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Research Paper

Prevalence of haemoparasites in Balami Sheep from Maiduguri, Northeastern Nigeria

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ABSTRACT

Haemoparasites of small ruminants reduce their productivity and could lead to high mortality. Information on the prevalence of haemoparasites in Balami sheep reared by the Fulani pastoralist in Maiduguri, Sudan – Sahel Savannah zone of Northeastern Nigeria need to be updated. Our study therefore aimed at investigating the prevalence of haemoparasites of Balami sheep and its effect on some haematological parameters. This study was carried out between the month of March and September 2015. Two hundred and fifty (250) blood samples were collected from apparently healthy sheep of various age groups of both sexes during the study period and examined for the presence of haemoparasites using standard parasitological techniques. An overall 18.40% prevalence rate of haemoparasitic infection was recorded in the sampled Balami sheep. *Anaplasma* (9.60%), *Babesia* (5.20%). *Theileria* (2.80%) and *Trypanosoma* (0.80%) species were the genera of haemoparasites encountered in the infected sheep. The haemoparasitic infection rates were found to be higher in adult (14.0%) sheep compared to the young (4.40%) ones. There was significant statistical difference (*P*-value= 0.0022) between haemoparasitic infection rate and age groups of infected sheep. Moreover, the haemoparasitic infections encountered was higher in females (10.80%) than in the male (7.60%) sheep. There was no significant statistical difference (*P*-value= 0.148) between haemoparasitic infection rate and sexes of infected sheep. Considering the relationship between body condition scores and haemoparasitic infection it was found that infection rate was statistical significantly (*P* – value = 0.045) higher in the poor (16.40%) than in the good (2.0%) body condition scored sheep. Packed cell volume (PCV) and haemoglobin concentration (Hb) of haemoparasites uninfected and infected Balami sheep examined revealed that, uninfected sheep had a significantly higher mean ± SD (range) of PCV and Hb of 28.84 ± 3.4 and 9.55 ± 1.1 against the infected sheep 21.42 ± 3.7 and 7.22 ± 1.2 respectively ($P < 0.05$). The prevalence of haemoparasites recorded among Balami sheep in the study area may suggest a preponderance of their vectors. It was also observed that Balami sheep infected with distinct genera of haemoparasites have relatively low PCV and Hb concentration which indicate anaemia. This revealed the existence of possible economic significant effect of the haemoparasites in Balami sheep in the study area which call for increased routine screening to reduce the pathophysiological effect of the parasites and sustainable strategic measures should be taken to control the vectors involved in their transmission.

Key words: Prevalence, *Anaplasma, Babesia, Theileria, Trypanosoma,* Balami sheep, Maiduguri, Sudan – Sahel Savannah, Northeastern Nigeria

INTRODUCTION

Domesticated ruminants represent an important source of good quality animal protein in many developing countries of Africa including Nigeria (Unigwe *et al.*, 2016). The small ruminants which include sheep and goats represent an important segment of the livestock system in Nigeria (Ademola and Onyiche, 2013). They form an important

