



Risk Factors and Knowledge of *Brucella* Infection in Camels, Attitudes and Practices of Camel Handlers in Katsina State, Nigeria

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SUMMARY

The study was conducted to determine the risk factors to brucellosis in one-humped (Dromedary) camels and to determine the knowledge, attitudes and practices of camel handlers to Brucellosis in Katsina State, Nigeria. Camels in herds and those brought to the abattoir for slaughter in the north and central senatorial districts of Katsina State were sampled for the study. Structured questionnaires were administered to determine knowledge, attitude and practices of camel handlers to camel brucellosis in Katsina state, Nigeria Modified Rose Bengal Plate Test (RBPT) and Serum Agglutination Test (SAT) with EDTA were used as screening and standard tests respectively. Out of a total of 980 camel sera tested, 11.2% and 10.5% were positive with RBPT and SAT, respectively. Female had OD 1.758 (95% CI = 1.157 – 2.669, $p = 0.008$) more chances of getting infected than males camels. There was statistical significant association ($\chi^2 = 7.189$, $p = 0.007$) observed in the prevalence rates in favour of females. It was also observed that camels of age group 16-20 years showed highest prevalence to brucellosis. There was statistical significant association ($\chi^2 = 13.602$, $p = 0.009$) observed in the prevalence rates according to age. It was determined that there is very poor knowledge of camel brucellosis amongst stakeholders as a result they had a 'laissez faire' attitude towards the disease and no practices towards prevention of infection either to them or their animals. There is the need to carry out awareness campaigns to enlighten camel owners, herdsman, abattoir staff about the dangers of poor hygiene during meat and milk processing, the importance of use of protective clothing when carrying out these operations and the dangers of zoonotic diseases and the dangers of consumption of unpasteurized camel milk and milk products, the public health significance of the brucellosis and that there is the need to develop a strategic plan to decrease spread of brucellosis in the study area.

Key words: Brucella, Seroprevalence, Camels, KAP, Risk Factors.

INTRODUCTION

The one humped camel (*Camelus dromedarius*) is a comparatively hardy animal herded in semi-arid and arid areas in Africa (OIE, 2003). They have an estimated global population of 17.44 million increasing at a rate of 1.62% annually (Biu and Abbagana, 2007). Approximately 11 million dromedaries, representing two thirds of the world's camel population, are in the arid areas of Africa and of these, Nigeria is estimated to have between 25,000 and 90,000 dromedary camels (Adamu and Ajogi 1995). The one humped camel is an important livestock species in Northern Nigeria as they are traditionally used for transport. Additionally, its role in supplementing animal proteins for humans in terms of meat and milk is presently attracting the attention of scientists in this part of the world (Salihuet *al.*, 2009). The importance of the camel as a source of animal protein in Northern Nigeria cannot be over emphasized. Camel meat is accepted and consumed readily by the populace and is replacing beef and mutton in the diet of many families in Northern Nigeria because it is cheap and tastes good (Ghaji and Adogwa, 1986). The size of the animal and relative cheap cost makes it an ideal source of affordable meat. Also the populace in the North believes that camel milk and urine, when consumed, serve as cure for various diseases including HIV/AIDS, epilepsy and various cancers (Salisu, 2016). Cheese made from camel milk is known as "cikwi" in the local dialect of Hausa and is a delicacy that is consumed with dates frequently in the area (Salisu *et al.*, 2017). The camel is also one of the animal species usually sacrificed during the Eid festivities in Northern Nigeria.

Nigeria like most sub-Saharan African countries is faced with the problems of many enzootic livestock diseases including brucellosis. Brucellosis is an infectious disease of domestic and wild animals with serious zoonotic and economic implications in humans (Falade and Shonekan, 1982; Hadush *et al.*, 2013). Amongst reproductive

diseases of livestock, brucellosis is of major significance in Nigeria and indeed the world over (Abdulssalam and Fein, 1976). This is especially true in the cattle and small ruminant industry (Kaltungo, 2013; Buhari, 2014). This is because it causes considerable losses through abortion, infertility, neonatal death, reduced milk yield, dystocia and uterine prolapse (Bertu *et al.*, 2010). It also causes stillbirths, decreased calving, delayed calving, birth of weak calves (Adamu, 2009). It also leads to and loss of man-hours in infected people (Adamu, 2009). A previous study in Northern Nigeria identified abortion among others factor as some of the major constraints to camel production (Jaji *et al.*, 2017)

