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Research Article

Prevalence of *Cryptosporidium* Infection in Slaughtered Dromedary Camels (*Camelus dromedary*) in Maiduguri Central Abattoir, Borno State, Nigeria

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ABSTRACT
Cryptosporidiosis is on the increase due to the high incidence of human immunodeficiency virus/acquired immunodeficiency syndrome and other debilitating diseases. This study was carried out to determine the age- and sex-specific prevalence of *Cryptosporidium* infection in slaughtered dromedary camels in Maiduguri, Borno State, Nigeria. A total number of 170 faecal samples were collected and examined using the modified Ziehl-Neelsen (MZN) staining technique under a light microscope. The overall prevalence of Cryptosporidium oocysts was 27.6%. Camels with age <2 years had the higher prevalence of 31.4%, and the lowest was seen in camels between 2 and 3 years. For camels aged 4-5 years and >5 years, the prevalence was 30.4% and 24.6%, respectively. There was a statistically significant (P=0.001) association between age and detection of *Cryptosporidium* oocysts in Dromedary camels. Males had a higher prevalence of 29.6% compared to females, who had a prevalence of 25.0%. Soft stools had a higher (34.6%) Cryptosporidium compared to semi-solid and solid faeces with 18.2% and 10.5%, respectively. Cryptosporidium infection was not significantly associated with the sex of camels (P=0.24). Cryptosporidiosis poses a serious threat to the camel industry and public health in Maiduguri, Borno State. It was also observed that butchers, animal handlers, and abattoir crews were at risk of contracting the infection and were therefore recommended to wear personal protective clothing (hand gloves and aprons) and also adopt the practice of hand washing to prevent contamination and exposure to the parasites.

Keywords: Abattoir; Cryptosporidiosis; Dromedary camel; Maiduguri; Prevalence

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INTRODUCTION

Cryptosporidiosis was ranked the 5th most important food-borne parasite of public health importance globally (Bamaiyi *et al.*, 2013). *Cryptosporidium* is a protozoan parasite of the Apicomplexa phylum with zoonotic implications belonging to the Cryptosporidiidae family (Bamaiyi *et al.*, 2013). The infection is caused by some recognized species of the genus Cryptosporidium (namely *C. parvum* and *C. ubiquitum*), which infect a wide host range (more than 170) of vertebrates, including camelids (Olabanji *et al.,* 2016; Feng *et al.,* 2018), and is mainly transmitted via faecal-oral route (Fayer, 2004). The history of human civilization has shown that camels play an important role in the economy, agriculture, and cultural activities of many countries, particularly

the Sahel Savannah or desert areas of the world (Allen and Saman, 1992). It has been reported that camels can withstand harsh climatic conditions in desert areas due to their unique anatomical and physiological nature. In addition, the species exhibits tolerance to parasitic infections compared to other livestock (Radfar and Gowhari, 2013). *Cryptosporidium* has higher morbidity and recorded a slightly high mortality rate in exceptional conditions, which makes the *Cryptosporidium* infection a disease of economic importance (Casemore *et al.*, 1997). In general, the principal manifestations of Cryptosporidiosis are more severe in newborn animals and characterized by severe watery, yellow, or pale brown diarrhea, which may be mucoid, anorexia, lethargy, weight loss or reduced milk intake, dehydration, growth retardation, stiffness, hyperpnoea, slow gait and depression (Casemore *et al.*, 1997; Fayer, 2004). Although adult camels are more resistant to infection and may persist as asymptomatic carriers, infected animals shed large numbers of oocysts into the environment and remain a main source of infection to other susceptible domestic and wild animals (Xiao *et al*., 1993; Feng *et al.,* 2018). According to Khalafalla *et al*. (2024), there are about 35 million in the whole population of Old World camels, and they are distributed in 47 countries, mainly in Africa and Asia. The majority (95.0%) of the camels are believed to be one-humped dromedary camels (*Camelus dromedarius*), serving as a rich source of meat and milk. Therefore, in semi-arid and arid zones, the dromedaries changed from a "ship of the desert" to a "food of animal origin." However, this trend revealed the economic value of camels. In addition to zoonotic disease transmission in unhygienic poor communities of developing nations (Khalafalla *et al*. 2024). In Nigeria, one-humped camels are mainly found in the semi-arid northern part of the country, as reported by Adamu *et al.* (1997) and Mohammed *et al.* (2007). This study was aimed at determining the prevalence of *Cryptosporidium* infection in one-humped camels (*Camelus dromedarius*) slaughtered at the Maiduguri Central Abattoir and to facilitate further studies on the zoonotic transmission of the disease from animals to humans.

