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Research article

Prevalence and risk factors associated with *Giardia lamblia* infection among cattle from Jere local government area of Borno state, Northeastern Nigeria

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Abstract

This study was designed to determine the prevalence and associated risk factors of *Giardia lamblia* infection among cattle in Jere local government area (LGA) of Borno State, Northeastern Nigeria. A total of 279 faecal samples were randomly collected from 12 cattle herds of the six wards of Jere LGA. The samples were screened for *Giardia lamblia* antigens with Copro-antigen Enzyme-Linked Immunosorbent Assay (ELISA) kit. Risk factors were analyzed using Chi-square or Fisher's exact test where appropriate, and multivariable logistic regression. The overall prevalence of *Giardia lamblia* infection among cattle was 5.7% (95% CI = 3.20, 8.60). Location-specific prevalence of 5.4% (95% CI = 1.1, 9.8), 4.3% (95% CI = 0.0, 10.6), 4.3% (95% CI = 0.0, 10.6), 8.7% (95% CI = 0.0, 21.7), 6.4% (95% CI = 0.0, 14.9) and 8.7% (95% CI = 0.0, 21.7) for Old Maiduguri, Khaddamari, Bale Galtimari, Mashamari, Maimusari and Dusuman wards were respectively detected among the cattle herds. Multivariable logistic regression model revealed that *Giardia lamblia* positivity among cattle could be strongly predicted by age (Young cattle ≤ 1 year; OR = 32.0; 95% CI = 8.40, 120.13; $p < 0.0001$). The even spread of the infection among cattle throughout the wards could be described as endemic in Jere LGA suggesting high risk potential for infection of cattle handlers from calves. Therefore, further studies on genetic characterization to determine the incriminating assemblage as well as public enlightenment of cattle handlers on the public health significance of giardiasis in the study area was recommended.

Keywords: Cattle, Giardia lamblia, Jere Local Government, Prevalence, Risk factors

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INTRODUCTION

Giardiasis is a common intestinal infection caused by single-celled flagellate protozoan, *Giardia lamblia* (synonym *Giardia duodenalis* and *Giardia intestinalis*) (Ryan and Zahedi, 2019; Belkessa et al., 2021). Globally, one of the most common causes of water and foodborne disease (Moreira and Bondelind, 2017; Kudah et al., 2018; Kifleyohannes and Robertson, 2020) and is classified as one of the Nationally Notifiable Disease by the United States Centre for Disease Control (CDC) (Beer et al., 2017; Nakao et al., 2017; Coffey et al., 2021). *Giardia* species are endemic in areas of the world that have poor hygiene (Roshidi et al., 2021); and they have a very wide host range including humans, non-human primates, domestic and wild animals, with high frequency of the infection commonly seen in young age. (Rayan and Zahedi, 2019; Belkessa et al., 2021).

The risk factors for the emergence of zoonotic giardiasis such as close contact between humans and animals, close contact with school children, low standards of personal hygiene, open defecations, unsafe methods of water storage and poor food-related practices at the household level are present in the study area (Jere LGA and environs of Borno State) due to lack of adequate information on the disease, poverty and reduced access to health care (Roshidi et al., 2021; Hajara et al., 2022). Giardiasis is known to rapidly spread in situations of conflicts – such as in Jere LGA and environs – because of the displacement and forceful resettlement of large number of persons (as seen in internally displaced persons, IDPs, camps) as well as their livestocks' closeness to their households (Chen et al., 2021). Jere LGA of Borno State experienced increased cattle rearing activities in recent time partly due to massive movement of the herders and their livestock from insurgent ravaged areas of the state to the LGA. It is also worthwhile mentioning that Jere LGA being part of the Maiduguri metropolis has been the epicenter of the *boko haram* insurgency since last decade (Granville, 2020). The on-going insurgency has negatively impacted on the lives, livelihoods and livestocks of > 3 million rural people resulting in their forceful displacement from their rural communities as IDPs (Lenshie and Henry, 2016).

