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Seroprevalence of *Brucella melitensis* and Knowledge, Attitudes, and Practices (KAP) Regarding Reproductive Diseases among Goat Handlers in North-Eastern Nigeria

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ABSTRACT

This study investigated the seroprevalence and risk factors of *Brucella melitensis* in goats within Maiduguri, Borno State, while simultaneously assessing the knowledge, attitudes, and practices (KAP) of animal vendors and handlers in Borno and Yobe states regarding reproductive diseases. A total of 160 goats were sampled and tested using the rapid immunochromatographic assay. The overall seroprevalence of *B. melitensis* was 5.0%. Prevalence varied by location within Maiduguri (df = 2, N = 160) = 5.6, p = 0.033). Older goats were apparently more seropositive (Odds Ratio (OR): 3.129; 95% CI: 0.802, 12.206), and weight was a significantly associated factor (OR: 0.655; p<0.05). Furthermore, the KAP survey revealed that 77.3% of handlers observed clinical signs like abortion/retained placenta or swollen knees, yet only 9.5% consulted a veterinarian, while 38.1% practiced self-medication. Overall, the respondents exhibited poor level of Knowledge (47.3%), Attitude (59.2%), and Practice (24.6%). The study identifies a critical gap in managing reproductive diseases within the sampled population and indicates an unmanaged zoonotic risk. The heavy reliance on self-medication and the lack of veterinary consultation further exacerbates the challenge of controlling Brucellosis and similar reproductive infections. The low prevalence suggests that goats designated for restocking programs may represent a low-risk source; however, the significant knowledge and practice gaps among handlers represent a persistent and high risk to both animal and public health in the conflict-affected regions of Northeastern Nigeria.

Keywords: seroprevalence, risk factors, *Brucella melitensis*, goats, reproductive disease, knowledge, attitudes, practices

INTRODUCTION

Brucellosis is a globally significant zoonotic disease caused by the Gram-negative, facultative intracellular bacteria of the genus *Brucella*. In small ruminants, particularly goats, the disease is primarily caused by *Brucella melitensis* (*B. melitensis*), which is also the most virulent strain for humans, causing Malta fever (Mirnejad *et al*., 2017; González-Espinoza *et al*., 2021). The bacterium has a tropism for the reproductive organs, and transmission commonly occurs through the ingestion of contaminated materials, such as feed, water, or aborted foetuses (Pizarro-Cerdá *et al*., 1998; González-Espinoza *et al*., 2021).

The disease causes reproductive disorders such as abortion, stillbirth, infertility and retained placenta. Abortions typically occur in the last trimester of pregnancy. Infected females may experience placentitis and metritis, while males may experience orchitis and epididymitis (Neta *et al*., 2010). The infection leads to substantial economic losses in the livestock sector due to reproductive failure, including abortion, stillbirths, and infertility (Aiyedun *et al*., 2022).

The epidemiology of brucellosis is highly influenced by management practices, animal movement, and agro-ecological zones (Dadar *et al*., 2021). Northeast Nigeria presents a unique and critical context due to the protracted Boko Haram conflict, which has resulted in the massive displacement of human populations and the severe depletion of livestock (Higazi, 2022). The crisis has disrupted livestock production and livelihood with little or no veterinary services support in the crisis affected areas (Sadiq et. al., 2019). In response, governmental and non-governmental organizations have engaged in extensive livestock restocking programs, procuring and distributing thousands of goats to vulnerable, internally displaced, and

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returnee communities to re-establish livelihoods (FAO, 2018; Badewa and Dinbabo, 2023).

The rapid and large-scale movement of animals, sourced from different markets and localities for these restocking efforts, poses a substantial, unquantified risk for the spread of endemic, high-impact diseases, including brucellosis (Adamu *et al*., 2015; Mohammed *et al*., 2020). Given that these distributed goats are intended to reproduce quickly, the absence of prior screening for reproductive diseases, particularly *B. melitensis*, could jeopardize the entire intervention program and create new zoonotic reservoirs.

