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OCCURRENCE AND RISK FACTORS OF TUBERCULOSIS IN CAMELS FROM THREE NORTH-WESTERN STATES OF NIGERIA

Salisu, U.S.[1*], Kudi, A.C.[2], Danbirni, S.[2], Mamman, P.H.[3], Saidu, S.N.A.[2], Garba, M.G.[2], Sanusi, A.Z.[2], Yusuf, A.[2] and Ishaq, A.[4]

[1]Department of Animal Science, Federal University Dutsin-Ma

[2]Department Veterinary Medicine, Ahmadu Bello University, Zaria, Nigeria

[3]Department Veterinary Microbiology, Ahmadu Bello University, Zaria, Nigeria

[3]Department of Animal Science, Federal University of Agriculture, Zuru, Kebbi State, Nigeria

*Corresponding author: usalisu@fudutsinma.edu.ng

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ABSTRACT

The study determined the occurrence as well as risk factors of Mycobacterial infections in camels in three northwestern states. Three hundred and eighty-four blood samples were collected from camel herds, and another 384 from camels presented for slaughter at abattoirs in three States of Kano, Katsina and Jigawa to obtain sera which were used to determine the presence of antibodies to tuberculosis using a lateral flow assay test. Three hundred and eighty four camels were sampled at slaughter at the central abattoirs in the three sates for tuberculous lesions. The results revealed a total occurrence rate of 8.98% for the presence of antibodies to TB in sera and a total occurrence rate of 5.98% based on occurrence of tuberculous lesions in camels in the study area. There was no significant difference ($p \leq 0.05$) in occurrence across study States via lateral flow or occurrence of lesions though Katsina State recorded a numerically higher occurrence of 11.26% and 11.46% than Kano (8.97%; 3.49%) or Jigawa (7.03%, 6.78%) respectively. Occurrence by sex and age was not statistically significant ($\rho \leq 0.05$) as no difference was observed between bulls and cows or adults and young camels. However, a significant difference ($\rho=0.01$) was observed in the occurrence of TB by body condition score, with the highest occurrence in camels with poor body condition score. It was thus recommended that there is need for improved surveillance, monitoring and quarantine services especially at Border States to control trans-border movement of diseases such as tuberculosis into the country and also an urgent need for increased awareness amongst camel stakeholders of the dangers of zoonotic infections from consumption of untreated camel milk and products also bearing in mind the close proximity between camels and their owners/herders. It was also recommended that the National policy on tuberculosis control in humans should be reviewed to include animals, camels inclusive.

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INTRODUCTION

Tuberculosis in animals is a zoonotic disease that is caused by members of the *Mycobacterium tuberculosis* complex, including *Mycobacterium tuberculosis*, *M. africanum*, *M. microti*, *M. bovis*, *M. caprae*, *M. canettii* and *M. pinnipedii* (Brites and Gagneux, 2017).

Infected animals progressively develop specific granulomatous lesions or tubercles in lung tissue, lymph nodes and other organs (Vohra and Dhaliwal, 2024). The incubation period ranges from months to years, but acute stages of the disease can develop during infection, when lesions progress rapidly (Vohra and Dhaliwal, 2024).

The disease is zoonotic and is spread by inhalation of aerosols or the ingestion of unpasteurized milk (Ravi *et al.,* 2018). The disease is rare or eradicated in developed countries via eradication programmes, however, reservoirs in wildlife can make complete eradication difficult (Pokam *et al.,* 2019). However, tuberculosis in animals is still a problem in less developed countries leading to severe economic losses due to livestock deaths, chronic disease and trade restrictions (Mohammed and Hamid, 2016). Cattle are the primary hosts for *M. bovis* (Ejo *et al*., 2021) and Bovine TB is usually maintained in cattle populations, but other domesticated and wild mammals can also be infected (Faye, 2020). A few animal species serve as reservoirs or maintenance hosts (CFSPH, 2019). Most species are considered to be spillover hosts. The brush–tailed Opossums (and possibly ferrets) in New Zealand, Badgers in the United Kingdom and Ireland, Bison and Elk in Canada, and Kudu and African Buffalo in Southern Africa all serve as maintenance hosts (CFSPH, 2019). Sheep, goats, horses, pigs, dogs, cats, ferrets, camels, llamas along with many species of wild ruminants including deer and elk; elephants, rhinoceroses, foxes, coyotes, mink, primates, opossums, otters, seals, sea l ions, hares, raccoons, bears, warthogs, large cats (including lions, tigers, leopards, cheetahs and lynx) and several species of rodents are considered as spill over hosts for the disease (CFSPH, 2019). Most mammals may be susceptible (CFSPH, 2019).