In Nigeria, prevalence of giardiasis varies with 16%, 19.5% and 25% prevalences being reported among dogs in Maiduguri Metropolis (Mustapha, 2017), white Fulani cattle in Niger State (James et al., 2013), and among cattle slaughtered in Sokoto Metropolitan abattoir (Magaji et al., 2013) respectively. However, despite these few studies reporting on the prevalence of giardiasis in Northern Nigeria, there is still paucity of information regarding the prevalence and risk factors of *Giardia lamblia* infection in cattle in the study area. Therefore, the aim of this study was to determine the prevalence and animal-level risk factors associated with *Giardia lamblia* infection among cattle from Jere LGA of Borno State, Northeastern Nigeria.

MATERIALS AND METHODS

Study area

The study was conducted in Jere LGA of Borno State, Northeastern Nigeria. Semi-arid zone characterized by a rather austere climate conditions with dry season from November to early June, during which daily temperature varying between 30°c to 41°c especially from March to June (Eresanya, 2018). The rainy season is usually from late June to October with low relative humidity and short wet seasons. The LGA has 12 wards including Alau, Bale Galtimari, Dala Lawanti, Dusuman, Gomari, Gongulong, Maimusari, Mairi, Mashamari, khaddamari, Old Maiduguri and Tuba. The population of the Local Government was estimated to be 293,800 in 2016 with population density of 326.2 inhabitants per km^2. Water bodies (rivers, streams and dam), Market places for livestock and goods, and abattoir are found across the LGA.

Study design and sampling technique

A cross-sectional study was conducted in accordance with the method recommended by Charan and Biswas (2013). Six out of the 12 wards in the study area were selected purposively based on the availability of cattle farms/herds, people settlements and security. The selected wards were Dusuman, Khaddamari, Bale Galtimari, Old Maiduguri, Maimusari, and Mashamari. A total of 279 faecal samples were collected randomly from cattle of all ages and sexes from 12 available cattle herds. Cattle sampled were proportionately allocated to at least one herd in the selected wards (Table 1). At herd level, cattle were sampled by systematic random sampling technique as recommended by Thomas (2022). Total number of cattle in the herd was divided by the number of samples required in the herd to obtain the sampling interval. Therefore, cattle to be sampled were selected at the end count of the fixed periodic interval. Ethical approval was obtained from University of Maiduguri committee on animal use and care, dated 20th September 2021 with a reference number FVM/UNIMAID/AUEC/2021/003.

Table 1 Frequency of samples (n=279) collected for the assessment of *Giardia lamblia* among cattle in Jere LGA, Borno State, Northeastern Nigeria.

Ward	Number of herds sampled	Number of samples collected
Old Maiduguri	4	92
Khaddamari	2	47
Bale Galtimari	2	47
Maimusari	2	47
Mashamari	1	23
Dusuman	1	23
Total	12	279

Sample processing and analysis

Fresh faecal samples were collected into clean sterilized sample bottle after appropriate labeling, preserved in 10% formalin in a ratio of 1:3 volumes, properly capped and transported at ambient temperature using cool box to the Immunology Laboratory of the University of Maiduguri Teaching Hospital. The samples were then subjected to analysis using the commercial coproantigen ELISA kit (Epitope Diagnostic, Inc. San Diego, USA) for the detection of *Giardia lamblia* antigen in faecal samples (Hooshyar et al., 2019) according to the manufacturer's instructions. Information on host related factors (age, sex and breed), animal source, husbandry type as well as body condition score and faecal consistency were obtained at the time of sample collection.

Statistical Analysis

The data generated from this study were analyzed using the IBM® SPSS Statistics version 20 (IBM, Armonk, NY: IBM Corp.). The results obtained were presented using tables and percentages. Variables (risk factors) were assessed for association using Chi-square or Fisher's exact—where appropriate—reporting Odds ratio (OR) and their respective 95% confidence intervals. Age and faecal consistency with univariate level of significance $p < 0.2$ were selected for further inclusion into the model as covariates. Collinearity between the predictor variables was assessed using Chi-square test for independence ($\chi^2 = 2.482$, df = 1, $p = 0.115$). Multivariable logistic regression analysis model was also constructed using the forward stepwise likelihood ratio. Hosmer-Lemeshow test was used to examine the overall goodness-of-fit of the model to the data. Values of $p \leq 0.05$ were considered statistically significant.

