# Sero-prevalence and risk factors associated with brucella infection in cattle in Nasarawa South Senatorial Zone, Nasarawa State, Nigeria

**Anzaku, E.A.[1], Agada, C. A.[2], Ofukwu, R. A.[2], Kwaga J. K. P. [3], Ogugua, A. J.[4]**

[1]*Department of Animal Science College of Agriculture, Science and Technology, Lafia, Nasarawa State, Nigeria*

[2]*Department of Veterinary Public Health and Preventive Medicine, College of Veterinary Medicine, Federal University of Agriculture, Makurdi, Nigeria*

[3] *Department of Veterinary Public Health and Preventive Medicine, Faculty of Veterinary*

[4]*Department of Veterinary Public Health and Preventive Medicine, Faculty of Veterinary Medicine, University of Nigeria Nsukka.*

**Corresponding email**: Ogugua.akwoba@unn.edu.ng: +2348033844475

**Abstract**

*Brucellosis is a zoonotic disease caused by Brucella species prevalent in Nigeria. Although Nasarawa South Senatorial Zone, Nasarawa State, Nigera has the highest number of grazing reserves in the state, data on the disease in resident cattle are scarce in the literature. This study therefore aimed to determine the prevalence of Brucella infection and the risk factors in resident cattle herds in the senatorial zone. A cross-sectional study was conducted on 2,600 cattle from 130 herds in the five Local Government Areas (Awe, Doma, Lafia, Obi and Keana LGAs) of the senatorial zone. Serum samples from these animals were examined for antibodies against brucellosis using the Rose Bengal Test (RBT) and risk factors for the seropositivity determined. Data generated were analysed with Chi-square at 0.05 level of significance. Out of the 2,600 cattle screened for seropositivity to Brucella infection, 201 (7.7%) were positive. The individual animal prevalence of Brucella infection was found to be associated with locations (p = 0.003) and age (p = 0.000 respectively). Herd prevalence was found to be 10% with the prevalence being highest in Awe LGA. Factors associated with seropositivity to brucellosisin theherd were location (p = 0.003) and age (p = 0.001) of the animals. Herd owners in the area should be educated on brucellosis, and as well screened for Brucella infection.*

**Keywords**: Sero-Prevalence, Risk Factors, Rose Bengal Test, Cattle

**Running title:** Catlle herds brucellosis in South Senatorial Zone, Nasarawa State

# Séroprévalence et facteurs de risque associés à l'infection à Brucella chez les bovins dans la région sénatoriale sud de Nasarawa, État de Nasarawa, Nigéria

**Résumé**

*La brucellose est une maladie zoonotique causée par des espèces de Brucella et répandue au Nigéria. Bien que la région sénatoriale sud de Nasarawa, dans l'État de Nasarawa, compte le plus grand nombre de réserves de pâturage de l'État, les données sur cette maladie chez les bovins résidents sont rares dans la littérature. Cette étude visait donc à déterminer la prévalence de l'infection à Brucella et les facteurs de risque dans les troupeaux bovins résidents de cette zone sénatoriale. Une étude transversale a été menée sur 2 600 bovins provenant de 130 troupeaux dans les cinq zones de gouvernement local (Awe, Doma, Lafia, Obi et Keana) de la zone sénatoriale. Des échantillons de sérum de ces animaux ont été analysés pour détecter la présence d'anticorps contre la brucellose à l'aide du test au Bengale rose (Rose Bengal Test, RBT), et les facteurs de risque associés à la séropositivité ont été déterminés. Les données obtenues ont été analysées à l'aide du test du Chi carré, avec un seuil de significativité de 0,05. Sur les 2 600 bovins testés pour la séropositivité à l'infection à Brucella, 201 (7,7 %) se sont révélés positifs. La prévalence individuelle de l'infection à Brucella était associée à la localisation (p = 0,003) et à l'âge (p = 0,000) des animaux. La prévalence au niveau des troupeaux était de 10 %, la plus élevée étant observée dans la zone de gouvernement local d'Awe. Les facteurs associés à la séropositivité pour la brucellose étaient la localisation (p = 0,003) et l'âge (p = 0,001) des animaux. Les propriétaires de troupeaux dans la zone devraient être sensibilisés à la brucellose et également dépistés pour l'infection à Brucella.*

**Mots-clés** : Séroprévalence, Facteurs de risque, Test au Bengale rose, Bovins

## Introduction

Bovine brucellosis is a contagious systemic disease primarily of ruminants, characterized by inflammation of the genital organs and foetal membranes, abortion, sterility, and formation of localized lesions in the lymphatic system and joints (CDC, 2011). In humans, brucellosis results to grave and debilitating condition requiring prolonged and costly treatments (O'Callaghan, 2020). Thus, the disease presents a serious threat to the livestock industry and public health (McDermott *et al*., 2013). Brucellosis is considered one of the most widespread zoonoses in the world (Hull and Schumaker, 2018) and has great impact on emerging economies and in resource poor countries (Ukwueze *et al*., 2022). Although eradicated in ruminants in most European countries, the USA, Canada, Australia and a few other countries (Blasco *et al*., 2023), *Brucella* infection is, prevalent in parts of Asia (Chahota *et al*., 2003); South America (Dias *et al*., 2009); and Africa (Ogugua *et al*., 2015). Moreover, the intensification of livestock caused by rising food demand has increased the risk of the spread of the disease and other zoonoses (Jones *et al*., 2013).

