



Prevalence of parasites of wildlife in Yankari game reserve and Sumu wildlife park in Bauchi State, Nigeria

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Abstract

The role of wildlife in the epidemiology of parasites in Yankari Game Reserve and Sumu Wildlife Park in Bauchi State, Nigeria was investigated by analysis of blood, faeces and ticks collected from 106 wildlife including 4 elephants (*Loxodonta africana*), 11 waterbucks (*Kobus ellipsiprymus*), 1 hartbeest (*Alcelaphus baselaphus caama*), 24 elands (*Taurotragus oryx*), 53 zebras (*Equus quagga crawshayi*), 1 kudu (*Tragelaphus strepsiceros*) and 12 wildebeest (*Connochaetes taurinus*). Blood samples were examined for haemoparasites by classical parasitological techniques i.e Geimsa's stained thin, thick and buffy coat blood smear. Whereas faecal samples were examined for gastrointestinal tract (GIT) parasites using floatation and sedimentation techniques while ticks were identified morphologically. Overall prevalence of haemoparasites was fifty six percent (56%). The identified haemoparasites were *Anaplasma marginale*, *Babesia bigemina*, *Babesia bovis*, *Theileria equi*, *Babesia caballi*, *Trypanosoma* spp and *Ehrlichia ruminantium*. Haemoparasites identified alone or in combination with others had a significant ($P < 0.05$) effect on mean PCV of infected animals. Sixty percent (60%) of the wildlife species were infected with GIT parasites. Types of GIT parasites identified were two protozoans (*Balantidium coli* and *Eimeria* spp) and helminths from eighteen genera including ten nematodes (*Strongyle* type-egg, *Dictyocaulus*, *Cooperia*, *Strongyloides*, *Haemonchus*, *Trichuris*, *Trichonema*, *Oesophagostomum*, *Bunostomum*, and *Ancylostoma*), four Trematodes (*Fasciola*, *Schistosoma*, *Paramphistomum* and *Gastrodiscus*) and three Cestodes (*Anoplocephala*, *Taenia* and *Moniezia*). Four genera of ticks, *Amblyomma*, *Boophilus*, *Hyalomma* and *Rhipicephalus* were identified on the wildlife species. Our findings indicated the presence of infective parasites in wildlife and potential risks of transmitting these parasites to in contact domestic animals and humans in the study area. Control measures should be focused on reducing parasitic infections by proper management of wildlife in the Game Reserves in Bauchi State, Nigeria.

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Introduction

Parasites play an important role in the dynamics of wildlife populations (Van Wyk & Boomker, 2011). They can cause substantial losses in production or even acute clinical signs and death (Wall, 2000). There is abundant evidence of parasitic infections in wildlife worldwide and studies have demonstrated that they may be carriers of gastrointestinal parasites (Ogunji *et al.*, 1984; Muriuki *et al.*, 1998; Oyeleke & Edungbola 2001; Karere & Munene, 2002; Moudgil & Singla 2013), ectoparasites (Kalema-Zikusoka *et al.*, 2002; Jongejan & Uilenberg, 2004) and haemoparasites (Nizeyi *et al.*, 2001; Mutani *et al.*, 2003; Munang'andu *et al.*, 2012). In addition to the physical injury caused by parasites, some serve as hosts of many viral, rickettsial, bacterial and protozoan diseases (Ghandour *et al.*, 1995; Murray *et al.*, 2000; Alvarado-Rybak *et al.*, 2016). In Nigeria, wildlife conservation areas such as Yankari Game Reserve (YGR) and Sumu Wildlife Park (SWP) are natural heritage and means of generating revenue (Ogunji *et al.*, 1984; Olokesusi, 1990; Oyeleke & Edungbola 2001; Eneji *et al.*, 2016) and parasitic infections may constrain the health of the variety of wildlife species in these conservation areas. Haemoparasites and gastrointestinal parasites have generally been shown to cause anaemia, jaundice, anorexia, weight loss, decrease in growth rate, late maturity, infertility and sometimes death of animals (Mbaya *et al.*, 2008; Moudgil *et al.*, 2015; Alvarado-Rybak *et al.*, 2016). Therefore, adequate knowledge about prevalence of parasites associated with wildlife from these conserved areas in Bauchi State is necessary. Wildlife and livestock contact is a key risk factor for disease transmission through spill over or spill back mechanism (Brown, 2004; Swai & Kaaya, 2012; Ernieenor *et al.*, 2017) and the role of wildlife in disease transmission has been explored extensively in other countries (Muriuki *et al.*, 1998; Brown, 2004; Ryan *et al.*, 2012; Alvarado-Rybak *et al.* 2016). However, in Nigeria, despite the large population of livestock with increasing potentials of disease transmission at the wildlife-livestock interface (Atuman *et al.*, 2014), studies on the role of wildlife as a reservoir of parasitic infections is limited (Mbaya *et al.*, 2008; Mafuyai *et al.*, 2013). More so, wildlife appears to be capable of living with high parasite loads without any apparent ill-effect on their health (Weyher *et al.*, 2006; Erkenwick *et al.*, 2017). This study was therefore carried out for the first time in the area to identify the parasites of wildlife and the potentials for transmission at the wildlife-livestock and human interfaces in YGR and SWP in Bauchi State

