Effect of maternal haemoglobin variants and lamb genotype on pre-weaning growth rate of sheep of Northern Nigerian and their crosses

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Abstract

Pre-weaning growth trait of sheep of Northern Nigerian (Balami, Uda and Yankasa) subjected to diallel crossing were estimated using 127 lambs. The study was conducted at National Animal Production Research Institute (NAPRI), Zaria, Nigeria. Blood (5ml) samples were collected from ewes and rams that produce the lambs to evaluate the effect of parental haemoglobin (Hb) variant on the pre-weaning growth rate of lambs. Weight and average daily gain (ADG) of lambs were obtained at 2 weeks interval to 12th week. The data obtained were subjected to analysis of variance using General Linear Model Procedure of SAS. Pair-wise difference was used to separate the mean. Frequency of ewes' Hb genotype in relation to lambs was sorted and tested with Chi Square Procedure of SAS. The result showed that HbAB was the predominant (P<0.01) variant in the studied population, observed in 60% of the ewes and 100% of the sires. Allele A had the highest frequency (62%) in the dam population. The genotypic distribution of Hb variants in the population significantly deviated from Hardy Weinberg equilibrium (χ^2 = 50.8, P<0.01). HbAB and HbBB dams gave birth to lambs that were heavier (P<0.01) than lambs from HbAA from birth to 12 weeks of age. Crossbred lambs from Balami rams and Uda ewes (BL x UD) recorded the highest weight (4.47±0.20 kg) at birth while the least weight (1.73±0.20 kg) at birth was obtained from crossbred lambs given birth to by Yankasa rams and Balami ewes (YK X BL). Pure Balami lambs (BL X BL) was outstandingly superior (P<0.05) to lambs from other genotypes starting from the second week of age up to weaning (12th week). BL X BL also recorded the highest (238.09±12.42 g) average daily gain from birth to 2 weeks of age (ADG2). The ADG decreased linearly as the lambs advanced in age from birth to weaning. Balami sheep are capable of expressing their genetic potentials (better growth than others) in the Northern Guinea Savannah zone of Nigeria. Genetic improvement of growth traits of Nigerian sheep using indigenous stock should focus on the exploitation of genetic potentials in terms of faster growth rate of Balami sheep.

Keywords: Maternal haemoglobin variants, lamb genotype, growth rate and sheep

Introduction

Nigerian sheep population consists of four breeds – Yankasa, Uda, Balami and West African Dwarf. Adu and Ngere (1979) reported that the indigenous sheep of Nigeria have good potentials for meat production which can be exploited through better management. Not many attempts have been made at improving the Nigerian breeds of sheep using the genetic resources within and between breeds in the country. Osinowo and Adu (1985) advised farmers to raise those breeds that predominate in a particular ecological zone because of the variations in the amount of rainfall, temperature and relative humidity in different ecological zones in Nigeria.

Breed differences in performance characteristics are important genetic resources for improving efficiency of mutton (Demeke *et al*., 2004). Diverse breeds are required to match genetic potential with diverse markets, feed resources and climates (Dickerson, 1969). The genetic diversity of sheep can be exploited by the development of composite breeds through crossbreeding to combine the most important traits of economic and adaptation significance (Maijala and Terrill, 1991).

Several studies had linked adaptive and productive features of sheep to some variants of blood proteins (Gootwine, 1988; Salako, *et al*., 2007; Akinyemi, 2010). Electrophoretic study of sheep haemoglobin types showed that there are three main genotypes, which are HbAA, HbBB and HbAB (Miresan, 2003; Tapio *et al*. 2003; Salako *et al*., 2007 and Akinyemi, 2010).