In cattle, the disease is transmitted by contact with infected uterine discharges and maternal transfer either by suckling or *in vivo* (Corbel, 2006). When the reproductive performance of the carrier animals seems unaffected, they are retained in herds especially in developing countries like Nigeria despite the presence of pathognomonic clinical signs in some cases, making effective control programmes are extremely difficult (Mai *et al*., 2012).

In cattle herds, *Brucella* infection results in huge economic losses due to decreased calving percentage, culling for infertility, decreased milk production, abortion, stillbirth or birth of weak calves; as well as loss of man hours in infected people (McDermott and Arimi2002; Ocholi *et al*., 2004; Adamu, 2009). The presence of brucellosis in cattle herds portends a major public health problem, especially to individuals with regular contact with cattle as well as the members of the general public who consume unpasteurised milk and milk products of cattle origin. *Brucella* infection remains a problem in Nigeria due to lack of official policy for the control of the disease (Ibironke *et al*., 2008), uncontrolled movement of slaughtered cattle within and from neighbouring countries (Nwakanma and Aina, 2023), nomadism (Tuki, 2023) and poor knowledge and practices concerning the diseases among farmers and other risk groups (Adesokan *et al*., 2013). In Nasarawa South Senatorial Zone, many farmers are involved in agro-pastoralism whereby cattle are raised in small herds in the backyard of the farmers where grasses are cut and given to the animals or the animals are taken to the nearby communal grazing lands. The animals are therefore resident in the communities and not involved in long-distance movement in search of feed and water. Being resident herds, they are close to homes, resulting to regular contact between the herds and owners. The presence of brucellosis in these herds therefore portends a risk of infection to handlers and in-contact herds with *Brucella*. Screening these animals for brucellosis and determining risk factors for the disease will therefore provide useful information for the control of the disease in humans and animals in the area. This study, therefore determined the prevalence of brucellosis and the associated risk factors in resident cattle herds of Nasarawa South Senatorial Zone, Nasarawa State, Nigeria.

## Materials and Methods

### *Study Areas*

Nasarawa State is in North-Central Nigeria, and lies between (Latitude 8.33N and Longitude 8.33 E) at an altitude of 181.35m above sea level), with a population of 2,040,097 and an area of 27,117sq km (population density 75 persons/sq. km) (National Population Commission 2006)). The State lies within the Guinea savannah zone of the country with an average rainfall of 1182mm annually (Nigerian Meteorological Agency, 2010). It shares boundaries with Benue and Kogi States in the South, Taraba and Plateau States in the East, in the North with the Nassarawa Eggon Local Government Area, and in the West with the Kokona Local Government Area. The occupations of the inhabitants include civil service and trading, but the majority are

farmers. Major livestock in the area are cattle, sheep, goats and pigs. The Nasarawa South Senatorial Zone is made of five Local Government Areas (LGAs): Awe, Keana, Obi, Lafia and Doma (Figure 1). Except for Obi, the other four LGAs harbour grazing reserves. The Awe and Keana grazing reserves were established in 1979 and gazetted in 1992 (Hir, 2016). The Awe grazing reserve has the largest size with 2600 hectares, while the rest Keana, Lafia and Doma are 1700 hectares each (Fudeco, 2024) Although, Obi LGA has no grazing reserve, it lies at the middle of the other four LGAs.