Nigeria. This could provide basis for intervention and further studies.

Materials and Methods

Study area

The study locations were YGR and SWP in Bauchi State, Nigeria. The YGR covers an area of about 2,244 square kilometres, it is an important refuge for over 50 species of mammals and over 350 species of birds and is one of the few remaining areas where wild animals are protected in their natural habitat in Nigeria (Odunlami & Lake, 2003; Omondi *et al.*, 2006). Whereas SWP covers about 40 square kilometer area and harbour species of wildlife including impala (*Aepyceros melampus*), springbok (*Antidorcas marsupialis*), oryx (*Orynx gazelle*), eland (*Taurotragus oryx*), zebra (*Equus quagga crawshayi*) kudu (*Tragelaphus strepsiceros*), blue wildebeest (*Connochaetes taurinus*), and giraffe (*Giraffa camelopardalis*) and is located about 60 km north of the State capital Bauchi (Atuman *et al.*, 2014).

Sample collection

A total of one hundred and six (106) wildlife species were sampled, which included elephant (*Loxodonta africana*) (4), waterbuck (*Kobus ellipsiprymus*) (11), Hartbeest (*Alcelaphus buselaphus caama*) (1) from YGR and eland (*Taurotragus oryx*) (24), zebra (*Equus quagga crawshayi*) (53), kudu (*Tragelaphus strepsiceros*) (1) and blue wildebeest (*Connochaetes taurinus*) (12) from SWP. Wildlife were immobilized for sample collection using a combination of Etorphine Hydrochloride (M99® Krüger-Med South Africa) at 0.5-2 mg/kg and Azaperone (Stresnil®, Janssen Pharmaceuticals (Pty.) Ltd., South Africa) at 0.1mg/kg delivered intramuscularly (IM) from a distance of about 25 meters on ground in a 3 mls dart syringe fitted with barbed needles using a Dan-Inject® rifle (Dan-Inject APS, Sellerup Skovvej, Denmark). Ten millilitres of blood samples were collected from the jugular vein of each animal and dispensed into EDTA vacutainer bottles. Faeces were collected from rectum of each animal into well-labelled sterile polythene bags and external parasites (ticks) were pulled off from the animals with forceps and placed in sterile loosely capped plastic universal sample bottles. All samples were transported in a cold box with ice packs to the National Veterinary Research Institute Laboratory Bauchi and were promptly analysed for parasites examination accordingly.

Haemoparasites, endoparasites and ectoparasites detection methods

Haemoparasites were detected by placing a drop of blood on a grease free glass slide, then preparing thin and thick blood smears for each sample. All smears were prepared and the thin smears were fixed in methanol for 2-3 minutes. Both thin and thick smears were stained in 10% Giemsa’s stain and rinsed in buffered water (Jain 1986; Gupta & Singla 2012). The smears were examined at x100 magnification on an Olympus microscope. Each blood sample was introduced into a plain glass microhaematocrit tube, one end of the tube was sealed using plasticine and the tubes were spun for 5 min at 1500 rev in a microhaematocrit centrifuge (Hawksley, England). Packed Cell Volume (PCV) was determined using a haematocrit reader (Hawksley, England) and buffy coat examined for motile blood parasites as describe by Jain (1986). Flootation and sedimentation techniques were performed to identify endo parasites as described by Soulsby (1982). Morphological identification of ticks was carried out as described by Walker (2003). Ticks were mounted on slides and examined using a stereoscope microscope at a magnification of × 40, × 80 and × 100.