Information obtained from variants of haemoglobin had been proposed as genetic markers for important economic traits and diseases and was suggested as an important means of selection of superior animals for breeding purposes. However, the polymorphism of these important blood proteins had not been linked with productive and reproductive traits in the populations of Balami, Uda and Yankasa sheep. Study of the influence of variations in haemoglobin genotype and lamb genotype on growth traits such as birth weight and average daily gain can help in selection of sheep on the basis of lambs with the best performing haemoglobin genotype along with other sources of variations. This study was therefore aimed at evaluating the effect of maternal haemoglobin variant and lamb genotypes on the pre-weaning growth rate of lambs in a diallel crossbreeding involving Yankasa, Uda and Balami in Northern Guinea Savannah of Nigeria.

Materials And Methods

This study was conducted at the Sheep Project Unit of Small Ruminant Research Programme (SRRP) of National Animal Production Research Institute (NAPRI), Ahmadu Bello University, Shika-Zaria. Zaria is located in the semi-arid, Northern Guinea Savannah zone of Nigeria on latitude 11°08´N and longitude 07°41´E with an elevation of 2178 feet (663.77 metres) above sea level (http://www.trueknowledge.com).

The sheep breeds used for this study were Balami, Uda and Yankasa which were subjected to diallel crossing as shown in Table 1. Pen mating method was used at the ratio of 1 ram to 10 ewes. All the lambs used were given birth to as singles. At birth, lambs were given temporary tag number and were weighed within 24 hours after birth.

Blood samples (5ml) were collected from 125 ewes and 10 rams that produced lambs between 2009 and 2010 through jugular venipuncture. The blood samples were placed in ethylene diamine tetra-acetic acid (EDTA) tubes to prevent coagulation and were transported in ice-pack to the Genetic and Breeding Laboratory, Department of Animal Science, University of Ibadan, Nigeria.

Table 1: Diallel breeding pattern and the resulting number of lambs

Sire breed	Dam breed	Lamb genotype	N
Yankasa	Yankasa	YK X YK	30
Uda	Uda	UD X UD	10
Balami	Balami	BL X BL	12
Yankasa	Uda	YK X UD	20
Yankasa	Balami	YK X BL	5
Uda	Yankasa	UD X YK	12
Uda	Balami	UD X BL	18
Balami	Yankasa	BL X YK	15
Balami	Uda	BL X UD	5
		Male	65
		Female	62

YK = Yankasa; UD = Uda; BL = Balami, N = Number of lambs

Red blood cells (RBCs) were prepared from the erythrocyte fraction of blood by centrifuging at 3000 rpm for 10 minutes at 4°C. The supernatant was decanted leaving the sediment (RBCs). The RBCs were washed in saline (0.155M NaCl) three times and centrifuged at 3000 rpm for 5 minutes at 4°C. The RBCs were lysed by using haemolysing reagent (0.3g EDTA; 2 ml potassium cyanate and 120 ml distilled water) to release haemoglobin. Subsequently, 0.5 ml of the haemolysing reagent was added to individual animal sample's sediment in a test tube to produce the haemolysates. Electrophoresis was carried out in a Shandon electrophoresis tank on cellulose acetate strips 34.5 x 150 mm with 0.26 M Tris buffer (pH 8.4) at both anode and cathode. The strips were ran for 40 minutes at a constant voltage of 350V according to the procedure described by RIKEN (2006) and Akinyemi (2010).

On separation, the strips were stained with Ponceau-S, 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, with haemoglobin AA (single band) being the fastest while haemoglobin BB (single band) was the slowest and haemoglobin AB (double band) having slow and fast bands (Abdusamad *et al*., 2004; RIKEN, 2006; Akinyemi, 2010) as shown in Plate I.