Immunochromatographic Test (ICT) for brucellosis has been developed, standardized and evaluated to show high diagnostic sensitivity, specificity and accuracy for diagnosis of brucellosis in bovine, small ruminants and swine (Shome *et al*., 2018; Ge *et al*., 2021). Serhan *et al*. (2019) compared four serological tests for the diagnosis of brucellosis in dromedary camels (*Camelus dromedarius*) and found that ICT showed the highest sensitivity, 98.67%, followed by the Fluorescence Polarization Assay (FPA) with 95.05% and Competitive Enzyme-Linked Immunosorbent Assay (c-ELISA) with 94.94%.

Kaltungo *et al.* (2022) reported an overall seroprevalence of 6.67% B. *melitensis* infection in goats slaughtered in Abuja metropolis, Nigeria. However, a systemic review by Akinyemi *et al*. (2022) found a pooled seroprevalence in goats of 9% in the North-East Nigeria, which was significantly lower than the prevalence in the North-West (19.2%) and North-Central (13.8%) regions. However, they reported that considerably fewer animals were sampled in the North-East, Nigeria.

All stakeholders require information on reproductive disease risks associated with goat restocking programs during the recovery phase of post-conflict North-Eastern Nigeria. Thus, this study was designed to determine the seroprevalence and associated risk factors of *B. melitensis* infection among goats in Bauchi, Borno and Yobe States, North-East, Nigeria. Additionally, the knowledge, attitude, and practices (KAP) of animal handlers and vendors regarding reproductive diseases and brucellosis in Bauchi, Borno and Yobe states were evaluated to inform effective 'One Health' control strategies tailored for this post-conflict, high-movement environment.

MATERIALS AND METHODS

Study Design

A cross-sectional study was conducted in Maiduguri, Borno State, Nigeria. The study population comprised Sahelian goats (the common breed used in restocking programs) aged 1.5 years and above (determined by dentition), sourced from markets in Bauchi and Yobe states for distribution, as well as resident in local flocks within the study area.

The required sample size (n=126) was calculated using the formula by Thrusfield (2018) using the prevalence of *B. melitensis* in the Northeast of Nigeria (9%) reported by Akinyemi *et al*. (2022). A total of 160 adult goats were sampled for increased precision.

$$n = \frac{(Z_{0.05})^2 * P(Q)}{d^2} = \frac{(1.96)^2 * 0.09(1-0.09)}{(0.05)^2} = 126$$

Where:

n = required sample size.

Z = a value for 95% confidence level (1.96)

P = expected proportion,

Q = 1- P

d = level of precision (5% or 0.05)

Ethical permit for this study was sought from the Borno State Livestock Management Agency (BOLMA) via letter Ref; BOLMA/AREC/2023/003 dated 02/03/2023. Informed consent of each goat farmer and handler/vendor was sought using their native language and only those that consented were sampled.

Goats were sampled from three major locations in Maiduguri: Old GRA, Old Maiduguri, and Field Station (an institutional farm), serving as convenient collection points as shown in Figure 1. The goats sampled at the Old GRA and Old Maiduguri were trade stock, primarily sourced from Soro and Darazo markets in Bauchi State, as well as Babangida market in Yobe State. The goats sampled at Old GRA were sourced from Jaji Maji, Garin Alkali, and Geidam markets in Yobe State. In these locations, the Sahel goat breed was available for goat restocking programs in Borno State. The sampling at the Field Station involved a resident flock within Maiduguri, providing a localized reference point. Data on signalment (age, ecotype, weight, sex, body condition score) and reproductive history (history of abortion/retained placenta) were collected and recorded for each animal.

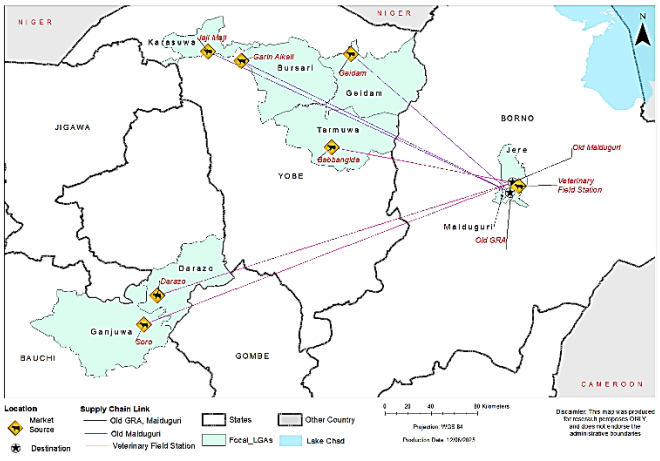

Figure 1: Map showing market locations from which goats for livestock restocking programs were sourced: Maiduguri (Borno State), Bauchi, and Yobe States, Nigeria.