RESULTS

Prevalence of *Giardia lamblia* in Jere LGA of Borno State, Nigeria:

Out of the 279 faecal samples, 16 were positive given an overall prevalence of 5.7% (95% CI = 3.20, 8.60). The highest location-specific prevalence of 8.7% was recorded in Mashamari and Dusuman followed by Maimusari 6.4%. However, with the exception of Old Maiduguri where 5.4% specific prevalence was recorded, each of the remaining 2 wards recorded 4.3% specific prevalence of *Giardia lamblia* infection as shown in Table 2.

Table 2 Prevalence of *Giardia lamblia* Among Cattle (n=279) in Jere LGA of Borno State, Northeastern Nigeria.

Location	No. Sampled	Prevalence	
		n	% Positive (95% CI)
Old Maiduguri	92	5	5.4 (1.1, 9.8)
Khaddamari	47	2	4.3 (0.0, 10.6)
Bale Galtimari	47	2	4.3 (0.0, 10.6)
Mashamari	23	2	8.7 (0.0, 21.7)
Maimusari	47	3	6.4 (0.0, 14.9)
Dusuman	23	2	8.7 (0.0, 21.7)
Overall Prevalence	279	16	5.7 (3.20, 8.60)

No., Number; %, Percent; CI, Confidence interval

Univariate analysis for *Giardia lamblia* infection among Cattle in Jere LGA:

Calves (cattle ≤ 1 year) had a significantly higher ($p < 0.0001$) prevalence of 30.2% compared to adults (Cattle > 1 year) with 1.3% as was shown in Table 3. Male cattle had 7.1% as compared with the female cattle 4.3% and this was not statistically significant ($p = 0.324$) (Table 3). The prevalence in Wadara breed was 5.3% as compared with other breeds with 6.4% and this was not statistically significant ($p = 0.693$) (Table 3). Indigenous cattle from Borno State had prevalence of 5.5% as compared to cattle from other sources 6.3% and this was not statistically significant ($p = 0.782$) (Table 3). Intensive and semi-intensive cattle had 6.2% and 5.1% prevalence rates respectively, however, this was not statistically significant ($p = 0.711$) (Table 3). Cattle with diarrhoeic faecal consistency had a significantly lower ($p < 0.010$) prevalence of 1.0% as compared to non-diarrhoeic cattle with prevalence of 8.4% (Table 3). Cattle with poor body condition score had 6.8% prevalence as compared to those with good body condition score 5.4% and this was not statistically significant ($p = 0.771$) (Table 3).

Table 3 Percentage distribution and Univariate analysis of variables associated with *Giardia lamblia* infection among Cattle from Jere LGA, Borno State, Northeastern Nigeria (variables with $p<0.2$ were selected for further multivariable analysis).

Variables	No. Tested	No. (%) Positive	OR (95% CI)	Chi-square test	*P* – Value
Age					
≤ 1 year	43	13 (30.2)	33.7 (9.07, 124.94)	7.499*	<0.0001
> 1 year	236	3 (1.3)	Ref.		
Sex					
Male	141	10 (7.1)	1.7 (0.59, 4.75)	0.972	0.324
Female	138	6 (4.3)	Ref.		
Breed					
Wadara	170	9 (5.3)	0.8 (0.29, 2.26)	0.156	0.693
Others[1]	109	7 (6.4)	Ref.		
Animal source					
Borno	199	11 (5.5)	0.9 (0.30, 2.61)	- 0.234*	0.782
Others[2]	80	5 (6.3)	Ref.		
Management system					
Intensive	162	10 (6.2)	1.2 (0.43, 3.43)	0.137	0.711
Semi-Intensive	117	6 (5.1)	Ref.		
Feacal Consistency					
Diarrhoeic	101	1 (1.0)	0.1 (0.01, 0.84)	6.592	0.010
Non-diarrhoeic	178	15 (8.4)	Ref.		
Body condition					
Poor	74	5 (6.8)	1.3 (0.43, 3.81)	0.440*	0.771
Good	205	11 (5.4)	Ref.		

