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Captive wild animals as potential reservoirs of haemo and ectoparasitic infections of man and domestic animals in the arid-region of Northeastern Nigeria

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ABSTRACT

Haematological examination of 114 captive wild animals belonging to 3 groups revealed blood infection with one or more haemo or ecto-parasites per animal. The carnivores harboured infections with mainly *Babesia canis*, *Babesia felis*, and *Trypanosoma brucei*. Those encountered among the *Artiodactyla* were mainly *Trypanosoma vivax*, *Trypanosoma congolense* and *Anaplasma marginale*. No haemoparasites were encountered in the *Proboscidae.* On the other hand, the primates had mainly *Plasmodium* schizonts and gametocytes. Parasitaemia due to trypanosomosis in the three animal groups were significantly ($P<0.05$) low and ranged between 2.5×10^3 to 4.5×10^3. Similarly, the percentages of RBC parasitized by *Babesia*, *Anaplasma*, *Theileria* and *Haemobartonella* as well as the number of monocytes parasitized by *Ehrlichia*, ranged from the lowest value of 6% in the pygmy hippopotamus (*Choriopsis liberiansis*) due to *Anaplasma marginale* to the highest value in the Cheetah (*Acinonyx jubatus*) which had 70% of its RBC parasitized with *Babesia canis.* The cheetah in question was imported from East Africa to Maiduguri Zoological Garden but later died as a result of the babesiosis before commencement of treatment during the period. Various species of ticks and large scores of haematophagus mechanical arthropod vectors were incriminated in the transmission processes. The significance of the results and potential risks to humans and domestic stock in the area is discussed.

Key words: captive wild animals, ectoparasites, haemo-parasites, reservoirs

Introduction

A wide range of African wild ungulates have been reported by several workers as reservoirs of animal trypanosomosis (SOULSBY, 1982; SOULSBY, 1994; MARIE, 1998;

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REICHARD, 2002) and to human sleeping sickness trypanosomes such as *Trypanosoma brucei gambiense* and *Trypanosoma brucei rhodesiense* (KAGERUKA, 1992; ROLF and STEVEN, 2005). The African buffalo (*Cyncerus caffer*) for instance has been known to be a reservoir of East coast fever (Theileriosis) due to infection with *Theileria parva* in Kenya (BARNET and BROCKLESBY, 1968; GROOTENHUIS et al., 1987). Meanwhile the waterbuck (*Kobus deffasa*) has been reported to be a reservoir of both *Theileria* and *Babesia* species (FAWCET et al., 1987). Similarly the wild *Felidae* and *Canidae* have been reported to be reservoirs of *Babesia felis* and *Babesia canis* (SOULSBY, 1982).

The chimpanzee (*Pan troglodytes*), on the other hand, among other primates often harbours either single or mixed infections of human malarial parasites (*Plasmodium ovale* and *Plasmodium vivax*) in endemic areas while *Plasmodium knowlesei* occur in monkeys, transmitted by *Anopheles* mosquitoes. The disease in monkeys is usually mild in natural infection, but often fatal in experimentally infected rhesus, vervet and red pattas monkeys. *Plasmodium rechanaski* on the other hand, causes mild tertian malaria in chimpanzees in endemic areas (SOULSBY, 1982; NUNES, 1989).

In spite of the rich fauna in the Nigerian ecosystem, which led to the establishment of eight National Parks for the purpose of *in situ* conservation, coupled with its large livestock population, the role of wildlife as a reservoir of haemoparasitic, infections have been extensively studied in East Africa and to a lesser extent in West Africa in general and Nigeria in particular. It is therefore a known fact that there is a lack of information in this regard, probably due to the lack of trained personnel in the field of wild animal capture, the enormous cost of capture equipment and that of the "Knock down" neuroleptanalgesics used for the restraint of wild animals. This study was therefore carried out for the first time and particularly in the arid region of Northeastern Nigeria, because the area harbours 13.9 million of the total cattle population in Nigeria (BOURN et al., 1994). Similarly, the recent outbreak of trypanosomosis among red fronted gazelles in Maiduguri and Abuja Zoological Gardens (MBAYA, 2007), coupled with the fact that the Maiduguri zoo is located in the heart of Maiduguri metropolis, and its close proximity to sedentary and feedlot cattle, in conjunction with the preponderance of biting flies within the Park was investigated as a likely source of the high prevalence of trypanosomosis among domestic stock in the area.