In dromedary camels, *Mycobacterium bovis, M. tuberculosis*, *M. bovis*, *M. caprae* and *M. microti* have been isolated from tissue lesions and bulked camel milk and atypical mycobacteria such as *M. kansasii*, *M. aquae*, *M. fortuitum* and *M. smegmatis* (Elmossalami *et al.*, 2010; Zubair *et al.*, 2004; Wernery and Kinne, 2012; Kinne *et al.*, 2006; Pate *et al.*, 2006; Gumi *et al.*, 2012; Zerom *et al.*, 2012; Mamo *et al*., 2011).

Camelids are members of the biological family *Camelidae*, and are classified in the suborder *Tylopoda* (pad-footed animals). They are also in the order Artiodactyla (even-toed ungulates) (Adamu and Ajogi, 1995). The one humped camel (*Camelus dromedarius*) is an important livestock species in Northern Nigeria. Camels are traditionally used for transport and haulage. However, their 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 (Salihu *et al.,* 2009).

Tuberculosis in Camels has been found in Egypt, the United Arab Emirates, Pakistan, Kazakhstan, Nigeria and Ethiopia to mention a few. *Mycobacterium bovis*, *M. tuberculosis* and Non - Tuberculous Mycobacteria (NTBC) such as *M. kansasii*, *M. aquae*, *M. fortuitum* and *M. smegmatis* have all been isolated as causative agents of camel TB (Jibril *et al*., 2016).

The dromedary camel (*Camelus dromedarius*) is a multipurpose livestock species that is uniquely adapted to different types of harsh environments making it especially important in sub Saharan Africa. They can be used for meat, milk, wool and hide production and transportation and as a source of entertainment and competition (Fesseha and Desta, 2020).

The current world camel population is assumed to be more than 35 million (Faye, 2020). This is a notable increase from the Food and Agricultural Organization statistics (FAOSTAT 2001) figures of about 19 million camels in the world, of which 15 million are found in Africa and 4 million in Asia. Approximately two thirds of the world's camel population is in the arid areas of Africa notably Ethiopia, Sudan, Somalia, Djibouti, Niger, Kenya and Nigeria (Faye, 2020). Of the camels in Africa, Nigeria was estimated to have over 380,000 found in Kebbi, Sokoto, Zamfara, Katsina, Kano, Jigawa, Yobe and Borno states where they are used for transportation, haulage and as a source of meat, milk and hides (Faye, 2020).

The camel is one of the domesticated animals that serve as a spillover host for members of the tuberculosis complex (Duguma, 2022). Camels serve as important sources of milk, meat, draught power and transportation for the pastoralists (Faye, 2020). Zoonotic infections are closely associated with camel pastoralists because of their close contacts with their camels (Kaltungo, 2016) and their

habit of consuming raw camel milk which they regard as being medicinal (Duguma, 2022).

The dromedary camel (*Camelus dromedarius*) is extremely important for the livelihood of pastoral communities (Mamo *et al.,* 2011) and in these communities, camel milk is consumed raw. This habit combined with close physical contact between camel herdsmen and owners and their camels gives rise to a potential public health concern for transmission of zoonotic diseases such as tuberculosis (TB) from animals to the pastoralist (Mamo *et al.,* 2011).

