



# Biokemistri

An International Journal of the Nigerian Society for Experimental Biology

## Original Article

### Haematological responses of three Nigerian goat breeds to field acquired helminthes infection and their haemoglobin types

Adekayode Olanrewaju Sonibare<sup>1</sup>, Hussein Adam Kumshe<sup>2</sup>, Emmanuel Adeniyi Okewole<sup>3</sup>, Richard Adekunle Joshua<sup>3</sup>, Joshua Luka<sup>2\*</sup>, and Ebenezer Babatunde Otesile<sup>1</sup>.

<sup>1</sup>College of Veterinary Medicine, University of Agriculture, Abeokuta, Ogun State, Nigeria.

<sup>2</sup>Faculty of Veterinary Medicine, University of Maiduguri, P.M.B, 1069, Maiduguri, Borno State, Nigeria.

<sup>3</sup>Faculty of Veterinary Medicine, University of Ibadan, Ibadan, Oyo State, Nigeria

\*Corresponding author: Joshua Luka. E-mail: joshuadiriki@yahoo.com; Tel.: +2348030407578

Received: 06 January 2014; Revised 29 March 2014; Accepted: 30 March 2014

**ABSTRACT:** Response of goats to natural helminth infection was investigated among 277 Nigerian indigenous goats belonging to three different breeds [West African dwarf (WAD), Red Sokoto (RS) and Sahel White (SW)] through the determination of parasitological and haematological parameters. The results showed that 65% of the sampled animals were positive for one helminth or two. Mixed infection due to *Haemonchus contortus* and *Trichostrongylus colubriformis* constituted 33.33% prevalence rate, while *Haemonchus contortus* and *Oesophagostomum columbianum* mixed infection had 26.67% rate of infection among the sampled animals. However, single infection due to either of *Haemonchus contortus*, *Oesophagostomum columbianum*, *Trichostrongylus colubriformis*, *Strongyloides papillosus*, *Cooperia punctata*, *Trichuris ovis*, *Paramphistomum cervi* and *Moniezia benedini* constituted 5.0%. There was no significant ( $p>0.05$ ) difference in mean faecal egg count (FEC) among the breeds investigated. Similarly, correlation coefficient between *Haemonchus* worm count (HWC) and FEC showed positive correlation value which was significantly ( $p<0.01$ ) higher among WAD (0.661) than SW (0.427) and RS (0.350) breeds. Three (3) different haemoglobin types (HbAA, HbAB and HbBB) were detected among the goats investigated. Goats with HbAA showed significantly ( $p<0.05$ ) higher PCV compared to those with HbAB/HbBB alleles. In addition, Sahel White and Red Sokoto breeds had microcytic, hypochromic anaemia with a significantly ( $p<0.05$ ) lower haematocrit values than the West African Dwarf breed. Eosinophil count of RS and SW goats did not vary significantly between the parasitized and the non-parasitized goats. However, in WAD, the eosinophil count was significantly higher ( $p<0.05$ ) in parasitized than non-parasitized goats. In conclusion, the WAD breed appears to be more resistant to helminthes infections and *H. contortus* in particular, than RS and SW, and this may be due to high frequency of HbAA alleles in this breed. The advantage of this relative resistance could be exploited by crossbreeding WAD with other breeds.

**KEYWORDS:** Nigerian goats, Field helminthosis, Haematology, Faecal egg counts, Haemoglobin types.

BKM.2014.006 © 2014 Nigerian Society for Experimental Biology; All rights reserved. Printed in Nigeria  
This article is downloadable online in PDF format at <http://www.bioline.org.br/bk>

## INTRODUCTION

Caprine parasitic gastrointestinal infection is worldwide in distribution (Baker *et al.*, 1999; Chiejina *et al.*, 2002), especially in the tropical and other sub tropical areas, ostensibly due to poor management practices and inadequate control measures (Akhtar *et al.*, 2000). In addition, different countries have reported varied parasite species from their microenvironment where livestock are found (N'Depo, 1987; Bishop and Stear, 2001). Studies

carried out in different geographical locations in Nigeria revealed that *Haemonchus contortus*, *Trichostrongylus colubriformis*, *Oesophagostomum* and *Gaigeria* species are the commonest and are generally responsible for most field outbreaks of Parasitic Gastro Enteritis (PGE) in small ruminant (Fabiya, 1970, Chiejina 1987). The use of anthelmintics, management of grazing land, adequate stocking rate and appropriate rotation strategies are the available control measures (Soulsby, 1982). There are

