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Seroprevalence of *Brucella Abortus* in Camels and Assessment of Knowledge, Attitudes and Practices of Camel Handlers on Brucellosis in Northern Senatorial District of Yobe State, Nigeria

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ABSTRACT: *Brucellosis is an important but often neglected zoonosis that results in serious economic losses in both livestock and human populations. In Nigeria, the prevalence of Brucella is increasing, particularly among camels. A cross-sectional study was conducted in the Northern senatorial district of Yobe State, which includes Karasuwa, Machina, Nguru, and Yusufari, to determine the seroprevalence of Brucella abortus in camels and assess the knowledge, attitudes, and practices (KAP) of camel handlers regarding brucellosis. A total of 250 blood (serum) samples were collected from camels of various sexes and ages using convenience sampling. The samples were tested using the Rose Bengal Plate Test (RBPT), Serum Agglutination Test (SAT), and Enzyme Linked Immunosorbent Assay (ELISA). A Structured, close-ended questionnaire was also employed and administered to the camel handlers. Results showed that 106 samples (42.4%) were seropositive by RBPT, 56 (22.4%) by SAT, and 42 (16.8%) by ELISA. Notably, 40 out of 56 camels with SAT titers had clinically significant antibody levels (≥1:80), indicating infection. Prevalence was higher in females compared to males across all tests, with statistical significance ($p < 0.05$). Additionally, adult camels aged 7 years and above showed a higher prevalence than younger camels (<7 years) based on RBPT results ($p < 0.05$). However, no significant differences were found among locations within the study area ($p > 0.05$). Analysis of the structured questionnaire revealed that camel handlers lacked comprehensive knowledge about brucellosis and its zoonotic potential but were aware of the disease in other species like cattle and goats. They did not practice preventive measures such as quarantine and consumed unboiled milk without protective clothing while handling camels. The study established a seroprevalence of Brucella abortus antibodies in camels in Yobe State and highlighted the lack of knowledge among camel handlers regarding the disease and its risks. Recommendations include monitoring herds with positive camels, advising culling of positive reactors, conducting public awareness campaigns on brucellosis's public health significance, and instituting routine surveillance and control programs in the region.*

Keywords: Attitudes and Practices, Brucella abortus, Camels, Camel Handlers, Knowledge, Seroprevalence, Yobe State, Nigeria.

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INTRODUCTION

Brucellosis is an important zoonotic disease, with around 500,000 human cases annually, making it the second most important zoonosis after rabies (Pappas *et al.,* 2022). It causes considerable economic losses in livestock and human populations (Avila-Granados *et al.,* 2019). The causative agent, Brucella, is a gram-negative, aerobic coccobacilli that primarily infects reproductive organs, leading to abortions and sterility (Roop *et al.,* 2022). The disease includes at least six species categorized by host preference: *B. melitensis* (sheep and goats), *B. abortus* (cattle), *B. suis* (pigs), *B. canis* (dogs), *B. ovis* (sheep), and *B. neotomae* (wood rats) (Pappas *et al.,* 2022; Adnan and David, 2016). Infections occur through ingestion of contaminated feed or contact with infected bodily fluids, with human transmission mainly via unpasteurized dairy products (Arif *et al.,* 2017). In animals, brucellosis manifests as reproductive failure, characterized by abortion and reduced fertility; clinical signs in camelids are similar to those in cattle but result in fewer abortions (Poester *et al.,* 2013). The incubation period typically ranges from 30 to 60 days, influenced by factors such as gestation stage and host resistance (Nicoletti, 1980). The disease often localizes in the udder in non-pregnant animals, leading to prolonged bacterial shedding in milk (Mdegela *et al.,* 2004). The insidious nature of brucellosis often means it goes unnoticed until it poses a risk for human infection through animal trade (Sprague, 2012). Humans infected with Brucella may experience symptoms like fever, malaise, and arthralgia; severe cases can lead to complications such as arthritis and endocarditis (Masuka *et al.,* 2020). The disease remains a public health concern due to its zoonotic potential, especially for individuals working closely with livestock in endemic regions (Kurdoglu *et al.,* 2015). Diagnosis is challenging due to varied clinical manifestations and typically involves serological tests and culture methods; confirmatory diagnosis requires isolation of Brucella spp. or detection of its DNA via PCR, necessitating specialized facilities (Nielsen and Yu, 2010; OIE, 2010). Brucellosis has a dynamic geographical distribution with new foci emerging globally; it significantly impacts domestic animals like camels, causing economic losses from abortion and low fertility rates (Ocholi *et al.,* 2005; Gessese *et al.,* 2014). In Nigeria, brucellosis prevalence can reach up to 13.5%, posing a higher threat to human and animal health due to its endemic nature (Bertu *et al.,* 2010; Adamu, 2009). Serological evidence of infections has been found in camels and small ruminants in regions where they closely coexist with other domestic animals. The study aims to leverage the economic potential of camels for poverty alleviation in Northern Yobe State by addressing diseases like brucellosis that hinder livestock productivity. Understanding the prevalence and distribution of brucellosis is crucial for effective control measures.