The epidemiologies of brucellosis, including its risk factors and knowledge, attitude and practices of affected stakeholders have been investigated extensively in cattle and small ruminants at different geographical areas in Nigeria. There is, however, little information available as on this disease in camels in the study area. This could be due to the fact that camel production in remote areas coincides with poor infrastructure (Schwartz and Dioli, 1992). Difficulties can arise in the diagnosis of camel brucellosis, especially since this disease provokes only few clinical signs in contrast to its clinical course in cattle (Mousa *et al.*, 1987). Apart from economic losses through abortions, reduced fertility and cross transmission to other animal species, the zoonotic impact of the disease in camels should not be overlooked (Kudi *et al.*, 1997). Studies have shown that *Brucella abortus* and *Brucella melitensis* are frequently isolated from camels infected by Brucellosis (Radwan *et al.*, 1992; Gameel *et al.*, 1993; Agab *et al.*, 1994; Abou-Eisha, 2000; Hadush *et al.*, 2013).

Katsina State is one the states that has a relatively large population of camels in Northern Nigeria. Katsina State shares a porous border with Niger Republic and as such there is free influx of camels into the state from neighbouring towns of Niger Republic where the camel population is

quite large. Thus it is imperative to carry out studies on the prevalence of the disease in camels, it's possible risk factors and to determine the knowledge, attitudes and practices of camel handlers in the study area.

MATERIAL AND METHODS

Study area

Katsina State covers an area of 24,971 square kilometers. It is located between latitudes 11°08'N and 13°22'N and longitudes 6°52'E and 9°20'E. According to the Köppen Climate Classification system, Katsina has a semi-arid climate and an average annual rainfall of 623mm. The climate varies between a cool dry (harmattan) season from December to February; a hot dry season from March to May; a warm wet season from June to September; and a less marked season after rains characterised by decreasing rainfall and gradual lowering of temperature during the months of October to November (Ati *et al.*, 2010). The state is bordered on the South by Kaduna State, on the East by Jigawa and Kano States, on the West by Zamfara State and shares an international Border with Niger Republic to the North. Its population is approximately 5,801,584 (2006 National Population Census figures) and it accounts for 4.1% of Nigeria's total population. It is located at an elevation of 605 meters above sea level.

Study design/study population

A cross-sectional study was carried out using Judgemental sampling method. Camels in Katsina North and Central Senatorial district of Katsina State were sampled because camels are rarely found in the South Senatorial district of the state. Camels from nomadic herds as well as those brought to the abattoir for slaughter in selected Local Government Areas (LGA's) were sampled for the study. Herds were selected based on cooperation of the herd owners. The camels were managed extensively. Camels brought for slaughter to the abattoirs in Katsina main town, Daura

and Dutsinma were sampled. These are the major abattoirs where camels are slaughtered in Katsina State. Camel herds in border towns of Jibiya, Mai-Adua, Daura and Zangon-Daura where camel populations are high were sampled. All camels sampled were classified into five groups based on age. Group 1 consists of camels of age less than 1 year, Group 2 consists of camels aged one to five years, Group 3 consists of camels aged six to ten years, Group 4 consists of camels aged eleven to fifteen and Group 5 consists of camels sixteen years and above. The herds encountered were of two extremes viz: those with very few camels, usually between one to five, who keep and fatten for a year or two and then sell off and those with large herds of usually thirty animals and above. All animals encountered with owners that had a few camels were sampled while every third camels in those from large herds were sampled. Simple random sampling was used to sample camels at the abattoir. Every third camel slaughtered was sampled.

Sampling procedure

The age of camels brought to the abattoir for slaughter and those in herds was determined using rostral dentition as described by Bello *et al.* (2013) and recorded. Sex and location of herd were also recorded for each camel sampled. Following proper restraint five millilitres (5mls) blood were collected via jugular venepuncture from each camel using a 10ml syringe and 18G needle. The blood was then gently transferred into anticoagulant free sample bottles and labelled appropriately. The samples were immediately transported to the laboratory in leak proof ice-packed containers, where they were centrifuged at 1000g for 5 minutes to allow for proper separation of serum from the clotted blood. The sera were then decanted, using sterile Pasteur pipettes, into a 5 ml plastic serum tube which was appropriately labelled. All the extracted serum samples were then stored at - 20°C until used.