Camels are also bred predominantly in rural settings and are commonly in contact with small ruminant and cattle which could serve as source of infections especially those infected with *Mycobacterium species* (Salisu, 2016). Camel trade is also carried out at livestock markets such as Maigatari and Maiadua livestock markets in the study area which are amongst the largest in West Africa, and camels come into contact with small ruminants, cattle and even equine species at these markets and infection could be spread at these places.

In many arid and semi-arid regions, camels play a critical role in bridging food security and sustaining pastoral livelihoods. Camels are slaughtered for their meat, and their milk is processed into various dairy products such as cheese (Abubakar *et al*., 2021) (locally called cikwi).

Camels are also not routinely screened against Tuberculosis as in other animals such as cattle. There is little information available as to the prevalence of this disease in camels in northern Nigeria. The camel is an important source of animal protein in Northern Nigeria. Camel meat is accepted and consumed and is slowly replacing beef and mutton in the diet of many families because it is cheap and tastes good. The relatively cheap cost of camel meat makes it an ideal source of affordable meat (Salisu, 2016). This poses risks to consumers, particularly regarding food safety and zoonotic diseases. In areas with inadequate veterinary care and poor meat inspection systems, camel meat can harbor pathogens like *Mycobacterium* and other zoonotic infections.

The populace in Northern Nigeria believes that camel milk and urine, when consumed, can cure for various diseases including HIV/AIDS, epilepsy and various cancers (Salisu, 2016). The camel is also one of the animals used as sacrificial animals during the Eid festivities in Northern Nigeria.

The habit of people in the study area of consumption of unpasteurized milk and in some cases even the urine of camels puts the populace at great risk of zoonotic disease should such substances contain the pathogens. Also, the close contact between camels and their owners/herdsmen puts these individuals at high risk of contracting tuberculosis from infected camels should the camels be infected with mycobacteria. This, coupled with the belief of the local populace that the milk and urine have therapeutic effects in the cure of certain diseases and the public health implications of tuberculosis makes it imperative to have a clear picture of the status of camel tuberculosis in the study area. Therefore, investigation of camel TB and identification of its causative agents in the study area is important to control the disease and reduce its risk of zoonosis to the pastoralists and camel handlers. The present study was designed to investigate the status of TB in camels and identify the causative agent(s) in the study area using molecular tools.

MATERIALS AND METHODS

The study was conducted in 3 States viz: Katsina, Kano and Jigawa States (Figure 1). Katsina State covers an area of 24,971 square kilometers (Wikipedia, 2021). It is located between Latitude 11°08'N and 13°22'N and Longitude 6°52'E and 9°20'E. It is located at an elevation of 605 meters above sea level (Wikipedia, 2021). Katsina State is one of the seven States that form Nigeria's North-West geopolitical zone. It is bordered by Jigawa and Kano States to the East, Kaduna State to the South and Zamfara State to the West. It shares an international border with the Republic of Niger to the North (Wikipedia, 2021). The vegetation in Katsina provides suitable grazing grounds for camels (Ghude *et al*., 2024). Temperatures during the dry season can be very high, frequently exceeding

40°C (104°F) between March and May (WeatherSpark, 2024). Katsina receives moderate rainfall during the wet season, with annual precipitation generally ranging from 600 mm to 800 mm (Abubakar *et al*., 2024). The recent estimate of camel population in Katsina State is approximately 52,000. This estimate is based on data from the Nigerian Agricultural Quarantine Service and other sources related to livestock statistics in Nigeria (NAQS, 2024).