The lambs were weighed at 2 weeks interval up till 3 months of age. Average daily gain (ADG) of lambs was calculated as weight difference between two ages divided by number of days involved. Weight and ADG data of lambs were subjected to analysis of variance using General Linear Model Procedure of SAS

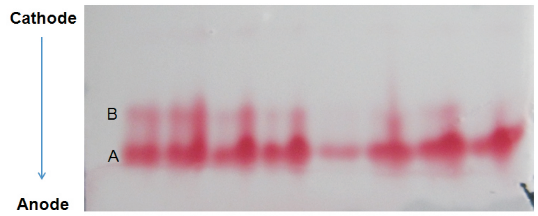

Plate I: Electropherogram of haemoglobin variants

Genotype frequency of dams' haemoglobin variants was calculated thus:

$$AA = \frac{\text{Number of AA}}{\text{Total number of samples}} \times 100$$

$$AB = \frac{\text{Number of AB}}{\text{Total number of samples}} \times 100$$

$$BB = \frac{\text{Number of BB}}{\text{Total number of samples}} \times 100$$

(SAS, 2003). Pair-wise difference was used to separate the mean (SAS, 2003). The pre-test effects of season of birth on pre-weaning growth traits (birth weight and ADG) considered in this study were not significant (P>0.05). The linear model used was as summarized below:

$$Y_{ijklmq} = \mu + G_i + D_j + \varepsilon_{ijklmq}$$

Where:

Y_{ijk} = Observable characteristics.

μ = Overall Mean

G_i = i^{th} effect of lamb genotype (I = 1,2,3,4,5,6,7,8,9);

D_j = j^{th} effect of dam's haemoglobin type (J = 1,2,3);

ε_{ijk} = Random error effect.

While allelic frequency was calculated thus:

A = Total number of AA x 2 + ½ AB

Table 2: Frequency of haemoglobin variants

Genotype frequency					
Dam Hb	**Frequency**	**Percent**	**Sire Hb**	**Frequency**	**Percent**
AA	40	32.0	AA	0	0.0
BB	10	8.0	BB	0	0.0
AB	75	60.0	AB	10	100.0
Gene frequency					
Dam			**Sire**		
A	0.62		A	50.0	
B	0.38		B	50.0	

Hb = Haemoglobin; $\chi^2 = 50.8$, P<0.01

B = Total number of BB x 2 + ½ AB

Frequency of ewes' Hb genotype in relation to lambs were sorted and tested with Chi Square Procedure of SAS (SAS, 2003).

Result and Discussion

Table 2 shows the gene and genotypic frequencies of haemoglobin (Hb) variants of sampled sheep population at NAPRI, Zaria, Nigeria. HbAB was the predominant (P<0.01) variant in the study population, observed in 60% of the ewes and 100% of the sires. However, allele A had the highest frequency (62%) in the dam population. This was in agreement with the report of Akinyemi (2010) on Hb frequencies from similar breeds of sheep. Evans *et al*. (1958) had earlier suggested that HbA has a selective advantage at higher altitudes because it constitutes the most common allele in highland breeds of sheep. However, Salako *et al*. (2007) reported higher frequency of HbB in population of West African Dwarf sheep at low altitude in South-West Nigeria.

Table 3 shows the least square means of growth rate of lambs as affected by dam's haemoglobin variant. HbAB and HbBB dams gave birth to lambs that were heavier (P<0.01) than lambs from HbAA from birth to 12 weeks of age. The heterozygous form of haemoglobin (HbAB) in the population was probably more adapted to prevailing climatic condition in the Northern Guinea Savannah region than the homozygous form HbAA. This is clearly seen in better

Table 3: Least square means (±SEM) of growth rate of lambs as affected by dams' haemoglobin variant

	Dam haemoglobin variant			
Trait	**AA**	**BB**	**AB**	**Overall mean**
BWT (kg)	2.91±0.09 [b]	3.34±0.16 [a]	3.01±0.05 [a]	3.00±0.06
2WT (kg)	4.66±0.16 [b]	5.27±0.27 [a]	5.29±0.09 [a]	5.09±0.09
4WT (kg)	5.69±0.19 [b]	6.56±0.34 [a]	6.43±0.11 [a]	6.21±0.11
6WT (kg)	6.21±0.21 [b]	7.14±0.37 [a]	7.20±0.12 [a]	6.88±0.12
8WT (kg)	7.01±0.24 [b]	7.85±0.42 [a]	8.07±0.14 [a]	7.72±0.14
10WT (kg)	7.69±0.22 [b]	8.71±0.47 [a]	8.86±0.15 [a]	8.47±0.15
12WT (kg)	7.96±0.30 [b]	8.85±0.52 [a]	9.30±0.17 [a]	8.83±0.16

[ab]Means across rows with different superscripts are significantly different (P<0.01).