Camels are increasingly important in local diets, replacing traditional meats like beef and mutton (Ghaji and Adogwa, 1986; Kadim *et al.,* 2008). Additionally, camel milk is consumed for its therapeutic effects on common diseases such as diabetes and asthma (Desalu *et al.,* 2013; Ejtahesd *et al.,* 2015; Salisu *et al.,* 2016; Kula, 2016). However, there is a lack of information regarding the seroprevalence of brucellosis and awareness levels among pastoralists in this region. Therefore, this research aims to provide evidence-based information on the seroprevalence of *Brucella abortus* in live camels and assess camel handlers knowledge, attitudes, and practices regarding brucellosis in Northern Yobe State.

MATERIALS AND METHODS

Study area

This study was conducted in northern senatorial district of Yobe which comprises of Karasuwa, Machina, Nguru and Yusufari (Figure 1). The State is located in the arid-zone of the North-Eastern part of Nigeria, with a total area of 45,502 square kilometers and latitude and longitude 12.2939º N and 11.4390º E.

Figure 1: Map of Yobe State showing the LGAs in the study area. Source: Modified from the Administrative Map of Yobe State

The State is dry and hot for most part of the year, except in the southern part of the State which has a milder climate (Figure 1). The arid zone has rather austere climatic conditions with a dry season starting from late November to late April with average daily peak temperature especially in April and May of 34.4–37.8^{0}C. The State is located in northern Nigeria that share international border with Niger Republic which enhances trans-border movement of livestock between the two countries (Ola, 2002).

The major occupation of the people of Yobe State is agriculture, mainly for food and cash crops and rearing of livestock (YBHPPC, 2010).

Study design

A cross-sectional study was carried out. Convenience sampling technique was used based on availability of camels at a given time and willingness of the owners to participate in the study. Camels from pre-identified major camel market in each of the four (4) Local Government Areas in the Northern Senatorial District of Yobe State (Karasuwa, Nguru, Machina and Yusufari) were selected for the study.

Sample size

The sample size was calculated using the formula described by Thrusfield (2007) base on reported prevalence of 16.5% (Adamu *et al*., 2014b).

$$n = \frac{z^2 pq}{d^2}$$

Where:

n – Minimum sample size
z – Appropriate value for the standard normal deviate set at 95% confidence interval (1.96)
p – Prevalence of 16.5% (Adamu *et al*., 2014b)
q – Complementary probability (1-p)
d- Level of precision (0.05)

$$\text{Sample size} = \frac{(1.96)^2 \, x \, 0.165 \, x \, (1-0.165)}{(0.05)^2}$$

$$= \frac{3.8416 \, x \, 0.165 \, x \, 0.835}{0.0025}$$

= 211.7

To increase precision, a total of 250 samples was collected and used for this study

Animals used in the study

A total of 250 camels (*camelus dromedarius*) were sampled from the study area. Of these, 70 were sampled from Karasuwa, 60 from Nguru, 60 from Machina and 60 from Yusufari Local Government Areas of Yobe State.

Sample collection

The age of camels brought to the herds was determined using rostral dentition as described by Bello *et al.* (2013). The method involves the use of the eruption and wear of the deciduous and permanent incisors. Also, sex and location of herd for each camel was recorded. Camels were restrained properly on sternal recumbency using ropes around the feet to prevent the camel from getting up and five milliliters (5 ml) of blood samples were aseptically collected through the jugular vein of camels using 10 ml syringes and 18 G needles. The blood was then immediately transferred into a 10 ml clean sampling bottle and labeled appropriately (key features = age, sex and location). The bottles were immediately kept slanting in a Cole-man box containing ice packs to enable sufficient serum formation. The samples were then centrifuged (1000 rpm for 5 minutes) after 4 hrs (in Yobe) or after 24 hrs (in Bacterial Zoonoses Laboratory in the Department of Veterinary Public Health and Preventive Medicine, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria). Sera were stored at -20 °C until assayed.