emerging evidences that suggest a genetic basis for resistance to gastro intestinal nematodes by livestock (Walkden-Brown *et al.*, 2008). There have been reports of both inter and intra breed genetic differences responsible for resistance to infection by gastrointestinal nematodes. On goats, Costa *et al.* (2000) reported from Brazil variability of resistance of three breeds of nematode free goats introduced to contaminated paddock as measured by their egg per gram (EPG), packed cell volume (PCV) and haemoglobin concentration (Hb). Similar observation on resistance to *Haemonchus contortus* by the Nigerian West African Dwarf goat was reported (Fakae *et al.*, 1999; 2004; Chiejina and Behnke, 2011). However, there have been few or no published reports on genetic parameters responsible for resistant traits in the three different breeds of Nigerian goats (WAD, Red Sokoto and Sahel white), particularly the role of haemoglobin genotype in conferring resistance to helminth infection or otherwise.

The distribution of haemoglobin polymorphism among Nigerian indigenous goat breeds was previously investigated (Alphonsus *et al.*, 2012, Agaviezor *et al.*, 2013) with haemoglobin types A, AB and B being the most commonly encountered haemoglobin types in older animals, while haemoglobin AC among the younger animals. Alphonsus *et al.* (2012) observed that the haemoglobin type AA was predominant among the indigenous breeds (RS, SW and WAD) when compared to the AB and BB types with the trend of dominance decreasing from the more humid, high altitude, rain forests breeds of goats to the dryer, low altitude regions of the Sahel zone. Similarly, the HbA has been reported to confer genetic resistance to helminth infection in the West African dwarf sheep. This is thought to also occur in the WAD goat, since the WAD goat has been reported to possess high frequency of HbAA alleles compared to RS and SW breeds of goats.

The present study aimed to determine the responses of these indigenous breeds of Nigerian goats to naturally acquired helminthes infection through the determination of haematological and parasitological parameters and investigate the role of haemoglobin type in this response.

## MATERIALS AND METHODS

### Experimental Animals

Three breeds of Nigerian goats [West African Dwarf (WAD), Sahel White (SW) and Red Sokoto (RS)] commonly slaughtered at the Bodija Municipal Abattoir, Ibadan were randomly selected and used for this study. The care and use of experimental animals' protocol was strictly adhered to during the time of sampling (Ochei and Kolkatar, 2000). Breeds were identified phenotypically according to Steel

(1996). All the goats sampled were tagged at the neck for proper identification.

### Collection of Samples

Prior to slaughter, blood sample was collected from the jugular vein of each goat into sterile bottles containing Ethylene Diamine Tetra Acetic Acid (EDTA) as anticoagulant, while about 10 grams of faecal sample was collected directly from the rectum of each goat into faecal sample bottle. Briefly, the index finger was inserted directly into the rectum after wearing a hand glove and proper restraint of the animal. The faeces collected were transferred to the sample bottle before being transported to the laboratory. Following slaughter and evisceration, abomasum of each identified goat was ligated at both ends and separated from the mesenteric, omasal and the duodenal attachments. All samples (blood, faeces and abomasa) were properly labeled to ensure that samples from each goat were treated as a unit.

**Table 1: Faecal egg count (FEC) expressed as Mean  $\pm$  SD and *Haemonchus* abomasal worm count (range) of three breeds of Nigerian goats infected naturally with helminthes.** The left column shows the range of worm count and the number infected is shown in parenthesis. Different superscripts in rows and columns differed significantly ( $p < 0.05$ )

Worm count	WAD	RS	SW
1-50 (38)	1121.05 $\pm$ 765.88 <sup>a</sup>	2108.33 $\pm$ 1361.80 <sup>a</sup>	2345.76 $\pm$ 1965.94 <sup>a</sup>
51-100 (19)	2305.26 $\pm$ 1467.22 <sup>a</sup>	3080.00 $\pm$ 1662.70 <sup>a</sup>	2896.00 $\pm$ 1805.84 <sup>a</sup>
101-150 (11)	4309.09 $\pm$ 2023.09 <sup>c</sup>	4837.50 $\pm$ 2748.47 <sup>a</sup>	4737.69 $\pm$ 1408.08 <sup>a</sup>
Total (68)	2696.52 $\pm$ 1401.32 <sup>a</sup>	3827.52 $\pm$ 1301.19 <sup>a</sup>	3179.94 $\pm$ 1293.35 <sup>a</sup>