N = Frequency of haemoglobin variants; BWT = Birth weight;

2WT = Weight at 2 weeks; 4WT = Weight at 4 weeks; 6WT = Weight at 6 weeks;

8WT = Weight at 8 weeks; 10WT = Weight at 10 weeks; 12WT = Weight at 12 weeks.

performance (in terms of pre-weaning growth rate) of the lamb and the abundance of the genotype (HbAB) in the sampled population. Gootwine (1988) corroborated the result of this study in his report which stated that ewes belonging to the HbAB genonotype showed a significant advantage over the other Hb genotypes in both lamb and milk production.

Table 4 shows the effect of lamb genotype on pre-weaning growth rate of sheep of Northern Nigerian. Crossbred lambs from Balami ram and Uda ewe (BL X UD) recorded the highest weight (4.47±0.20 kg) at birth while the least weight (1.73±0.20 kg) at birth was obtained from crossbred lambs given birth to by Yankasa rams and Balami ewes (YK X BL). Taiwo (1979) obtained 2.26±0.08, 2.37±0.10, 2.68±0.10 and 2.71±0.08 as birth weight for pure West African Dwarf sheep (WAD), Permer X WAD, Yankasa X WAD and Uda X WAD, respectively. Pure Balami lambs (BL X BL) was outstandingly superior ($P<0.05$) to lambs from the other genotypes starting from the second week of age up to weaning (12^{th} week). BL X BL lambs weighed 12.20±0.43 kg at 12 weeks. The least weight at weaning was recorded by pure Yankasa lambs (YK X YK) and lambs of crosses between Uda rams and Balami ewes (UD X BL) which weighed 7.83±0.26 kg and 7.76±0.37 kg, respectively. Sharma (2004) reported heavier weaning weight for lambs of Malpura sheep (11.86kg) and Garole X Malpura sheep (11.07 kg) than the weight obtained for YK X YK and UD X BL. The weaning weight obtained for Balami lambs agreed with Adu and Ngere (1979) who had reported that Balami sheep are the fastest growing sheep in Nigeria.

Effect of lamb genotype on pre-weaning average daily gain (ADG) of sheep of Northern Nigerian was shown in Table 5. Pure Balami lambs (BL X BL) recorded the highest (238.09±12.42g) average daily gain between birth to 2 weeks of age (ADG2) while crossbred lambs from Yankasa rams and Uda ewes (YK X UD) recorded the lowest (105.66±9.30g) value for ADG2. At weaning, crossbred lambs from Balami ram and Yankasa ewe (BL X YK) had the highest (44.37±3.69 g) while crossbred lambs from Uda rams and Balami ewes had the lowest ADG (13.38±3.34 g). The ADG decreased linearly as the lambs advanced in age, except for a sharp decline that was recorded for ADG6. The values for ADG were 149.03 g, 79.66 g, 48.17 g, 59.77 g, 54.06 g and 25.80 g for ADG2, ADG4, ADG6, ADG8, ADG10 and ADG12, respectively. The linear decrease in ADG at 2 weeks interval in this study was in agreement with the report of Oni *et al*. (1989) and Iyiola-Tunji (2007). They reported that body weight of Bunaji cattles' calves and Red Sokoto goats' kids with higher birth weight grow slower, because of increasing body surface area.