sources of income, meat and dairy products in urban and rural areas in Nigeria (Nwosu *et al*., 2007). Apart from being the source of animal protein, their wastes are also very important organic manure in agriculture (Nwosu *et al*., 2007). These animals are also used for sacrifices during religious worships, traditional ceremonies and cultural festivals in most parts of Nigeria (Elele *et al*., 2013). Nigeria has a population of about 8 to 13.2million sheep out of which about 3.4million are found in the southern/humid region and the larger proportion of the animal in the northern region of the country (Lawal-Adebowale, 2012). The most available breeds of sheep in Nigeria are mainly indigenous which include the West African Dwarf (WAD) sheep, Balami, Uda and Yankasa. Out of these four major indigenous breeds of sheep in the country, the WAD breed are most commonly found in the southern region while the Balami, Uda and Yakansa breeds in the northern region of the country (Lawal-Adebowale, 2012). Presently, there is either little or no attention given to these animals in the rural areas of the country where most of the sheep are reared in large flocks (Omoike *et al*., 2014). In general, sheep husbandry are inadequately managed in Nigeria's agricultural sector owing to the fact that large flocks population of these animals are mostly owned and managed by the Fulani pastoralists either on free range nomadic extensive or semi-intensive system Under the free range nomadic system, sheep move about freely even with other ruminants to feed on forages, pastures, hay, grasses and farm produce left over, which are usually available on grazing field during the raining and dry seasons. Though, this management system is basically influenced by cheap means of feeding the sheep all year round (Omoike *et al*., 2014). Unfortunately, this type rearing system on the other hand predisposed the animals to vectors of infectious diseases and parasites (Okaiyeto *et al*., 2008; Lawal-Adebowale, 2012). High prevalence of diseases and parasites has been reported as major constraint, causing high mortalities and preventing these animals to express their full genetic potential which is generally considered low (Rushton, 2009; FAO, 2009; Akande *et al.,* 2010; Mirkena *et al*., 2010). Haemoparasitic diseases in sheep caused by the various haemoparasites is widespread in some parts of Nigeria and they occur in the northern, southern and western regions of the country (Thornton, 2010; Jatau *et al*., 2011; Adamu and Balarabe, 2012; Nwoha *et al*., 2013; Ukwueze and Ekenma, 2015; Opara *et al*., 2016). Haemoparasitic disease especially Babesiosis, Anaplasmosis, Theleriosis and Trypanosomosis are considered as major impediments to ruminant production including sheep (Useh *et al*., 2006; Lako *et al*., 2007). They have generally been shown to cause destruction of red blood cells resulting in anaemia, anorexia, high morbidity and mortality, infertility, jaundice and weight loss (Akande *et al*., 2010; Ademola and Onyiche, 2013; Sharifi *et al*., 2016; Opara *et al*., 2016). Anaemia has been reported as a reliable indicator for the severity of haemoparasitic infections (Adejinmi *et al*., 2004; Opara *et al*., 2016). Despite several reported incidence rates of haemoparasitic infections in Nigeria, infection with haemoparasites remains persisting as the major challenge to livestock production (Okaiyeto *et al*., 2008; Jatau *et al*., 2011; Onoja *et al*., 2013; Gebrekidana *et al*., 2013; Setotaw *et al*., 2014; Mans *et al*., 2015; Ukwueze and Kalu, 2015; Anyanwu *et al*., 2016; Opara *et al*., 2016). A proper understanding of the epidemiology of haemoparasitic diseases is a prerequisite to having a rational design for the effective control and preventive strategies against these dreadful diseases (Opara *et al*., 2016). Several in depth studies on the prevalence of these infections have been conducted in various parts of the Sub-Saharan Africa, including Nigeria. Despite these economic significant consequences of haemoparasites to ruminant, the prevalence and magnitude of haemoparasites infection in Balami sheep have not been assessed in Maiduguri, Northeastern Nigeria. Therefore, information on prevalence, distribution, and potential risk factors of haemoparasites of sheep is significant because the outcome could be used to make objective decisions on control strategies. The finding would also be useful in formulating strategies to meet the current shortage of protein from animal product created by the rapidly increasing human population caused by the influx of insurgency displaced population to Maiduguri Township. Hence, the present study was aimed to identify haemoparasites in the blood of Balami sheep in Maiduguri, to determine the prevalence of haemoparasites in relation to risk factors such as age, sex and body condition score of Balami sheep, to study the effect of haemoparasites on PCV and Hb concentration and finally to recommend suitable preventive and control strategies.

MATERIALS AND METHODS

Study area

The study was carried out in Maiduguri which the capital and largest city of Borno State, a North Eastern region of Nigeria. It is located in the Arid Zone with an area of about 69,436 km^2 and lies within latitude 10°-13°N and longitude 12° 15° E. It lies within the Sahel Savannah Zone with low records of rainfall. The area falls in the tropical continental North with dry Months between 4 and 8 Months (October - May) followed by a short rainy season from late June to early October. The State has a boundary with Chad republic to the North East, and Cameroun republic to the East.

Sample collection

Blood samples were randomly collected aseptically from

the jugular veins of 250 apparently healthy Balami breed of sheep of both sexes and various age groups reared extensively by the Nomadic Fulani pastoralist herdsmen in the study area. Following an ethical physical restrain procedures for sheep; 2-3 ml of blood was collected from the jugular vein of each sampled sheep into bijou bottle containing Ethylene Diamine Tetra Acetate (EDTA) which was then labeled appropriately. Observing the standard procedures and precaution for the collection and transportation of whole blood sample from small ruminants, the samples were transported to the Department of Veterinary Parasitology and Entomology research laboratory, University of Maiduguri for processing and examination. During blood samples collections parameters such as the sex, age and body condition score of each animal was evaluated and were recorded accordingly.