Sample size determination for questionnaire respondents:

A preliminary study was used to identify a total of 51 goat farmers and handlers/vendors in the study area. Yamane's formulae (Yamane, 1967) was used to determine the sample sizes from among the consenting goat farmers and handlers/vendors.

$$n = \frac{\mathrm{N}}{1 + N(e^2)} = \frac{51}{1 + 51(0.05^2)} = 45.23$$

Where:

n = the desired sample size

N = the total population size (51)

e = the margin of error (usually 5% or 0.05 for 95% confidence interval)

Questionnaire design and data collection

The structured questionnaire was designed, pretested and validated using Cronbach's alpha (0.83). The questionnaire consists of four sections: respondents' demography, respondents' knowledge, attitude, and practices. The questionnaires were administered to 45 consenting goat farmers and handlers/vendors proportionately in Borno (n=27) and Yobe (n=18) states were randomly selected using simple random by balloting, to assess their KAP regarding reproductive diseases, including brucellosis. The questionnaire, administered by face-to-face interaction with respondents, captured respondents' experience with reproductive diseases and control/treatment practices.

Sampling and Laboratory Analysis

Approximately 5 mL of whole blood was collected from each restrained goat into sterile plain vacutainer tubes. The blood was allowed to clot at room temperature and then centrifuged (Thermo Fisher Scientific. USA) at 3000 rpm for 15 minutes to harvest the serum and stored at −20°C until serological analysis was performed at the Bacterial Research Laboratory at Ahmadu Bello University, Zaria.

Serological testing was performed using the Anigen® Rapid Antibody Test Kit (Bionote Inc., Korea), a chromatographic immunoassay designed for the qualitative detection of *B. melitensis* antibodies with a sensitivity of 98.3% and a specificity of 100%. The test was conducted according to the manufacturer's instructions. The results are recorded as positive (+) or negative (-) for each sample.

Data Analyses

The association between *B. melitensis* serostatus (positive/negative) and predictors (age, sex, ecotype, weight, location and body condition scores (BCS) of goats were assessed according to Vall *et al.* (2025), based on 6-levels assessment from 0 (emaciated) to 5 (overweight) and recorded for each animal selected. The data was analyzed using logistic regression to determine the odds ratios (ORs) and their 95% confidence intervals (CIs). The significance of prevalence across locations was tested using Fisher's exact test. Values ($p \leq 0.05$) were considered statistically significant.

The Knowledge, Attitude, and Practice (KAP) of the respondents were assessed using a structured scoring system. Each correct or desirable response was assigned a point, and the cumulative scores for each domain were converted into percentages. The KAP study were scored using the 3-point Likert scale (Lehman and Hulbert, 1972). The scores were categorized into three tiers based on modified Bloom's cut-off points for KAP study: {80%–100% (good); 60%–79% (moderate), and ≤59% (poor)} as described by Cloete *et al*. (2019).

RESULTS

The overall seroprevalence of *B melitensis* in Maiduguri was 5.0 % (Table 1). Table 2 shows that older goats were more likely to be positive for *B melitensis* (95% CI: 0.802, 12.206) but there is no significant difference. Female goats were apparently 17% more seropositive than the male goats (95% CI (0.233 .5.933), however, that is not statistically significant. The prevalence differed across the three sampled locations (X^2 = 5.6, p = 0.033), with the Field Station recording the highest prevalence (11. 8%), this is also statistically significant. Weight was the only variable that showed a statistically significant association with seropositivity (OR: 0.655, p=0.016).