Sample processing

Rose Bengal Plate Test (RBPT)

The stored sera samples were thawed and then subjected to RBPT as described by Alton *et al.* (1975) and Bertu (2014) using *B.abortus* antigen sourced from the ID screen® Brucellosis Serum Indirect Multi-Species, 310 Rue Louis Pasteur 34790 Grabels, France. Briefly, for each test a volume of 30µl of serum was placed on a white ceramic tile and 30µl of RBPT antigen was placed beside it after which they were mixed in a circular manner using an applicator stick and then the tile was rocked gently for 4 minutes and observed for agglutination. The formation of distinct pink granules (agglutination) was recorded as positive while the absence of agglutination was recorded as negative.

Serum Agglutination Test (SAT)

Five agglutination test tubes were required per sample. For the 1st tube, 0.8ml of phenol saline was dispensed, while 0.5ml was applied to the 2nd, 3rd 4th and 5th tubes using micro pipette fitted with corresponding tips. Similarly, 0.2ml of the test serum was added to the 1st tube and mixed properly.

Serial dilution was then carried out by pipetting 0.5ml of mixture in 1st and 2nd, then to the 3rd then to the 4th and then 5th tubes. The final 0.5ml from the 5th tube was discarded, 0.5ml of antigen (diluted 1:10 with phenol saline) was added to all the tubes. The tubes were covered, unshaken and incubated at 37^0C for 20 hours. The result was then read and agglutination titres determined. Titres of 1:40 (50 IU/ml) and above were taken as diagnostic for brucellosis (Hollanders *et al*., 1997). Known positive and negative control sera were set up along with the test sera.

Enzyme Linked Immunosorbent Assay (ELISA)

The ELISA Kit was obtained from Central Veterinary Laboratory, Weybridge, Surrey, U.K. The procedure was done according to manufacturer's manual as follows: The microtiter plate has 96 wells coated with *B. abortus* antigen and were arranged horizontally (1-12 wells) while vertically, weight wells were arranged (A-H). The plate was prepared by adding 100ul of diluting buffer to each well, followed by 20ul of negative control sera into wells A11, A12, B11, B12, C11 and C12 while 20ul of negative control sera into wells F11. A12.G11, G12, H11 and H12. Wells D11, D12, E11 and E12 served as conjugate controls. Twenty microitre (20ul) of each of the test sera were then added to the remaining wells giving a serum dilution of 1/6. One hundred microlitre (100ul) of the prepared conjugate was immediately dispensed into the wells. The microtitre plate was shaken with hand for 2 minutes, in order to mix the serum and conjugate solution. The microtitre plate was then covered with lid and left at room temperature for 30 minutes. The microtitreplate was again shaken for 30 seconds, followed by 10 seconds hand shaking at 10 minutes interval for an hour. This was done carefully to keep the liquid within solution and then dried by tapping on an absorbent tissue paper. The substrate chromagen solution was immediately prepared and mixed thoroughly; 100ul of the solution was then added to each well. The plate was left at room temperature for 10minutes; the reaction was slowed by adding 100ul of the stopping solution to each well (Manufacturers' Guidelines).

Interpretation

Negative (-) = Very weak or no colour development in wells indicated absence of antibodies in the serum.
Positive (+) = A strong colour development (blue) in wells indicated presence of *Brucella* antibodies.

Questionnaire

A structured, close-ended, pretested questionnaire were administered to camel handlers in the designated markets to obtain information on their knowledge, attitudes and practices (KAP) as regards camel brucellosis and its potential risk to human health. The questions were translated into Arabic and Hausa languages for the camel handlers who do not understand English language and then filled accordingly.

Statistical Analysis

The data collected (from laboratory evaluations and questionnaires) were entered into Excel spreadsheet (Version 2016). The data were then analyzed using the Statistical Package for Social Sciences (SPSS; version 20). The data were subjected to Chi-square (x^2) and Fishers exact tests. The level of significance was set at *p-value* < 0.05. Results were presented in Tables. The questionnaire was analyzed using descriptive statistics.

RESULTS

Total of 250 camels (*Camelus dromedarius*) were sampled from the study area. The highest number of samples collected 200 of the total population were from adult camels (>7yr) and 50 from young camels (<7yr) (Table 1). With regards to sex, 190 of the sampled camels were females while the remaining 60 were males (Table 2).

