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Research Article

Seroprevalence and Associated Risk Factors of Camel Brucellosis in Two Selected Districts of Jarar Zone, Somali Region, Ethiopia

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Abstract

Brucellosis is a highly contagious zoonotic disease caused by bacteria of the genus *Brucella*. Camel brucellosis poses significant public health concerns and hampers socio-economic development in developing countries, particularly in pastoral regions. Despite its endemic status in many areas, limited attention has been given to the disease in camels. This study aimed to determine the seroprevalence and associated risk factors of camel brucellosis in the Dagahbur and Dagahmadow districts of the Jarar zone, Somali Regional State, Ethiopia. A cross-sectional study was conducted from July 2024 to May 2025. A total of 384 camels from six kebeles across the selected districts were included using a multi-stage sampling technique. Serum samples were tested using the Rose Bengal Plate Test (RBPT) and confirmed with Competitive ELISA (cELISA). Logistic regression analysis was performed to identify associated risk factors. The overall seroprevalence was 27.86% by RBPT and 3.9% by cELISA. Camels with a history of abortion were over twice as likely to test positive (AOR = 2.23, p = 0.002), and those with retained fetal membranes had a sixfold increased risk (AOR = 6.27, p = 0.001). Demographic factors such as sex, age, and herd size showed no significant association. Camel brucellosis remains prevalent in the study area, with reproductive disorders identified as key risk factors. Coordinated efforts among stakeholders are needed to implement preventive and control measures, alongside increasing public awareness to curb the spread and reduce disease prevalence.

Keywords

Seroprevalence, Brucellosis, Camel, Public Health, ELISA, RBPT, Risk Factors

1. Introduction

The world camel population is steadily expanding and is expected to reach 60 million in the next 25 years [1]. Africa is home to more than 80% of the world's dromedary population (16.5 million), with East Africa accounting for 63%. Chad, Somalia, and Sudan have the highest camel populations in Africa, hosting approximately 9.4, 7.4, and 4.9 million camels, respectively [2].

Brucellosis is a highly contagious, infectious, and communicable disease caused by Brucella bacteria, recognized as one of the world's most common zoonoses by global health organizations including the Food and Agriculture Organization (FAO), World Health Organization (WHO), and the

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World Organisation for Animal Health (OIE) [3]. According to the OIE, it is the world's second most important zoonotic disease after rabies, accounting for over 500,000 human cases reported each year [4]. The disease is prevalent in camel-rearing regions worldwide, including the Middle East, Africa, and Latin America, with exceptions such as Australia [5, 6].

In Africa, brucellosis is widespread, with persistent cases reported in humans and domestic animals in countries such as Tanzania, Nigeria, Uganda, Kenya, Zimbabwe, and Somalia [7]. In East Africa, the disease is endemic in most IGAD member states, causing substantial economic losses and health challenges [8]. Cross-species transmission is common, with Brucella bacteria affecting various domestic and wild animals, leading to significant reproductive losses in sexually mature animals [9]. Studies have identified B. abortus and B. melitensis as the primary strains isolated from infected camels, particularly from milk, aborted fetuses, and vaginal swabs [10-12].

Brucellosis is among the most critical zoonotic diseases globally, largely due to a lack of public awareness and effective control measures, particularly in low-income countries [13]. In Ethiopian pastoral settings, brucellosis is often endemic and difficult to control due to limited access to veterinary healthcare services and traditional livestock practices that contribute to the spread of the disease [14]. The disease causes abortion, sterility, and reduces milk yield in animal health [15]. Camel herders in pastoral areas are at high risk of contracting the disease because of close contact with camels and camel products for their livelihood [16].

Brucellosis affects humans by causing symptoms such as fever, sweating, and joint pain, which can lead to serious complications if left untreated [17]. Pregnant women infected with brucellosis are at risk of miscarriage, stillbirth, or premature birth [18]. Additionally, the disease can cause economic losses including the cost of treatment, fetal losses, infertility, reduced milk production, prolonged calving intervals, and losses due to the culling of animals [19].