Results

Out of 106 wildlife animals screened, 60(56.6%) were positive for haemoparasites (Table 1). In SWP: elands had the highest prevalence 19/24(79.2 %), followed by wildebeests 8/12 (66.7 %) and zebras 24/53(45.3 %), while the only sample collected from kudu was also positive for *Babesia* spp. (Table 1). In YGR: elephants had the highest prevalence 2/4 (50.0%) followed by waterbucks 5/11 (45.5%), while the only hartbeest examined was also positive for *Ehrlichia ruminantium* (Table 1). The identified haemoparasites were *Anaplasma marginale*, *Babesia bigemina*, *Babesia bovis*, *Theileria equi*, *Babesia caballi*, *Trypanosoma* spp and *E. ruminantium* (Table 2). Most of the samples parasitized by *Babesia*, *Anaplasma*, and *Ehrlichia* spp. alone or in combination had a significantly (P<0.05) lower mean PCV than those parasitized by *Trypanosoma* spp. and non parasitized animals (Table 3). Results on GIT parasites of wildlife showed that out of the 106 faecal samples collected 63(59.4%) were positive with GIT parasites (Table 4). Of the four wildlife species from SWP examined for GIT parasites, prevalence was highest in eland 16/24 (66.7%) followed by wildebeests 7/12 (58.3%), zebras 29/53 (54.7%) and

Table 1: Prevalence of Haemoparasites of some Wildlife from the Yankari Game Reserve and Sumu Wildlife Park in Bauchi State, Nigeria.

Wildlife	No. sampled (%)	No. positive (%)
Sumu wildlife park		
Eland (<i>Taurotragus oryx</i>)	24 (22.6)	19 (79.2)
Wildebeest (<i>Connochaetes taurinus</i>)	12 (11.3)	8 (66.7)
Zebra (<i>Equus quagga crawshayi</i>)	53 (50.0)	24 (45.28)
Kudu (<i>Tragelaphus strepsiceros</i>)	1 (0.9)	1 (100.0)
Yankari game reserve		
Waterbuck (<i>Kobus ellipsiprymus</i>)	11 (10.4)	5 (45.5)
Elephant (<i>Loxodonta africana</i>)	4 (3.8)	2 (50.0)
Hartbeest (<i>Alcelaphus buselaphus caama</i>)	1 (0.9)	1 (100.0)
Overall	106 (100.0)	60 (56.6)

Table 2: Haemoparasites of wildlife from Yankari Game Reserve and Sumu Wildlife Park in Bauchi State Nigeria

Haemoparasite	Waterbuck No. (%)	Elephant No. (%)	Hartbeest No. (%)	Zebra No. (%)	Wildebeest No (%)	Eland No. (%)	Kudu No. (%)
<i>Anaplasma marginale</i>	5 (45.5)	1 (25.0)	0 (0.0)	0 (0.0)	7 (58.3)	15 (62.5)	0 (0.0)
<i>Babesia</i> sp	2 (18.2)	0 (0.0)	0 (0.0)	0(0.0)	5 (41.7)	14 (58.3)	1 (100)
<i>Trypanosoma</i> sp	1 (9.1)	1 (25.0)	0 (0.0)	1 (1.9)	1 (8.3)	4 (16.7)	0 (0.0)
<i>Theileria equi</i>	0 (0.0)	0 (0.0)	0 (0.0)	14 (26.4)	0 (0.0)	0 (0.0)	0 (0.0)
<i>Babesia caballi</i>	0 (0.0)	0 (0.0)	0 (0.0)	9 (17.0)	0 (0.0)	0 (0.0)	0 (0.0)
<i>Ehrlichia ruminantium</i>	0(0.0)	0 (0.0)	1 (100.0)	0 (0.0)	5 (41.7)	7 (29.2)	0 (0.0)

the only kudu examined was also positive with GIT parasite (Table 4). Also, of the three wildlife species from YGR examined for GIT parasites, prevalence was shown to be high in waterbucks 7/11 (63.6%) followed by elephants 2/4 (50.0%) and the only hartbeest examined was also positive with GIT parasites (Table 4). Overall, a number of GIT parasites including two protozoans (*Balantidium coli* and

Eimeria spp.) and helminths from 18 genera including 10 nematodes (*Strongyle* type-egg, *Dictyocaulus*, *Cooperia*, *Strongyloides*, *Haemonchus*, *Trichuris*, *Trichonema*, *Oesophagostomum*, *Bunostomum*, and *Ancylostoma*), 4 Trematodes (*Fasciola*, *Schistosoma*, *Paramphistomum* and *Gastrodiscus*) and 3 Cestodes (*Anoplocephala*, *Taenia* and *Moniezia* were identified from the faecal samples (Table 5).