Sample preparation, staining procedure and microscopy for haemoparasites

A thin blood smear was prepared from each blood sample using the standard method described by Cheesbrough, (2000). A drop of blood is placed on one end of a clean glass slide, then using a cover slip as a spreader to spread the blood by allowing the spreader to touch the blood at an angle of 45^0, and then spread gently but firmly along the surface of the horizontal slide so that the blood is dragged behind the spreader to form the film with a feathered edge, air-dry using the slide racks, and fixed in methanol for 5 min. Stained in 1:10 Giemsa and Buffer dilution and stain for 30-40 min and rinse with distilled water then allow to air dry again using the slide racks. The smears were examined under the light microscope at x 100 objective magnification (oil immersion) for presence of haemoparasites and identification as described by (Mosqueda *et al*., 2012). Parasites were identified using the key standard characteristics of the parasites described by Soulsby, (1986) and Brar *et al.* (2011).

Packed cell volume determination

The remaining blood samples were used to determine the packed cell volume (PCV). After gently mixing the blood, a 75 × 1.5 mm capillary tube was filled with blood up to ¾ of its length by capillary action and one end sealed. Then, all of the blood-filled tubes were centrifuged for 4 min at 16000 rpm using a micro-haematocrit centrifuge. Finally, each tube was placed in a micro-haematocrit reader, to determine the percentage of packed red cell volume (PCV) for each animal (Hansen and Perry, 1994; Urquhart *et al*., 1996).

Haemoglobin count (Hb) determination

Haemoglobin count was determined using the Acid Hematin method as described by Brar *et al.,* (2011) using Sahli's instruments. 0.1N HCl was taken into diluting tube of haemoglobinometer up to the mark 10 on the percentage side. The haemoglobinometer pipette was filled up to the mark. The total volume was 20 mm^3. The pipette was immersed into HCl and blown gently. Distilled water was drawn into the pipette and added to the diluting tube fluid. The blood was mixed with the acid and after 30 min; distilled water was added drop by drop stirring with glass stirrer till the colour of tube matched with standard colour in the comparator. The tube was removed and reading was taken at the level of fluid.

Age, sex and body condition score determination

During sampling periods, sexes, ages and body condition score of each animal were recorded accordingly. Sex differentiation was made based on the appearance of external genitalia that is presence or absence of testis and udder. While, ages of the sampled sheep were considered in two age categories, young (up to one year) and adult (older than one year) using owner's information and was supported by dentition as described by Hassan and Nwannenna, (2009).

Body condition scores were determined according to procedures documented by Thompson and Meyer, (1994), sampled animals as poor, medium, and good classes following 1 up to 5 grading system. However, the present study was conducted on free range nomadic Balami sheep flocks; the body condition score of most of the studied sheep was not really appreciative. Thus, differentiating among medium and poor conditioned animals was difficult. Therefore, for the convenience of classification, the sampled sheep where categorized into poor or good body condition score groups. A poor body condition score was given for sheep which were extremely thin, having prominent spinous and transverse processes into which a finger could be easily pushed, and had less depth of loin muscle. A good body condition score was given for sheep when the spinous and transverse processes were smoothing, rounded, and well covered and with full loin muscle (Otoikhian *et al*., 2008; CFSPH, 2011; Shirzeyli *et al*., 2013).

Statistical analysis

All the data generated from this study were analyzed using descriptive statistics and the prevalence (%) of haemoparasites was expressed in percentage as described by Thrusfield, (2005).

The PCV and HBC were analyzed using One-Way analysis of variance (ANOVA). Chi-square students' test was also used to test for association between the sexes, age and body condition score of sheep. P values < 0.05 were considered significant using GraphPad prism version 4.0 Windows from Graphpad Software, San Diego, California USA.