Materials and methods

Study area. The Maiduguri Zoological Garden where the study was conducted is located in Maiduguri, the capital and largest urban center in Borno State, Nigeria. The state lies between latitude $11^0$05'N and $11^0$40'N and longitude $13^0$05'E and $13^0$25'E. It is located between the Sudan Savannah and Sahel vegetation Zones. The Zoological Garden

was first established in 1975 with a few donated wild animal species. The zoo presently has 37 different species representing over 320 captive wild animals.

Restraint, sample collection and examination. The study involved 114 animals in captivity representing 18 species and belonging to 3 groups. The *Artiodactyla / Proboscidae* were immobilized using varied doses of etorphine hydrochloride and remobilized using its analogue diprinophine hydrochloride. The smaller antelopes were captured using 10cm mesh drop nets of 25 meters length and 3 meters height. The primates and carnivores were trapped in squeeze cages and immobilized intramuscularly with varied doses of ketamine hydrochloride (Ketalar, Parke-Davies®). Blood samples were aseptically taken from the jugular vein in the *Artiodactyla*, the ear vein in the *Proboscidae*, the sapheneous vein in the carnivores and the brachial vein in the primates into sterile vacutainers containing EDTA as anti coagulant. Initial detection of parasitaemia due to trypanosomes was by wet mount and buffy coat microscopy BMC according to standard criteria (MURRAY et al., 1983) and estimated by the rapid matching technique (HERBERT and LUMSDEN, 1976).

Thick, thin, and buffy coat smears were stained with 10% Giemsa stain according to MURRAY et al. (1983) and examined for haemoparasites according to standard criteria (SOULSBY, 1982). The percentage of red or white cells parasitized was determined by counting and differentiating 100 of such cells according to standard criteria PRATT (1987). Ectoparasites were collected manually, while skin scrapings in cases where skin lesions were evident was carried out and identified according to standard criteria (SOULSBY, 1982; SOULSBY, 1994). Haematophagus arthropod vectors in the various animal enclosures were trapped using Biconical and Nitse traps baited with ox-odour attractants and identified according to standard criteria (SOULSBY, 1982).

Statistical analysis. Data obtained were either summarized as means ± standard deviation or percentages. $P<0.05$ were considered significant at 95% confidence limit (MAED and CURNOW, 1983).

Results

Tables 1, 3 and 5 show the various haemoparasites and associated parasitaemia or percentage of red or white cells parasitized in the various animal groups examined during the study. All the animals in the three groups harboured infection with one or more haemoparasites. The parasitaemia due to trypanosomosis were generally low and ranged between 2.5×10^3 to 4.5×10^3. The percentage of RBC parasitized due to *Babesia*, *Anaplasma*, *Theileria*, or *Haemobartonella* or monocytes due to *Ehrlichia* were also low and ranged from 6% in the pygmy hippopotamus (*Choriopsis liberiansis*) due to *Anaplasma marginale* to the highest value in the cheetah (*Acinonyx jubatus*) which had (70%) of its RBC parasitized with *Babesia canis*. The cheetah letter died of the infection with PCV as low as 14.5% before treatment commenced. The most common haemoparasites

encountered in the carnivores were *Babesia felis*, *Babesia canis* and *Trypanosoma brucei*. Those encountered in the *Artiodactyla* were mainly *Trypanosoma vivax*, *Trypanosoma congolense* and *Anaplasma marginale*. No haemoparasites were however detected in the *Proboscidae*. On the other hand, the primates had mainly *Plasmodium* schizonts and gametocytes in their RBC. The percentage of RBC parasitized ranged from 6% in the baboon (*Papio anubis*) to 30% in the chimpanzee (*Pan troglodytes*).