MATERIALS AND METHODS

Study Area

This study was conducted at Maiduguri Central Abattoir (Latitude 11° 51'N, Longitude 13° 10'E) Maiduguri, Borno State, Northeastern part of Nigeria. The state lies between latitude 10°N and 13°E and longitude 12°N and 15°E. The state has an area of about 69,43659 square kilometers, with an estimated population of 4.2 million people. It has a hot climate with average peak of daily temperature ranging from 34 to 40 ^{o}C in the months of April to July, but it is slightly milder in the southern part of the state. It occupies the greatest part of the Chad Basin. The state has two vegetation zones; Sahel in the North which is hot and with severe desert encroachment covering most of the Chad Basin areas and Sudan Savannah in the South which is slightly milder. The rainy season lasts from June-September in the North which has Sahelian vegetation and from May-October in the south with Sudan vegetation with relative humidity of 49%. Borno State shares boundaries with the Republic of Niger to the North, Chad Republic to the North-east and Cameroon to the East. Within the country, the state shares border with Adamawa to the south, Yobe to the West, Bauchi and Gombe to the South-west. Previous report revealed that daily, 30-40 and monthly 900-1200 camels are being slaughtered at the Maiduguri Central Abattoir.

Determination of Sample Size

An Epi Info™ 7.2.2.2 was used to determine the sample size. A total of n=305 were used as the population size. Therefore, at 95% confidence level the sample size was determined to be n=170. A convenient sampling technique was employed to collect a total of 170 faecal samples, based on the availability of slaughtered camels and butchers' compliance from the month of June to August, 2019.

Sex and Age Determination of the Animals

The sex (male and female) of the sampled camels was determined as they were brought into the abattoir for slaughter by quickly observing the perineal area and genital organs. The age of camels was determined based on dentition by dental eruption according to Payne and Wilson (1999) and substantiated by information (Ali Seid *et al*., 2016).

Collection of Samples, Transportation and Storage

A total of one hundred and seventy (170) faecal samples were collected from apparently healthy slaughtered camels (*Camelus dromedarius*) comprising of 98 male and 72 females of both young and adults. About 5gram of fresh faecal sample was

collected per-rectum of each camel and emptied into a wide-mouthed disposable plastic container identified and labeled. The faecal samples were transported to Veterinary Parasitology and Entomology Research Laboratory at University of Maiduguri for further analysis. The samples were preserved in 75% alcohol at room temperature until processed (Jongwutiwes *et al*., 2002).

Detection of Cryptosporidial Oocyst

The collected faecal sample of each animal was examined by direct smear technique. To determine oocysts shedding, samples that were negative by direct smear examination were concentrated by centrifugal sedimentation (2,500 rpm for 2 min) and Clayton-Lane flotation techniques using standard Sheather solution (Soulsby, 1982). The presence of *Cryptosporidium*-like oocysts in all samples was confirmed by modified Ziehl-Neelsen (MZN) staining (Henricksen and Polenz, 1981). The diameter of 100 *Cryptosporidium* like oocysts of each infected camel was measured at 1,000 × magnification. A sample was considered positive when at least one oocyst showed correct morphologic characteristics; *Cryptosporidium*-like oocysts were 4-6 µm, spherical containing a residuum, sporozoites and usually within a clear hollow, against a blue background (Rafiq et al. 2024).

Data Analysis

Data were analysed using statistical package for social sciences (SPSS) version 20.0. Chi-square (χ^2) was used to determine the association between variables and *Cryptosporidium* infection. Odds ratio (OR) and 95% confidence interval on OR (95% CI OR) were calculated to measure likelihood and strengths of association between variables and infection. Tables were constructed using Microsoft Excel 2010. Value of P<0.05 was considered significant throughout the study. The prevalence rate *Cryptosporidium* infection (*Cryptosporidium oocyst*) was calculated using the formula: by Thrusfield (2007).

$$Prevalence = \frac{Numberofsamplepositive}{Totalsampleanalysed} \times 100$$

RESULTS

Out of the 170 samples, 47(27.6%) were positive for *Cryptosporidium* species. The prevalence varies with age, age group <2years had the higher prevalence of 31.4% as compared to the lowest 24.0% in age group 2-3years. The other age-related prevalence is presented in Table 1. There were statistically significant differences (p<0.05) between age and *Cryptosporidium* infection (Table 1).

The sex specific prevalence of *Cryptosporidium* infection revealed that, of the 47 positive samples, 18(25.0%) were female while 29 (29.6%) were male. However, there was no statistically significant difference (p>0.05) between age and *Cryptosporidium* infection (Table 2). the soft stool recorded higher (34.6%, 37/107) intensity of *Cryptosporidium* oocyst compared to semi-solid 18.2% (8/44) and solid 10.5% (2/19) respectively (Figure 1).