RESULTS

The overall prevalence of haemoparasites in Balami sheep in Maiduguri from month of February to August 2014 is presented in (Table 1). Out of 250 Balami sheep that were examined in this present study, a total of 46 sheep were found to be infected with haemoparasites with an overall prevalence rate of 18.40%. The prevalence rates of haemoparasites infection comprised of *Anaplasma* 24(9.60%), *Babesia* 13(5.20%), *Theileria* 7(2.80%) and *Trypanasoma* 2(0.80%).The prevalence of haemoparasites in Balami sheep according to the examined animal age groups, sexes and body condition scoring is presented in (Table 2). The haemoparasitic infection rates were found to be higher in adult 39(14.0%) Balami sheep compared to the infection rates in the examined young 7(4.40%) sheep. There was statistical significant difference (*P*-value= 0.0022 at 95% CI; RR= 1.168) between haemoparasitic infection rate and ages groups of sheep. Moreover, haemoparasites infection rates were found to be higher in the females 27(10.80%) Balami sheep when compared to the infection rates in males 19(7.60%) sheep examined. There was no statistical significant difference (*P*-value= 0.1479 at 95% CI; RR= 1.082) between haemoparasitic infection rate and sexes of sheep. The present study classified body condition scores into two *viz* good and poor body condition of Balami sheep examined and haemoparasitic infections were found to be more frequent in Balami sheep with poor 36(16.40%) body condition when compared to the infection rates in sheep with good 10(2.0%) body condition. There was statistical significant difference (*P*-value= 0.0447 at 95% CI; RR= 1.110) between haemoparasitic infection rate and body condition of sheep. The result of mean ± SD (range) of some haematological parameters viz: Packed cell volume (PCV) and haemoglobin concentration (Hb) of normal and infected Balami sheep examined were shown in (Table 3). The uninfected Balami had a significantly higher mean ± SD (range) for PCV and Hb of 28.84 ± 3.4 and 9.55 ± 1.1 compared to the haemoparasitic infected Balami sheep 21.42 ± 3.7 and 7.22 ± 1.2 respectively ($P < 0.05$).

DISCUSSION

Haemoparasitic infections are considered as major constraints to farm animal production in the world significantly affecting their productivity (Kasozi *et al.,* 2014; Demessie and Derso; 2015; Salih *et al.,* 2015; Opara *et al*., 2016). Therefore, survey on prevalence of haemoparasites and their economic significance is important to the livestock industry especially the small ruminants in developing countries including Nigeria (Ademola and Onyiche 2013; Kasozi *et al*., 2014; Opara *et al*., 2016). The finding of this present study revealed an overall prevalence rate of 18.40% haemoparasitic infections in Balami sheep. This finding is relatively higher than 12.50% reported in sheep by Opara *et al*. (2016) in Lafia, Nassarawa State and lower than 20.38% reported from Kano State (Jatau *et al*. (2011), 33.0% from Zaria, Kaduna State (Okaiyeto *et al*., 2008), 21.0% from Bauchi State (Adamu and Balarabe, 2012) and 56.32% from Karu, Nassarawa State (Anyanwu *et al*., 2016). This present study confirms the reports of previous studies on the prevalence of haemoparasites in sheep in Nigeria and also suggests a continuous challenge by the parasites and the existence of carrier state in Balami sheep in Maiduguri, Borno State. However, the reason for the differences in the reported prevalence rates might be due to difference in climatic/geographical variation of sampling areas, period of sample collections, sample size and breed variation of sheep among others. Amongst the haemoparasites encountered in the infected Balami sheep from the present study, *Anaplasma* (9.60%) had the highest prevalence rate followed by *Babesia* (5.20%), *Theileria* (2.80%) and *Trypanosoma* (0.80%) in descending order of prevalent rate. The finding of this present study agrees with those of Okaiyeto *et al.* (2008), Takeet *et al.* (2009), Jatau *et al*. (2011), Adamu and Balarabe (2012) and Opara *et al*. (2016) who also have reported *Anaplasma* species as the most prevalent haemoparasites in sheep while our finding was not in line with those of Anyanwu *et al.* (2016) who have reported *Babesia* species as the most prevalent haemoparasites in sheep. The finding of *Babesia*, *Theileria* and *Trypanasoma* species in sheep in this present study is not first of its kind but consistent with previous reports by Ng'ayo *et al.* (2005), Jatau *et al.* (2011), Nwoha *et al*. (2013) and Anyanwu *et al.* (2016) who have previously reported the occurrence of these haemoparasites in sheep. Even though, small ruminants such as the sheep have been reported to be endemically unstable for *Babesia* parasite, those that may have been infected and recovered from Babesiosis become immune to re-infection as observed by Jatau *et al.* (2011) and Adamu and Balarabe (2012). The finding of *Theileria* (2.80%) in sheep in this present study is lower than 6.79% and 8.05% reported by Jatau *et al*. (2011) and Anyanwu *et al.* (2016) respectively. However, coinfection of all these fore mentioned haemoparasites infection in sheep has been documented in the world (Renneker *et al*., 2013). The prevalence rate of *Trypanosoma* (0.80%) in sheep reported in our study is relatively lower than 1.1% and 7.4% reported by Ohaeri (2010) and Nwoha *et al.* (2013) from Abia State respectively. The relatively low prevalence of *Trypanosoma* in the sampled Balami sheep in this study might be connected to the fact that our study area falls within the *Glossina* species Tsetse free zones of Nigeria and probably because small ruminants are not natural hosts for the mechanically transmitted Trypanosomosis which is considered endemic in camel and cattle in the study area (Kamani *et al*., 2010; Paul *et*

Table 1. Overall prevalence of haemoparasites in Balami sheep in Maiduguri, Nigeria.

