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Seroprevalence of *Trypanosoma evansi* in camels using CATT/*T. evansi* technique in Borno and Yobe states, Nigeria

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ABSTRACT

Trypanosoma evansi is an important camel pathogen with dissimilar mammalian hosts and is the most widely distributed pathogenic animals' trypanosomes worldwide that affects domesticated animals. Four hundred and six blood samples were collected using homogeneous purposive sampling techniques from camels of all age groups (206 from Borno State and 200 from Yobe State, Nigeria). Each animal was examined and information on age and gender were recorded. The card agglutination test for *T. evansi* (CATT/*T. evansi*) was used to estimate the seroprevalence of *T. evansi* infection. The seroprevalence of *T. evansi* based on age and sex in Borno State, Nigeria was 38.83% (95% CI = 32.44%, 45.63%) in adult camels, whereas, the seroprevalence of *T. evansi* in young camels was significantly lower 2.91%, (95% CI = 1.34%, 6.20%), $p < 0.05$). The seroprevalence of *T. evansi* in male camels was estimated at 14.08% (95% CI = 9.99, 19.49) whereas, in female camels the seroprevalence was estimated at 27.67% (95% CI = 22.01%, 34.15%, $p < 0.05$). Furthermore, the seroprevalence of *T. evansi* in Yobe State, Nigeria in the adult camels was 27.50% (95% CI = 21.78%, 34.07%) whereas, the seroprevalence of *T. evansi* in young camels was 19.00%, (95% CI = 14.17%, 25.00%). The seroprevalence of *T. evansi* in male camels was 30.0% (95% CI = 24.07%, 36.68%), whereas, the seroprevalence of *T. evansi* in female camels was 16.5% (95% CI = 12.00%, 22.27%). Therefore, the present study aimed to provide information on the seroprevalence of *T. evansi* and the related risk factors in camels in Borno and Yobe States, Nigeria using CATT/*T. evansi* technique.

1. Introduction

Trypanosoma evansi is an important camel pathogen, belonging to the family Trypanosomatidae, genus *Trypanosoma* and the subgenus *Trypanozoon*, that infects several mammals including humans (Desquesnes et al., 2013; Ngaira et al., 2002; Mossaad et al., 2017; Kamidi et al., 2018). It is also the most widely distributed pathogenic animal trypanosomes that have devastating effects on livestock production in Africa, Asia, Central and South America (Office of International Epizootics (OIE), 2004; Sánchez et al., 2015; Hasan et al., 2006; Muhanguzi et al., 2017). *T. evansi* originated in Africa and spread to other continents (Ngaira et al., 2002). It is primarily a parasite of camels and horses in Africa, present in the Sahara zone, above the tsetse belt, where it is mechanically transmitted by heamtophagous insects such as tabanids and *stomoxys* (Eyob and Matios, 2013; Thompson et al., 2014). The role of carrier animals can be highlighted by the fact that severe disease occurs in horses and camels

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(Aregawi et al., 2019). Camels contribute substantially to the incomes of numerous countries in Africa (Mohamed et al., 2020). However, the economic impact of this parasite is often underestimated and these include morbidity of up to 30%, mortality of about 3%, and abortion (Abera et al., 2015), reduced work resistance, poor carcass performance, weight loss, reduced milk production, low reproductive efficiency, treatment costs, abortion and then death (Aregawi et al., 2019; Elhaig and Sallam, 2018). The disease may develop as either acute or chronic form, which may last for many months, possibly years (Aregawi et al., 2019). Classical clinical symptoms of surra include intermittent fever, fatigue, lethargy, neurological disorders, anaemia, mostly caused by haemolysis and erythrophagocytosis (Jaiswal et al., 2015).