Distribution of *Brucella abortus* in Camels Based on Age, Sex and Location in Northern Senatorial District of Yobe State

Distribution of Brucella abortus in Camels Based on Age using RBPT, SAT and ELISA in Northern Senatorial District of Yobe State, Nigeria

Based on age, out of the total of 250 camels (*Camelus dromedarius*) tested, the results showed higher prevalence of *Brucella abortus* among adult camels of age-group, 7 years and above (28.0 %, 15.2 % and 10.8 %) than in young camels of age group < 7 years (14.4 %, 7.2 % and 6.2%) based on RBPT, SAT and ELISA respectively and there was statistically significant difference observed in the seroprevalence *Brucella abortus* between the two age groups for RBPT ($p < 0.05$), but not for SAT and ELISA (Table1).

Distribution of Brucella abortus in Camels Based on Sex using RBPT, SAT and ELISA in Northern Senatorial District of Yobe state, Nigeria

A total of 60 males and 190 female camels sampled, the seroprevalence of *Brucella abortus* detected more in females (27.4%, 12.4% and 10%) than in male camels (15.2%, 10.0% and 7.2%) using the RBPT, SAT and ELISA respectively and were statistically significant ($p < 0.05$) (Table 2). From the results females showed higher prevalence rates than males which was statistically significant ($p < 0.05$).

Distribution of Brucella abortus in Camels Based on Location using RBPT, SAT and ELISA in Northern Senatorial District of Yobe State, Nigeria

Of the 250 camels sera serially tested for *Brucella abortus* antibodies more camels were found to be seropositive 106 (42.4 %), 56 (22.4 %) and 42 (16.8 %) for RBPT than SAT and ELISA tests respectively and base on location shows there was no statistically significance difference between the prevalence of *Brucella abortus* antibody and location using RBPT, SAT and ELISA respectively.

Table 1: Distribution of *Brucella abortus* in Camels Based on Age using RBPT, SAT and ELISA in Northern Senatorial District of Yobe State, Nigeria.

AGE	Total No. sampled	RBPT (%)	x^2	*p-value*	SA (%)	x^2	*p-value*	ELISA (%)	x^2	*P-value*
Young	50	36(14.4)	4.250	0.039	18(7.2)	0.890	0.345	16(6.2)	2.628	0.105
Adult	200	70(28.0)			38(15.2)			27(10.8)		
Total	250	106 (42.4)			56 (22.4)			43 (16.8)		

Table 2: Distribution of *Brucella abortus* in Camels Based on Sex using RBPT, SAT and ELISA in Northern Senatorial District of Yobe State, Nigeria.

Sex	Total No. sampled	RBPT (%)	x^2	*p-value*	SAT (%)	x^2	*p-value*	ELISA (%)	x^2	*P-value*
Male	60	38 (15.8)	13.077	0.000	25 (10)	16.031	0.000	18 (7.2)	8.583	0.003
Female	190	68 (27.4)			31 (12.4)			25 (10)		
Total	250	106 (42.4)			56 (22.4)			42 (16.8)		

Table 3: Distribution of *Brucella abortus* in Camels Based on Location using RBPT, SAT and ELISA in Northern Senatorial District of Yobe State, Nigeria.

Location	Total Sample	RBPT (%) +ve	x^2	*p*-value	SAT (%) +ve	x^2	*p*-value	ELISA (%) +ve	x^2	*p*-value
Karasuwa	70	36 (14.4)	6.703	0.082	18 (7.2)	2.404	0.493	12 (4.8)	1.483	0.686
Nguru	60	24 (9.6)			10 (4.0)			8 (3.4)		
Machina	60	18 (7.2)			12 (4.8)			10 (4.0)		
Yusufari	60	28 (11.2)			16 (6.4)			12 (4.8)		
Total	250	106 (42.4)			56 (22.4)			42(16.8)		

Table 4: Distribution of *Brucella abortus* SAT amongst Camels in Northern Senatorial District of Yobe State, Nigeria.

Location	Total SAT Positives	1:40	1:80	1:160	x^2	*p*- value
Karasuwa	18	4	6	8	2.404	0.493
Nguru	10	3	4	3		
Machina	12	1	6	5		
Yusufari	16	8	2	6		
Total	56	16	18	22		

However, Seroprevalence of *Brucella abortus* in camels sampled from pre-identified major camel market was higher in camels in Karasuwa LGA for both RBPT 36 (14.4 %), SAT 18 (7.2 %) and ELISA 12 (4.8 %) and the lowest sero-prevalence 18 (7.2 %) for RBPT was recorded in Machina, while Nguru LGA had seroprevalence 10 (4 %) for SAT and 8 (3.4 %) by using ELISA (Table 3).