Haemoparasites encountered	Number of infected animals (N= 250)	Prevalence rate (%)
Anaplasma spp.	24	9.60
Babesia spp.	13	5.20
Theileria spp.	7	2.80
Trypanasoma spp.	2	0.80
Total	46	18.40

N = Total number of Balami sheep examined.

Table 2. Prevalence of haemoparasites in Balami sheep on the basis of age, sex and body condition scores.

Risk factors	Parameters	No. of animals examined	No. of animals infected	Prevalence (%)	95% CI LL – UL	*P*-value	RR
Age (month)	Young(3 – 6)	96	7	4.40	0.8651 - 0.9722		
	Adult(7–above)	154	39	14.0	0.7341 - 0.8521	*P*-value= 0.0022	1.168
Sex	Male	135	19	7.60	0.8139 - 0.9240	*P*-value = 0.1479	
	Female	115	27	10.80	0.7350 - 0.8706		1.082
Body condition	Good	93	10	2.0	0.8288 - 0.9524	*P*-value = 0.0447	
	Poor	157	36	16.40	0.7516 - 0.8660		1.110

Key: LL – UL = Lower Limit – Upper Limit; CI = Confidence Interval; RR = Relative Risk

Table 3. Mean ± SD (Range) PCV (%) and Hb (g/dl) of normal and haemoparasites infected Balami sheep in Maiduguri, Nigeria.

Haematological values	Non infected with haemoparasites	Infected with haemoparasites
Packed cell volume (PCV %)	28.84 ± 3.4	21.42 ± 3.7*
Haemoglobin conc. (g/dl)	9.55 ± 1.1	7.22 ± 1.2*

**P*<0.05 compared to mean values of uninfected group of examined Balami sheep.

al., 2016). The finding of these haemoparasites in Balami sheep in the present study is not surprising; because infections with these arthropod borne haemoparasites is likely to occur due to the common mixed livestock nomadic grazing system practiced by the Fulani pastoralists, where the sheep are usually herded and grazed with other ruminants as observed by Okaiyeto *et al*. (2008). This could possibly create chances for cross infection and mechanical transmission of the diseases amongst different species of ruminants during grazing in the abundance of the vectors especially the ticks.

The finding of this present study revealed high prevalence of haemoparasites in adult (14.0%) Balami sheep compared to the younger (4.40%) ones. There was statistical significant (*P*-value = 0.002 at 95% CI) difference between the ages of sheep infected and the infection rate of the haemoparasites. This finding agrees with those of Opara *et al.* (2016) who also reported significantly high level of haemoparasites infection rate in adult sheep (100%) compared to the young (0.0%) ones. However, our finding contradicts those of Opara *et al.* (2016) who reported low level of haemoparasites infection rate in lambs (11.5%) compared to the adults (30.4%) sheep. Previous studies have confirmed higher level of haemoparasitaemia in adult sheep reared under nomadism compared to same infection in lambs (Ademola and Onyiche, 2013; Nwoha *et al*., 2013; Anyanwu *et al*., 2016). This may be due to the fact that the lambs are closely watched and cared for by the Fulani pastoralists during grazing than the adults this may probably reduce infestation rate with arthropod vectors such as ticks and the corresponding disease.

The finding of this present study also revealed high haemoparasitaemia in female (10.80%) Balami sheep compared to the male (7.60%) ones. Although, the difference is not statistically significant (*P*-value = 0.148 at 95% CI). This signifies that both sexes of Balami sheep shares equal chance of getting haemoparasitic infection when they are equally exposed to the same foci of infection. This result supported previous finding of Opara *et al.* (2016), who have reported high prevalent rate of haemoparasites in female (21.40%%) sheep compared to male (5.60%) ones. Our finding also corroborates the reports of Abenga *et al*., 2008; Ohaeri (2010), Ademola and Onyiche (2013) and Nwoha *et al*. (2013) who have also reported more frequent occurrence of haemoparasitaemia in female sheep compared to their males. However, the variation in the respective finding of

haemoparasitic infections in females against the male sheep could be attributed to the proportion of the female sheep population sampled. Moreover, most of the Fulani pastoralists keep large number of female sheep than males especially for the purposes of breeding while the males are usually sold out for cash in terms of needs, which may affect the proportion of the sex infection. It has also been reported that the female ruminants are generally more prone to infection by haemoparasites due to their extended breeding for economic purposes such as parturition and milk production (Ukwueze and Kalu, 2015; Anyanwu *et al*., 2016) as well as the stress of breeding, milking and cyclical hormonal changes associated with gestation, parturition and calving processes. However, the result of the present study is contradictory to previous findings of Anyanwu *et al.* (2016) who reported higher prevalence of haemoparasites in males (23.77%) than in the female sheep (19.62%).