Kano State is a State located in Northern Nigeria. it was created on May 27, 1967 from part of the Northern Region. It is located between Latitude 12°00'N and Longitude 8°31'E and borders Katsina State to the northwest, Jigawa State to the northeast, Bauchi State to the southeast and Kaduna State to the southwest. Kano State has a tropical savanna climate, marked by a significant variation between wet and dry seasons. Temperatures during the dry season can be extremely high, often exceeding 40°C (104°F), especially from March to May (Abaje *et al*., 2014). Temperatures during the wet season are slightly cooler but can still be warm, with average temperatures ranging from 25°C to 35°C (77°F to 95°F). Kano is a major hub for camel trade in Nigeria. As of the latest available data, the camel population in Kano State, Nigeria, is estimated to be around 95,000. This estimate is derived from various livestock statistics and agricultural reports (NAQS, 2024).

Jigawa State is one of the thirty-six States that constitute Federal Republic of Nigeria. It is situated in the northwestern part of the country between Latitude 11.00°N and 13.00°N and Longitude 8.00°E to 10.15°E. The State shares a border with Kano and Katsina States to the west, Bauchi State to the East and Yobe State to the Northeast. To the North, Jigawa shares an international border with Zinder Region in The Republic of Niger. The State has a total land area of approximately 22,410 square kilometers. Jigawa State has a tropical savanna climate, characterized by distinct wet and dry seasons. Temperatures can be extremely high during the dry season (October - May), often surpassing 40°C (104°F) from March to May. During the wet season (June - September), temperatures are slightly cooler, ranging between 25°C and 35°C (77°F to 95°F). Jigawa's markets, such as the Maigatari market plays a crucial role in the trade of camels and camel products thereby contributing greatly to the local economy (Jigawa State Government, 2024). The population of camels in Jigawa State, Nigeria, is significant due to the State's favourable environment for camel rearing. However, specific and recent population figures can be challenging to find in general publications. While specific figures for Jigawa State are not readily available, it's important to consider that Jigawa is one of the States in Nigeria where camel rearing is significant due to its Sahelian climate, which is conducive to camel husbandry (NAQS, 2024).

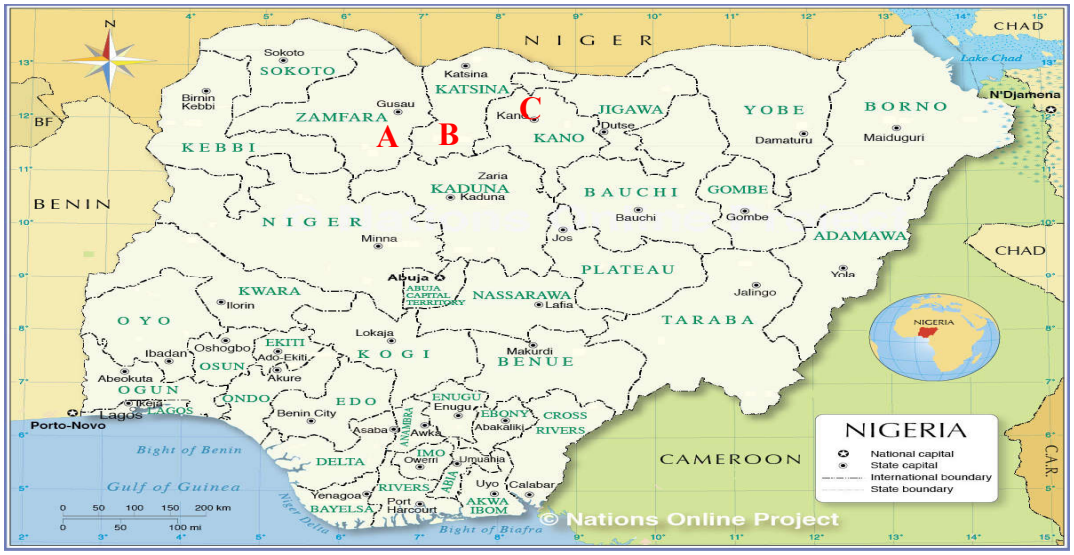

Figure 1: Map of Nigeria showing Sampling States (Source: Ntionsonline.org, 2021)

Figure 2: Map of sample States (Source: Nationsonline.org, 2021)

Study Design

A cross-sectional study using a purposive sampling method was carried out in camel herds. Systematic random sampling was carried out at abattoirs where every third camel intended for slaughter was examined. Lateral flow assay-based kit (rapid assay kit) was used to determine the presence or absence of antibodies in serum obtained from camels in herds and abattoirs.