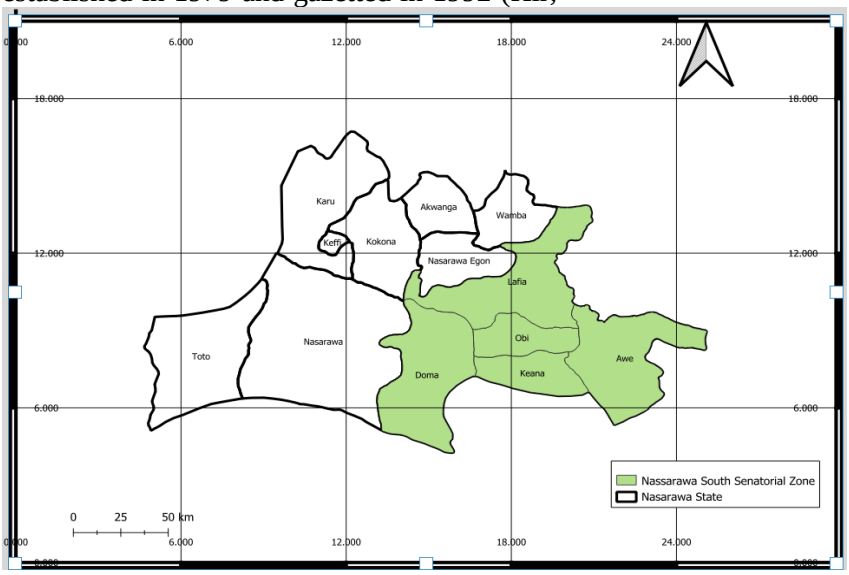


**Figure 1: Map of Nasarawa State showing the study area**

***Study design***

The study adopted a herd-based cross-sectional study to determine the sero-prevalence and the associated risk factors for *Brucella* infection among cattle herds in the Nasarawa South Senatorial Zone, Nasarawa State, Nigeria.

***Sample size and sampling***

The required number of cattle sampled for this study was calculated to be 1474 using the individual animal prevalence of 4.1% (Ibrahim *et al*., 2019) calculated with the sample size calculation formular for cross-sectional studies: $n = 1.96^2 P\text{exp}\ (1- P\text{exp})/d^2$ (Thrusfield, 2018). However, samples were collected from 2600 animals originating from from 117 herds..

***Consent***

Oral consent was obtained from each participant herd owner/caretaker.

***Animal sampling, sample collection and handling***

Blood samples were aseptically collected from the jugular veins of cattle at the farms visited. However, about 10% of animals in each herd were screened in each Local Government Area. For each animal, about 7 mL of blood was collected from the jugular veins into 15 mL sterile tubes with 10 mL syringe and 19 guage needle.. Animals' parameters such as breed, sex, age and location were recorded on each bottle. The age of the animals was determined by the dentition technique (Lasisi *et al*., 2002; Pace and Wakeman, 2003) into two age groups of young cattle which are ≤ 2 years and adult cattle of > 2 years of age. The blood samples were allowed to clot and transported in flasks in ice packs to the laboratory. In the laboratory, the blood samples were centrifuged at 3000*g* for 5 min. Serum samples were then decanted and stored at – 20 °C until assay. The serum samples were examined with Rose Bengal Test (RBT) (Alton *et al*., 1988).

***Statistical Analysis***

Data collected was entered into Excel sheets and analyses were performed using the statistical software package STATA version12. Data was analysed to determine the association between seropositivity to *Brucella* antibodies and the location, breed, sex and age. Group differences were tested using Chi-square statistics for categorical variables. A multi-variable adjusted logistic regression was carried out using all the variables statistically significant at the 10% level with the main outcome measures Rose Bengal Test (RBT) in

bivariate analysis. All tests were two-tailed and statistical significance was set at $p < \alpha$ (0.05).

**Results**

The individual animal prevalence of Brucella infection in cattle was measured with the Rose Bengal Test (RBT) in Nasarawa South Senatorial Zone, Nasarawa State, Nigeria.

The study showed seropositivity in 7.7% (201/2600) of the 2,600 individual cattle screened with Rose Bengal Test (RBT). Individual animal prevalence of Brucella infection was higher in Awe, Keana and Obi 120/1,289 (9.3%) than in Lafia and Doma 81/1,303 (6.2%). Older animals (> 5 years) had the highest prevalence (16 %) followed by those aged 2 - 5 years (9.8%), while those of 0 - 2 years had the least with the prevalence of 3.9%. The prevalence was almost the same in both sexes with the female having a slightly higher prevalence (7.9%) than the male (7.4%). There was statistical significant association between Brucella seropositivity and location ($p = 0.003$) as well as the age ($p = 0.001$) of the cattle (Table 1). Cattle aged five years and above were found to be five times more likely to be seropositive for *Brucella* infection followed by cattle aged between greater than 2 years and 5 years being three times more likely to be positive to the infection.