Determination of the Titers of Antibodies against *Brucella abortus* in Camels in the Northern Senatorial District of Yobe State

There was no statistical significance difference in *Brucella abortus* antibody titres amongst the camels from the different locations within the study area. However, 40 out of 56 camels (71.4 %) had clinically significant *Brucella abortus* antibody titers (≥1:80) as shown in (Table 4).

Determination of the Factors Associated with the Occurrence of Brucellosis in Camels in the Northern Senatorial District of Yobe state

Risk Factors Associated with Camel Brucellosis

The difference between antibodies to *Brucella abortus* was not statistically significance difference between the adult and young camels, therefore age was not identified as risk factors to the occurrence of camel Brucellosis in the study area. Likewise, *Brucella* antibodies was statistically significant difference between male and female, however sex was not identified as risk factor for the occurrence of camel brucellosis in the study area. Age and sex were identified as not potential risk factors for camel brucellosis and were estimated using odds ratio. Results showed that females had 0.570 (95% CI = 0.376 – 0.866) more chances of getting infected than males. This association was found to be not statistically significant ($p < 0.05$) (Table 5).

For age, the results showed that adult camels were at highest risk of infection with odds ratio value of 0.779 (95% CI = 0.090 – 6.752), while the younger ones with (OR = 0.768, 95% CI = 0.098 – 6.001) (Table 5). A statistically significant association was observed for this finding ($p < 0.05$). Female camels were found 0.570 (95% CI = 0.376 – 0.866, $p = 0.007$) more chances of getting infected than male camels. There was statistically significant association ($x^2 = 13.077$, $p = 0.000$; $x^2 = 16.031$, $p = 0.000$; $x^2 = 8.583$, $p = 0.003$). Therefore, the above result shows there was no association between the occurrence of brucellosis and sex or age in the present study; hence, age and sex were not risk factor for the occurrence of brucellosis in camel in this study area.

Table 5: Factors associated with occurrence of camel Brucellosis in the Northern Senatorial District of Yobe state.

Category	No. sampled	Positive (%)	*p-value*	x^2	OR	95% CI
Sex						
Male	60	18 (7.2)	**0.003**	**8.583**	0.570	0.376 - 0.866
Female	190	25 (10.0)				
Total	**250**	**43(16.8)**				
Age						
Young	50	16	**0.105**	**2.628**	0.779	0.090 – 6.752
Adult	200	27				
Total	250	43 (16.8)				

*Reference; OR- Odds ratio; CI - Confidence Interval

Assessment of the Knowledge, Attitude and Practice of Camel Handlers on Brucellosis in the Northern Senatorial District of Yobe State

A total of 58 (71 %) questionnaire were administered to respondents in pre-identified major camels' market of

Karasuwa, Machina, Nguru and Yusafari. Knowledge of respondents on Brucellosis in camels in Northern senatorial district of Yobe State, Nigeria. Of the 58 respondents 33 (56.8 %) were aware of brucellosis as a disease mainly in cattle while 8 (13.8 %) respondents were aware that brucellosis affects camels. There was a statistically significant association observed between respondents that were aware of brucellosis in camels and those that were not in both herds and cattle ($p < 0.05$). Also, 19 (57.6 %) respondents indicated that they could only recognize brucellosis on the basis of abortion, while 6 (18.2 %) responded that retained placenta and/or hygroma in addition to abortion were signs they used to identify brucellosis in their herds. Also 24.2 % of respondents aware of brucellosis, but could not identify the disease at all. Respondents' responses as how animals contract brucellosis showed that 26 (44.8 %) of the respondents did not know how brucellosis is transmitted to animals and 19 (32.8 %) indicated that transmission was by mating. Also 6 (10.3 %) respondents said transmission was by ingestion of contaminated materials and 7 (12.1 %) respondents inferred that transmission could be by both mating and ingestion of contaminated materials in abattoir and herds respectively. Statistically significant difference was observed in the results of herd respondents as regards knowledge on transmission of brucellosis ($p < 0.05$). On the zoonotic nature of the disease, 20 (34.5 %) of the respondents said the disease was zoonotic, while 38 (65.5 %) said they were not aware the disease was zoonotic. Of those that said brucellosis was zoonotic 6 (30 %) said transmission to man was via contact with an infected animal, 3 (15 %) replied via consumption of milk from an infected animal and 11 (55 %) replied transmission could be by both contact in the herd and milk consumption as shown in (Table 6).