### Determination of Packed Cell Volume (PCV), Eosinophil count and Haemoglobin types

The packed cell volume (%) was determined using the micro haematocrit method (Murray *et al.*, 1983), Eosinophil count according to the standard procedure described by Dacie and Lewis (1995). The haemoglobin type of each goat was determined by electrophoresis of lysed erythrocytes on cellulose acetate strip using electrophoresis buffer of pH 8.6 with known Hb haemosylate type standard of AS, SC of human blood according to the methods of Olusanya (1975) and Rifkin and Yong (1984).

### Examination of abomasum for *Haemonchus* species

For each goat sampled, the abomasum was ligated at both ends *in situ* and transported in physiological saline solution to the Veterinary Medicine laboratory, Department of Veterinary Medicine, University of Ibadan, Ibadan, Nigeria. In the

laboratory, the abomasa were opened along the greater curvature. Thereafter, adult worms were counted and identified to species level on a stereo microscope using morphometric and morphologic characteristics described by Soulsby (1982).

### Faecal Examination and larval culture

Faecal egg count was determined by the modified McMaster method. Briefly, the two chambers of the McMaster slide were filled with resulting mixture of 1 g faecal matter and 14 ml of saturated sodium chloride solution. The mixture was left for 2 minutes before commencing counting. The value of eggs per gram (Epg) was obtained by multiplying the number of eggs in the two chambers by 100. Faeces were cultured to the third stage larvae in order to identify parasite species (Hansen and Perry, 1990; Zajac and Garya, 2006).

infection rate was distributed thus; 68 WAD (68.00%), 59 RS (60.82%) and 53 SW (66.25%). Similarly, mixed infections consisting of *Haemonchus contortus* and *Trichostrongylus colubriformis* was found among 60 (33.33%) goats, while 48 (26.67%) had *Haemonchus contortus-Oesophagostomum columbianum* combination. Single infection by either of *Haemonchus contortus*, *Oesophagostomum columbianum*, *Trichostrongylus colubriformis*, *Strongyloides papillosus*, *Cooperia punctata*, *Trichuris ovis*, *Paramphistomum ovis* and *Moniezia benedini* was found in 72 (40%) goats. The result of faecal egg count (FEC) and abomasal worm count among naturally infected breeds of Nigerian goats is presented in Table 1. Abomasal worm count range of (1-50) had the highest frequency of 38 worms, while ranges of (51-100) and (101-150) had 19 and 11 worms respectively.

**Table 2: Haematological parameters [PCV (%) and Eosinophil ( $\times 10^3/L$ )] of three Nigerian breeds of goat.**

Different superscripts in rows and columns differed significantly ( $p < 0.05$ )

Helminth status	WAD		RS		SW		Total (Mean)	
	n	PCV	n	PCV	n	PCV	n	PCV
Non-Parasitized	32	31.58±5.43 <sup>b</sup>	38	32.00±6.94 <sup>b</sup>	27	29.41±5.59 <sup>a</sup>	97	30.96±6.39 <sup>b</sup>
Parasitized	68	25.32±7.60 <sup>ab</sup>	59	22.40±7.99 <sup>ab</sup>	53	20.55±4.78 <sup>abc</sup>	180	23.67±5.36 <sup>ab</sup>
	n	Eosinophil	n	Eosinophil	n	Eosinophil	n	Eosinophil
Non-parasitized	32	1.00±0.40 <sup>ab</sup>	38	0.85±0.40 <sup>a</sup>	27	0.90±0.60 <sup>a</sup>	97	0.95±0.40 <sup>a</sup>
Parasitized	68	3.39±0.90 <sup>a</sup>	59	2.93±0.60 <sup>a</sup>	53	1.95±0.70 <sup>a</sup>	180	2.90±0.30 <sup>a</sup>

### Statistical Analysis

Data generated were analyzed using the Statistical Analysis System version 8.0 (SAS, 2003). The data were tested for significant differences among breeds by the means of Analysis of variance (ANOVA). The means were separated using Duncan multiple range test. Pearson Product Moment Correlation (PPMC), which tested for relationship between parameters, was also used. All significant differences were at 0.05 levels.