Table 1. Haemo-parasites and associated parasitaemia and red blood cells or monocytes parasitized among captive carnivores examined in Maiduguri Zoological Garden

Animals	N^o	Parasites encountered	N^o infected (%)	Parasitaemia ± SD or (%) of cells infected
Lion (*Panthera leo*)	8	(i) *Babesia felis*	6 (75.0)	12.5(%)
Striped Hyeana (*Hyeana hyeana*)	6	(i) *Trypanosoma vivax*	1 (16.67)	$4.5\times10^3 \pm 0.28$
		(ii) *Trypanosoma brucei*	1 (16.67)	$4.5\times10^3 \pm 0.28$
Spotted hyeana (*Crocuta crocuta*)	4	(i) *Trypanosoma vivax*	2 (50)	$2.5\times10^3 \pm 0.26$
		(ii) *Babesia canis*	1 (25)	$2.5\times10^3 \pm 0.26$
		(iii) *Ehrlichia canis*	1 (25)	30 (%)
Jackal (*Canis aureaus*)	6	(i) *Babesia canis*	1 (16.67)	30 (%)
		(ii) *Ehrlichia canis*	1 (16.67)	6 (%)
		(iii) *Bartonella canis*	4 (66.67)	20 (%)
Cheetah* (*Acinonyx jubatus*)	1	(i) *Babesia canis*	1 (100)	70 (%)
Total	25		19 (76)	

*Cheetah died a few days later

Tables 2 and 4 show the various ecto-parasites recovered and identified from the various wild animals in the zoological garden when blood samples were taken, while Table 6 shows the various haematophagus arthropod vectors caught with biconical and Nitse traps placed in the perimeter and enclosures of the animal cages. *Rhipicephalus sanguineus* was the most common ectoparasite encountered in the carnivores, while *Boophilus decoloratus* and *Amblyomma variegatum* were the predominant ectoparasites encountered among the *Artiodactyla*. No ectoparasites were however recorded from the *Proboiscidae* or the primates. Out of 1018 haematophagus arthropod vectors caught in the Park, *Stomoxys*, *Hippobosca*, *Tabanus*, and mosquitoes were encountered most.

Table 2. Ectoparasites encountered among the captive carnivores examined in Maiduguri Zoological Garden

Animals	No.	Ectoparasites	Number infected (%)
Lion (*Panthera leo)*	8	(i) *Rhipicephalus sanguineus* (ii) *Notoedres cati*	6 (75) 2 (25)
Striped hyeana (*Hyeana hyeana*)	6	(Nil)	(Nil)
Spotted hyeana (*Crocuta crocuta*)	4	(i) *Rhiciphalus sanguineus*	2 (50)
Jackal (*Canis aureaus*)	6	(i) *Rhipicephalus sanguineus* (ii) *Ctenocephalides canis*	3 (50) 1 (16.67)
Cheetah (*Acinonyx jubatus*)	1	(i) *Rhipicephalus sanguineus*	1 (100)
Total	25		15 (60)

Table 3. Haemoparasites and associated parasitaemia or number red blood cells parasitized among captive *Artiodactyla* or *Proboscidae* examined in Maiduguri Zoological Garden

Animals	N°	Haemoparasites encountered	N° infected (%)	Parasitaemia ± S.D. or % RBC infected
African elephant (*Loxodanta africana*)	2	(i) Nil	Nil	Nil
Cape eland (*Tauratragus oryx*)	1	(i) *Theileria annulata*	1 (100)	10%
Pygmy hippopotamus (*Choriopsis liberiansis*)	1	(i) *Anaplasma marginale*	1 (100)	6%
Grimms duiker (*Sylvicapra grimmia*)	6	(i) *Trypanosoma vivax* (ii) *Anaplasma marginale*	3 (50) 1 (16.67)	$2.5\times10^3 \pm 0.45$ 40%
Western kob (*Kobus kob*)	2	(i) *Trypanosoma vivax*	1 (50)	$2.5\times10^3 \pm 0.45$
Dorcas gazelle (*Gazella dorcas*)	10	(i) *Trypanosoma congolense* (ii) *Trypanosoma vivax*	1 (10) 2 (20)	$4.5\times10^3 \pm 0.28$ $2.5\times10^3 \pm 0.45$
Sitatunga (*Tragelaphus speikei*)	6	(i) *Trypanosoma vivax* (ii) *Trypanosoma congolense*	1 (16.67) 2 (33.33)	$2.5\times10^3 \pm 0.45$ $4.5\times10^3 \pm 0.28$
Senegal hartebeest (*Damaliscus korrigum*)	2	(i) *Babesia bovis*	1 (50)	20%
Red fronted gazelles (*Gazella ruffifrons*)	14	(i) *Trypanosoma bruce* (ii) *Trypanosoma congolense*	7 (50) 1 (7.14)	$2.5\times10^3 \pm 0.45$ $2.5\times10^3 \pm 0.45$
Total	44		22 (50)	

