differences observed may simply reflect genotype – environment interactions. In such case, polymorphic biochemical markers can help to compare genetic variability within and between populations (Menrad *et al*., 1994). This paper is proposed to describe the distribution of haemoglobin genotypes among the Red Sokoto goat in a sampled population in Ibadan, Southwestern Nigeria.

Material and Methods

The biological material used for investigating the haemoglobin polymorphism was composed of Red Sokoto goats obtained from the Northern part of Nigeria, transported live to Bodija Market in Southwestern Nigeria for slaughtering. Blood samples from adult goats were collected by jugular venipuncture into 5ml heparinized bottles and transported in ice pack to the Animal breeding and genetics lab, University of Ibadan.

The blood samples were centrifuged at 3500 rotations per minute for five minutes, the plasma supernatant was eliminated and then the erythrocyte obtained was washed thrice in 0.9g sodium chloride solution after each centrifugation the washing solution was removed. The erythrocyte obtained after the third washing was haemolysed using equal volume of distilled water to produce erythrocyte lysis. The haemoglobin solutions which resulted from the haemolysed red cells were ready for electrophoresis to separate the globin fractions of the β-chains of haemoglobin.

The electrolytic solution contained Tris EDTA and Boric acid. The pH of the electrolytic solution was stabilized at 8.4. The electrophoretic migration time was four hours till the bands migrated to about 4cm from the start line. The cellulose acetate paper was stained with Ponceau Stain The strips were destained with 5% acetic acid.

Statistical Analysis

Haemoglobin genotype and gene frequencies were estimated as follows:

$$\text{Genotype frequency of AA} = \frac{\text{no. of individuals with AA}}{\text{no. of individuals sampled}} \times 100$$

$$\text{Genotype frequency of AB} = \frac{\text{no. of individuals with AB}}{\text{no. of individuals sampled}} \times 100$$

$$\text{Genotype frequency of BB} = \frac{\text{no. of individuals with BB}}{\text{no. of individuals sampled}} \times 100$$

$$\text{Gene frequency of A} = \frac{AA + 1/2AB}{\text{Total no. of alleles}}$$

$$\text{Gene frequency of B} = \frac{BB + 1/2AB}{\text{Total no. of alleles}}$$

$$\text{Heterozygosity (H)} = 1 - \sum_{i=1}^{k} p_i^2$$

Where pi is the frequency of the ith of k alleles.

Hardy-Weinberg's equilibrium used for testing the significance of genotypic ratios was based on the expansion of the binomial (p+q) 2 = p2+2pq+q2.

Results and Discussion

By the electrophoresis method, the haemoglobin fractions were separated. The identification of the haemoglobin types in the goats was achieved in accordance with the migration speed of the light spots on the cellulose acetate strip, detected from the start line towards the cathodal zone.

The haemoglobin polymorphism in the Red Sokoto goats was pointed out by three migration zones which had the same electrophoretic characteristics as in sheep.

The fast haemoglobin named Hb^A type, identified by a dark band in the anodal zone.

The haemoglobin with intermediate migration labelled Hb^{AB} type, identified by two bands of different chromatic intensities, the anodal band being lighter than the cathodal one.

The slow haemoglobin designed Hb^B type, identified by a dark band in the cathodal zone.

These three haemoglobin phenotypes were produced by two codominant alleles Hb^A and Hb^B. The two haemoglobin alleles have a differentiated spreading within the breed, the allele Hb^A (60.4%) being more frequent than its codominant Hb^B (39.6%) (Fig.1).

The haemoglobin alleles control three phenotypes: two homozygous (Hb^AHb^A and Hb^BHb^B) and one heterozygous (Hb^AHb^B). The distribution of the haemoglobin genotypes in the red Sokoto breed is relatively unbalanced. The most wide spread individuals are heterozygous Hb^A (64.2%), over half of the goat population being heterozygous for this allele. The Hb^B had the lowest frequency (7.55%) within the population.