**Table 1. Individual Animal Prevalence of *Brucella* Infection in the Cattle as Measured with the Rose Bengal Test (RBT) in Nasarawa South Senatorial Zone, Nasarawa State, Nigeria**

| Variables | Characteristics | Positive (%) | Negative (%) | Chi-square | P-value | Odds Ratio |
|---|---|---|---|---|---|---|
| Location (LGAs) | Awe, Keana, and Obi | 120 (9.3) | 1169 (90.7) | | | 1.55 |
| | Lafia and Doma | 81 (6.2) | 1222 (93.2) | 8.667 | 0.003 | |
| Age of animals | 0 - 2 years | 38 (3.9) | 943 (96.1) | | | 1 |
| | > 2 – 5yrs | 153 (9.8) | 1404 (90.2) | | | 2.7 |
| | > 5 yrs | 11 (16.9) | 54 (83.1) | 37.614 | 0.001 | 5.1 |
| Sex | Male | 60 (7.4) | 748 (92.6) | | | |
| | Female | 141 (7.9) | 1652 (92.1) | 0.15 | 0.699 | 1.1 |
| Herd size | 1 – 39 | 13 (24.5) | 40 (75.5) | | | |
| | ≥ 40 | 20 (42.6) | 27 (57.5) | 3.7 | 0.056 | 2.3 |

**Herd Prevalence of *Brucella* Infection in the Cattle as measured with the Rose Bengal Test (RBT) in Nasarawa South Senatorial Zone, Nasarawa State, Nigeria**

The overall herd prevalence in this study is 10% (13/130) while the herd prevalence of *Brucella* infection in the different LGAs was found to be 23.07, 11.54, 7.69, 3.85 and 3.85% in Awe , Doma, Lafia, Obi and Keana respectively (Table 2).

**Table 2: Herd prevalence of *Brucella* infection in cattle as measured with the Rose Bengal Test (RBT) in Nasarawa South Senatorial Zone, Nasarawa State, Nigeria**

| **Locations** | **No of herd sampled** | **Positive (%)** | **Negative (%)** |
|---|---|---|---|
| Awe | 26 | 6 (23.07%) | 20 (76.93) |
| Doma | 26 | 3 (11.54%) | 23 (88.46) |
| Lafia | 26 | 2 (7.69%) | 24 (92.31) |
| Obi | 26 | 1 (3.85%) | 25 (96.15) |
| Keana | 26 | 1 (3.85%) | 25 (96.15) |
| **Total** | **130** | **13 (10.00)** | **117 (90.00)** |

**Discussion**

The individual animal prevalence of *Brucella* infection recorded in Nasarawa South Senatorial Zone, Nasarawa State was 7.7%. This infection rate observed is comparable to 7% recorded in Bauchi State (Ahmad *et al*., 2020) and 9.6% in Plateau State (Nanven *et al*., 2013). The prevalence could be attributed to the

lack of policies being implemented to control the disease in Nigeria (Cadmus *et al*., 2020), uncontrolled movement of livestock within the country and from neighbouring countries (Umoh, 2017), grazing in game reserves, ignorance of the mode of transmission the disease among farmers (Adesokan *et al*., 2013), retaining of animals showing pathognomonic signs of the disease (Ocholi *et al*., 2004) and many other factors. However, the prevalence recorded is lower than 26.3% in three northern states of Nigeria (Ocholi *et al*., 2004), 42.1% in Obudu Cross River State (Nanven *et al*., 2013) and 25.9% in Ethiopia (Warioba *et al*., 2023). This low prevalence could be due to the fact that the majority of the cattle sampled were from resident herds and are not involved in seasonal migration which is a risk factor to pastoralist herds in Nigeria (Mbuk *et al*., 2011). It is a common knowledge that resident herds are relatively small (Agada *et al*., 2017) and small herds are at lower risk of exposure to brucellosis (Megersa *et al*., 2011). This is in tandem with the fact that the study recorded a higher prevalence (42.6%) in herds with 40 and above number of animals. The finding is similar to what was recorded in other studies that found the prevalence of brucellosis to be higher in large herds than in small herds (Jergefa *et al*., 2009; Makita *et al*., 2011; Megersa *et al*., 2011, Cadmus *et al*., 2020). This is in line with the epizootiological rule of "large herds, large incidence and small herds, low incidence" observed by Akakpo and Bornarel (Akakpo and Bornarel, 1987). With the increased herd size, there is high stocking density when compared to small herds, increasing the likelihood of exposure to contaminated materials (Cadmus *et al*., 2020).

Herd prevalence of *Brucella* infection was highest in Awe LGA. This LGA harbours the biggest and oldest grazing reserve in the state. It therefore serves as the biggest point of cattle herd aggregation in the state. In addition, due to the absence of restriction, inadequate grazing lands, water and other amenities, there is continuous movement of different herds in, out and between the grazing reserves in Nigeria (Ducrotoy *et al*., 2016). Increased contact between different herds elevates the exposure potential given the high degree of interaction among different potentially infected herds while sharing grazing lands and watering points (Ocholi *et al*., 2004; Matope *et al*., 2011). Previous findings have shown that the aggregating of cattle herds especially during the dry season enhances *Brucella* transmission among herds (Ocholi *et al*., 2004). Communal pastures and common watering points are very important locations for acquiring the infection (Mohammed *et al*., 2020; Simango *et al*., 2024). In addition, continuous movement of pastoral herds, and indiscriminate grazing are known to contaminate the environment and grazing areas thereby exposing resident herds to *Brucella* infection (Lokamar *et al*., 2022).