## RESULTS

### Effect of helminthes infection in three breeds of Nigerian Goats

A total of 277 Nigerian goats [100 West African Dwarf (WAD), 97 Red Sokoto (RS) and 80 Sahel White (SW)] were screened for gastro-intestinal helminthes. Among the screened goats, 180 (65%) were positive for one helminth or two. Based on the number of goats sampled per breed, the

There was no statistical significant ( $p > 0.05$ ) difference in FEC among the breeds examined, however the WAD breed with worm count (101-150) showed a significantly ( $p < 0.05$ ) higher value when compared to those with lower worm count. There was a significant positive correlation between haemonchus worm count and FEC in all the breeds examined. Haemonchus worm count (HWC) of 101-150 showed higher correlation coefficient between FEC and HWC in WAD breed (+0.661) than RS (+0.365) and SW (+0.427) at  $p < 0.01$ .

### Effects of helminthes on haematology of goats

The effect of natural infection with helminthes on three breeds of Nigerian goats is presented in Table 2. There was a statistically significant difference between the parasitized and the non-parasitized goats distributed across all the three breeds. A significantly ( $p < 0.05$ ) lowered PCV was observed among the parasitized animals when compared with their respective non-parasitized in all the three breeds

investigated. Similar trend was observed in the total (mean) of parasitized and non-parasitized goats.

Eosinophil count of both parasitized and non-parasitized goats of RS and SW breeds and the total (mean) did not show any significant difference ( $p < 0.05$ ). However, significantly ( $p < 0.05$ ) higher count was observed among parasitized WAD when compared to the non-parasitized.

Results presented in Table 3 showed that there was no significant ( $p < 0.05$ ) difference in mean HWC and PCV values among goats across all the breeds. However, those with worm range of 101-150 showed a significantly lowered PCV when compared to the total of all the breeds investigated.

### Haemoglobin types

The result of the distribution of various haemoglobin types among three breeds of Nigerian goats naturally infected with helminthes is presented in Table 4. HbAA type significantly ( $p < 0.05$ ) differed from HbAB and HbBB types within each of the three breeds of goats investigated. However there was not statistically significant difference in the haemoglobin types among the breeds examined. Table 5 presents the result of the PCV, Mean worm count and FEC of three breeds of Nigerian goats infected with helminthes naturally. The mean FEC and worm count among goats with the three different alleles showed no significant ( $p < 0.05$ ) variation, while mean PCV of goats with HbAB, HbBB and total (mean) were significantly ( $p < 0.05$ ) lower than for those with HbAA alleles.

*papillosus*, *Cooperia punctata*, *Trichuris ovis*, *Paraphistomum cervi* and *Moniezia benedini* were also found among the goats examined. Similar prevalence of infection has previously been reported in Nigeria (Fakae, 1990). However, the infection rate seems higher for some regions of the world (Qamar et al., 2011). The predominant gastrointestinal parasites in this study agrees with similar studies by previous workers in Nigeria (Schillhorn van Veen, 1978; Chiejina, 1987; Fakae et al., 1999) who reported that *H. contortus*, *Oesophagostomum columbianum* and *T. colubriformis* were the most common and are generally responsible for most field outbreaks of parasitic enteritis in small ruminants. The mixed infection due to *H. contortus* and *T. colubriformis* and *H. contortus* and *O. columbianum* infers that concurrent infection with more than one member of the PGE complex family is a common phenomenon. The species of parasite encounter also agrees with an earlier report that *Strongyle* infections predominantly *H. contortus*, *T. colubriformis* and *O. columbianum* were very common in the rain forest and derived savannah zones of Nigeria, which provides environment favorable for the development of the pre-parasitic stages (Fagbemi and Dipeolu, 1982). The prevalence of (0.70%) of cooperiasis as reported in this study contradicts earlier report that *Cooperia spp.* is not an important cause of ovine and caprine parasitic gastrointestinal parasitism in Nigeria (Fabiyyi, 1970). The parasitological (FEC and HWC) and haematological (PCV and Eosinophil counts) parameters were observed to vary in order of WAD, RS and SW, with the latter manifesting the

**Table 3: Mean PCV (%) and Haemonchus worm count [HWC (Mean and range)] of three Nigerian breeds of goats infected with helminthes.** Different superscripts in rows and columns differ significantly ( $p < 0.05$ )