In Africa, *T. evansi* is present in all countries where camels are reared. Three districts in Kenya had a total seroprevalence of 45.9% (Njiru et al., 2004), the prevalence in South of Algeria (Boushaki et al., 2019), Somaliland (Salah et al., 2019), Benadir, Somalia (Mohamed et al., 2020) and Egypt (Abdel-Rady, 2008) was estimated at 32.4%, 26.4%, 65% and 43.5%, respectively in camels. Furthermore, 36 dromedary camels tested in the Canary Islands out of 745 were positive for *T. evansi* (Gutierrez et al., 2000). Chad share borders with Borno and Yobe States of Nigeria and there is usually a free movement and trade of camels across the borders. The overall seroprevalence of *T. evansi* in camels in West of Niger was estimated to 12.0% and the seroprevalence of *T. evansi* in eastern Chad was estimated to be 30.5% in 2831 camels tested (Pacholek et al., 2000; Delafosse and Doutoum, 2004). The camels are mainly mixed breeds originating from eastern and northern Africa (Jaji et al., 2017). There is a substantial number of camel pastoralists in the Northeastern part of Nigeria where camel population was estimated to 26,866 during the 1990s (Jaji et al., 2017). The Nigerian camel population is mainly present in northern semi-arid region (Jaji et al., 2017), and these include Borno, Yobe, Kano, Jigawa, Katsina, Sokoto, Kebbi and Zamfara states (Ochappa, 1988; Nneka Chizoba Enwezor and Kojo Bedu Sackey, 2005). Data on the seroprevalence of *T. evansi* using CATT/*T. evansi* technique is lacking in camels in the studied areas. Therefore, the present study aimed to provide information on the seroprevalence of *T. evansi* and the related risk factors in camels in Borno and Yobe States, Nigeria using CATT/*T. evansi* technique.

2. Materials and methods

2.1. Study area

This study was carried out in Borno and Yobe States, Nigeria. Borno state is located at an elevation of about 310 m above the sea level (MSL) along latitude 11° 49′ N and longitude 13° 9′ E. The vegetation of Borno state consists of Sahel Savannah in the north and Sudan Savannah in the south (Adamu et al., 2015). Yobe state is located at an elevation of about 370 MSL and lies within latitude 12° 11′ and longitude 11° 42′. The Yobe state is dry and hot during a major part of the year, except in the southern part of the state which has a milder climate. The Yobe state shares a border with Niger Republic which enhances trans-border movement of humans and livestock between the two countries (Olani et al., 2016; Fig. 1). (See Table 1.)

2.2. Blood samples collection

A homogeneous purposive sampling was conducted to obtain blood samples for a period of 6 months (July–December 2018). Four hundred and six blood samples were collected from camels of both sexes and different age groups, consisting of 206 animals from Borno State and 200 from Yobe State. Sampling was conducted at slaughter at the Maiduguri abattoir in Borno State and the livestock market in Geidam in Yobe state where all the camels were brought from Niger through Sudan. The camels in Borno came from Niger, Chad and Cameroon. Each animal was examined and information on age and gender were recorded. The camels were ranked into two age groups: young (≤1 to ≤5 years) and adult (>5 years). Venous blood samples were collected at the point of slaughter in plain vacutainer tubes. Samples were stored on ice and transported to the laboratory. Blood samples were centrifuged for 10 min at 2000 $\times g$ and the serum aliquoted and stored at $-80^{\circ}C$ until used.

2.3. Serological analysis

Sera were tested for the presence anti-*Trypanosoma evansi* in sampled camels, using the card agglutination test for *T. evansi* (CATT/*T. evansi*; Institute of Tropical Medicine, Antwerp, Belgium).

Approximately, 45 μl of the CATT antigen was transferred onto the test card and mixed with 25 μl of the test sera diluted at "1:4" with PBS pH 7.2 as per manufacturer's instructions. The card was agitated for 5 min and the presence of agglutination was checked. In each plate, a positive and a negative controls were added.

2.4. Statistical analysis

The data obtained were analysed using prevalence percentage with 95% confidence intervals and nominal logistic regression to test the association between infection prevalence and different risk factors with JMP version 11 software (SAS Institute Inc., Cary, NC) at 5% threshold.

Fig. 1. Map of Nigeria showing Borno and Yobe States in Nort East. Source: Google Map.

3. Result

The overall seroprevalence of *T. evansi* in camels found in Borno and Yobe States was estimated at 44.09% (95% CI = 39.34%, 48.95%). The infection prevalence of *T. evansi* in Borno State was (41.75%, CI = 35.23%, 48.58%) and Yobe state was (46.50%, CI = 39.72%, 53.41%). The infection prevalence in adult camels in Borno State 38.83% (95% CI = 32.44%, 45.63%) was significantly higher $p < 0.05$ when compared to the adult camels in Yobe state 27.50% (95% CI = 21.78%, 34.07%). Whereas, the seroprevalence of *T. evansi* in young camels in Borno State 2.91% (95% CI = 1.34%, 6.20%) was significantly lower $p < 0.05$ compared to the infection prevalence in the young camels in Yobe State 19.00% (95% CI = 14.17%, 25.00%). The seroprevalence of *T. evansi* in male camels in Borno State 14.08% (95% CI = 9.99%, 19.49%) was significantly lower $p < 0.05$ compared to the male camels of Yobe State 30.0% (95% CI = 24.07%, 36.68%), but the seroprevalence of *T. evansi* in female camels in Borno State 27.67% (95% CI = 22.01%, 34.15%) was significantly higher $p < 0.05$ compared to the female camels in Yobe State 16.5% (95% CI = 12.00%, 22.27%).