Table 1: Prevalence of *B. melitensis* in Maiduguri, Nigeria

Location/Group	*B melitensis* Status	
	Positive	**Negative**
Old GRA	1 (1.3 %)	77 (98.7 %)
Old Maiduguri	3 (6.2 %)	45 (93.8 %)
Field Station	4 (11.8 %)	30 (88.2 %)
Total	8 (5.0 %)	152 (95.0 %)

X^2 = (df= 2, N = 160) = 5.6, p = .033

Table 2: Risk factors of *B. melitensis* in Maiduguri, Nigeria

Variables	Odds ratio	P- value	95 % C.I.	
			Lower	**Upper**
Age	3.129	0.101	0.802	12.206
Body Condition Score	0.729	0.648	0.187	2.836
Ecotype	1.219	0.617	0.561	2.648
Weight	0.655	0.016	0.465	0.923
Sex	1.176	0.844	0.233	5.933

Knowledge, Attitude, and Practices (KAP) of Respondents

The survey included 45 respondents (60% from Borno, and 40% from Yobe State).

Knowledge of Respondents on Reproductive Diseases

The assessment of knowledge, as shown in Table 3, indicates that the majority of respondents (52.4%) perceived their knowledge level regarding reproductive diseases as "moderate," whereas 30.9% rated it as "low" or "very low." Although more than half (53.5%) were aware of infectious diseases that cause abortion and infertility, there was a significant gap in specific disease identification; 82.2% of respondents did not know which specific outbreak they had observed, and only 17.8% identified Brucellosis. Furthermore, a slight majority (51.2%) were unaware of the zoonotic potential of these diseases, indicating a risk to public health.

Attitude of Respondents toward Reproductive Diseases

The attitudes toward preventive health measures are shown in Table 5. Vaccination coverage was low, with 44.2% of respondents reporting their flocks were not vaccinated and 23.3% being unaware of their flock's vaccination status. Among those who were vaccinated, 36.4% administered the PPR vaccine, but none reported vaccinating against Brucellosis. Despite this, there was a high level of clinical observation, as 77.3% of respondents had observed symptoms like abortion or retained placenta in their herds. While 90.4% expressed some degree of concern regarding disease impact, the majority (61.9%) were only "moderately" concerned.

Practices of Respondents on Reproductive Diseases

As shown in Table 6, preventive and reactive practices were suboptimal. A significant majority (65.1%) of respondents implemented no preventive measures (such as quarantine or nutrition management) to control reproductive diseases. In response to a detected disease, nearly half (47.6%) took no action, and 38.1% resorted to self-medication. Professional veterinary consultation was utilized by only 9.5% of the participants, highlighting a major gap in formal animal healthcare practices.

The cumulative assessment of respondents in Table 6 indicates that Knowledge, Attitude, and Practice were all categorized as "Poor." The lowest score was recorded in the Practices domain (24.6%), suggesting that even when respondents had moderate knowledge or concern, it did not translate into effective action. The Total KAP score for the study population was 43.7%, falling well within the "Poor" description.

Table 3: Knowledge of respondents on reproductive diseases (n=45)

Variable	Response	Frequency	Percentage (%)
How would you rate your knowledge about reproductive diseases in livestock			
	Very low	5	11.9
	Low	8	19.0
	Moderate	22	52.4
	High	7	16.7
	Very high	0	0
	Total	**42**	**100**
Are you aware of infectious diseases that can cause abortion and infertility			
	Yes	23	53.5
	No	20	46.5
	Total	**43**	**100**
Which of the following outbreaks have you observed			
	Brucellosis	8	17.8
	Campylobacteriosis	0	0.0
	Leptospirosis	0	0.0
	Toxoplasmosis	0	0.0
	Don’t know	37	82.2
	Total	**45**	**100**
Are you aware that some reproductive diseases are zoonotic			
	Yes	20	48.8
	No	21	51.2
	Total	**41**	**100**

Table 4: Attitude of respondents on reproductive diseases (n=45)

Variable	Response	Frequency	Percentage (%)
Were the flocks vaccinated?			
	Yes	14	32.6
	No	19	44.2
	Don’t know	10	23.3
	Total	**43**	**100**