Laboratory analysis

The modified Rose Bengal Plate Test as described by Bale (2008) and modified by Bertu (2010) was carried out as a screening test while the Serum Agglutination Test with Ethylene Di-amine Tetra acetic acid (SAT-EDTA) as described by Brown *et al* (1981) was carried out as standard test on all serum samples collected.

Questionnaire survey

A structured, open ended, pretested questionnaire was administered to abattoir staff, herdsman, camel traders and other individuals responsible for rearing and handling camels in order to obtain information on their knowledge, attitudes and practices (KAP's) as regards camel brucellosis and its potential risk. All herdsmen encountered in herds where camels were sampled were assigned questionnaires to fill. Also resident veterinarians/abattoir managers at abattoirs as well as selected butchers, meat sellers and abattoir staff also served as respondents. The questionnaires were completed on a single visit during the sampling programme. The questions were translated to Hausa language for the herdsmen and abattoir staff who did not understand English.

Data analysis

Data obtained from serological tests and questionnaires were analysed using SPSS version 20.0 statistical package. Descriptive

statistics, Chi square and Fishers Exact tests were used to test for association between categorical variables. Level of significance was set at P values < 0.05 were considered significant. Odds Ratio was used to estimate risk factors.

RESULTS

Seroprevalence of *Brucella* infection in Camels based on sex in Katsina State, Nigeria

(TABLE 2), of the 503 males sampled 46 (9.1%) were positive for RBPT while 40 (8.0%) were positive for SAT-EDTA. In contrast, 64 (13.4%) of the 477 females sampled were positive for RBPT while 63 (13.2%) were positive for SAT-EDTA (TABLE 1). Females showed higher prevalence rates than males and this difference was statistically significant (P < 0.05).

Seroprevalence of *Brucella* infection based on age of camels in Katsina State, Nigeria

The group with the largest number of animals sampled was group 3 (ages 6 - 10) which had 505 camels. Group 1 (<1 year) had the lowest number - 14 camels. The highest prevalence by age was seen in group 5 (16 - 20 years) with a prevalence rate of 21.7% while the lowest prevalence by age was recorded in group 2 (1-5 years) with a prevalence rate of 6.7% (TABLE 2). There was statistical significant difference observed in the

TABLE 1: Seroprevalence of *Brucella* Infection Based on Sex of Camels in Katsina State, Nigeria

Sex	Total no. sampled	RBPT (%)	χ^2	P-value	SAT (%)	χ^2	P-value
Male	503	46 (9.1)	4.484	0.034	40 (8.0)	7.132	0.008
Female	477	64 (13.4)			63 (13.2)		
Total	980	110 (11.2)			103 (10.5)		

TABLE 2: Seroprevalence of *Brucella* Infection Based on Age of Camels in Katsina State, Nigeria

Age	Total no. sampled	RBPT positive (%)	χ^2	P-value	SAT (%)	χ^2	P-value
< 1 year	14	3 (21.4)	13.602	0.009	1 (7.1)	5.521	0.248
1 - 5 years	89	6 (6.7)			8 (9.0)		

6 - 10 years	505	47 (9.3)	46 (9.1)
11 - 15 years	303	39 (12.9)	36 (11.9)
16 - 20 years	69	15 (21.7)	12 (17.4)
Total	110	980 (11.2)	103 (10.5)

prevalence rates according to age for RBPT ($P < 0.05$).

Risk factors associated with camel brucellosis

Age and sex were identified as potential risk factors to camel brucellosis and were estimated using odds ratio. Results showed that females had OD1.758 (95% CI = 1.157 – 2.669) more chances of getting infected than males (TABLE 3). Statistically significant association was observed for this finding ($P < 0.05$).