Table 4: Prevalence of Gastrointestinal Parasites of some Wildlife from Sumu Wildlife Park and Yankari Game Reserve in Bauchi State, Nigeria.

Wildlife	No. sampled (%)	No. positive (%)
Sumu wildlife park		
Eland (<i>Taurotragus oryx</i>)	24 (22.6)	16 (66.7)
Wildebeest (<i>Connochaetes taurinus</i>)	12 (11.3)	7 (58.3)
Zebra (<i>Equus quagga crawshayi</i>)	53 (50.3)	29 (54.7)
Kudu (<i>Tragelaphus strepsiceros</i>)	1 (0.9)	1 (100.0)
Yankari game reserve		
Waterbuck (<i>Kobus ellipsiprymus</i>)	11 (10.4)	7 (63.6)
Elephant (<i>Loxodonta africana</i>)	4 (3.8)	2 (50.0)
Hartbeest (<i>Alcelaphus buselaphus caama</i>)	1(0.9)	1 (100.0)
Overall	106(100.0)	63 (59.4)

Table 5: Distribution of types of Gastrointestinal Parasites identified in some Wildlife from Yankari Game Reserve and Sumu Wildlife Park in Bauchi State, Nigeria.

Gastrointestinal parasites	Waterbuck No. (%)	Elephant No. (%)	Hartbeest No. (%)	Zebra No. (%)	Wildebeest No. (%)	Eland No. (%)	Kudu No. (%)
Protozoans							
<i>Balantidium coli</i>	2 (18.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
<i>Eimeria</i> spp	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (12.5)	0 (0.0)
Trematodes							
<i>Fasciola</i> spp	4 (36.4)	2 (50.0)	1(100.0)	9 (17.0)	7 (58.3)	11 (45.8)	0 (0.0)
<i>Paramphistomum</i> spp	2 (18.2)	0 (0.0)	0 (0.0)	0 (0.0)	1 (8.3)	4 (16.2)	0 (0.0)
<i>Schistosoma</i> spp	2 (18.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
<i>Gastrodiscus</i> spp	0 (0.0)	0 (0.0)	0 (0.0)	5 (9.4)	0 (0.0)	0 (0.0)	0 (0.0)
Cestodes							
<i>Anoplocephala</i> spp	0 (0.0)	0 (0.0)	0 (0.0)	4 (7.6)	0 (0.0)	0 (0.0)	0 (0.0)
<i>Taenia</i> spp	2(18.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
<i>Moniezia</i> spp	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (8.3)	0 (0.0)
Nematodes							
<i>Strongyle</i> type egg	1 (9.1)	1 (25.0)	1 (100.0)	0 (0.0)	6 (50.0)	6 (25.0)	1 (100.0)
<i>Strongylus</i> spp	0 (0.0)	0 (0.0)	0 (0.0)	13 (24.5)	0 (0.0)	0 (0.0)	0 (0.0)
<i>Ancylostoma</i> spp	2 (18.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
<i>Haemonchus</i> spp	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (16.7)	3 (12.5)	0 (0.0)
<i>Strongyloides</i> spp	0 (0.0)	1 (25.0)	0 (0.0)	5 (9.4)	0 (0.0)	3 (12.5)	0 (0.0)
<i>Dictyocaulus</i> spp	1 (9.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
<i>Cooperia</i> spp	1 (9.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
<i>Trichuris</i> spp	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (4.1)	0 (0.0)
<i>Oesophagostomum</i> spp	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (8.3)	0 (0.0)
<i>Bunostomum</i> spp	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (8.3)	0 (0.0)
<i>Trichonema</i> spp	0 (0.0)	0 (0.0)	0 (0.0)	6 (11.3)	0 (0.0)	1 (4.1)	0 (0.0)

Results of ticks infestation showed that wildlife sampled from SWP including zebras and elands were the most affected having 4 different genera of ticks including *Amblyomma*, *Boophilus*, *Hyalomma* and *Rhipicephalus* followed by wildebeest and kudu with 3 genera each (*Amblyomma*, *Hyalomma* and *Rhipicephalus* and (*Amblyomma*, *Rhipicephalus* and *Boophilus*) respectively, whereas wildlife sampled from YGR which included elephants, waterbuck and hartebeest were infested with both *Amblyomma* and *Boophilus* genera (Table 6).