The adult camels were 1.36 times more likely to be infected with *T. evansi* infection in Borno State when compared to the young camels and it does not reach statistical significance (OR = 1.36, CI = 0.49, 4.11; p-value = 0.56). The male camels

Table 1
Seroprevalence and test of association of *T. evansi* according to age and gender in camels in Borno and Yobe States, Nigeria.

Risk factors	Borno State (n = 206)				Yobe State (n = 200)				Overall Prev. % [95% CI]
	SPC/SNC	% SPrev. [95% CI]	OR (95% CI)	*p*-Value	SPC/SNC	% SPrev. [95% CI]	OR (95% CI)	*p*-Value	
Gender category									
Male camels	29/40	(14.08 [9.99, 19.49])	1.04 (0.57, 1.88)	0.89	60/64	(30.00 [24.07, 36.68])	1.16 (0.48, 1.55)	0.62	(21.92 [18.17, 26.20])
Female camels	57/80	(27.67 [22.01, 34.15])			33/43	(16.50 [12.00, 22.27])			(22.17 [18.40, 26.46])
Overall	86/120	(41.75 [35.23, 48.58])			93/107	(46.50 [39.72, 53.41])			(44.09 [39.34, 48.95])
Age category									
Young camels	6/11	(2.91 [1.34, 6.20])			38/37	(19.00 [14.17, 25.00])	1.26 (0.70, 2.28)	0.43	(10.84 [8.17, 14.24])
Adult camels	80/109	(38.83 [32.44, 45.63])	1.36 (0.49, 4.11)	0.56	55/70	(27.50 [21.78, 34.07])			(33.25 [28.84, 37.97])
Overall	86/120	(41.75 [35.23, 48.58])			93.107	(46.50 [39.72, 53.41])			(44.09 [39.34, 48.95])

SNC = Seronegative camels; SPC = Seropositive camels; %SPrev. = % Seroprevalence; OR = Odd ratio; CI = 95% Confidence Interval (Lower and Upper values); n = number of camels in each state.

were 1.04 times more likely to be infected with *T. evansi* infection in Borno State when compared to the female camels and it does not reach statistical significance (OR = 1.04; CI = 0.57, 1.88; *p*-value = 0.89). The young camels were 1.26 times more likely to be infected with *T. evansi* infection in Yobe State compared to the adult camels and it does not reach statistical significance (OR = 1.26; CI = 0.70, 2.28; *p*-value = 0.43). Furthermore, the male camels were 1.16 times more likely to be infected with *T. evansi* infection in Yobe State compared to the female camels and it does not reach statistical significance (OR = 1.16; CI = 0.48, 1.55; *p*-value = 0.62).

4. Discussion

In the present study, the CATT/*T. evansi* technique showed that almost half of the camels investigated in Borno (41.75%, CI = 35.23%, 48.58%) and Yobe States (46.50%, CI = 39.72%, 53.41%) were infected by *T. evansi*. This high seroprevalence could be due to vector density, and lack of knowledge of the seriousness and economic impact of the infection by camel owners. In a recent study conducted in six farms in Somalia, Mohamed et al. (2020) reported a higher seroprevalence (65%, CI = 57.65%, 70.80%) of *T. evansi* infection. The present study has a similar sample population with the Somalian survey, but the discrepancies observed in the percentages of seroprevalence could be ascribed mainly to camel density in Somalia. The country has the highest camel population in the world with about seven million camels scattered all over the country. This high concentration of camels within the country may favour vector transmissions and promote *T. evansi* infection.

The seroprevalence of *T. evansi* in Borno and Yobe States were similar to the total seroprevalence of *T. evansi* in camels in the three districts of Kenya (45.9%, 41.77%, 50.08%) (Njiru et al., 2004). A study conducted in Egypt by Abdel-Rady (2008) also detected anti-*Trypanosoma* antibodies in (43.5%, CI = 36.72%, 50.57%) of camels indicating comparable findings with the present study.