The age group of 16-20 years were at highest risk of infection with odds ratio value of OD2.737 (95% CI = 0.326 – 22.963) followed by the 11 – 15, 6-10 and 1 – 5 age groups respectively (OD = 1.759, 95% CI = 0.223 – 13.853; OD = 1.303, 95% CI = 0.167 – 10.185; OD = 1.284, 95% CI = 0.148 – 11.131) (TABLE 3).

Knowledge, attitude and practices of camel handlers on brucellosis in camels in Katsina State, Nigeria

A total of 82 questionnaires were administered of which 58 (71%) were administered to respondents encountered in herds while 24 (29%) were administered to respondents at the abattoirs.

Knowledge of Respondents to Brucellosis in Camels in Katsina State, Nigeria

Whereas, 33(56.8%) of the 58 respondents in the herds were aware that brucellosis is a

disease in cattle, 12 (50%) of the 24 respondents interviewed in abattoirs had the same knowledge. In contrast, 5(20.8%) and 8 (13.8%) respondents in abattoirs and herds respectively were aware that brucellosis affects camel (TABLES 4 and 5). 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 abattoir ($p < 0.05$).

4 (36.4%) and 19 (57.6%) respondents of 58 and 24 respondents in herds and abattoirs respectively indicated the major clinical sign of brucellosis to be abortion while 3 (27.3%) and 6 (18.2%) responded that retained placenta and/or hygroma in addition to abortion are signs they used to identify brucellosis. There were 36.3% of abattoir respondents and 24.2% of herd respondents that were aware of brucellosis but could not identify the disease at all (TABLES 4 and 5).

The study showed that 12 (50%) and 26 (44.8%) respondents of 24 and 58 in abattoirs and herds respectively did not know how brucellosis is transmitted to animals while 5 (20.8%) and 19 (32.8%) responded that transmission was by mating. Also 1 (4.2%) and 6 (10.3%) respondents said transmission

TABLE 3: Risk factors to Camel Brucellosis in Katsina State

Category	No. sampled	Positive (%)	p-value	χ^2	OR	95% CI
Sex						
Male	503	40 (8.0)	0.008	7.132	1*	
Female	477	63 (13.2)			1.758	1.1578 - 2.669
Total	980	103 (10.5)				

Age (Years)

< 1	14	1 (7.1)	0.248	13.602	1*	
1 – 5	89	8 (9.0)			1.284	0.148 – 11.7131
6 – 10	505	46 (9.1)			1.303	0.167 – 10.185
11 – 15	303	36 (11.9)			1.759	0.223 – 13.853
16 – 20	69	12 (17.4)			2.737	0.326 – 22.963
Total	980	103 (10.5)				

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

TABLE 4: Respondents' Responses on Knowledge of Camel Brucellosis (Abattoir Respondents) in Katsina State

Category	Frequency (%)	χ^2	p-value
Have you heard of Brucellosis?			
Yes	12 (50.0)	10.00	0.540
No	12 (50.0)		
How did you hear of Brucellosis?			
Herdsmen	2 (16.7)	4.67*	0.198
Radio	1 (8.3)		
Veterinary personnel	3 (25.0)		
Others	6 (50.0)		
How do you recognize Brucellosis?			
Abortion	4 (36.4)	0.18*	0.913
All of the above	3 (27.3)		
Cannot	4 (36.3)		
Does Brucellosis affect camels?			
Yes	5 (20.8)	5.0	0.008
No	19 (79.2)		
How do animals contact brucellosis			
Mating	5 (20.8)	10.33*	0.016
Ingestion	1 (4.2)		
All of the above	6 (25.0)		
I don't know	12 (50.0)		
Do You know Brucellosis is zoonotic			
Yes	8 (33.3)	8.00	0.153
No	16 (66.7)		
How is Brucellosis Transmitted to Man?			
Contact	2 (25.0)	3.25*	0.197
Milk	1 (12.5)		
All of the above	5 (62.5)		

*Fishers Exact Test

is by ingestion of contaminated materials while 6 (25%) and 7 (12.1%) respondents inferred that transmission could be by both mating and ingestion of contaminated materials in abattoirs and herds respectively. Statistically significant difference was observed in the results of both abattoirs and herds respondents as regards knowledge on transmission of brucellosis ($P < 0.05$).