Attitudes of Respondents towards Brucellosis in Camels in Northern Senatorial District of Yobe state, Nigeria

Of the 40 respondents that answered yes to carrying out operations such as milking of camels in herds, none took a precaution such as washed hands adequately with soap and water after milking (Table 7). Also, of all the respondents questioned, only 1 (1.7 %) respondent processed camel milk prior to consumption, while 57 (98.3 %) did not. There was a statistically significant difference observed between processing of camel milk before

Table 6: Knowledge of Respondents on Camel Brucellosis in Northern Senatorial District of Yobe State, Nigeria.

Category	Frequency (%)	x^2	*p-value*
Have you heard of Brucellosis?			
Yes	32 (55.2)	**32.000**	**0.657**
No	26 (44.8)		
How did you know/ hear of Brucellosis?			
Herdsmen	8 (13.8)	**32.207**	**0.000**
Radio	2 (3.4)		
Extension workers	7 (12.1)		
Veterinary personnel	9 (15.5)		
Others	7 (12.1)		
How do you recognize Brucellosis?			
Abortion	19 (32.8)	**16.897**	**0.001**
Retained Placenta	0 (0.0)		
Hygroma	0 (0.0)		
All of the above	6 (10.3)		
Cannot	8 (13.8)		

Does Brucellosis affect camels?	`		
Yes	8 (13.8)	**8.000**	**0.000**
No	50 (86.2)		
How do animals contract brucellosis?			
Mating	19 (32.8)	**19.379**	**0.000**
Ingestion	6 (10.3)		
All of the above	7 (12.1)		
I don't know	26 (44.8)		
Do you know that brucellosis is zoonotic?			
Yes	20 (34.5)	**20.000**	**0.026**
No	38 (65.5)		
How is Brucellosis Transmitted to Man?			
Contact	6 (10.3)	**6.000**	**0.000**
Milk consumption	52 (89.7)		
Meat	7(12.1)		
Drinking camel urine	2(3.4)		
All of the above	11 (55.0)		

Table 7: Attitudes of Respondents on Camel Brucellosis in Northern Senatorial District of Yobe State.

Category	**Frequency (%)**	x^2	***p-value***
Have you had abortions in your herd?			
Yes	7 (14.9)	**40.00**	**0.000**
No	40 (85.1)		
If yes, at what stage?			
1st trimester	1 (14.3)	**2.00***	**0.368**
2nd trimester	2 (28.6)		
3rd trimester	4 (57.1)		
How do you dispose of fetuses			
Burying	5 (71.4)	**5.00***	**0.450**
Throw away	2 (28.6)		
Do you wash hands with soap and disinfectant after processing camel milk			
Yes	0 (0.0)	**35.00***	**0.000**
No	40 (100.0)		
Do you process milk before consumption?			
Yes	1 (1.7)	**57.00***	**0.000**
No	57 (98.3)		

consumption and not processing in both locations ($p < 0.05$) (Table 7). Of the 7 herds that experienced abortion in the past one year, the fetuses were buried in 5 (71 %) of them, while in the other two (29 %) herds the fetuses were simply thrown away (Table 7).

Practices of Respondents towards Brucellosis in Camels in Northern Senatorial District of Yobe State, Nigeria

Of the 58 camel handlers, 15 (25.9 %) kept only camels with no other animal species in their herds, while 15 (25.9 %), 7 (12.1 %), 4 (6.9 %) and 1(1.7 %) kept cattle, sheep, goats and poultry with camels respectively. The remaining 16 (27.6 %) had more than one species in addition to camels in their herds. Out of 42 respondents 24 (57.1 %) said their camels mixed with other animal species during grazing, while 18 (42.9 %) said they grazed separately. When questioned about their practices when introducing new camels to their herds, 2 (4.3 %) said they quarantined prior to addition to the herd, 24 (51 %) said they carried out some form of prophylactic treatment upon purchase before introducing them to the herd, while 21 (44.7 %) said they did absolutely nothing. The respondent when questioned about carrying out vaccination or any specific action to prevent their camels from contacting brucellosis all the 47 respondents said no (Table 8).

Table 8: Practices of Respondents on the Prevention of Camel Brucellosis in the Northern Senatorial District of Yobe State.