Table 4. Ectoparasites encountered among the captive *Artiodactyla* or *Proboscidae* in Maiduguri Zoological Garden

Animals	Nº ined	Ectoparasites encountered	Number (%) infected
African elephant (*Loxodonta africana*)	2	Nil	Nil
Cape eland (*Tauratragus oryx*)	1	(i) *Boophilus decoloratus*	1 (100)
Pygmy hippopotamus (*Choriopsis liberiansis*)	1	(i) *Amblyomma variegatum*	1(100)
Grimms duicker (*Sylvicaprea grimmia*)	6	(i) *Boophilus decoloratus* (ii) *Amblyomma variegatum*	1 (16.67) 5 (83.33)
Western kob (*Kobus kob*)	2	(i) Nil	Nil
Dorcas gazelle (*Gazella dorcas*)	10	(i) Nil	Nil
Sitatunga (*Tragelaphus speikei*)	6	(i) Nil	Nil
Senegal hartebeest (*Damaliscus korrigum*)	2	(i) *Boophilus decoloratus* (ii) *Amblyomma variegatum*	1 (50) 1 (50)
Red fronted gazelle (*Gazella rufifrons*)	14	(i) Nil	Nil
Total	44		10 (22.73)

Table 5. Haemoparasites encountered and percentage of red blood cells parasitized among captive primates in Maiduguri Zoological Garden

Animals	Nº	Haemoparasites encountered	Nº infected (%)	(%) of RBC infected
Chimpanzee (*Pan troglodytes*)	2	(i) *Plasmodium vivax*	1 (50)	30 (%)
Baboon (*Papio anubis*)	13	(i) *Plasmodium vivax*	4 (30.77)	6 (%)
Tantalus monkey (*Cercopethicus aethiopes*)	10	(i) Nil	Nil	Nil
Red pattas monkey (*Erythrocebus pattas*)	20	(i) *Plasmodium falciparum*	10 (50)	20 (%)
Total	45		15 (33.33)	

Table 6. Biting flies caught using flytraps in the vicinity of Maiduguri Zoological Garden

Location	Total catch	Types of flies	Number (%)
Carnivores' cages	88	(i) *Stomoxys*	20 (22.73)
		(ii) *Tabanus*	36 (40.91)
		(iii) *Lyperosia*	16 (18.18)
		(iv) *Hippobosca*	6 (6.82)
		(v) Unclassified	10 (11.36)
Artiodactyla/ *Proboscidae* enclosures	410	(i) *Stomoxys*	210 (51.22)
		(ii) *Tabanus*	170 (41.46)
		(iii) *Lyperosia*	10 (2.44)
		(iv) *Hippobosca*	18 (4.39)
		(v) Unclassified	2 (0.49)
Primates complex	520	(i) *Stomoxys*	100 (19.23)
		(ii) *Tabanus*	80 (15.38)
		(iii) Mosquitoes	300 (57.69)
		(iv) Unclassified	40 (7.69)
Total	1018		