The work also recorded statistically significant association between *Brucella* seropositivity and the age of cattle with the older animals being more likely to be infected. This could be attributed to the fact that brucellosis is a chronic disease and susceptibility is seen to increase after sexual maturity and pregnancy (Bekele *et al*., 2011; Ocholi *et al*., 2004; Ana *et al*., 2018), thereby resulting to the seroprevalence being higher in adults than young animals. This is in tandem with the reports of Cadmus *et al.* (2010) and Assange *et al.* (2015), but in contrast with some studies (Ogugua *et al*., 2015; Warioba *et al*., 2023) that reported prevalence being higher in young animals. Additionally, older animals have longer exposure potentials (Ducrotoy, 2016) during their lifetime (Demissie *et al*., 2024) and re-infection may continue to occur (Ogugua *et al*., 2015).

Cows showed slightly higher seropositivity to the infection compared to bulls. Given that more cows are retained for breeding and milk production, they last longer in the herds increasing their likelihood of infection. Moreover, the higher prevalence in cows may be due to the tropism of *Brucella* to the pregnant uterus (Carvalho *et al*., 2023), and an increased parity number has been associated with *Brucella* infection (Nath *et al*., 2023). Erythritol sugar which is preferentially metabolised by the organism is produced in the placenta (Neta *et al*., 2008). Furthermore, stress associated with pregnancy, parturition and lactation, which cows usually undergo, tends to lower their immunity and predisposes them to *Brucella* infection. The pregnancy period which precedes milking is noted to be associated with brucellosis (Swai and Schoonman, 2010). The multiplication of the *Brucella* organism results in inflammation that leads to abortion which may not occur in

subsequent pregnancies (Corbel, 2006). However, such animals may become latent carriers that could only be detected by serological tests during and after pregnancies (CFSPH, 2009). Retaining animals with signs of brucellosis in herds is common in Nigeria (Mai *et al*., 2012).

**Conclusion**

It was evident from this study that *Brucella* infection is endemic in Nasarawa South Senatorial Zone. Location, age and herd size were significantly associated with the prevalence of the disease in the area. This is very important given that these resident herds live with the owners. Therefore, the chances of transmission to the owners are very high. In addition, the productivity of these herds will be economically affected.

**Recommendations**

Farmers in the area should be educated on the control of the disease among the heads and ways to prevent themselves from infection. Herd owners should minimize grazing their animals in communal grazing areas and water points. Animals showing clinical signs of brucellosis should be culled. Herders and their families in the area should be screened for brucellosis and found positive be referred to the hospital for further tests and treatment.

***What is already known about brucellosis in Nigeria***

Brucellosis is prevalent in Nigeria with cattle brucellosis being the most common type in livestock in the country.

***What this study adds***

This study has shown the prevalence of brucellosis in cattle in Nasarawa State, Nigeria. This brings to light the fact that individuals in close contact with cattle in the state are at risk of contracting brucellosis.

***Competing interests***

The authors declare no competing interest.

***Authors' contributions***

**AEA**: Design, literature search, data acquisition, data analysis, manuscript preparation, statistical analysis

**ACA**: Design, data analysis, manuscript preparation, manuscript editing, manuscript review

**ORA**: Concept, design, manuscript editing, data analysis, manuscript review

**JKPK:** supervision

**OAJ:** Design, manuscript preparation, manuscript editing, manuscript review, map drawing

**Acknowledgements**

We wish to acknowledge the McArthur Foundation supportd Centre of Excellence in Veterinary Epidemiology Department of Veterinary Public Health and Preventive Medicine, Ahmadu Bello University, Zaria for sponsoring this project. We appreciate the farmers at Doma, Lafia, Obi, Keana and Awe for consenting to the use of their cattle.

**References**

**Adamu N. B. 2009.** Epidemiology of brucellosis infection in ruminant and humans and its Public Health Implication in Borno State, Nigeria. PhD thesis vet Publ. health and Preventive Medicine Department ABU, Zaria, Nigeria

**Adesokan H. K., Alabi P. I., Stack J. A., Cadmus S. I. B. 2013.** Knowledge and practices related to bovine brucellosis transmission amongst livestock workers in Yewa, South western Nigeria. Journal of the South African Veterinary Association. 84: 121-12

**Agada C. A., Goden C. P., Ogugua J. 2017.** Prevalence of bovine brucellosis and analysis of risk factors in resident cattle herds of Kanke local government area, Plateau State. *Nigeiar Veterinary Journal*; 38:104-16.

**Agada C. A., Ogugua A. J., Anzaku E. J. 2018.** Occurrence of brucellosis in small ruminants slaughtered in Lafia central abattoir, Nasarawa State, Nigeria. *Sokoto Journal of Veterinary Sciences*, *16* (1), 16–23.