Table 1: Age-specific prevalence of *Cryptosporidium* infection in dromedary camel (*Camelus dromedarius*) in Maiduguri Central abattoir, Borno State

Age (Years)	Number Examined	Number Infected	Prevalence (%)	OR	95%CI	χ^2	P-value
<2	35	11	31.4	Baseline		50.64	0.0001
2-3	75	18	24.0	0.76	0.33-1.78		
4-5	46	14	30.4	0.96	0.39-2.4		
>5	14	4	28.6	0.91	0.24-3.3		
Total	**170**	**47**	**27.6**				

Table 2: Sex-specific prevalence of *Cryptosporidium* infection in dromedary camel (*Camelus dromedarius*) in Maiduguri Central abattoir, Borno State

Sex	Number Examined	Number Infected	Prevalence (%	OR	95%CI	χ^2	*p*-value
Female	72	18	25.0	Baseline	0.61-2.23	1.2	0.24
Male	98	29	29.6	1.2			
Total	**170**	**47**	**27.6**				

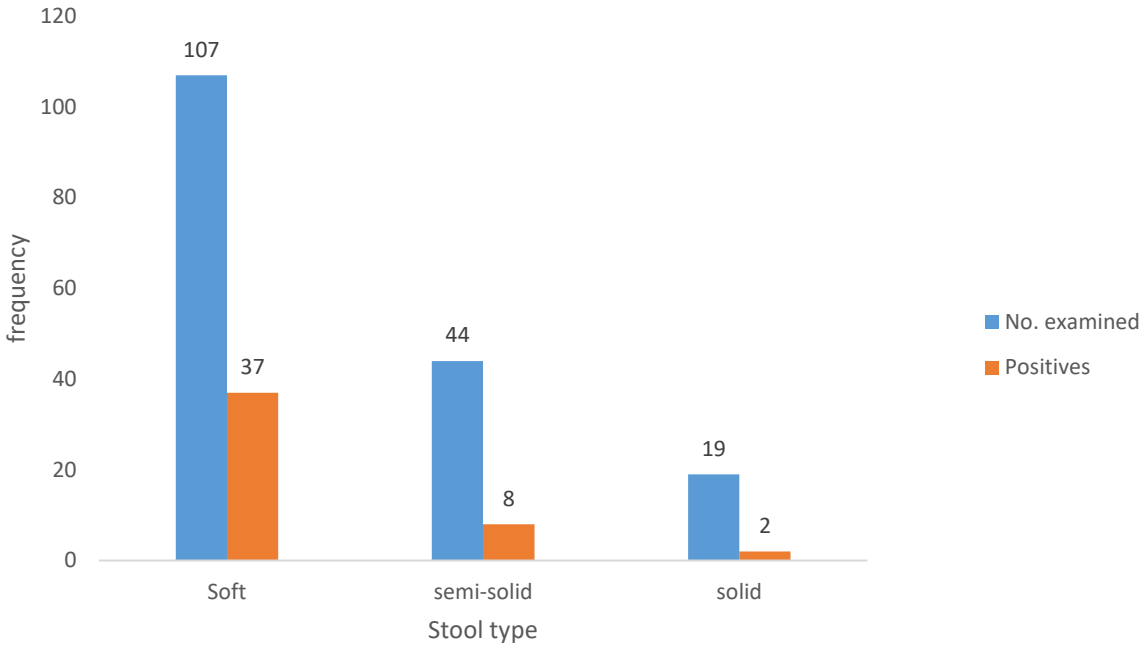

Figure 1: Intensity of *Cryptosporidium* oocyst observed in in different stool type of camelin Maiduguri