Conclusion and Recommendation

Haemoglobin genotype AB (HbAB) was the predominant variant in the sheep population in NAPRI, Zaria, Nigeria. Balami sheep are capable of expressing their genetic potentials (better growth than others) in the Northern Guinea Savannah of Nigeria. Genetic improvement of growth traits of Nigerian sheep using indigenous stock should focus on the exploitation of genetic potentials in terms of faster growth rate of Balami sheep.

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References

Abdussamad, A.M., Esievo, K.A.N. and

Table 4: Effect of lamb genotype on pre-weaning growth rate of Nigerian sheep breeds

Lamb genotype	Birth weight (kg)	2 weeks weight (kg)	4 weeks weight (kg)	6 weeks weight (kg)	8 weeks weight (kg)	10 weeks weight (kg)	12 weeks weight (kg)
YK X YK	2.80 ± 0.08^{de}	4.63 ± 0.13^{e}	5.57 ± 0.17^{d}	6.20 ± 0.18^{c}	6.78 ± 0.21^{f}	7.38 ± 0.23^{e}	7.83 ± 0.26^{f}
UD X UD	3.10 ± 0.16^{cd}	5.75 ± 0.23^{c}	7.00 ± 0.29^{c}	8.15 ± 0.32^{b}	9.10 ± 0.36^{b}	10.05 ± 0.41^{b}	10.36 ± 0.45^{b}
BL X BL	3.40 ± 0.13^{b}	6.73 ± 0.23^{a}	8.26 ± 0.28^{a}	8.91 ± 0.31^{a}	10.10 ± 0.35^{a}	11.67 ± 0.39^{a}	12.20 ± 0.43^{a}
YK X UD	3.43 ± 0.10^{bc}	4.91 ± 0.17^{d}	5.82 ± 0.21^{e}	6.70 ± 0.23^{c}	7.81 ± 0.26^{d}	8.48 ± 0.29^{d}	9.18 ± 0.32^{d}
YK X BL	1.73 ± 0.20^{f}	4.42 ± 0.34^{f}	6.21 ± 0.42^{d}	6.84 ± 0.46^{c}	8.28 ± 0.53^{c}	8.89 ± 0.59^{c}	9.62 ± 0.65^{c}
UD X YK	3.00 ± 0.14^{cd}	4.85 ± 0.23^{d}	6.10 ± 0.29^{d}	6.75 ± 0.32^{c}	7.30 ± 0.36^{e}	8.40 ± 0.41^{d}	8.96 ± 0.45^{de}
UD X BL	2.94 ± 0.10^{cd}	4.95 ± 0.17^{d}	5.78 ± 0.22^{e}	6.41 ± 0.27^{d}	7.14 ± 0.27^{e}	7.42 ± 0.30^{e}	7.76 ± 0.33^{f}
BL X YK	2.38 ± 0.11^{e}	4.61 ± 0.19^{e}	5.87 ± 0.24^{e}	6.24 ± 0.26^{d}	7.19 ± 0.30^{e}	8.33 ± 0.33^{d}	9.20 ± 0.37^{d}
BL X UD	4.47 ± 0.20^{a}	6.38 ± 0.34^{b}	7.79 ± 0.42^{b}	8.05 ± 0.46^{b}	8.32 ± 0.53^{c}	8.31 ± 0.59^{d}	8.71 ± 0.65^{e}
Overall	3.00	5.09	6.20	6.88	7.72	8.47	8.83
SEM	0.06	0.09	0.11	0.12	0.14	0.16	0.17

[abcd]Means within column with different superscripts are significantly different ($P<0.05$) ; SEM = Standard error of the mean

Table 5: Effect of lamb genotype on pre-weaning average daily gain of Nigerian sheep