On the zoonotic nature of the disease, 8 (33.3%) and 20 (34.5) of respondents in the abattoir and herds respectively agreed that the disease is zoonotic while 16 (66.7%) and 38 (65.5) said they were not aware of this. Of those that agreed that brucellosis is zoonotic 2 (25%) and 6 (30%) said transmission to man was via contact with an infected animal, 1 (12.5%) and 3 (15%) replied via consumption of milk from an infected animal and 5 (62.5) and 11 (55%) replied transmission could be by both contact and milk consumption in abattoir and herds respectively (TABLES 4 and 5).

Attitude of Respondents towards Brucellosis in Camels in Katsina State, Nigeria

Results from the abattoir showed that 4 (16.7%) respondents took adequate precautions and washed their hands with soap and water following processing of camel meat while the remaining

TABLE 5: Respondents' Response on Knowledge of Camel Brucellosis (Herd Respondents) in Katsina State

Category	Frequency (%)	χ^2	p-value
Have you heard of Brucellosis?			
Yes	33 (56.8)	32.00	0.511
No	25 (43.2)		
How did you hear of Brucellosis?			
Herdsman	8 (24.2)	4.42*	0.352
Radio	2 (6.1)		
Extension workers	7 (21.2)		
Veterinary personnel	9 (27.3)		
Others	7 (21.2)		
How do you recognize Brucellosis?			
Abortion	19 (57.6)	8.909	0.012
All of the above	6 (18.2)		
Cannot	8 (24.2)		
Does Brucellosis affect camels?			
Yes	8 (13.8)	8.00	0.000
No	50 (86.2)		
How do animals contact brucellosis?			
Mating	19 (32.8)	19.38	0.000
Ingestion	6 (10.3)		
All of the above	7 (12.1)		
I don't know	26 (44.8)		
Do you know brucellosis is zoonotic?			
Yes	20 (34.5)	20.00	0.026
No	38 (65.5)		
How is Brucellosis Transmitted to Man?			
Contact	6 (30.0)	4.90*	0.086
Milk	3 (15.0)		
All of the above	11 (55.0)		

*Fishers Exact Test

20 (83.3%) did not (TABLE 6). There was statistical significance observed in favour of unhygienic attitudes ($P < 0.05$). Of the 40

respondents that milk camel in herds it was discovered that none took any adequate precaution or washed hands adequately with

soap and water after milking (TABLE 7). Furthermore, only 2 (8.3%) and 1 (1.7%) respondents in the abattoir and herds respectively processed camel milk prior to consumption while 22 (91.7%) and 57 (98.3%) did not. There was statistical significance observed for processing of camel milk before consumption in both locations ($P < 0.05$) (TABLES 6 and 7). Of the 7 herds that experienced abortion in the past one year 5 (71%) buried the foetus

while 2 (29%) said they threw the foetuses away (TABLE 7).

Practices of Respondents towards Brucellosis in Camels in Katsina State, Nigeria

Of the 58 respondents from herds, 15 (25.9%) had only camels with no other species of animal in their herds while 15 (25.9%), 7 (12.1%), 4 (6.9%) and 1(1.7%) had cattle, sheep, goats and poultry, respectively

TABLE 6: Respondents' Responses on Attitude to Camel Brucellosis (Abattoir Respondents) in Katsina State, Nigeria

Category	Frequency	χ^2	p-value
Do you wash hands with soap and disinfectant after processing camel meat			
Yes	4 (16.7)	4.00*	0.002
No	20 (83.3)		
Do you process milk before consumption?			
Yes	2 (8.3)	2.00*	0.000
No	22 (91.7)		

*Fishers Exact Test

TABLE 7: Respondents' Responses on Attitude to Camel Brucellosis (Herd Respondents)in Katsina State, Nigeria

Category	Frequency(%)	χ^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 meat			
Yes	0(0.0)	-	-
No	40(100.0)		
Do you process milk before consumption?			
Yes	1(1.7)	57.00*	0.000
No	57(98.3)		

***Fishers Exact Test**

(TABLE 8). The remaining 16 (27.6%) had more than one species in addition to camels in their herds.