DISCUSSION

The occurrence of *Cryptosporidium* infection in camels in Maiduguri, Northeastern Nigeria, poses a risk of zoonotic transmission to humans through the faecal-oral route (contamination). The major source of camels (dromedary) to the Maiduguri abattoir is Chad, Niger, and Sudan, which happen to be deserts in vegetation. Therefore, there is a likelihood of trans-border movement of infected animals across the border unchecked. This may be attributed to porous borders between such countries, negligence, and lack of sustained disease surveillance systems. The high prevalence of *Cryptosporidium* infection recorded in slaughtered camels in Maiduguri may be an indication that cryptosporidiosis could be one of those neglected, emerging, and transboundary parasitic zoonotic diseases. The established prevalence was high compared to 3.37-19.30% in Egypt as reported by Abdel-wahab and Abdel-Maogood (2011); 16.9% obtained from Southern Iraq by Nazifi *et al.* (2010), and 20.3% obtained from Yazd province, Iraq by Khalafalla *et al.* (2024). This finding, agrees with the report of Zahedi *et al*. 2018 who reported the presence of *Cryptosporidium parvum* in Camel. The disparity in prevalence rates could be due to porous borders between Nigeria and other neighboring states, differences in environmental condition and hygienic measures adopted in their management and other determinants in the various countries. The clinical causes and severity of infection can vary considerably from individual to individual, depending largely on the immune status of the host. However, there are many recent findings on varying prevalence of *Cryptosporidium* on other ruminant's species including cattle as reported by Salama *et al*. (2023). Previous studies in the same study area have reported that trade camels brought for slaughtered harbours different genera of gastrointestinal parasites which include nematodes, trematodes, cestodes and protozoans which are of economic and public health importance to the production of camels and population at risks. This finding is consistent with those of Bamaiyi and Kalu (2011) and Wakil *et al*. (2017) who reported the same genera of gastrointestinal parasites in camels from Maiduguri and Sokoto, Nigeria respectively. Protozoans (*Cryptosporidium* species) were the second most prevalent gastrointestinal parasites in camels after Nematodes species as reported by Duguma *et al.* (2014). In our study, there was no apparent manifestation of clinical signs of Cryptosporidium infection among the studied camels. This indicates

that infected dromedary camel may remained carrier for a long time without manifesting the signs. *Cryptosporidium* oocyst can remain infective under cool moist conditions for many months, especially were water temperatures in rivers, lakes and ponds remain low but above freezing point (Fayer, 2004). This present study showed that prevalence rate was higher 31.4% in young (<2 year) dromedary camels than older ones. This agrees with the majority of the previous studies that reported a higher prevalence rate of *Cryptosporidium* infection in young camels (Razavi *et al.,* 2009; Bamaiyi *et al.,* 2011; Adamu *et al.,* 2015). Comparatively, young animals are much more susceptible to the infections than adult ones in other species of animals (Olson *et al.,* 1997), but contrary to other findings by Adamu *et al.* (2015), who reported higher prevalence in adult cattle in the same study area. These findings suggest that the age-related distribution of *Cryptosporidium* infection in this age group is not similar to those previously reported in camels (Borji *et al.,* 2009). Previous authors identified *C. muris*, *C. andersoni,* and *C. parvum* as the species of Cryptosporidium found in camels (Fayer *et al.,* 2008). Although this study showed that the prevalence rate was slightly higher in males' camels than in females, the difference was not statistically significant. This could be due to the fact that both sexes have equal chances of being infected or might be attributed to the fact that males are the first line to be attacked by pathogens, especially during grazing, because they are more active. These findings are in agreement with the report of Wakil *et al.* (2017). Although infected camels in this study were asymptomatic, they may act as healthy carriers of *Cryptosporidium* and may be sources of infection to man and other susceptible animals. Camels and other animal species grazing in the same area may be infected because quite a number of oocysts must have been released by the infected camels (those heavily infected in the surface water and pasture) and may facilitate fecal-oral route transmission. From the study findings, we therefore urge for standard diagnosis, control, and preventive measures to be put in place to curtail the transmission of the disease to human beings. There is a possibility of contamination of vegetables and other food items by the *Cryptosporidium* oocysts present in the feces through the use of manure and abattoir effluent for irrigation farming. This may pose serious public health implications, particularly among immunocompromised HIV/AIDS patients and others with debilitating diseases such as cancer (Maikai *et al*., 2013). In most developing countries, such as Nigeria, the increasing number of people living below $2/day (economic burdens), poor hygienic practices together with relatively high HIV prevalence rates, and other debilitating diseases played important roles toward the spread of *Cryptosporidium* infection among humans. This finding was in agreement with those made by Mehdiazami (2007), who reported higher rates of infection among calves than adult cattle. The study indicated that the adult animals were highly susceptible to infection with cryptosporidiosis compared to young animals. This could be as a result of other factors like management practice, concurrent infection, seasonal variation, and others than the sole impact of *Cryptosporidium* species. From the study findings, diagnosis, control, and preventive measures should be put in place to curtail the transmission of the disease to human beings. *Cryptosporidium* infection should be focused or directed towards the diagnosis and prevention of its spread.

CONCLUSION

A prevalence of 27.6% *Cryptosporidium* oocyst was detected in camels. Male and younger camels are more prone to *Cryptosporidium* infection than female and adult, indicating age- and sex-related susceptibility. Soft stools faecal samples contained more abundant oocysts, demonstrating a clear link between stool consistency and infection intensity. These outcomes emphasize the importance of focused preventive strategies and strengthened monitoring in camels' herds.

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