Lamb genotype	ADG 2 (g)	ADG 4 (g)	ADG 6 (g)	ADG 8 (g)	ADG 10 (g)	ADG 12 (g)	pw-ADG (g)
YK X YK	130.95 ± 7.40^{e}	66.67 ± 4.84^{e}	45.24 ± 3.89^{c}	41.67 ± 3.08^{f}	42.86 ± 4.87^{d}	21.43 ± 2.58^{e}	58.14 ± 2.55^{f}
UD X UD	189.29 ± 12.83^{b}	89.29 ± 7.77^{d}	82.14 ± 6.74^{a}	67.86 ± 5.33^{d}	67.86 ± 8.44^{c}	10.71 ± 4.47^{f}	84.52 ± 4.42^{c}
BL X BL	238.09 ± 12.42^{a}	109.21 ± 7.52^{b}	46.77 ± 6.52^{c}	84.78 ± 5.16^{b}	111.73 ± 8.17^{a}	30.73 ± 4.33^{cd}	103.55 ± 4.28^{a}
YK X UD	105.66 ± 9.30^{f}	64.74 ± 5.63^{e}	62.92 ± 4.89^{b}	79.34 ± 3.87^{c}	47.71 ± 6.12^{d}	33.44 ± 3.25^{bc}	65.63 ± 3.21^{e}
YK X BL	192.26 ± 18.61^{b}	127.66 ± 11.27^{a}	45.58 ± 9.77^{c}	102.04 ± 7.74^{a}	43.87 ± 12.24^{d}	36.68 ± 6.49^{b}	91.35 ± 6.41^{b}
UD X YK	132.14 ± 12.83^{e}	89.32 ± 6.23^{d}	46.43 ± 6.74^{c}	39.29 ± 5.33^{f}	78.57 ± 8.44^{b}	28.57 ± 4.47^{d}	69.05 ± 4.42^{e}
UD X BL	143.72 ± 9.57^{d}	59.23 ± 5.79^{f}	44.94 ± 5.03^{c}	52.15 ± 3.98^{e}	19.73 ± 6.29^{e}	13.38 ± 3.34^{f}	55.52 ± 3.30^{f}
BL X YK	159.32 ± 10.56^{c}	90.17 ± 6.40^{cd}	27.10 ± 5.55^{d}	67.35 ± 4.39^{d}	81.29 ± 6.95^{b}	44.37 ± 3.69^{a}	78.26 ± 3.64^{d}
BL X UD	136.31 ± 18.61^{de}	100.91 ± 11.27^{c}	18.70 ± 9.77^{e}	19.38 ± 7.74^{g}	1.01 ± 12.24^{f}	20.46 ± 6.49^{e}	49.13 ± 6.41^{g}
Overall	149.03	79.66	48.17	59.77	54.06	25.80	69.41
SEM	4.69	2.73	2.28	2.27	3.36	1.63	1.76

[abcd]Means within column with different superscripts are significantly different ($P<0.05$); SEM = Standard error of the mean; ADG2 = Average daily gain between birth to 2 weeks of age; ADG4 = Average daily gain between 2 weeks to 4 weeks of age; ADG6 = Average daily gain between 4 weeks to 6 weeks of age; ADG8 = Average daily gain between 6 weeks to 8 weeks of age; ADG10 = Average daily gain between 8 weeks to 10 weeks of age; ADG12 = Average daily gain between 10 weeks to 12 weeks of age; pw-ADG = pre-weaning average daily gain from birth to weaning.

Akpa, G.N. 2004. Haemoglobin types in the Nigerian Zebu and their crosses in Zaria. In: *Proceedings of the 29th Annual Conference of the Nigerian Society for Animal Production*. 21st – 25th March, 2004. Usman Dan Fodio University, Sokoto, Nigeria. pp 31-37.

Adu, I.F. and Ngere, L.O. 1979. The indigenous sheep of Nigeria. *World Review of Animal Production*, 15(3): 51-62.

Akinyemi, M.O. 2010. Morphological and biochemical diversity in Balami, Uda and Yankasa sheep of Nigeria. Ph.D Thesis, Faculty of Agriculture and Forestry, University of Ibadan, Nigeria. 174pp.