The finding of the present study revealed higher infection rate of haemoparasites in Balami sheep with poor body condition score (16.40%) compared to those in good flesh (2.0%). Progressive emaciation in sheep in some instances might be due to physiological wasting away or poor nutrition. Poor nutrition lowers the resistance of the animals to infectious diseases, thus enhancing the establishment of haemoparasitaemia and increasing the pathogenicity of the parasites (Waruiru *et al*., 2004; Knox *et al*., 2006). It is also well known that adequately fed animals are more able to tolerate parasitism than animals on a low plane of nutrition (Waruiru *et al*., 2004; Knox *et al*., 2006). Moreover, haemoparasitaemic animals are reported to be anaemic and emaciated with poor performances and decrease in milk and meat production (Masiga *et al*., 2002; Ngole *et al*., 2003). The present study demonstrated a statistical significant difference (*P*-value= 0.045) between haemoparasitaemia and body condition score. This means that as haemoparasites increased in the blood the infected animal continues to emaciate vice versa. This finding is in line with the report of Okaiyeto *et al*. (2008) who have made similar observations in sheep infected with haemoparasites.

The Packed cell volume (PCV) value in this present study was calculated having considered (22 – 45%) as normal for sheep whereby mean PCV value below 22% is classified anaemia and dehydration when it is above 38% (Chandrawathani *et al*., 2008). Our finding revealed significant decrease ($p<0.05$) in the mean packed cell volume and the haemoglobin concentration (Hb) of all the categories of the haemoparasites infected Balami sheep examined compared to the uninfected ones. Decrease in PCV (21.42 ± 3.7) and its corresponding drop in haemoglobin concentration (7.22 ± 1.2) as against the normal range in infected sheep in this present study signify anaemia and physiological loose of blood proteins as previously indicated by Jatau *et al*. (2011) and Opara *et al*. (2016).

The finding of this present study also agrees with Adejinmi *et al.* (2004), Okaiyeto *et al*. (2008), Okorafor and Nzeako, (2014), Josiah *et al.* (2015) and Anyanwu *et al.* (2016) who have also reported anaemia consequence of low PCV as a reliable indicator for the severity of haemoparasitic infections in sheep. However, our report contradicts the finding of Ademola and Onyiche, (2013) who reported no significant difference ($p > 0.05$) in the mean packed cell volume (PCV) of animals with mixed or single haemoparasitic infection in a similar study. The difference in the PCV and Hb of haemoparasites infected sheep from various reports might be as a result of difference in nutritional and health status of the infected sheep. Well-nourished and healthy sheep may not show significant changes in their blood pictures especially during subclinical infection with blood parasites (Adejinmi *et al*., 2004; Anyanwu *et al*., 2016). However, the effects of haemolytic activities of the haemoparasites might be the cause of anaemia in the infected Balami sheep in this present study which supported the fact that haemoparasites are capable of inducing erythrocytolysis and erythrophagocytosis as previously reported by Okaiyeto *et al*. (2008) and Jatau *et al*. (2011).

Conclusions

The result of this present study clearly reveals the presence of haemoparasitic infection in Balami sheep reared by the Fulani pastoralists in Maiduguri, Borno State. It also revealed anaemia as the possible negative effect of the haemoparasites in blood of the infected sheep.

The herdsmen may not have noticed the effects of the parasites on their animals due to the subclinical or chronic nature of the infection, which in most cases do not result in severe clinical disease manifestation or mortality. However, their pathophysiological effects might usually manifested in significant losses in the animal productivity which may be in the form of stunted or decreased growth rate in lambs, progressive emaciation, late maturity, weight loss, and increased susceptibility to other infectious diseases.

Therefore, there is need for prevention and control programs against these parasites, which call for routine screening to reduce the pathophysiological effect of the parasites. Moreover, strategic measures should be taken to control the vectors involved in their transmission. When these are adequately carried out it will go a long run to improve the production potentials of these breed of sheep in the present study area.

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