Type of vaccine administered?			
	Q fever	0	0.0
	PPR	16	36.4
	Brucellosis	0	0.0
	None	28	63.6
	Total	**44**	**100**
Which of the following outbreaks have you observed			
	Brucellosis	8	17.8
	Campylobacteriosis	0	0.0
	Leptospirosis	0	0.0
	Toxoplasmosis	0	0.0
	Don't know	37	82.2
	Total	**45**	**100**
Have you observed abortion/retained placenta or swollen knees in your flock/herd before			
	Yes	34	77.3
	No	10	22.7
	Total	**44**	**100**
How concerned are you about the impact of reproductive diseases on your livestock?			
	Not concerned	0	0.0
	Somewhat concerned	4	9.5
	Moderately concerned	26	61.9
	Highly concerned	9	21.4
	Very highly concerned	3	7.1
	Total	**42**	**100**

Table 5: Practices of respondents on reproductive diseases (n=43)

Variable	Response	Frequency	Percentage (%)
What preventive measures do you currently implement to control reproductive diseases?	Vaccinations	1	2.3
	Quarantine of new arrivals	10	23.3
	Regular health checks	1	2.3
	Proper nutrition	3	7.0
	None above	28	65.1
	Total	**43**	**100.0**
If a reproductive disease is detected, what actions do you take?	Isolate affected animal	1	2.4
	Consult a veterinarian	4	9.5
	Self-medication	16	38.1
	Cull affected animal	1	2.4
	No action	20	47.6
	Total	**42**	**100.0**

DISCUSSION

The observed seroprevalence of 5.0% for *B. melitensis* in goats in the current study is in agreement with Buhari *et al.* (2020), who found a brucellosis seroprevalence of 5.08% in small ruminants in Zaria, Kaduna State, Nigeria. However, it is lower than the previously reported regional pooled prevalence of 9% for Northeast Nigeria (Akinyemi *et al*., 2022). It is also considerably lower than figures from other parts of Nigeria, which range from 9.6% to 34.2% (Magaji *et al*., 2013; Ogugua *et al*., 2014). Olufemi *et al.* (2018) also reported a prevalence of 9.6% in Wukari, Taraba State, Nigeria. This relatively low figure in the current study could be due to several factors, including the possible depletion of heavily infected flocks during the conflict, the use of a more specific diagnostic assay such as ICT compared to the less specific Rose Bengal Plate Test (RBPT) used in some previous studies, or, most critically, the fact that many of the sampled animals may have been sourced from low-risk areas specifically for restocking.

The significant spatial variation in prevalence, where the Field Station recorded the highest prevalence (11.8%) compared to Old GRA (1.3%), highlights the micro-epidemiological complexity of the goat population within these locations. The goats sampled at the Field Station were from a permanent flock in existence for several years and located close to an established international cattle route from Nigeria to Cameroun, Chad and beyond. Thus, compared with those sampled at the Old GRA, the goats at the Field Station might have had exposure to the *Brucella* infection from flocks and herds passing through the cattle route. It could be deduced that the differences in prevalence are likely driven by variations in animal movement, farm management, and source of animals. Although livestock restocking programs, which involve large-scale animal movement, are recognized as a major mechanism for the spatial dissemination of high-risk pathogens like *Brucella* across areas as reported by Salajegheh-Tazerji *et al*. (2025), the opposite was found in the current study.

Kaltungo *et al.* (2019) had also reported variations in the geo-spatial distribution of *B. melitensis* infection in selected local government areas of Katsina and Sokoto States, Nigeria. The lower prevalence in the sourced goats may reflect successful sourcing from low-risk areas, but the higher prevalence in others suggests that screening programs for all flocks remain essential.

Regarding risk factors, the non-significant but notable finding that older goats were over three times more likely to be seropositive aligns with numerous studies (Gompo *et al*., 2021). Olufemi *et al.* (2018) also reported that age was a significant risk factor in brucellosis infection. It was suggested that older animals, especially females, have a greater cumulative risk of exposure over time due to repeated breeding and contact with aborting animals or contaminated environments (Gompo *et al*., 2021; Abichu *et al*., 2025).

The significant finding that weight was associated with seroprevalence is interesting and warrants further investigation. This negative association could imply that older, heavier goats may be less likely to be infected compared to younger goats that were potentially lighter. Gompo *et al.* (2021) also found that older sheep and goats were a significant risk factor for Brucella infection.