Discussion

The prevalence of haemoparasitic infections in wildlife population in this study was high and most of the wildlife species were found to be parasitized by one or more haemoparasites. It is interesting to note that major tick-borne parasitic diseases affecting livestock in Nigeria (Enwezor *et al.*, 2009; Kamani *et al.*, 2010; Agu & Amadi, 2001; Pam *et al.*, 2013; Okarafor and Nzeako, 2014) were detected in the wildlife species during the study. The study showed high haemoparasites prevalence with no obvious clinical manifestations. These findings are consistent with other studies that have shown that detection of blood parasites in wildlife is often incidental and they are resistant to haemoparasite infections and that clinical disease is often stress related (Homer *et al.*, 2000; Schuster, 2002; Mbaya *et al.*, 2008;

Munang'andu *et al.*, 2009; Munang'andu *et al.*, 2010; Duscher *et al.*, 2014). Wildlife species from SWP had high prevalence of the haemoparasites than those from the YGR, this could be associated with high tick infestation observed on wildlife from SWP than those from the YGR. Furthermore, it could be linked to nutritional and environmental stressors especially during dry season as a result of limited grazing area in SWP which can have dramatic effects on immunocompetence thereby increasing susceptibility and vulnerability to parasitic infections (Friedman & Lawrence, 2002; Acevedo-Whitehouse & Duffus, 2009) whereas in YGR there is vast grazing land with thick vegetation for the wildlife species almost all through the year (Omondi *et al.*, 2006). Tick borne haemoparasites mentioned singly or in combination led to significant (P<0.05) reduction in the Mean PCV of the wildlife species.

This finding lends credence to the fact that tick borne haemoparasites still poses a serious health challenge in animals in sub Saharan Africa (Enwezor *et al.*, 2009; Kamani *et al.*, 2010; Swai & Kaaya, 2012). In contrast *Trypanosoma* spp did not cause significant reduction in PCV in wildlife species during the study; it is suggestive that trypanosomosis might not be a serious problem of wildlife in the study area. This finding agrees with a study conducted by Mattioli *et al.* (1990) during studies on incidence of trypanosomosis in wildlife species in Burkina Faso

Table 6: Distribution of ticks collected from some Wildlife in Yankari Game Reserve and Sumu Wildlife Park in Bauchi State, Nigeria.

Wildlife	No. examined	Tick species identified
Zebra	53	<i>Amblyomma variegatum</i> <i>Hyalomma</i> spp <i>Boophilus</i> spp <i>Rhipicephalus</i> spp
Eland	24	<i>Amblyomma variegatum</i> <i>Hyaloma</i> spp <i>Boophilus</i> spp <i>Rhipicephalus</i> spp
Wildebeest	12	<i>Amblyomma variegatum</i> <i>Hyalomma</i> spp <i>Rhipicephalus</i> spp
Kudu	1	<i>Amblyomma variegatum</i> <i>Boophilus</i> spp <i>Rhipicephalus</i> spp
Elephant	4	<i>Amblyomma variegatum</i> <i>Boophilus decolaratus</i>
Waterbuck	11	<i>Amblyomma variegatum</i> <i>Boophilus decolaratus</i>
Heartbeest	1	<i>Amblyomma variegatum</i>

where infection with *Trypanosoma* spp did not seem to affect the health status of the monitored wild animals. Similarly, studies in India (Sudan *et al.*, 2017; Parashar *et al.*, 2018) also agreed with findings from this study. The high prevalence of gastrointestinal parasites found in this study could be due to the favourable environment that enables the survival of the GIT parasites couple with the feeding habit of the wildlife species. A finding which is consistent with previous studies from sub-saharan Africa (Oyeleke & Edungbola, 2001; Van Wyk & Boomker, 2011; Mbaya & Udendeye 2011; Munang'andu *et al.*, 2012; Swai & Kaaya, 2012). In this study, waterbucks from YGR and elands from SWP had the highest burden of GIT parasites than the other wildlife species sampled. The feeding habit of eland which grazes purely on grasses and leaves compared to zebra and wildebeest which mostly graze together and have other options of feeding on coarse plants like stem and sheaths (Thaker *et al.*, 2010) exposes eland to high risk of transmission of GIT parasites at the pastures (Maingi *et al.*, 2004). Waterbuck being water dependent had high infection rate due to their habit of feeding on moist herbage which predisposes them to continuous exposure to infective helminth larva at pastures. Munang'andu *et al.* (2012) observed similar findings among water dependent wildlife species in Zambia. The study showed that nematode infections were particularly high followed by trematodes, cestodes and protozoans. High nematode infection has huge impact on livestock production since they result in reduced milk, meat, wool, hide products and stamina of working animals (Stien *et al.*, 2002; Ekong *et al.*, 2012). This can result in diminution of production potentials such as decreased growth rate, weight loss in the young and late maturity of the animals (Swai *et al.*, 2006, Adedipe *et al.*, 2014). *Fasciola* spp. was the most prevalent among the helminths identified during the study. Snail, an intermediate host of helminth species like *Fasciola* and *Schistosoma* were seen during the study, they often concentrate in marshy areas or marginal shallow water areas (Phiri *et al.*, 2007; Singla *et al.*, 2017). This would account for the reason why waterbucks were found to be infected by these helminths as they are the final host and they predominantly occupy marshy areas. Both Mir *et al.* (2013) and Parsani *et al.* (2013) reported that *Fasciola* spp. was the most prevalent helminth in studies carried out in India and Ethiopia respectively and associated their findings to moist pastures close to water sources and availability of snail intermediate host.