Out of 42 respondents with mixed herds 24 (57.1%) said their camels mix 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 only 2 (4.3%) of the respondents said they quarantined prior to addition to herds, 24 (51%) said they carried out some form of prophylactic treatment upon purchase before

TABLE 8: Respondents' Practices on Camel Brucellosis in Katsina State

Category	Frequency (%)	χ^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 specie	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)		

***Fishers Exact Test**

physiological stresses than the males (Walker, 1999). Hirsh and Zee (1999) reported that male animals are less susceptible to *Brucella* infection due to the absence of erythritol which is found in the uterus. Also female camels are kept longer in herds for breeding purposes than male camels which are fattened and sold off except for a few that are kept to service the females, for haulage, transport and other such purposes (Adamu, 1997). Even then

introducing them to the herd while 21 (44.7%) said they did absolutely nothing (TABLE 8).

Also when questioned about carrying out vaccination or any specific action to prevent their camels from contacting brucellosis all 47 herd owners responded no (TABLE 8).

DISCUSSION

A higher prevalence was recorded in female camels than male. The relatively higher susceptibility of she-camels could be due to the fact that female camels have more

such males are changed regularly while breeding females are only sold off when they generally become old. The long stay of females in the herds could explain the higher prevalences in females. This finding is in agreement with the result of Adamu (1997), who carried out a study to determine the prevalence of camel brucellosis in three northern states in Nigeria and reported higher prevalence rates for females than males in all three states of Borno, Kano and

Kaduna. Berhanu *et al.* (2013) also recorded a higher prevalence rate 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 is higher in female than male animals. Abu-Damir *et al.*, (1984) however reported equal distribution of *Brucella* antibodies between both sexes. The higher prevalence rates in females further puts the populace at risk of infection due to the zoonotic nature of the disease since milk is gotten from female animals (Shalom *et al.*, 2012). Shalom *et al* (2012) reported a case of human brucellosis outbreak in 15 extended Bedouin family members acquired through Camel milk ingestion in Southern Israel. The family tested positive to RBPT and Agglutination test and the offending she-camel tested positive to the same tests and the milk was positive to the milk ring test.

The number of camels sampled based on age was uneven. This was because most of the camels sampled at the abattoir were of adult age between 8-15 years which are ready for slaughter. This greatly increased the number of camels in the 6-10 and 11-15-year-old camel groups. The highest prevalence however was recorded in animals 16-20 years old with the lowest prevalence recorded in camels < 1 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. Also older animals mating with other camels tend to be at higher risk than younger animals. Berhanu *et al* (2013) found the highest prevalence in camels older than 11 years and the lowest in camels less than 4 years of age and they suggested that the higher sero-prevalence in older animals was in line with previous reports of Radostits *et al.* (2007) which indicated that infection may occur in animals of all age groups but persists commonly in sexually mature animals.

Respondents to questionnaires showed very poor knowledge of brucellosis in camels. Those who knew of brucellosis in cattle did

not know the disease could be transmitted to camels. The finding could be due to 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 makes most local herdsmen naïve to knowledge of diseases affecting the camel.

The poor attitudes of respondents towards the disease could be due to a lack of education/awareness on the dangers involved in consumption of unpasteurized camel milk and milk of other domestic animals in terms of disease transmission because of the role of milk in transmission such of zoonotic diseases such as brucellosis. Shalom *et al* (2012) reported a case of zoonotic *Brucella* infection in a family in Israel. The family tested positive to RBPT and Agglutination test and the offending she-camel tested positive to the same tests and the milk was positive to the milk ring test. This highlights the dangers of consumption of unpasteurized camel milk which according to our findings is the predominant state in which the populace consumes it and the possibilities of transmission of zoonotic diseases.

In conclusion, the study determined that the sero-prevalence of *Brucellosis* in camels was higher in female camels where a sero-prevalence of 13.4% was recorded than male camels that had a sero-prevalence of 9.1% using the RBPT. Also that the sero-prevalence of *Brucellosis* in camels in the study areas was highest in camels aged 16 – 20 years with a sero-prevalence of 21.7% with the lowest sero-prevalence seen in camels aged 1 – 5 years with a sero-prevalence of 6.7% using the RBPT and that there is very poor knowledge of brucellosis amongst camel herds men and that they do not do anything to prevent their camels or themselves from being infected with brucellosis.