**Ahmad A. A, Mai H. M. Abdullahi U. S. 2020**. Prevalence Of Brucellosis In Some Settled Cattle Farms In Bauchi Local Government Area, Bauchi State, Nigeria Nigerian Society For Animal Production (Nsap) 45th Annual Conference – Bauchi. 2020 Book of Proceedings: 528 – 531.

**Akakpo A. J., Bornarel P. 1987.** Epidémiologie des brucelloses animales en Afrique tropicale: Enquêtes clinique, sérologique et bactériologique. Revue scientifique et

technique de l'Office international des épizooties. 6: 981–4181027.

**Alton G. G., Jones L. M., Angus E. D., Verger J. M. 1988**. *Techniques for the brucellosis laboratory*. Paris: Institute National De La Recherche Agronomique 147, rue de I'Universite, 75007 Paris.

**Ana C. C., Juan G. D., Adosinda M. C. 2015**. Risk Factors for *Brucella* spp in domestic and wild animals. https://www.intechopen.com/books/updates-on-brucellosis/risk-factors, retrieved 10-7-2023.

**Assenga J. A., Matemba, L. E., Muller S. K., Malakalinga J. J., Kazwala R. R. 2015.** Epidemiology of Brucella infection in the human, livestock and wildlife interface in the Katavi- Rukwa ecosystem, Tanzania. *BMC Veterinary Research*. 11:189. PubMed | Google Scholar.

**Bekele M., Mohammed H., Tefera M., Tolosa T., 2011.** Small ruminant brucellosis and community perception in Jijiga district, Somali Regional State, eastern Ethiopia. Tropical Animal Health and Production, 43 (4): 893-898.

**Blasco, J.M., Moreno, E., Muñoz, P.M., Conde-Alvarez R., Moriyon, I., 2023**. A review of three decades of use of the cattle brucellosis rough vaccine *Brucella abortus* RB51: myths and facts. *BMC Veterinary Research* **19**: 211. https://doi.org/10.1186/s12917-023-03773-3.

**Cadmus S. I. B., Adesokan H. K., Adedokun B. O., Stack J. A., 2010.** Seroprevalence of bovine brucellosis in trade cattle slaughtered in Ibadan, Nigeria, from 2004-2006. Journal of the South African Veterinary Association; 81(1):50-53

**Cadmus S. I., Akporube K. A., Ola-Daniel F., Adelakun O. D., Akinseye V. O. 2020**. Seroprevalence and associated factors of brucellosis and Q-fever in cattle from Ibarapa area, Oyo State, South-western Nigeria. Pan African Medical Journal; 29;36:370. doi: 10.11604/pamj.2020.36.370.24925. PMID: 33235647; PMCID: PMC7666694.

**Carvalho TP, Silva LAD, Castanheira TLL, Souza TD, Paixão TAD, Lazaro-Anton L, Tsolis RM, Santos RL. 2023.** Cell and Tissue Tropism of Brucella spp. Infect Immun. 16;91(5):e0006223. doi: 10.1128/iai.00062-23. Epub 2023 Apr 27. PMID: 37129522; PMCID: PMC10187126.

**CDC 2011**. Centre for Disease Control and Prevention. Summary of Notifiable Disease. United States 209, MMWR 58 (53) 1-1001.

**CFSPH. 2009.** Bovine Brucellosis: Brucella abortus. Center for Food Security and Public Health, College of Veterinary Medicine, Iowa State University, Ames, Iowa., pp. 1–6.

**Chahota R., Sharma M. and Katoch R. C. 2003**. Brucellosis outbreak in an organized dairy farm involving cows and in contact human beings, in Himachal Pradesh, India. Veterinarski Arhive, 73 (2), 95–102.

**Corbel M. J. 2006.** *Brucellosis in humans and animals*. World Health Organization, 20 Avenue Appia, 1211 Geneva 27, Switzerland. Retrieved from http:// www. who.int/csr/resources /publications/Brucellosis.pdf May, 2014.

**Demissie W., Asmare K., Legesse M., Aragaw K., Sheferaw D. 2024.** Sero-epidemiological study of brucellosis in cattle under pastoral/agro-pastoral and mixed crop-livestock systems in South Omo, southern Ethiopia, Heliyon, 10(12):e33413 https://doi.org/10.1016/j.heliyon. 2024.e33413.

**Dias, R. A., Gonçalves V. S. P., Figueiredo V. C. F. 2009.** Epidemiological situation of bovine brucellosis in the State of São Paulo, Brazil. Arquivo Brasilero Medicina Veterinaria Zooteccnia, 61 (1), 118– 125.