Worm Count	WAD		RS		SW	
	HWC	PCV	HWC	PCV	HWC	PCV
1-50	38.63±9.18 <sup>a</sup>	27.37±5.04 <sup>a</sup>	34.83±12.18 <sup>a</sup>	25.44±4.66 <sup>a</sup>	42.20±7.67 <sup>a</sup>	25.60±6.05 <sup>a</sup>
51-100	77.11±15.90 <sup>b</sup>	24.89±4.25 <sup>a</sup>	72.33±13.84 <sup>b</sup>	22.73±5.71 <sup>a</sup>	79.60±16.93 <sup>b</sup>	21.10±4.31 <sup>a</sup>
101-150	128.18±22.61 <sup>b</sup>	20.35±6.42 <sup>a</sup>	117.50±16.26 <sup>b</sup>	15.00±3.55 <sup>a</sup>	126.63±14.28 <sup>b</sup>	15.63±1.85 <sup>a</sup>
Total	87.45±12.38 <sup>b</sup>	25.32±7.60 <sup>a</sup>	75.39±20.42 <sup>b</sup>	22.40±7.99 <sup>a</sup>	82.36±5.36 <sup>b</sup>	20.55±4.78 <sup>a</sup>

## DISCUSSION

The present study reports on the parasitological and haematological response of three breeds of Nigerian goats to natural helminthes infections. Similarly, haemoglobin types were determined. We report an infection rate of 65% in this study with parasite species consisting of *Haemonchus contortus*, *Oesophagostomum columbianum* and *Trichostrongylus colubriformis* predominating. *Strongyloides*

severest (low PCV, high FEC and HWC) form of haemonchosis. Similarly, correlation coefficient between HWC (1-150) and FEC (fecundity) shows high positive correlation value as significantly higher ( $p < 0.01$ ) correlation factor was found among WAD (0.661) than SW (0.427) and RS (0.350). The apparent relative improved parameters (higher PCV and lowered FEC and HWC) of WAD in this study compared to other breeds investigated might be



attributed to the higher frequency of the haemoglobin HbAA genotype in the breed. It is known that carriers of HbA have demonstrated resistance against helminthes infections. The higher PCV and lowered FEC / HWC in the goats with haemoglobin HbAA genotype compared to those of HbBB which had lower PCV and higher FEC/HWC as observed in this study lend credence to the report of Allonby and Urquhart (1975) that less severe anaemia and other pathological lesions occurred in sheep of HbAA genotype. Several studies have suggested that haemoglobin genotypes that are genetically determined are of the different alleles and that HbAA alleles provided higher resistance to *H. contortus* than HbBB alleles (Laffau et al., 1981, 1990). Similarly, the relatively low FEC, adult haemonchous worm counts and higher PCV of the WAD goats might reflect a higher frequency of HbAA alleles in the sample than in the RS and SW samples. Sheep with HbAA type were better able to cope with haemorrhagic and climatic stress because of physiological advantage of having higher affinity for oxygen than HbBB. When sheep with HbAA become anaemic, they produce HbC (Blunt and Evans, 1963). These might also be applicable to WAD goats with HbAA alleles, given the higher frequency of the genotype in the randomized WAD sample.

**Table 4: Distribution of haemoglobin types among three breeds of Nigerian goats infected with helminthes.** Different superscripts in rows differed significantly (p<0.05)

Breed (n)	Haemoglobin types {n (%)}		
	HbAA	HbAB	HbBB
WAD (68)	33 (48.53) <sup>a</sup>	22 (32.35) <sup>b</sup>	13 (19.12) <sup>b</sup>
RS (59)	27 (45.76) <sup>a</sup>	18 (30.50) <sup>b</sup>	14 (23.73) <sup>b</sup>
SW (53)	25 (47.17) <sup>a</sup>	13 (24.53) <sup>b</sup>	15 (28.30) <sup>b</sup>
Total (180)	85 (47.22) <sup>a</sup>	53 (29.44) <sup>b</sup>	42 (23.33) <sup>b</sup>

**Table 5: Mean PCV, Worm count (WC) and FEC of three breeds of infected Nigerian goats based on their haemoglobin types.** Different superscripts in rows differed significantly (p<0.05)