It is recommended therefore that awareness campaign should be carried out to enlighten camel owners, herdsmen, and abattoir staff

about the dangers of poor hygiene during meat and milk processing, the importance of the use of protective clothing when carrying out these operations and the dangers of consumption of unpasteurized camel milk and milk products.

REFERENCES

- ABDULSSALAM M and FEIN DA (1976). Brucellosis as a world problem. *Developments in Biological Standardization*. 31: 9- 23.
- ABOU-EISHA A.M. (2000). Brucellosis in camels and its relation to public health. *Asuit. Vet. Med. J.* 44:54-64.
- ABU-DAMIR H, KENYON SJ, KHALAFALLA AE and IDRIS OF (1984). *Brucella* antibodies in Sudanese camels. *Tropical Animal Health and Production*. 16:209-212.
- ADAMU, N.B and AJOGI, I. (1995). Serological investigation of camel (*Camelus dromedarius*) slaughtered at Kano Municipal Abattoir for evidence of brucellosis. *Tropical Veterinarian*. 18: 45- 48.
- ADAMU N.B. (1997). Camel Brucellosis in three northern states of Nigeria. An MSc thesis submitted to the Department of Public Health and Preventive Medicine, Ahmadu Bello University Zaria.
- ADAMU, N. B. (2009): Epidemiology of *Brucella* infection in ruminants and humans and its public health implications in Borno State, Nigeria. PhD Thesis, Veterinary Public Health and Preventive Medicine Department, Ahmadu Bello University, Zaria, Nigeria.
- AGAB H., ABBAS B., EL-JACK A.H. and MAOUN I.E. (1994). First report on the isolation of *Brucella abortus* biovar 3 from camel (*Camelus dromedarius*) in the Sudan. *Rev. Elev. Med. Vet. Pays. Trop.* 47:361-363.
- AJOGI, I. and ADAMU, N. B. (1998): The one-humped camel: A potential source of *Brucella* infection to other livestock and man in Nigeria. Proceedings of silver anniversary conference of NSAP held in Abeokuta March 21-28. 377-378.
- ATI, O.F. IGUISI E.O. and MOHAMMED S.O. (2010). Effects of El Nino/Southern Oscillation (ENSO) on rainfall characteristics in Katsina, Nigeria. *The African Journal of Agricultural Research*. 5(23): 3273-3278
- BALE, J.O.O. (2008). Serological test used in the diagnosis of brucellosis: Usefulness and Limitations. ISBN 978-194017-4 Published by: Delta Modern Press, 28 Warri Street, SabonGari, Zaria.
- BEKELE MB (2004). Sero-epidemiological study of brucellosis in camels (*Camelus dromedarius*) in Borena lowland pastoral areas, Southern Ethiopia. MSc Thesis. Addis Ababa University, Faculty of Veterinary Medicine, DebreZeit, Ethiopia.
- BELLO, A., SONFADA, M.L., UMAR, A.A., UMARU, M.A., SHEHU, S.A., HENA, S.A., ONU, J.E. and FATIMAO.O. (2013). Age estimation of camels in Nigeria using rostral dentition. *Scientific Journal of Animal Science*. 2(1): 1-6
- BERHANU T., MERGA B., KELAY B. and ENDRIAS Z. (2013). Camel brucellosis and management practices in Jijiga and Babile districts, Eastern Ethiopia. *Journal of Veterinary Medicine and Animal Health* 5(3): 81-86.
- BERTU, W.J., AJOGI I., BALE J.O.O., KWAGA J.K.P. and OCHOLI, R.A. (2010). Sero- epidemiology of Brucellosis in small ruminants in Plateau State, Nigeria. *African Journal of Microbiology Research*, 4(19): 1935- 1938.