Demeke, S., van der Westhuizen, C., Fourie, P.J., Neser, F.W.C. and Lemma, S. 2004. Effect of genotype and supplementary feeding on growth performance of sheep in the highlands of Ethiopia. *South African Journal of Animal Science 2004,* 34 (Supplement 2): 110-112.

Dickerson, G.E., 1969. Experimental approach in utilizing breed resources. *Animal Breeding Abstract*, 37: 191-202.

Evans, J.V., Harris, H. and Warren, F.L. 1958. The distribution of haemoglobin and blood potassium type in British breeds of sheep. *Proceedings of Royal Society London*, 149: 249-262.

Gootwine, E. 1988. Haemoglobin type frequencies in the Assaf (Awassi x East Fresian) dairy sheep 20 years after its formation. *Genetics, Selection and Evolution,* 20(1): 99-104.

http://www.trueknowledge.com/q/zaria_longitude_and_latitude (Accessed on 13 June, 2011)

Iyiola-Tunji, A.O. 2007. Factors affecting growth traits and litter size of Red Sokoto goats in Shika, Zaria. Unpublished MSc Thesis. Ahmadu Bello University, Zaria. 118pp.

Maijala, K. and Terill, C.E. 1991. Breed structure, dynamics and new breed development in sheep. In: Genetic Resources of Pig, Sheep and Goat. Ed. Maijala, K., World Animal Science, B8. Elsevier Science Publishers B.V. pp 305-327.

Mireşan, V. 2003. Evolution of the main blood indices in Tsigai fattening sheep. *Journal of Central European Agriculture (online)*, 4(4): 405-410.

Oni, O. O., Buvanendran, V. and Dim, N. I. 1989. Estimates of Genetic and Phenotypic Parameters for Body Weight in Bunaji (White Fulani) Cattle. *Tropical Agriculture (Trinidad)*, 66 (4): 369-371.

Osinowo, O.A. Abubakar, B.Y., Olayemi, M.E., Balogun, R.O., Onifade, O.S., Adewuyi, A.A., Trimnell, A.R. and Dennar, F.O. 1992. Preweaning performance of Yankasa sheep under semi-intensive management. In: Small Ruminant Research and Development in Africa. Proceedings of the Second Biennial Conference of the African Small Ruminant Research Network, Arusha, Tanzania, 7-11 December, 1992. Eds: Lebbie, S.H.B., Rey, B. and Irungum, E.K. ILCA, Addis Ababa, Ethiopia. p.65-68.

Osinowo, O.A. and Adu, I.F. 1985. Guide on intensive sheep production. Publication and Information Unit, National Animal Production Research Institute, Ahmadu Bello University, Shika, Zaria.

RIKEN 2006. Genetic quality monitoring by biochemicalisozymes. RIKEN Bioresources Center. http://www.riken.go.jp/engn/

Salako, A. E., Ijadunola, T. O. and Agbesola, Y. O. 2007. Hemoglobin polymorphism in Nigerian indigenous small ruminant populations - preliminary investigation. *African Journal of Biotechnology*, 6 (22): 2636-2638.

SAS 2003. SAS User's Guide. SAS Institute Inc., Cary, NC, USA.

Sharma, R.C., Arora, A.L., Mishra, A.K., Kumar, S. and Singh, V. K. 2004. Breeding Prolific Garole with Malpura Sheep for Increased Reproductive Efficiency in Semi Arid Tropics of India. *Asian-Aust. Journal of Animal Science, 17(6): 737-742.*

Taiwo, B.B.A. 1979. Reproductive performance, growth and carcass merit of Nigerian Dwarf sheep and their crosses. Unpublished Ph.D Thesis. Faculty of Agriculture and Forestry, University of Ibadan. 210pp.

Tapio M., Miceikiené, I., Vilkki, J . and Kantanen, J . 2003. Comparison of microsatellite and blood protein diversity in sheep: Inconsistencies in fragmented breeds. *Molecular Ecology*, 12: 2045–2056.

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