Parameter	Mean PCV	Mean WC	Mean FEC
HbAA (n=85)	26.25± 5.60 <sup>a</sup>	75.80±40.50 <sup>b</sup>	3780.20±1129.2 <sup>b</sup>
HbAB (n=53)	23.90±7.00 <sup>ab</sup>	87.30±34.17 <sup>b</sup>	4750.78±2400.8 <sup>b</sup>
HbBB (n=42)	20.70±9.50 <sup>ab</sup>	88.37±20.30 <sup>b</sup>	4550.20±1489.00 <sup>b</sup>
Total (Mean±SD)	23.80±5.90 <sup>ab</sup>	81.17±38.40 <sup>b</sup>	4336.00±1490.30 <sup>b</sup>

The foregoing findings indicate that WAD was more resilient than SW and RS breeds and suggest that, there are variations in host acquired immune responsiveness to helminthes infection among the breeds examined. However, the consistent patterns of responsiveness in WAD are an important feature of this host parasite relationship and that of FEC is likely to be strongly influenced by the WAD genetic makeup. The practical values of these heritable FEC positive responsiveness has been demonstrated in a number of successful selective breeding programmes (Winton, 1990; Gray, 1991). There is good evidence that the same variability in egg per gram of faeces, which have been found to be heritable, may be true of WAD in this study. In conclusion, this study has demonstrated that there are variations in the response of the breeds of goat examined to natural helminth infections as evidenced by variations in PCV, FEC and HWC and that the type of haemoglobin genotype play an important role in the resistance of the examined goats to helminth infection.

**REFERENCES**

Agaviezor BO, Ajayi FO, Benneth NN (2013) Haemoglobin polymorphism in Nigerian indigenous goats in the Niger delta region, Nigeria. *International Journal of Science and Nature* 4: 415–419.

Akhtar MS, Zafar I, Khan MH and Lateef M (2000) Anthelmintic activity of medicinal plant with particular references to their use in animals in the Indo-Pakistan Sub continent. *Small Ruminant Research* 38: 99–107.

Alphonsus C, Akpa GN, Usman N, Barje PP, Byanet O (2012) Haemoglobin polymorphism and its distribution in smallholder goat herds in Abuja Nigeria. *Global Journal of Molecular Sciences* 7: 11–14.

Allonby E W and Urquhart J (1975) The influence of breed on the susceptibility of sheep and goats to a single experimental infection with *Haemonchus contortus*. *Veterinary Records* 103: 509–512.

Baker RL, Mwamachi DM, Audho JO, Aduda EO, Thorpe EW (1999) Resistant of Galla and small East African goats in the sub-humid tropics to gastro intestinal nematodes infections and peri-parturient rise in faecal egg count. *Veterinary Parasitology* 79: 53–64.

Bishop SC, Stear M J (2001) Inheritance of faecal egg counts during early lactation in Scottish Blackface ewes facing mixed, natural nematode infection. *Animal Science* 73: 389–395.

Blunt MH, Evans JV (1963) Changes in the concentration of potassium in the erythrocytes and in haemoglobin type in Merio sheep under a severe anaemia. *Nature* 200: 1215–1216.

Chiejina SN, Fakae BB, Behnke O, Nnadi PA, Musongoag GA, Wakelin D (2002) Expression of acquired immunity to local