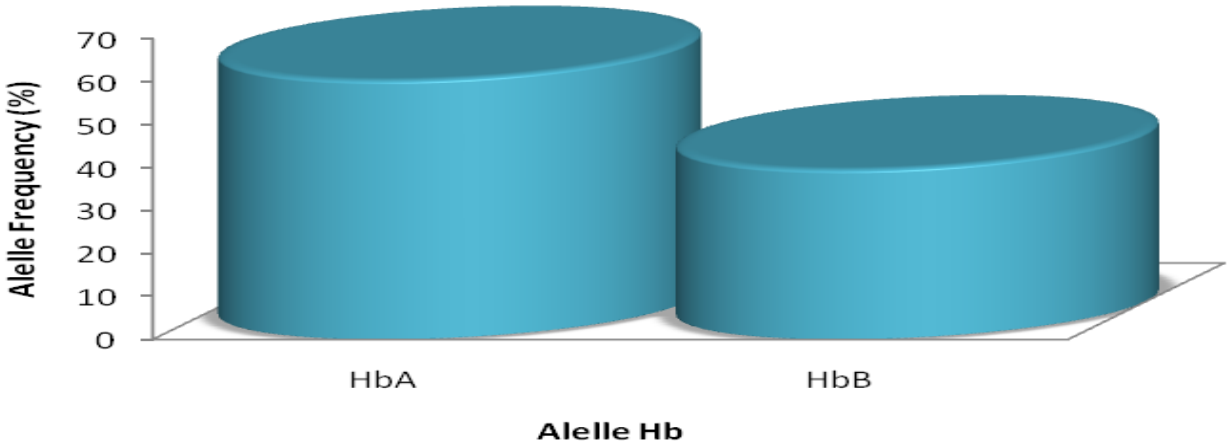
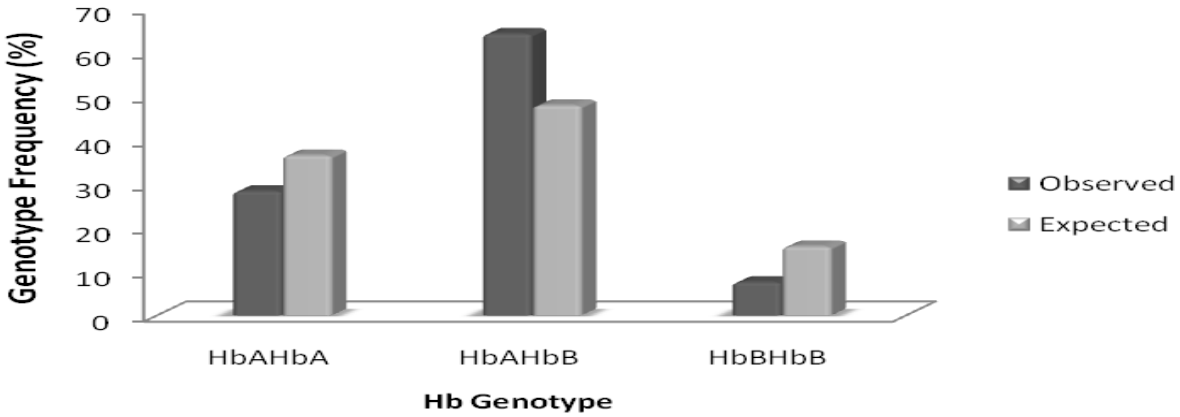


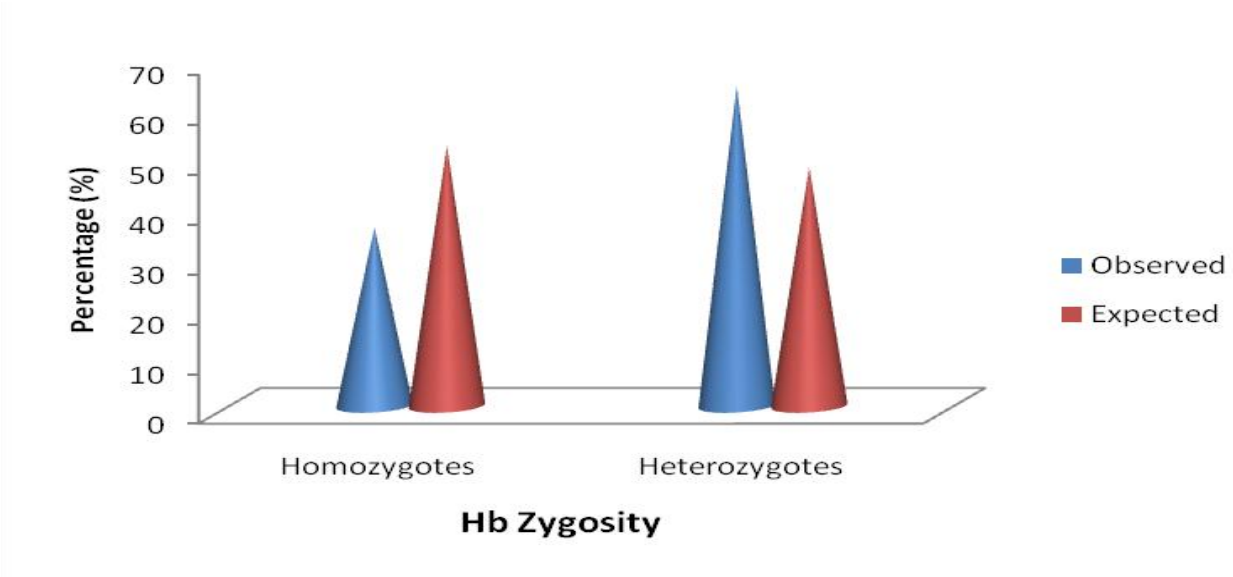
Fig. 1: Allelic structure at the Hb locus in Red Sokoto Goats.