Category	**Frequency (%)**	x^2	***p-value***
Others species in herd			
Cattle	15 (25.9)	**21.86***	**0.001**
Sheep	7 (12.1)		
Goats	4 (6.9)		
Poultry	1 (1.7)		
More than 1 animal species	16 (27.6)		
None	15 (25.9)		
Mixing with other animals when grazing			
Yes	24 (57.1)	**1.79**	**0.408**
No	18 (42.9)		
How do you introduce new animals to the herd			
Quarantine	2 (4.3)	**20.76***	**0.000**
Treat	24 (51.0)		
Nothing	21 (44.7)		
Do you do anything to prevent your animals contacting brucellosis			
No	47 (100.0)	-	-
Yes	0 (0.0)		

DISCUSSION

From the study, it has been established that the overall prevalence of *Brucella abortus* antibodies was (42.4 %, 22.4 % and 16.8 %) using RBPT, SAT and ELISA

respectively. Camels sampled in Karasuwa, Nguru, Machina, and Yusufari LGAs of Yobe State had antibodies to *Brucella abortus* with seroprevalence of (14.4 %, 9.6 %, 7.2 %, 11.2 %) for RBPT respectively (7.2 %, 4.0 %, 4.8 %, 6.4 %) for SAT and (4.8 %, 3.4 %, 4.0 %, 4.8 %) for ELISA respectively. More camels were found to be sero positive for RBPT than SAT and ELISA tests. This finding could be as a result that the RBPT is a screening test with relatively less specificity and high sensitivity when compared with SAT and ELISA test which are more specific (Kaltungo *et al.,* 2014). Salisu (2016) reported a slightly higher prevalence (11.22 %) for *B. abortus* using RBPT from Katsina State, while Kaltungo (2018) reported a seroprevalence of 13.5 % for *B. melitensis* using RBPT and 4.0 % using ELISA from small ruminants in Katsina State. Small ruminants are actually the natural hosts for *B. melitensis*. The fact that evidence for this species of *Brucella* to be seen in camels may be explained based on the management practice by the camel handlers and pastoralists in the study area where camels are being herded or housed in the same environment as other species of livestock (Salisu, 2016; Kaltungo, 2018). Despite the fact that camels in the study areas share common watering points and grazing fields with other livestock may expose them to infection by this organism. This is because discharges from aborting animals could contaminate grazing fields and watering points thereby exposing susceptible animals to the infection. Unrestricted movement of camels within and across the borders of Nigeria and Niger Republic could be also be responsible for evidence of *Brucella* infection in the sampled camels. This may be buttressed by the fact that Boukary *et al.* (2013) reported that brucellosis is a serious problem in cattle and sheep in Niger Republic.

With respect to livestock, brucellosis could be a considerable cause of economic losses through reduced productivity in the forms of abortions and birth of weak off-springs which could be a major stumbling block for trade and export. Also, the fact that camels can trek over long distances, there is the possibility of spreading the infection to neighbouring villages and towns as well as the neighbouring Niger Republic. It may also be a public health threat since *B. melitensis* has been reported to be most pathogenic of all the *Brucella* species. This is in view of the fact that camel milk is fast gaining importance for its supposed therapeutic purposes and this milk has been reported to be an important source of *Brucella* infection in Middle East countries and Mongolia which could possibly be applicable in Nigeria (Boral *et al.,* 2009). Also, camel milk, in its dried form ("chikwi"), has been a traditional delicacy in camel rearing communities in Nigeria. Furthermore, urine from camel can also be a source of threat as it is routinely used for traditional therapeutic purposes (Daffaallah, 2013; Salisu, 2016; Alebie *et al.,* 2017).

Sex and age of camels tested as possible risk factors for *Brucella* infection in this study were found not to be statistically significant. This finding agrees with the reports of Gusi *et al.* (2016) and Kaltungo *et al.* (2018) who reported that sex is not a risk factor for brucellosis but does not agree with Gusi *et al.* (2016) who reported that age is a significant factor for camel brucellosis in a study carried out in 3 abattoirs in Northern Nigeria.

Camels in Karasuwa and Yusufari recorded higher SAT titres than camels at other locations sampled which was possibly an indication of camels with active ongoing infections in these locations indicating higher chances of spread of *Brucella* organisms. This was attributed to the fact that most locations in these LGAs where camels were sampled had common watering points, where water was drawn and dispense into watering troughs for all animals including other species of livestock to drink and which could have encouraged the spread of *Brucella* organisms. A higher prevalence of brucellosis was recorded in females than males. This could be because more female camels were kept for breeding purposes than males and also males were fattened and sold off except for a few others that might be kept for drought, transport and other purposes. Even then, these are changed regularly while breeding females are only sold off when they are old. Female camels that are kept for breeding purposes stay for long periods in the herds (Adamu *et al.,* 2014). The long stay of females in the herds could explain the higher prevalences. The relatively higher susceptibility of she-camels could also be due to the fact that female camels experience more physiological stresses than the males (Walker, 1999). Hirsh and Zee (1999) reported that male animals were less susceptible to *Brucella* infection due to the absence of erythritol. This finding is in agreement with the result of Adamu (2009) and Salisu (2014) who carried out a study to determine the prevalence of camel brucellosis in three Northern states of Nigeria and found higher prevalence of *Brucella* infection in females than males in all the four states of Borno, Kano, Katsina and Kaduna. Berhanu *et al.* (2013) also recorded a higher prevalence of *brucella* infection in female camels in a similar study in Ethiopia. Bekele (2004) in Ethiopia and Ajogi and Adamu (1998) in Nigeria also revealed the likelihood of occurrence of infection to be higher in female than male camels. Abu-Damir *et al.* (1984), however, reported similar distribution of *Brucella* antibodies between both sexes. The higher prevalence of *brucella* infection in females further puts the populace at risk of infection due to the zoonotic nature of the disease resulting from consumption of contaminated milk (Shalom *et al.*, 2012). Shalom *et al.* (2012) reported a case of human brucellosis outbreak in 15 extended Bedouin family members who acquired the disease through Camel milk ingestion in Southern Israel.