Of great concern is the zoonotic implication of some of the GIT parasites identified which include *Fasciola* spp., *Dicrocoelium dendriticum*, *Taenia* spp., *Schistosoma* spp., *Moniezia* spp. and *Ancylostoma* spp. They are known to be zoonotic and have caused considerable economic losses and health problems (Oyeleke & Edungbola, 2001; Mbaya & Udendeye, 2011; Ryan *et al.*, 2012; Elele *et al.*, 2013; Mir *et al.*, 2013; Mafuyai *et al.*, 2013). Humans that are directly or indirectly in contact with wildlife especially during herding, processing and consumption of meat (bush meat) and other by-products from wildlife are at risk of exposure to zoonotic GIT parasites. The relatively few GIT parasites identified in some of the wildlife species could also be due to smaller population size and number of the wildlife sampled. Where a large number of wildlife species are present, cross-transmission can take place more readily (Boomker *et al.*, 2000). Cross-transmission of *Trichonema* spp. known to be specific helminth for equids (zebra, donkeys, horses) (Soulby, 1982) was identified in eland during the study. Mixed infections with GIT parasites were observed. Mixed infection was characterized by the presence of two or more helminthes or protozoan in the same animal. The phenomenon of immune suppression of the host immune system by mixed infections increases host susceptibility to other diseases or parasites (Wang & Macdonald, 2006; Gupta *et al.*, 2009; Singla *et al.*, 2015).

Wildlife species were shown to be infested with various ticks during the study, with *Amblyoma* and *Rhipicephalus* ticks infesting multiple host species than *Hyaloma* and *Boophilus* genus observed in fewer animal hosts. It is not known whether this difference was based on host preference or the relative abundance of the different tick genus on the game parks. Moreover, some animal species like waterbucks in YGR were mildly infested with ticks. Waterbuck are semi aquatic medium sized antelopes which often submerged up to the shoulders sometimes leaving only the nostrils when frightened (Nefdt & Thirgood, 1997). Ticks infesting such wildlife are likely to drop-off when they are submerged in water thereby reducing the attachment time on the host. This could be the reason for the low burden of ticks observed in them during the study. However, there is need for detailed experimental studies to determine the host preference for ticks and to establish reasons why some wildlife species are less infested with ticks than others. Information obtained from such studies would help in selecting wildlife species for culling especially in situation where

population reduction of selected wildlife species is aimed at reducing the tick burden. The increasing activities of domestic animals at the fringes and within YGR and SWP can facilitate cross-transmission of ticks from the wildlife to domestic animals, this is of immense concern to livestock production and conservation goals in the study area as tick infestation has been suggested as a cause of mortality in several ungulate species (Melton & Melton 1982; Gallivan *et al.*, 1995; Fyumagwa *et al.*, 2007; Muruthi *et al.*, 2016) some of which are also a threat to human health (Makala *et al.*, 2003; Sumbria & Singla, 2017) and more novel microbial associations have continued to be described (Jasinskas *et al.*, 2007). Overall, these findings point to the fact that wildlife could play an important role in the epidemiology of parasites in Bauchi, State, Nigeria. Wildlife management system in the study area which subjects them to continuous challenge of vectors, scarcities of feeds and stress from environmental and climate variations couple with illegal livestock and human activities are compounding factors to efforts at controlling parasitic infections in the study area. Health status of wildlife in the study area should be frequently monitored with concurrent public enlightenment campaign on importance of wildlife conservation and the implications of poaching activities to wildlife, livestock and human health.

Conflicts of Interest

The authors declare no conflict of interest.

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