**Ducrotoy M. J., Majekodunmi A.O., Shaw A. P. M., Bagulo H., Musa U. B., Bertu W. J., Gusi A. M., Ocholi R. A., Bryssinckx W., Welburn S. C. 2016.** Fulani cattle productivity and management in the Kachia Grazing Reserve, Nigeria. *Pastoralism* 6, 25.

https://doi.org/10.118 6/s13570-016-0072-y

**FUDECO. 2024.** List of grazing reserves, in Nigeria. Accessed 15/12/24 at chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://fudeco-ngo.org/wpcontent/ uploads/2024/07/ Grazing-reserves-in-Nigeria.pdf).

**Hir J. 2016**, **Tracing old grazing reserves, routes in Nasarawa** accessed 15/12/24 from https://dailytrust.com/tracing-old-grazing-reserves-routes-in-nasarawa/.

**Hull N. C., Schumaker B. A. 2018**. Comparisons of brucellosis between human and veterinary medicine. Infection Ecology and Epidemiology, 8: 1500846. DOI.

**Ibironke A. A., McCrindle C. M., Fasina F. O., Godfroid J. 2008**. Evaluation of problems and possible solutions linked to the surveillance and control of bovine brucellosis in sub-Saharan Africa, with special emphasis on Nigeria. *Veterinary Italiana;* 44:549-56.

**Ibrahim Y., Mai H. M., Kalla D. J. U., Kabir J., Nathaniel J. 2019**. Seroprevalence and potential risk factors of bovine brucellosis at the livestockwildlife interface area of Yankari game reserve, Bauchi State, Nigeria. Nigeria Journal of Animal Production; 46(4):33–44.

**Jergefa T., Kelay B., Bekana M., Teshale S., Gustafson H., Kindahl H. 2009.** Epidemiological study of bovine brucellosis in three agro_ecological areas of central Oromiya, Ethiopian Journal of Science and Technology 28 (3):933-943.

**Jones B. A., Grace D., Kock R, Alonso S., Rushton J., Said M. Y., McKeever D., Mutua F., Young J., McDermott J., Pfeiffer D. U. 2013.** Zoonosis emergence linked to agricultural intensification and environmental change. Proceedings of the National Academy of Sciences, U.S.A., 110: 8399–8404.

**Lasisi O. T., Ojo, N. A., Otesile E. B. 2002.** Estimation of age of cattle in Nigeria using rostral dentition. Tropical Veterinarian, 20: 204-208.

**Lokamar P. N., Kutwah M. A., Munde E. O., Oloo D., Atieli H., Gumo S., Ouma C. 2022.** Prevalence of brucellosis in livestock keepers and domestic ruminants in Baringo County, Kenya. PLOS Global Public Health, 15:2(8):e0000682. doi:10.1371/journal.Pgp h.0000682

**Mai H.M., Irons, P.C., Junaidu, K., Thompson P.N. 2012**. A large seroprevalence survey of brucellosis in cattle herds under diverse production systems in northern Nigeria. *BMC Veterinar Research*, 8: 1-14.

**Makita, K., Fèvre, E. M., Waiswa, C., Eisler, M. C., Thrusfield, M., & Welburn, S. C. (2011).** Herd prevalence of bovine brucellosis and analysis of risk factors in cattle in urban and peri-urban areas of the Kampala economic zone, Uganda. *BMC veterinary research*, *7*:1-8.

**Matope G., Bhebhe E., Muma J., Oloya J., Madekurozwa R., Lund A. 2011.** Risk factors for Brucellas pp. infection in smallholder household herds. *Epidemiology and Infection.*139 (1):157–164.

**Mbuk, E. U., Ajogi, I., Bale, J. O. O. Umoh, J. U. 2011.** Prevalence of Brucella antibodies in migratory Fulani cattle herds in Kaduna State, Nigeria. *Nigerian Veterinary Journal*, 32 (1), 26–29

**McDermott J, Grace D, Zinsstag J. 2013.** Economics of brucellosis impact and control in low-income countries. Revue scientifique et technique. Office international des épizooties, 32: 249–261. DOI: http://www.doi.org/10.20506/rst.32.1.2197.

**McDermott J. J., Arimi S. M. 2002**. Brucellosis in sub-Saharan Africa: epidemiology, control and impact. *Vet Microbiol*. 90 (1- 4):111-134.

**Megersa B., Biffa D., Niguse F., Rufael T., Asmare K. Skjerve E. 2011.** Cattle brucellosis in traditional livestock husbandry practice in Southern and Eastern Ethiopia, and its zoonotic implication. *Acta Veterinaria Scandinavica*, 53 (1), 24. doi:10.1186/1751-0147-53-24.