Camel herds were selected based on the cooperation of the herd owners. Camels from herds in Katsina, Kano and Jigawa States were sampled. Camels brought for slaughter to the central abattoir in the study States were sampled. Age, sex, body condition and origin of each camel were recorded prior to blood collection/slaughter.

Age estimation was carried out using rostral dentition as described by Bello *et al.* (2013). The method involves the eruption and wear of the deciduous and permanent incisors to determine the age of the camels. All camels sampled were distributed into two age groups, with camels aged ≤6 years considered young and camels aged ≥7 years considered adults**.** Body condition scoring (BCS) was carried out according to Faye *et al*. (2001) who used the visibility/prominence of the Hump, spinous and transverse processes of vertebra, hollow of flank, ischial and coxial tuberosity, rib and recto genital area with very visible/prominent being poor BCS, Slightly visible being fair BCS and not visible/prominent being good BCS.

Ethical Clearance

Ethical clearance for the study was sought from the Ethics and Research committee of the Federal Teaching Hospital Katsina with approval number FTHKTHREC REG 24/06/22C/210.

Sample Size Determination

The sample size was calculated using the formula described by Thrusfield, (2007).

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

Where:

n – Minimum sample size

z – Appropriate value for the standard normal deviation set at 95% confidence interval (1.96)

p – Prevalence 50% (expected prevalence)

q – Complementary probability (1-p)

d- Level of significance/desired absolute precision 5%

Therefore, $N = \frac{1.96^2 \text{ x (prevalence x 1-prevalence)}}{(0.05)^2}$

$$= \frac{1.96^2 \text{ x } (0.5 \text{ x } 1 - 0.5)}{(0.05)^2}$$

N = 384.16

The minimum sample size of 384 camels to be sampled at the abattoirs and another 384 in camel herds was thus determined giving a total of 768 camels to be sampled.

Blood sample collection

Camels were physically restrained properly on sternal recumbency using ropes around the feet to prevent the camel from rising. Blood samples were collected via jugular venipuncture. Ten (10) milliliters of blood was collected from each camel using a 20ml syringe and 18G needle from the jugular vein. The blood was then gently transferred into anticoagulant - free sample bottles and labeled appropriately based on location, age and sex of the camel and also recorded in a hard cover log book. The labeled bottles were

kept in a slanting position in a cooler on ice packs and taken to the laboratory where they were centrifuged at 1000g for 5 minutes to allow for proper separation of serum from the clotted blood. The serum was then decanted, using sterile pasture pipettes, into a 5 ml plastic serum tube which were appropriately labeled. All the extracted serum samples were then stored in the freezer at – 20ºC until use.

Lateral flow assay

Collected and stored serum was subjected to testing using a lateral flow assay-based kit (rapid assay kit) for tuberculosis diagnosis that employs immuno-chromatographic detection of antibodies in serum, plasma, or whole blood (Ranjan *et al.,* 2018).

The assay relies on chromatographic detection of MPT64, a protein that is produced by *M. tuberculosis* complex during its metabolism in cultures (Kinne *et al.,* 2012). The assay has the advantage of being inexpensive and easy to use. They are easily stored at room temperature and allow for results from positive samples within 15 minutes.

The thawed sera samples were analyzed according to the manufacturer's instructions. For each test serum, 20 µl of thawed serum was placed into the sample window of the test kit. This was followed by the addition of 4 drops of the diluents after which the kit was left on the laboratory bench for 20 minutes at room temperature. The test results were read after 20 minutes by visual inspection.