In Ethiopia, diverse prevalence proportions of brucellosis among camels have been documented across different regions. Studies have reported prevalence of 2% in Dire Dawa [20], 4.1% in Afar [21], and 2.8% in the Somali region [22]. A recent systematic review reported an aggregated prevalence proportion of 3% in camels at the national level in Ethiopia [24]. However, there is limited understanding of the extent of disease in camels in the Jarar zone, Somali Region, highlighting the need for this study.

This study is significant for improving disease control strategies, enhancing livestock welfare, and safeguarding the health of communities in the region. Educating the community about the importance of pasteurizing camel milk and adhering to proper hygienic practices is important given its impact on public health, animal health, and economic consequences, especially in pastoral Somali regions. There is a limited understanding of the extent of disease in camels and its herders that share the same ecological environment. The productivity of camel herds found in the Somali Regional State and Ethiopia in general is considered low.

Although the presence of bacterial diseases in livestock has been investigated in some parts of eastern Ethiopia [23], the seroprevalence of Brucella species in camels, their associated risk factors, and their public health implications in the Jarar Zone have not been adequately explored. This study was therefore designed to address this critical knowledge gap.

1.1. General Objective

To assess the seroprevalence and associated risk factors of camel brucellosis in selected districts of Jarar zone, Somali Region, Eastern Ethiopia.

1.2. Specific Objectives

1) To determine the seroprevalence of camel brucellosis in the selected districts of the study area.
2) To identify the associated risk factors for camel brucellosis in the selected districts of the study area.

2. Materials and Methods

2.1. Description of the Study Area

This study was conducted in two selected districts of Jarar zone, Somali Regional State of Ethiopia, namely Dagahbur and Dagahmadow. Jarar zone is bordered on the south by Korahey, on the southwest by Nogob, on the northwest by Fafan zone, on the southeast by Dollo, and on the northeast by Somaliland. Dagahbur district is located at 8°13'N latitude and 43°34'E longitude. The altitude of the district ranges from 1044 meters above sea level (m.a.s.l.). It has mean annual minimum and maximum temperatures of 5°C and 38.5°C, respectively. The mean annual rainfall in the area ranges from 300-400 mm. The two prevailing agricultural production systems in the district are pastoral and agro-pastoral production systems [25]. The district has a total population of 115,555, out of which about 65,081 are men and 50,474 are women. Most of the total population of the district are rural dwellers.

Dagahmadow district lies between 3- and 15-degrees north latitude and 33- and 48-degrees east longitude. Dagahmadow is bordered on the south and northwest by Fik zone, and on the east by Dagahbur. Based on the 2007 census conducted by the Central Statistical Agency of Ethiopia (CSA), the woreda has a total population of 58,487, of whom 34,199 are men and 24,288 are women [25].

2.2. Study Design

A cross-sectional study was conducted from July 2024 to May 2025 with the aim of investigating the seroprevalence and associated risk factors of brucellosis in camels in selected districts of Jarar Zone, Somali Regional State, Ethiopia.

2.3. Study Population

The study population comprised local breeds of camels kept under extensive management systems in the selected districts of Jarar zone, Somali Regional State, Ethiopia. Individual sampled animal background such as sex, age, herd size, parity, and history of abortion and retained fetal membrane were recorded. Age of animal was determined by dentition and based on information obtained from the owner.

2.4. Sample Size Determination and Sampling Technique

The total study animals were determined according to the formula set by Thrusfield [26] for simple and systematic random sampling, using 95% confidence level and 5% absolute precision. The relevant formula for a 95% confidence interval is:

$$n = \frac{\left(1.96^2 \times Pexp \times (1 - Pexp)\right)}{d^2}$$

Where N is required sample size, Pexp is expected prevalence, and d is level of absolute precision (5%). Due to the absence of reports on estimates of the prevalence of antibodies against brucellosis in the study areas, an arbitrary estimate of 50% was chosen to give the maximum sample size. As a result, a total of 384 camels were included for the determination of antibody prevalence against brucellosis.

A multi-stage sampling technique was used to select the study population. Firstly, districts were purposively selected based on camel population, accessibility to vehicles, proximity to livestock markets, and the presence of animal watering sites. However, simple random sampling method was used to select pastoral associations (PAs), commonly called Kebele, from the list provided by the districts' pastoralists development office. PAs with low camel production potential were excluded from the list during random sampling, and a total of three PAs from each district were selected.