**Mohammed F.U, Ibrahim S., Musa G. A., Kaltungo B. Y., Danbirni S., Kwaga J. K. 2020.** Brucella infection in migratory cattle herds in Jigawa State Nigeria: A cross sectional study Sokoto Journal of Veterinary Sciences Volume 18 (Number 4). 18 (4): 191–196 (P-ISSN 1595-093X: E-ISSN 2315-6201)

**Nanven M. A., Bale J. O., Kwanashie C. N., Ajogi I., Nanven M. B., Ngbede E. O., Maurice, N. A. 2013.** Bacteriological and Serological Studies of Bovine Brucellosis on the Obudu Plateau, Cross River State, Nigeria. *European Journal of Experimantal Biology*, 3 (6): 484–488.

**Nanven M. A., Wungak S. Y., Gana B. A., Nanven M. B., Ngbede E. O., Ibrahim M. 2013.** Seroprevalence of bovine brucellosis in Northern Plateau State, North Central Nigeria. *Asian Pacific Journal of Tropical Disease*. 3:337-40

**Nath D., Ahmed S. S. U., Malakar V., Hussain T., Deb L. C., Paul S. 2023.** Sero-prevalence and risk factors associated with brucellosis in dairy cattle of Sylhet District, Bangladesh: A cross-sectional study. Vet Med Sci. 9:1349–1358. DOI: 10.1002/vms3.1100

**National Population Commission. 2006.** National Population Council, Report.

**Neta A. V. C., Stynen A. P. R., Paixão T. A., Miranda K. L., Silva F. L., Roux C. M., Santos R. L. 2008.** Modulation of the bovine trophoblastic innate immune response by Brucella abortus. Infection and Immunity, 76 (5), 1897–907.

**Nigeria Meteroligical Agency. 2010**: Nigerian Meteorological Agency Lafia, Nasarawa State.

**Nwakanma N. F, Aina A. D. 2023.** Farmers-Herders Conflicts in Nigeria: Rethinking the Influence of Foreign Herders in North Central Region CTSMSR 2(1):75 – 91.

**O'Callaghan, D. 2020**. Human brucellosis: recent advances and future challenges. Infectious Diseases of Poverty; 9:101. https://doi.org/10.1186/s40249-020-00715-1

**Ocholi R. A., Kwaga J. K., Ajogi, I., Bale J. O. 2004.** Phenotypic characterization of *Brucella* strains isolated from livestock in Nigeria. *Veterinary Microbiology, 102* (1–2), 47–53.

**Ogugua A. J., Akinseye V. O., Ayoola M. C., Oyesola O. O., Shima F. K., Tijjani A. O., Stack J. A. 2015.** Seroprevalence and risk factors of brucellosis in goats in selected states in Nigeria and the public health implications. *African Journal of Medicine and Medical Sciences*, *43* (1): 121–129.

**Pace, J. E., Wakeman D. L., 2003.** Determining the Age of Cattle by Their Teeth, Gainesville, Accessed June 2022, from /https://extension.msstate.edu/sites/default/files/publications/publications/p2779_web.pdf

**Simango E., Tyasi T. L., Chitura T. 2024.** Prevalence of brucellosis in cattle and adopted control measures in South Africa from 2014 to 2019. German Journal of Veterinary Research 4(3):9-15. DOI:10.51585/gjvr.2024.3.0093

**Swai E. S., Schoonman, L. 2010**. The Use of Rose Bengal Plate Test to Asses Cattle Exposure to Brucella Infection in Traditional and Smallholder Dairy Production Systems of Tanga Region of Tanzania. *Veterinary Medicine International*, 2010. doi:10.4061/2010/837950.

**Thrusfield M., Christley R., 2018.** *Veterinary Epidemiology, 4th Edition*. (With). ISBN: 978-1-118-28027-0. February. Wiley-Blackwell. 896 pages

**Tuki D. 2023.** Pastoral conflicts and (dis)trust: Evidence from Nigeria using an instrumental variable approach. Discussion Paper SP VI 2023–101 Wissenschaftszentrum Berlin für Sozialforschung

**Ukwueze C. S., Kalu E., Odirichukwu E. O., Ikpegbu E, Luka P. D. 2022.** Overview of human and animal brucellosis in Nigeria and its economic impacts on production; African Journal of Clinical and Experimental Microbiology; 23 (3):227–237

**Umoh, N. R., 2017.** Pastoralism in Nigeria's Middle-Belt Region: A Resource or

Acurse? International Journal of Development and Economic Sustainability, 5(4):11-30

**Warioba, J. P, Karimuribo E. D., Komba E. V. G., Kabululu M. L., Minga G. A., Nonga H. E. 2023.** Occurrence and Risk Factors of Brucellosis in Commercial Cattle Farms from Selected Districts of the Eastern Coast Zone, Tanzania. Veterinary Medicine International. Volume 2023, Article ID 4904931, 8 pageshttps://doi.org/10.1155/2023/4904931

**Date received: 17th February, 2025**
**Date accepted: 15th April, 2025**