The semi-intensive farming system and small flock sizes, while typical of the Sahelian region, also contribute to the difficulty of implementing herd-level control. Since 65.1% of respondents had no specific control measures, the potential for rapid transmission, especially during the re-establishment of flocks through restocking is extremely high through contact with infected animals as reported by Brunetti *et al*. (2023). Conflicts have devastating effects including disruption of normal animal health services and surveillance, the destruction of wildlife habitats, and the increased interface between humans, wildlife, and domestic animals which contribute to spread of zoonotic pathogens from animals to humans (Salajegheh Tazerji *et al*., 2025). However, the prevalence of zoonotic pathogens such as *Brucella melitensis* varies regionally and is influenced by factors such as management practices, biosecurity measures, and the presence of competent vectors among many other factors (Mohammed*, et al.*, 2020; Arede*, et al.*, 2023). The lack of vaccination practices in Nigeria emphasizes the need for subsidized or government-led vaccination campaigns using the Rev. 1 vaccine to reduce the incidence of abortion and bacterial shedding as recommended by Pérez-Sancho *et al*. (2015).

The overall scores found in the current study were Knowledge (47.3%), Attitude (59.2%), and Practice (24.6%). The study identifies a critical deficit in managing reproductive diseases within the sampled population and indicates an unmanaged zoonotic risk.

The low knowledge score (47.3%) is especially alarming regarding zoonotic awareness (48.8%). While respondents recognized the existence of infectious diseases, they struggled to identify specific pathogens like Brucella or Leptospira. This suggests that current extension services fail to provide sufficient technical information. Furthermore, a profound gap exists between clinical observation and etiological understanding. Although 77.3% of respondents observed clinical signs (such as abortion and retained placenta), over 80% remained unaware of formal disease outbreaks, and only 17% suspected brucellosis. This finding may be explained by the subtle nature of the disease, as noted by Mazlina *et al*. (2021) that, *B. melitensis* often fails to produce gross lesions or obvious clinical symptoms in non-pregnant goats, despite causing internal inflammation.

Although poor knowledge itself is a problem, even in previous study by Batiha *et al*. (2018), who reported good knowledge of brucellosis among Jordanian healthcare workers yet failed to use protective wear despite professional or personal concern.

It was also found that 90.4% of respondents in the current study were moderately to highly concerned about reproductive disease impact, yet only 32.6% engaged in vaccination (PPR only). This aligns with findings by Cloete *et al*. (2019), who observed that while communal farmers perceive a high level of "threat," they often lack the technical self-efficacy or resources to implement biosecurity measures.

The practice score was the lowest recorded (24.6%), highlighting systemic failures in disease control. The reliance on self-medication (38.1%) and a high rate of "No Action" (47.6%) following disease detection facilitates the persistence of pathogens in the environment and leads to significant economic losses through livestock infertility. This behavioral gap remains a primary driver of human brucellosis cases in endemic regions, maintaining a critical and unmanaged zoonotic reservoir (Akinyemi *et al*., 2022; Mia *et al*., 2022).

In conclusion, the overall seroprevalence of *B. melitensis* in goats in Maiduguri, Borno State, was 5.0%, which is lower than historical regional data. However, the significant variation across locations suggests that the movement of animals presents an ongoing risk. Age and location were identified as important epidemiological factors, while weight showed a significant association with seropositivity. The poor scores found in this study across Knowledge (47.3%), Attitude (59.2%), and Practice (24.6%), suggest failure in managing reproductive diseases, which may continue to drive economic losses and pose a public health threat.

It is recommended that veterinary and public health departments should collaborate on "One Health" awareness campaigns on the zoonotic risks of Brucellosis, emphasizing the dangers of handling aborted fetuses without protection or consuming unpasteurized milk. Veterinary extension services should be strengthened to discourage self-medication, which can lead to antimicrobial resistance and ineffective disease control.

Authors Contributions

MMB and MAS designed the study and performed data collection; MA and KO conducted the data analysis and drafted the manuscript. CK and GSK provided supervision throughout the entire process, from conceptualization to final manuscript preparation. All authors have read and approved the final version of the manuscript.

Conflict of Interest

The first author (MMB) is an editor with the Sahel Journal of Veterinary Sciences

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