$\chi^2 = 11.186$; L.D.=2; $p<0.05$

Fig. 2: Genotypic structure at the Hb locus in Red Sokoto Goats.

With respect to zygosity, the haemoglobin heterozygotness (64.2%) is much more frequent than the haemoglobin homozygotness (35.8%) (Fig.3). Considering the values of the χ^2 test, the difference between the observed distribution and the expected ones are significant, so that the Red Sokoto goat in this study is not in the Hardy-Weinberg genetic equilibrium, both in respect to genotype partitioning (χ^2= 11.186) and in the ratio between homozygotness and heterozygotness (χ^2= 10.452) (Fig. 3, 4).



χ^2 = 10.452; L.D.=1; p<0.05

Fig. 3: Zygosity status at the Hb locus in Red Sokoto Goat.

From the genetic structure at the Hb locus, the Red Sokoto goats belongs to the group of goats in which all haemoglobin types are expressed. The Red Sokoto breed resembles the Carpathian breed, both breeds having the three normal haemoglobin types although with different incidence in the haemoglobin table. In Red Sokoto goat, the incidence of allele Hb^C have been reported (in conbination with the allele Hb^A) (Salako *et al*., 2007), having very low frequency; this allele, that determines the synthesis of the abnormal haemoglobin (HbC), has been associated with incidence of anaemia due to illness and environmental stress in small ruminants. The German goat breed, Edelziegen weiss, has the three haemoglobin types, with the Hb^A type being more prevalent in comparison with the heterozygous type, while the Hb^B is sporadically met (Fesus *et al*., 1983).

In some other goat breeds two haemoglobin types are reported as homozygotes Hb^AHb^A and heterozygotes Hb^AHb^B and no homozygotes Hb^BHb^B.

In another group such as the Batinah and Jebal Akhdar from Oman, only one haemoglobin type is expressed as homozygotes Hb^A or homozygotes Hb^B allele as in Damascus goat (Guney *et al*., 2003; Johnson *et al*., 2002).

The degree of polymorphism of haemoglobin system of each goat breed is defined by the number of alleles, the ratio between them, the interallelic combinatory capacity, the number of genotypes expressed, their distribution and the range of variability. It is demonstrated that extreme temperatures, relief, nutrition and breeding conditions permits the fixing of the allele Hb^A. Thus the allele Hb^A is characterised by a great selection advantage in comparison with allele Hb^B. In a great measure, the selective advantage of the allele Hb^A is due to the biophysical, biochemical and physiological peculiarities of the haemoglobin molecule of type A (Saturation capacity with oxygen, dissociation curve of oxyhaemoglobin, erythrocyte load with haemoglobin, metabolic profile of the erythrocyte) (Raushenbach and Kamenek, 1978).

Conclusion

The Red Sokoto goat presents a middle polymorphism at the Hb locus. The polynorphism is defined by the expression of three genotypes: two

homozygotes, HbAHbA and HbBHbB, and one heterozygote HbAHbB determined by two co-dominant alleles, HbA and HbB. The allele HbA. had higher frequency than the allele HbB. As a result the homozygotes HbBHbB had the least presentation, the heterozygote HbAHbB reached a high incidence and the homozygotes HbAHbA have a middling occurrence. On the whole, the haemoglobin homozygosity is less than the haemoglobin heterozygosity. The Red Sokoto goat in this current study is out of the Hardy-weinberg genetic equilibrium at the haemoglobin locus.

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