- BIU, A.A. and ABBAGANA, A. (2007). Prevalence of paramphistomes in camels slaughtered at Maiduguri abattoir, Nigeria. *Nigerian Journal of Parasitology*. 28(1):44-46.
- BROWN, S.L., GEORGE, C.K., FREDRICK, T.M. and JONES, W.I. (1981). Safranin O-stained antigen microagglutination test for detection of *Brucella* antibodies. *Journal of clinical microbiology*, 13(2): 398-400.
- BUHARI, H.U. (2014). Survey of Bovine Brucellosis in the North Senatorial District of Kaduna State, Nigeria. An MSc thesis submitted to the department of Veterinary Medicine, Ahmadu Bello University Zaria.
- FALADE, S and SHONEKAN, O.A. (1981). A serological survey of *Brucella abortus* infection in Nigerian Sheep. *Nigerian Veterinary Journal*. 2, 50.
- GAMEEL S.E., MOHAMMED S.O., MUSTAFA A.A. and AZWAI S.M. (1993). Prevalence of camel brucellosis in Libya. *Trop. Anim. Health. Prod.* 25:91-93.
- GHAJI A and ADOGWA AO. (1986). Significance of Camel production in Nigeria. *Nigerian Journal of Animal Production*. 13:29-35.
- HADUSH A., PAL M., KASSA T. and ZERU F. (2013). Sero-epidemiology of camel brucellosis in the Afar region of Northeast Ethiopia. *Journal of Veterinary Medicine and Animal Health*. Vol. 5(9), pp. 269-275
- HIRSH DC and ZEE YC (1999). *Veterinary microbiology*. Blackwell Science, Cambridge, Massachusetts, pp. 196-203.
- KALTUNGO, B. Y., SAIDU, S. N. A., SACKY, A. K. B. AND KAZEEM, H. M. (2013). A review on diagnostic techniques for brucellosis. *African Journal of Biotechnology*, Vol. 13(1), pp. 1-10, 1 January, 2014
- KUDI, A.C., KALLA, D.J.U., KUDI, M.C. and KAPIO, G.I. (1997). Brucellosis in camels. *Journal of Arid Environments*, 37: 413-417.
- MOUSA, A.M., ELHAG, K.M., KHOGALI, M. and SUGATHANT.N.(1987). Brucellosis in Kuwait. *Transactions of the Royal Society of Tropical Medicine and Hygiene* 81(6): 1020–1021.
- OFFICE OF INTERNATIONAL EPIZOOTICS (OIE) (2003). Camel: Clinical signs and diagnosis of cameldiseases in relation to epidemiology and ethno- veterinary practices. *Revue Scientifique et Technique O.I.E*, 22(3): 1043-1049.
- RADWAN A.I., BEKAIRI S.J. and PRASAD P. V. (1992). Serological and bacteriological study of brucellosis in camels in central Saudi Arabia. *Rev. Sci. Tech. Off. Int. Epiz.* 11:837-844.
- RADOSTITS, O.M., GAY, C.C., HINCHCLIFF, K.W. and CONSTABLE, P.D. (2007). *Veterinary Medicine, A textbook of the diseases of cattle, sheep pigs, goats and horses*. 10th Ed. Elsevier Saunders, London, pp. 389–390.
- SALIHU, M.D. JUNAIDU, A.U. ABUBAKAR, M.B. MAGAJI, A.A. and MOHAMMED, L.G. (2009): Isolation and characterization of *Campylobacter* species from Camel (*Camelus dromedarius*) in Sokoto State, Northwestern Nigeria. *International Journal of Animal and Veterinary Advances* 1(1): 25-27
- SALISU, U.S., KUDI C.A., BALE, J.O.O., BABASHANI, M., KALTUNGO, B.Y., SAIDU S.N.A., ASAMBE, A., and BABA, A.Y. (2017): Sero-prevalence *Brucella* antibodies in camel in Katsina State, Nigeria. *Tropical Animal Health and Production* DOI 10.1007/s11250-017-1297-5

SCHWARTZ, H.J. and DIOLI, M. (1992).
The one-humped camel in Eastern-
Africa. EditionsVerlag, Weikersheim
(Allemagne), pp. 282.

SHALOM B.S., LARISSA D., ILANA B.,
SVETLANA B., DAVID S., CHIYA
B. and DAVID G. (2012) Human
Brucellosis Outbreak Acquired

through Camel Milk Ingestion in
Southern Israel. Isreal Medical
Association Journal vol 14 pp 20-23,
August 2012.

WALKER RL (1999). Veterinary
Microbiology. Blackwells Science.
Cambridge, Massachusetts, pp. 196-
203.