On the contrary, a study performed in the Eastern part of Chad revealed a seroprevalence of 30.5% in 2831 camels tested (Delafosse and Doutoum, 2004). The discrepancy might be attributed to variation in sampling technique and the size of the population used. In Eastern Chad, surra is far large in transhumant systems, which allowed favourable breeding conditions for the speedy dissemination of *T. evansi* amongst camels. Pacholek et al. (2000) reported a total seroprevalence of (12%, CI = 8.45%, 16.82%) in West Niger, they reported variations in seropositivity in these regions as a result of seasonal herd movements. The result obtained by Pacholek et al. (2000) was different from the findings of the current study indicating much higher seroprevalence rates attributable to seasonal herd movements as Borno and Yobe states of Nigeria shares border with Niger. Similarly, since antibodies can persist for several months, it is not astonishing that the seroprevalence of *T. evansi* could indicate varying results from different studies. Additionally, dissimilar factors might be due to variable seroprevalences such as nutritional status, host susceptibility, and modification in strain virulence as suggested by Bezie et al. (2014).

In the present study, young camels (≤1 to ≤5) years of age in Yobe state showed higher seroprevalence 19% (CI = 14.17%, 25.00%) than those of Borno state 2.91% (CI = 1.34%, 6.20%). This is in line with Delafosse and Doutoum (2004) and Bhutto et al. (2010) findings where antibodies against *T. evansi* were higher in camels older than 3 years of age than those between 1 and 2 years of age. The finding was also per the study of Atarhouch et al. (2003) where *T. evansi* infection rate was reported to increase with age up to 7–10 years maximum. Perhaps, it is because calves do not forage with adults and therefore are not exposed to long-distance pastures where the vectors are present. Pathak and Khanna (1995), stated that all camel age categories are equally exposed to *T. evansi* irrespective of breed.

The seroprevalence of *T. evansi* in adult camels in Borno and Yobe States, Nigeria, indicated high infection rates, such result might be harmonised with the report that surra affects camels of all ages with a higher seroprevalence of the disease in younger camels (Njiru and Bett, 2002). However, the seroprevalence of surra was higher in adults than the younger ones in the present study. Therefore, an increase in seroprevalence with age could be a reasonable elucidation (Khosravi et al., 2015; Tehseen et al., 2015). There is enormous stress on camels in the rural areas. They have to trek for long distances in search of water and pasture. These strenuous activities may undermine their nutrition, immunity, quality of life, and render them more susceptible to infection by *T. evansi*. Fikru et al. (2015) and Tehseen et al. (2015) reported that the seropositivity rate in adult camels was

considerably higher than young animals, which was similar to the seroprevalence of adult camels in Borno State in the current study and this could come as a result of the trans-boundary trading with other African countries. Furthermore, Delafosse and Doutoum (2004) presented the associated risk factors in camels in Eastern Chad to be due to *T. evansi* infection, they found that the risk of infection increases with age.

The seroprevalence in male and female camels in Borno and Yobe States, Nigeria, were 441.75% (CI = 35.23%, 48.58%) and 46.50% (CI = (39.72%, 53.41%), respectively. The high proportion of seropositive specimens recorded proved that surra is highly prevalent in Borno and Yobe States, Nigeria, similar to other regions (Ngaira et al., 2002; Njiru et al., 2004). On the other hand, in Borno and Yobe States, the likelihood of infection in males can be explained by the fact that these animals are exposed to fatigue owing to physical work, traveling in terms of searching for food and water, and hence more exposed to vectors. Tehseen et al. (2015) reported a higher seroprevalence amongst the females (50.1%, CI = 45.98%, 54.20%) than male 44.5% (CI = 39.97%, 49.22%) camels. In Yobe and Borno States, Nigeria, seropositive camels are carriers of *T. evansi*, and represent a reservoir to other animals (camels but also to humans and other animal species).

5. Conclusion

The camels were mainly of mixed-breed from the neighbouring countries of Chad, Niger, and Cameroon. According to our knowledge, this is the first report on *T. evansi* infection in camels in Borno and Yobe States, Nigeria revealed by the use of CATT/*T. evansi* technique. The study indicated that *T. evansi* is circulating in dromedary camels of all age groups and both genders in Borno and Yobe States, Nigeria.

Authorship

The concept was developed and planned by Falmata Kyari, Albert Wulari Mbaya and Abdullahi Abubakar Biu; the data were gathered by Falmata Kyari. Falmata Kyari wrote the paper, and Lawan Adamu reviewed the manuscript, evaluating and interpreting the data statistically.

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Ethical statement

Collection of blood samples and handling of animals was authorized by the University of Maiduguri, Faculty of Veterinary Medicine.

Declaration of Competing Interest

No conflicting interest to declare.

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