Discussion

The haemoparasites encountered in the blood of the captive wild carnivores during the study have been reported in pet dogs in the Sudan Savannah (ADAMA et al., 1989) and in the Sahel Savannah (AHMED et al., 1994). Similarly most of the haemoparasites encountered among the *Artiodactyla* during the study have equally been reported among cattle in the area (NAWATHE et al., 1988; NAWATHE et al., 1994; GLAJI et al., 2005). In spite of the importance of wildlife in the epidemiology of cattle haemo-parasitism, however, no study has been conducted to evaluate similar situations among wild animals in the area. This study, being carried out for the first time, has shown that over 100 wild animals kept at the Maiduguri Metropolitan Zoological Garden located in the arid region of Northeastern Nigeria, harboured single or mixed infection with a variety of haemoparasites without showing typical symptoms of the infections. Some of the haemoparasites encountered in the various animal groups have previously been recorded in free-living and captive wild animals elsewhere in the world, either occurring sub clinically or during severe outbreaks (BAKER, 1968; SOULSBY, 1982; SILVA et al., 1995; PARIJA and BHATTACHARYA, 2001). Outbreaks of trypanosomosis recently among captive red fronted gazelles (*Gazella rufifrons*) in Maiduguri and Abuja Zoological Gardens in Nigeria, however, have been observed and reported to be associated with increased stress related corticosteroid output (MBAYA, 2007).

In this present study, *Rhipicephalus sanguineus* occurred most commonly among the lions (*Panthera leo*), spotted hyeana (*Crocuta crocuta*), jackal (*Canis aureaus*) and the cheetah (*Acinonyx jubatus*) with all of them harbouring either single or mixed infections of *Babesia canis*, *Babesia felis*, *Ehrlichia canis* and *Haemobartonella canis*. The presence of these haemoparasites coupled with the high degree of tick infestations might indicate that the ticks could be the possible vectors in the transmission process. *Rhipicephalus sanguineus* has been identified as the principal vector of *Babesia*, *Ehrlichia*, and *Haemobartonella* in canids (SOULSBY, 1982). The occurrence of the tick *Boophilus decoloratus* and *Amblyomma variegatum*, in several of the *Artiodactyla* harbouring latent infections with *Theileria annulata*, *Anaplasma marginale* and *Babesia bovis* is a clear indication that the ticks might have been the vectors responsible for maintaining the parasites among these species. These vectors might equally be of potential hazard to the sedentary herds and feedlot cattle located at close proximity to the zoological garden. The possibility of mechanical transmission through *Tabanus*, *Stomoxys*, *Hippobosca* and *Lyperosia* bites, whose painful bites irritate the hosts, which immediately ward them off thereby favouring interrupted feeding, have been reported as the mode of spread of trypanosomosis among livestock in the tsetse free-arid region of Northeastern Nigeria (MBAYA, 1988; NAWATHE et al., 1988; NAWATHE et al., 1990; NAWATHE et al., 1994). This might likely be the mode of cross transmission from one wild animal group to the other in the Maiduguri Metropolitan Garden on the one hand and from the wild animal to sedentary and feedlot cattle located in close proximity to the zoo on the other.

The occurrence of large scores of mechanical vectors, coupled with trypanosome infection encountered among these wild animal species might support this view. Furthermore, most of these species of wild animals have been reported by SASAKI et al. (1995) as a regular source of blood meal for haematophagus arthropod vectors, thereby facilitating mechanical transmission to livestock within an area. The occurrence of *Plasmodium* schizonts and gametocytes in the RBC of the primates, coupled with the all year round occurrence of *Anopheline* and *Culine* mosquitoes in the vicinity of the primate complex, could be of public health concern to both zoo attendants on the one hand and human visitors on the other. The role of primates as a reservoir of human malaria parasites has been reported (SOULSBY, 1982).