Interpretation of results;

a) Negative = when staining was observed only on the control line (single straight line).
b) Positive = when staining was observed on both the test and control lines (two lines)

Data Analyses

Data generated are presented in tables, charts and plates. Data was analyzed using SPSS version 25.0. Prevalence and isolation rate of *Mycobacterium species* was calculated using the formula

$$\frac{\text{Total Positive}}{\text{Total sampled}} \times 100$$

Bivariate as well as multivariate analyses were carried out.

For the Bivariate analyses Chi square test was used to test for association between categorical variables. *P* values ≤ 0.05 were considered significant.

RESULTS

Occurrence of *Mycobacterial* Infections in Camels in Study Area based on SD Bioline® TB Ag Lateral Flow Assay

The results revealed a total occurrence of 8.98% for the study from lateral flow assays using SD Bioline® test kits (Table 1). Katsina State recorded the highest total prevalence of 11.25% amongst the 3 States sampled, while Jigawa State recorded the lowest prevalence of 7.03% (Table 1).

Table 1: Occurrence of *Mycobacterial* Infections in Camels in Katsina, Kano and Jigawa States Based on SD Bioline® TB Ag Lateral Flow Assay

State	No of Camels Tested	Positive	Occurrence rate (%)	χ^2	ρ value
Katsina	222	25	11.26	**2.602**	**0.272**
Kano	290	26	8.97		
Jigawa	256	18	7.03		
Total	**768**	**69**	**8.98**		

Occurrence of *Mycobacterial* Infections based on sex of camels in the study area using SD Bioline® TB Ag lateral flow assay

A total of four hundred and fifty-two (452) male camels and three hundred and sixteen (316) female camels were sampled across the three States. Of these 31 males (6.42%) were positive while 38 (12.65%) of females were positive (Table 2). In all States sampled, female camels recorded higher occurrence (Katsina: 15.22%; Kano: 11.11%; Jigawa: 12.36%) than males (Katsina: 8.46%; Kano: 7.10%; Jigawa: 4.19%) (Table 3).

Table 2: Occurrence of *Mycobacterial* Infections Based on Sex of Camels in Katsina, Kano and Jigawa States

Sex	No of Camels Tested	Positive	Occurrence rate (%)	χ^2	ρ value
Male	418	31	6.42	**2.758**	**0.097**
Female	350	38	12.65		
Total	**768**	**69**	**8.98**		

Table 3: Occurrence of *Mycobacterial* Infections based on sex and location of camels in Katsina, Kano and Jigawa States

State		No of Camels Tested	Positive	Occurrence rate (%)	χ^2	ρ value
Katsina	Male	130	11	8.46	**2.758**	**0.097**
	Female	92	14	15.22		
	Total	222	25	11.26		
Kano	Male	155	11	7.10		
	Female	135	15	11.11		
	Total	290	26	8.97		
Jigawa	Male	107	7	4.19		
	Female	89	11	12.36		
	Total	256	18	7.03		
Total		**768**	**69**	**8.98**		

Occurrence of *Mycobacterial* Infections based on age of camels in the study area

Of 768 camels sampled, two hundred and eighty-six (286) were young (below the age of six) while four hundred and eighty-two (482) were adults (seven years and above). Of this 22 (7.69%) were positive amongst young while, 47 (9.75%) were positive amongst the adult camels (Table 4). In all States sampled, adults recorded higher occurrence (Katsina: 12.06%; Jigawa: 8.61%) than young camels (Katsina: 9.88%; Jigawa: 4.76%) except Kano where young camels had higher occurrence rate (9.00%) than adults (8.95%) (Table 5).