- isolate of *Haemonchus contortus* by the Nigerian West African Dwarf goats. *Veterinary Parasitology* 104: 229–242.
- Chiejina SN 1987 Some parasitic diseases of intensively managed West African Dwarf sheep and goats in Nsukka, Eastern Nigeria. *British Veterinary Journal* 143: 246–252.
- Chiejina SN and Behnke JM (2011) The unique resistance and resilience of the Nigerian West African Dwarf (WAD) goat to gastrointestinal nematode infections. *Parasites and Vectors* 4:12.
- Costa CAF, Vieira L.da S, Berne MEA, Silva MUD, Guidoni AL, Figueiredo EAP (2000) Variability of resistance in goats infected with *Haemonchus contortus* in Brazil. *Veterinary Parasitology* 88: 153–158.
- Dacie JV, Lewis SM (1995) Practical Haematology, 8th edition. Churchill Living stone 609 pp.
- Fabiya JP (1970) An investigation into the incidence of goat helminth parasites in the Zaria area of Nigeria. *Bulletine Epizooties Disease Africa* 18: 29–34.
- Fagbemi BO and Dipeolu OO (1982) Strongyle infections of small ruminant in Nigeria. *Veterinary Parasitology* 11: 347–353.
- Fakae BB (1990) The epidemiology of helminthosis in small ruminants under the traditional husbandry system in eastern Nigeria. *Veterinary Research Communications* 14: 381–391.
- Fakae BB, Chiejina SN, Behnke JM, Ezeokonkwo RC, Nnadi PA, Onyenwe WI, Gilbert FS, Wakelin D (1999) The response of Nigerian West African Dwarf goats to experimental infection with *Haemonchus contortus*. *Research in Veterinary Science* 66: 147–158.
- Fakae BB, Musongong GA, Chiejina SN, Behnke JM, Ngongeh LA, Wakelin D (2004) Variability in the resistance of the Nigerian West African Dwarf goats to abbreviated escalating trickle and challenge infections with *Haemonchus contortus*. *Veterinary Parasitology* 122: 51–65.
- Gray GD (1991) Breeding for resistance to *Trichostrongyle* nematodes in sheep. In: *Breeding for Disease Resistance in Farm Animals*. Eds. J.B. Owen and R.F.E. Oxford, P.P. Wallingford, CAB International, 139–161.
- Hansen J and Perry B (1990) The epidemiology and control of helminth parasites of ruminants, A handbook. International laboratory for research in animal diseases. ILRAD, Nairobi, Kenya 171pp.
- Laffau G, Perry P and Charley J (1981) Reponse immunitaire chez les ovins infestés expérimentalement par *Haemonchus contortus*. Etude comparative chez le mâle et chez la femelle. *Annales de Recherches Veterinaires* 12: 173–181.
- Laffau G, Tien khang JV, Bouix J, Nguyen TC, Cullen P, Ricordeau G (1990) Resistance to experimental infections with *Haemonchus contortus* in Romanov sheep. *Annual Genetic Selection Animal Evolution* 22: 205–229.
- Murray M, Trail JCM, Turner DA and Wissocq Y (1983) Livestock productivity and trypanotolerance. *Network Training Manual, ILCA (Ireland)* 6: 159–165.
- N'Depo EA (1987) Helminthiasis of the digestive system of sheep in Cote D' Ivoire *Conference proceedings of the first African Veterinary Day held at Hammamet, Tunisia, under the auspices' Office Internationale des Epizooties Paris, France, May 28th May to 1st June 1987*.
- Ochei J, Kolhatkar A (2000) Medical Laboratory Science Theory and Practice. *Tata McGraw Hill Publishing Company, New Delhi, India. VI(I): 1213*.
- Olusanya SK (1975) Electrolyte concentration and haemoglobin type in the blood of Nigerian Dwarf sheep. *Journal of Nigerian Veterinary Medical Association* 2: 59–63.
- Qamar MF, Magbool A, Khan MS, Ahmad N and Muneer MA (2011) Epidemiology of Haemonchosis in sheep and goats under different managemental conditions. *Veterinary World* 2: 413–417.
- Rifkin SG, Yong WK (1984) Recognition of sheep which have innate resistance to *Trichostrongylid* nematode parasite: In "Immunogenetic approaches to the control of endoparasites". Ed: Dineen J.K. and Outteridge, P.M. CSIRO. Australia, 30–38.
- SAS (2003) Statistical Analysis System version 8.0 developed in North Carolina University.
- Schillhorn van Veen TW (1978) Haemonchosis in sheep during the dry season in the Nigeria Savannah. *Veterinary Record* 102: 364–365.
- Soulsby E.J.L (1982) Helminth, Arthropods and Protozoa of domesticated animals. 7th ed. Bailliere Tindall, London United Kingdom 139-150.
- Steel M (1996) "Goat" In: *Tropical Agriculturist. Published by CTA 1-15pp*.
- Walkden-Brown S, Sunduimijid B, Olayemi M, Van Der Werf J, Ruvinski A (2008) Breeding fiber goats for resistance to worm infections--gastrointestinal nematode or helminth. Australian Government Rural Industries Research and Development Corporation Publication No 07/184. Project No UNE 69A; 2008: Abstract 4.
- Winton RG (1990) Selective breeding for control *Nematodiasis* in sheep. *Revue Scientifique et Technique de Office Internationale des Epizooties* 9: 555–576.
- Zajac MA, Garya C (2006) Veterinary Clinical Parasitology. 7th ed, Blackwell Publishing Company, United Kingdom 160-173pp.