The high prevalence of mixed or single infection due to trypanosomosis among captive carnivores might be associated with either biological transmission or oral transmission. The oral mode of transmission is likely to be a possible mode of transmission other than through the bites of haematophagus arthropod vectors among the wild carnivores. The usual feeding practice in the zoological garden for the past ten years involves feeding carcasses of wild ungulates that died in the zoo to captive carnivores due to unavailability of funds. This practice might have been responsible for the high prevalence

of trypanosomosis among the captive carnivores. Previous studies, however, have shown that in order for oral transmission to be successful, feeding of a dead infected animal to a non-infected animal must be done immediately after death for the trypanosomes to be infective. This is because "carrion" feeding does not favour this mode of transmission (BAKER, 1968; SASAKI et al., 1995). The authors reported that oral transmissions through abrasions caused by bone splinters in the oral mucosae in predatory carnivores preying on infected wild herbivores might be responsible for the high prevalence of trypanosomosis among free-living and captive carnivores. This mode of transmission has been produced experimentally by infecting two cats and a bush baby in this fashion with *Trypanosoma brucei rhodesiense* by allowing them to kill and eat an infected laboratory rat (DUKE et al*.,* 1934; HEISCH, 1963).

In spite of the fact that all the animals examined were maintaining the infection in an asymptomatic carrier status, many cases of presumed specific resistance to haemoparasitic diseases in free-living wild animals tend to break down. This occurs when animals are subjected to unnatural conditions such as captivity, draught, or intercurrent diseases (SILVA et al., 1995; MARIE, 1998; PARIJA and BHATTACHARYA, 2001; REICHARD, 2002; ROLF and STEVEN, 2005; MBAYA, 2007). During this study, the cheetah translocated from Central Africa to Maiduguri Zoo, had 70% of its RBC parasitized with *Babesia canis* and showed severe symptoms of anaemia and weakness. The cheetah died the next day before the commencement of treatment. *Babesia* spp. is known to be highly pathogenic in captive carnivores (NUNES, 1989).

Most of the animals involved in this study were captured at various times and brought into captivity from Sambisa Game Reserve, located about 40 km from the metropolis. The reservoir status of the animals in the zoo might be a typical representation of the status of the wild animals occurring naturally in the Game Reserve. If this hypothesis is true, then the large number of sedentary and migratory cattle that always graze at the borders of the National Park, which holds over 13.9 million of the total cattle population in Nigeria (BOURN et al., 1994), could be at risk of haemoparasitic infections, particularly trypanosomosis, due to the all year preponderance of mechanical arthropod vectors in the area. This study is important in being the first of its kind to be undertaken and particularly in the tsetse free arid region of Northeastern Nigeria, which holds the highest cattle population in the country. It is therefore recommended that the zoo be relocated to the outskirts of the metropolis; vector control or regular screening of zoo inmates may constitute a remedial control measure.

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SAŽETAK

Pretragom krvnih razmazaka 114 divljih sisavaca držanih u zatočeništvu, svrstanih u tri skupine, dokazana je infekcija jednom ili više vrsta parazita po životinji. U mesoždera su dokazane vrste *Babesia canis*, *Babesia felis* i *Trypanosoma brucei*. U *Artiodactyla*, najčešće su dokazane praživotinje *Trypanosoma vivax*, *Trypanosoma congolense* i *Anaplasma marginale*. U surlaša nisu dokazani krvni paraziti. U primata su uglavnom dokazani shizonti i gametocite roda *Plasmodium*. Parazitemija uzrokovana tripanosomama bila je u sve tri skupine značajno niska ($P<0,05$) i kretala se između 2,5×103 do 4,5×103. Postotak eritrocita invadiranih protozoima *Babesia*, *Anaplasma*, *Theileria* i *Haemobartonella* kao i broj monocita u kojima su dokazane erlihije kretao se od najnižih vrijednosti (6%) u pigmejskoga vodenoga konja (*Choriopsis liberiansis*) u kojega je utvrđena *Anaplasma marginale* do najviših vrijednosti u geparda (*Acinonyx jubatus*) u kojega je čak 70% eritrocita bilo invadirano vrstom *Babesia canis*. Gepard je bio uvezen iz istočne Afrike u Zoološki vrt u Maiduguriju gdje je i uginuo od babezioze prije započetog liječenja. Velika učestalost krvnih parazita povezuje se s velikom učestalošću broja krpelja i hematofagnih člankonožaca. Rezultati su raspravljeni u kontekstu moguće opasnosti za zdravlje životinja i ljudi.

Ključne riječi: divlji sisavci, ektoparaziti, krvni paraziti