Table 4: Occurrence of *Mycobacterial* Infections Based on Age of Camels in Katsina, Kano and Jigawa States

Age range	No of Camels Tested	Positive	Occurrence rate (%)	χ^2	ρ value
≤6 years (Young)	286	22	7.69	**0.930**	**0.335**
≥7 years (Adults)	482	47	9.75		
Total	**768**	**69**	**8.98**		

Table 5: Occurrence of *Mycobacterial* Infections Based on age and Location of Camels in Katsina, Kano and Jigawa States

State		No of Camels Tested	Positive	Occurrence rate (%)	χ^2	ρ value
Katsina	Young	81	8	9.88	**0.930**	**0.335**
	Adult	141	17	12.06		
	Total	222	25	11.26		
Kano	Young	100	9	9.00		
	Adult	190	17	8.95		
	Total	290	26	8.97		
Jigawa	Young	105	5	4.76		
	Adult	151	13	8.61		

	Total	256	18	7.03
Total		**768**	**69**	**8.98**

Occurrence of *Mycobacterial* Infections based on body score condition of camels in the study area

Three body score conditions were considered: Good, Fair and Poor. Of the 768 camels sampled, two hundred and ninety-one (291) had good body condition score, three hundred and three (303) had fair while one hundred and seventy-four (174) had poor body condition score (Table 6). Of these 15 (5.11%) of those with good body condition score were positive for antibodies against tuberculosis, 22 (7.28%) amongst those with fair body condition score were positive while 32 (18.50%) amongst those with poor body condition score were positive (Table 6). In all States sampled, camels with poor BCS recorded a higher occurrence (Katsina: 24.44%; Kano: 21.15%; Jigawa: 13.16%) than camels with good and fair BCS (Table 7).

Table 6: Occurrence of *Mycobacterial* Infections Based on Body Condition Score of Camels in Katsina, Kano and Jigawa States

Body condition score	No of Camels Tested	Positive	Occurrence rate (%)	χ^2	ρ value
Good	291	15	5.11	**25.148**	**0.01**
Fair	303	22	7.28		
Poor	174	32	18.50		
Total	**768**	**69**	**8.98**		

Table 7: Occurrence of *Mycobacterial* Infections Based on body condition score and Location of Camels in Katsina, Kano and Jigawa States

State		No of Camels Tested	Positive	Prevalence (%)	χ^2	ρ value
Katsina	Good	75	6	8.00	**25.148**	**0.01**
	Fair	102	8	7.84		
	Poor	45	11	24.44		
	Total	222	25	11.26		
Kano	Good	122	6	4.92		
	Fair	116	9	7.76		
	Poor	52	11	21.15		
	Total	290	26	8.97		
Jigawa	Good	96	3	3.12		
	Fair	84	5	5.95		
	Poor	76	10	13.16		
	Total	256	18	7.03		
Total		**768**	**69**	**8.98**		

DISCUSSION

A total of seven hundred and sixty-eight (768) serum samples were collected from camels in the study area across the States of Kano, Katsina and Jigawa with half being collected from camel herds while the other half were from camels slaughtered at central abattoirs in the capital cities of the States sampled. The samples collected from each State were not even but varied according to the presence/availability of camel herds and the total number of camels slaughtered per day at the central abattoirs. As a result two hundred and twenty two (222) samples were collected from Katsina State with one hundred (100) being from camel herds and one hundred and twenty two (122) from Katsina Central abattoir, two hundred and ninety (290) serum

samples were collected from camels in Kano State with seventy three (73) from camel herds and two hundred and seventeen (217) collected at Kano Central abattoir while two hundred and fifty six (256) samples were collected from camels in Jigawa State with forty five (45) from camels slaughtered at the central abattoir in Dutse and two hundred and eleven (211) camels were sampled from camel herds in various locations in Jigawa State. This distribution indicated that Jigawa State had the least number of camels being slaughtered at the abattoir per day while Kano State had the highest number of camels slaughtered in a day. The reverse was the case for camel herds as Jigawa State had the largest number of camel herds in the three States sampled while Kano State had the least. These differences led to the variations in the number of camels sampled per location.

The results revealed a total prevalence of 8.98% for the study from lateral flow assays using SD Bioline® test kits. Beyi *et al.* (2014) determined the prevalence of bovine tuberculosis in dromedary camels in Eastern Ethiopia to be 8.3%. However, Ahad *et al.,* 2023 reported an overall prevalence of 13% for camels in Nigeria as a whole.