The highest prevalence, however, was recorded in Camels 16-20 years old with the lowest prevalence recorded in camels < 7 year of age. This could be because

older camels have been exposed to mixing and grazing with other species of livestock for a longer time. In addition, older animals mating with other camels tend to be at higher risk than younger animals. Salisu (2016) reported highest prevalence of *brucella* infection in camels older than 9 years and the lowest in camels less than 3 years of age and Berhanu *et al.* (2013) reported highest prevalence of *brucella abortus* in camels older than 11 years and the lowest in camels less than 4 years of age and suggested the higher seroprevalence in older animals was in line with previous reports of Radostits *et al.* (2007) which reported that infection may occur in animals of all age groups, but persists commonly in sexually mature animals.

The results of the administration questionnaire of questions showed very poor knowledge of brucellosis in camels based on responses to the questions. Those who are aware of brucellosis as a disease in cattle are not aware the disease could be transmitted to camels. The finding could be as a result of paucity of information concerning camel diseases generally and also a lack of awareness campaigns on issues concerning camel health despite its growing importance. This, coupled with the hardy nature of the camel (Bitter, 1986), renders most local herdsmen naïve to the knowledge of diseases affecting the camel. The poor attitudes of respondents towards the disease could be due to a lack of education or awareness on the dangers involved in consumption of unpasteurized camel milk and milk of other domestic animals. Transmission of brucellosis to humans can occur through the consumption of contaminated unpasteurized camel milk (Kaltungo, 2018).

Base on the percentage practices revealed poor practices among the respondent. However, newly camel are introduce into the market with other camels without quarantine no history of vaccination and do nothing to protect their camels from contacting diseases about 57.1% camels mix with other animal species during grazing and shared same watering point.

Conclusion

In this study areas, *Brucella abortus* antibodies were detected more in adult camels (28.0 %, 15.2 % and 10.8 %) than in young camels (14.4 %, 7.2 % and 6.2 %) using the RBPT, SAT and ELISA, respectively. Likewise, *Brucella abortus* were detected more in female camels (27.4 %, 12.4 % and 10.0 %) than in male camels (15.2 %, 10.0 % and 7.2 %) using the RBPT, SAT and ELISA, respectively. In addition, the seroprevalences of *Brucella abortus* in camels (irrespective of age and sex) in the study area were 42.4 %, 22.4 % and 16.8 % using RBPT, SAT and ELISA, respectively. There was no statistically significant difference in the *Brucella abortus* antibody titers amongst the camels from the different locations within the study area. However, 40 out of 56 camels (71.4 %) had clinically significant *Brucella abortus* antibody titers (≥1:80). There was no association between the occurrence of brucellosis and sex or age in the present study; hence, age and sex were not risk factors for the occurrence of Brucellosis in camels in this study area. Finally, camel handlers in the study area had poor knowledge, attitude and practices toward Brucellosis.

Recommendations

i. Although RBPT is still a valid screening test for Brucellosis, ELISA (ELISA) should be considered as a diagnostic test in the detection of anti-Brucella antibodies in livestock.
ii. Since Brucellosis is a neglected transboundary animal disease (nTAD) of economic importance, government should institute effective control posts at the borders and restriction camel movements in Yobe State.
iii. Yobe State Government should organize quarterly sensitization workshops for camel handlers and merchants on the dangers of Brucellosis at the animal-human interface.
iv. Lastly, further research aimed at the isolation of the causative agents and identification of *Brucella* species in camels from Yobe State should be conducted in collaboration with Brucella reference laboratories.

Conflict of Interest

The authors declare no competing interests regarding publication of this paper.

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