No., Number; %, Percent; CI, Confidence Interval
[1]Other breeds (Sokoto Gudali, Red Bororo, White Fulani, Ambala and Kuri)
[2]Other sources (Bauchi, Sokoto, Tchad, Niger and Sudan)
Ref. – Reference Category
* Fisher's Exact test statistics

Multivariable logistic regression analysis of risk factors strongly associated with *Giardia lamblia* infection among Cattle:

The Hosmer-Lemeshow goodness of fit test showed that the final model adequately fitted the data ($\chi^2 = 0.234$, df = 1, $p = 0.628$). The Chi-square (χ^2) test for independence showed that the selected covariates were mutually independent. This model explained 41.1% (Nagelkerke R^2) of the variance in *Giardia lamblia* infection and correctly classified 94.3% of cases. The final model revealed that young cattle (≤ 1 year) were found to be significantly (OR = 32.0; 95% CI = 8.40, 120.13; $p < 0.0001$) associated with increased odds of *Giardia lamblia* positivity. Calves were approximately 32.0 times more likely to test positive for *Giardia lamblia* compared to adult cattle. Therefore, independent positive predictor of giardiasis is those cattle with ≤ 1 year of age. However, faecal consistency (diarrhoeic) was not found to be a predictor as shown in Table 4.

Table 4 Multivariable logistic regression analysis of risk factors strongly associated with *Giardia lamblia* infection among Cattle in Jere, Borno State, Northeastern Nigeria.

Variables	B	S.E	Wald	df	*p* – value	OR[1] (95% CI)
Age (≤ 1 year)	3.459	0.679	25.982	1	<0.0001	32.0 (8.40, 120.13)
Faecal Consistency (Diarrhoeic)	- 2.086	1.076	3.760	1	0.052	0.1 (0.02, 1.02)

[1]OR, Adjusted Odds Ratio; S.E, Standard Error; CI, Confidence Interval

DISCUSSION

The overall prevalence of 5.7% obtained in this study is of public health significance because of the close interaction between the herders and their cattle, asymptomatic nature of giardiasis and the fact that cattle can harbor and transmit zoonotic assemblages of *Giardia* as was observed by Chen et al. (2021) and Zajaczkowski et al. (2021). The result of infection in calves in this study contributed greatly to the obtained prevalence signifying the potential risk of infection from calves to the handlers. This was supported by Wu et al. (2022) findings and earlier presumption of possible zoonotic transmission of *Giardia* between animals and humans. Also considering the cattle population in the study area and severity of the diarrhoea particularly in dairy calves, infection to the tune of 5.7% is economically significant. This is also supported by Santin (2020) findings, which revealed that giardiasis is a major diarrhoeal disease with high morbidity, mortality and production loss. The present study documented lower herd-level prevalence in the study area, despite several studies documenting high farm-level prevalence of between 45% and 100% respectively in North America and Europe (Coklin et al., 2010; Santin et al., 2011; Geurden et al., 2012). The observed differences in prevalence rates could be due to variation in environmental temperature in the study area as was previously opined by Hajara et al. (2022). In addition, most of the herds examined in this study were shelter-free and cysts shaded into the environment may have been destroyed by direct sunlight, and this in turn will decrease the transmission burden of the parasite within the herds. The highest prevalence rates recorded in the study area were from Mashamari and Dusuman wards; and this could be associated with poor hygiene practice particularly in waste

product management in the herds and environs. Similarly, these wards possess more water bodies and active market places, which receive goods within and outside the metropolitan city adding more refuse dumps. In addition, the abattoir effluent from Maiduguri Municipal abattoir is discharged into the river stream that flows through these wards. Therefore, run off from these dump sites and abattoir effluent may contaminate the water bodies, from where infection with *Giardia* cyst may likely occur while grazing as was observed by Kifleyohannes et al. (2022).

The high prevalence of *Giardia* in young cattle could be as a result of slow development of immunity as such rendering them more susceptible to infection as was asserted by Mensah et al. (2019). Accidental licking of the anal region of infected dam during suckling could also be another reason. The results were also in agreement with the findings of multicenter study in Europe, where it was found that the risk of infection with *Giardia* was high in calves (Geurden et al., 2012). This is contrary to the findings of Mustapha (2017) among dogs in the study area, who reported that there was no significant association between age and *Giardia lamblia* infection.