Katsina State recorded the highest total prevalence (11.26%) of the three sampled States followed by Kano State (8.97%) and while Jigawa State (7.03%) recorded the lowest prevalence. This is not shocking since Jigawa State had least number of slaughtered camels and the highest numbers in herds. Herd owners would naturally sell off animals not doing well and keep the more promising ones for production and reproductive purposes. Abubakar *et al*., 2014 reported a prevalence of 22% in camels slaughtered at Kano abattoir though only based on serological tests while no current reports for Katsina and Jigawa States were found. This paucity of data in these States is worrisome as they are very important camel entry and distribution point into and around Nigeria because of the presence of the Maiadua and Maigatari markets respectively which are arguably the largest animal markets after Potiskum cattle market.

Female camels recorded higher prevalence than males though without significant difference in this study. This is probably due to the fact that female animals are always kept longer in the herds since they reproduce while most male animals are fattened and sold off leaving only a few studs. This long stay in the herds puts females at higher odds of being infected. A study on the prevalence and associated risk factors of camel tuberculosis at Akaki abattoir in Ethopia also reported numerically higher positives without statistical significance in females than males (Jibril *et* al., 2016) and also the findings of Zerom *et al*., 2013. The current study however disagreed with the findings of Ahmad *et al*., 2018 who reported that male dromedaries had 1.7 odds of being tuberculous than the females. It also was not at par with the study of Beyi *et al*., 2013 who also reported a higher prevalence in males.

Adult camels recorded higher prevalence of infection than young camels though no statistical significance was observed in the current study and this could be attributed to the chronic nature of tuberculosis. The prevalence in this study was determined from presence of antibodies in sera and as such the establishment of antibodies following challenge and the retention of memory cells would naturally tend to occur in older animals than young ones. This report was in tandem with the findings of Kasaye *et al*., 2013 who reported higher prevalence in adults than young however with no statistical significance. Jibril *et al*., 2016 however reported no significance in age of camels as risk factor to the occurrence of tuberculosis in camels.

Three body condition scores were considered: Good, Fair and Poor. Of the 768 camels sampled two hundred and ninety-three (293) had good body condition score, three hundred and two (302) had fair while one hundred and seventy three (173) had poor body condition score. Camels with poor body condition score despite being the least in number amongst camels sampled had a significant higher difference compared to these with fair and good body condition scores. This finding could be as a result of tuberculosis being a debilitating and wasting disease. The findings followed expected patterns as those with fair body condition score had the next largest

prevalence while those with good body condition score recorded the least. Kasaye *et al*., 2013 reported a numerically higher prevalence in camels of poor body condition score in Akaki, Ethiopia.

CONCLUSIONS

The study in camels observed a total occurrence of 8.98% antibody detection to Mycobateria species in Katsina, Kano and Jigawa States using SD bioline lateral flow test kit. Katsina State recorded the highest total prevalence of 11.26% followed by Kano State which had a prevalence of 8.97% and the least was Jigawa State recording 7.03%. No statistical significance was observed in the prevalence across the three States.

There was no statistically significant association for the prevalence based on sex and age of camels though females and adults recorded numerically higher prevalence's. Significant association was however observed for body condition score ($p \leq 0.01$).

RECOMMENDATIONS

I. There is a need for improved monitoring and quarantine services especially at Border States in Northern Nigeria as this is the major passage way for camels into Nigeria and proper monitoring at this point may limit the introduction of diseases into the country.

II. There is an urgent need for measures to increase awareness in camel herding and rearing communities as well as amongst consumers of camel product (camel milk, cikwi etc) as there is a high prevalence of low knowledge and poor practices especially towards tuberculosis in camels.

III. There is a need for review of the National policy on tuberculosis control in humans to include control in animals, camels inclusive, for the effective control of the disease in the country. The control of the disease should be based on a one health approach.

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