In the present study, high prevalence was recorded in male than female cattle. Although not statistically significant, the higher prevalence could be largely attributed to male calf being more active roaming around the herd, and in so doing might have encountered the infection from environmental exposure to cyst. Similar findings were observed by Suman et al. (2011). In contrast to our findings, other researchers reported similar prevalence rates among male and female calves in Zambia (Kakandelwa et al., 2016). Furthermore, a study among adult dairy cattle conducted in Pakistan demonstrated that more females were infected with *Giardia lamblia* than males (Ayaz et al., 2012). However, findings of our study revealed a higher prevalence in bulls compared to cows. The nature of bulls searching for a mate and licking the anal regions of cows might likely predispose them more to giardiasis than cows.

The highest prevalence rate of *Giardia lamblia* was recorded in other breeds (Sokoto gudali, Red bororo, White fulani, Ambala and Kuri breeds) compared to Wadara breed. The difference might be associated with some factors. For instance, both breeds have the same chance of exposure to the infection, where they are allowed to graze in open fields in many communities of the study area thereby predisposing the breeds in accessing stagnant water where infection with *Giardia* may likely occur as was previously documented (Makkar et al., 2018; Kifleyohannes et al., 2022). Although the chance of exposure to infection is similar in both breeds, the indigenous breeds (Wadara) are well established/adapted in the study area and might have come in contact with the infection as they grow. Whereas other breeds might not be adaptive to the environmental conditions of the study area and might have not been in contact with the infection in their life and thus, their immune system could not have triggered the production of antibodies against future contact with the organism.

The current study revealed that imported cattle (exotic breeds) were at higher risk and more prone to contacting *Giardia lamblia* infection than the indigenous cattle. Therefore, the higher prevalence observed among cattle from other sources than Borno State could be attributed to climatic variations in geographic regions as was previously reported by Hajara et al. (2022). We are also speculating that this could be connected to genetic and hereditary factors associated with the imported (exotic) breeds of cattle.

We found that prevalence rate among cattle under intensive management systems appeared higher compared to those in semi-intensive management. This is because intensive production settings tend to favour environmental contamination and accumulation of large number of cysts. Our findings also corroborated with Muhid et al. (2011), who reported a non-significant occurrence of *Giardia lamblia* infection among cattle from intensive and semi-intensive management systems. In respect to consistency of faecal samples, prevalence of *Giardia lamblia* was significantly higher among non-diarrhoeic cattle than those with diarrhoea. This is contrary to what has been documented in the literature where the prevalence of infection was always associated with young and diarrhoeic animals. This could be attributed to the persistent shedding of *Giardia lamblia* among infected animals in the chronic phase, which is always associated with non-diarrhoea. We are speculating that the shedding of the organism persists in infected animals in the chronic phase of infection. Another plausible explanation is that the implicating agent of diarrhoea among the cattle could be some enteric pathogens other than *Giardia lamblia*, which were not investigated in this study. Regarding the effect of age on *Giardia lamblia* infection, our finding is contrary to the findings of other similar studies stating that *Giardia* infection is more common among young animals and is often associated with diarrhoea as previously reported (Santin, 2020).

The present study documented that cattle with poor body condition had slightly higher prevalence rate of *Giardia lamblia* (OR = 1.3) compared to those with good body condition. Although this is not statistically significant, the difference could have resulted from reduced immune status associated with animals on poor quality feed. In addition, the poor body condition may also result from direct consequence of the pathogenesis of giardiasis, considering the severe diarrhoea associated with the acute stage of *Giardia lamblia* infection in calves (Mensah et al., 2019; Santin, 2020).

CONCLUSIONS

In conclusion, this study provided baseline epidemiological information of *Giardia lamblia* infection among cattle in Jere LGA of Borno State, Northeastern Nigeria. The even spread of the infection among cattle throughout the wards could be described as endemic in Jere, the study area. Age was also concluded to be an independent positive predictor of giardiasis in cattle, with the disease decreasing with increasing aging. As such, suggesting high risk potential for infection of handlers from calves. Further studies on genetic characterization to determine the incriminating assemblage and sensitization of cattle handlers on the public health importance of giardiasis in the study area were recommended.

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AUTHOR CONTRIBUTIONS

Conceptualization, study design and supervision, AOT and MKL; data acquisition, analysis and interpretation, DJ, SMJ and AYH; Investigation, DJ, SJ and PEG; funding acquisition, project administration and writing – original draft, DJ; writing – review, editing and approval DJ, AOT, MKL, SJ, PEG, AYH, ASM and SMJ.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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