2.5. Sample Collection and Laboratory Analysis

2.5.1. Blood Sample Collection and Serum Analysis

Blood samples were collected from each camel under proper restraint to prevent injury and minimize stress. The jugular vein was disinfected before collecting 10 ml of blood in sterile plain vacutainer tubes. The samples were labeled with herd number, sex, and Kebele code and then taken to the laboratory. After 24 hours at room temperature in a slanted position, serum was separated by centrifugation at 1500 rpm for 5 minutes. The serum was then decanted into sterile cryovials, labeled, and stored at −20°C.

2.5.2. Serological Tests

(i). Rose Bengal Plate Test (RBPT)

All serum samples collected were screened using the RBPT, according to the procedures described by Alton et al. [27] and the World Organisation for Animal Health [28]. The antigen used was Rose Bengal antigen, which constitutes a suspension of B. abortus (obtained from the Institute Pourquier, Montpellier, France) [29].

Twenty-five microliters of Brucella antigen (reagent) and 75 µl of sample serum was used for camel serum. After four minutes of rocking, any visible agglutination was considered positive [28]. Agglutinations were recorded as 0, +, ++, and +++, according to the degree of agglutination. A score of 0 indicates the absence of agglutination; + indicates barely visible agglutination; ++ indicates fine agglutination; and +++ indicates coarse clumping. Those samples with no agglutination (0) were recorded as negative while those with +, ++, and +++ were recorded as positive [29].

(ii). Competitive Enzyme Linked Immunosorbent Assay (cELISA)

All samples were tested with cELISA as a serial testing with the RBPT. 45 µl of sample dilution buffer was added into each well that would be used for serum samples and controls. 5 microliters of serum control, positive, weak positive, and negative were added into appropriate wells, running each control in duplicate. 5 µl of sample dilution buffer was added into two conjugate controls. 5 µl of tested sample was added in each appropriate well. 50 µl solution was added into all wells used for control and samples. The microplate was covered with adhesive plate sealer and mixed well for 5 minutes on a shaker, then incubated at 37°C for 30 minutes. The plate was rinsed with PBS-Tween Buffer and emptied by removing the fluids. 100 µL substrate solution was added to each well, and the plates were incubated at room temperature (18-25°C). 50 µl of stopping solution was added to each well and mixed thoroughly. Finally, the absorbance of the wells was read with a spectrophotometer at 450 nm within 15 minutes after adding stop solution.

2.6. Method of Data Analysis

All collected data were entered into MS Excel and analyzed using SPSS version 24. Descriptive statistics were used to determine the prevalence of brucellosis, and the risk factors associated with the disease (age, sex, abortion history, herd size, and history of retained fetal membrane) were related using Chi-square test (χ^2) for their significant difference at 95% confidence level and $p < 0.05$ for significance. Logistic regression model was applied to assess associations in univariate and multivariate analysis. Those factors positive in univariate analysis ($p = 0.05$) were used to develop multivariate logistic

regression model to assess multiple associations while controlling confounders.

3. Results

3.1. Characteristics of the Study Animals

This seroprevalence study was conducted in Dagahbur and Dagahmadow districts of Jarar zone, Somali Regional State of Ethiopia. A total of 384 animals from 60 herds were sampled for seroprevalence test of camel brucellosis using RBPT and cELISA. From these 384 animals, 192 (50%) were from Dagahbur district and 192 (50%) from Dagahmadow district. In addition, out of these 384 animals, 34% were adult, 41% were old, and 25% were young animals. Lastly, out of these 384 animals, 19% were male animals and 81% were female animals (Table 1).

Table 1. *Frequency distributions of selected variables describing the study animals at selected districts of Jarar zone, Somali Region, Eastern Ethiopia, 2025 (n = 384).*

Variables	Category	Total	Frequency (%)
District	Dagahbur	192	50
	Dagahmadow	192	50
Herd size	Small	73	19
	Medium	150	39
	Large	161	42
Age	Young	95	25
	Adult	131	34
	Old	158	41
Sex	Male	74	19
	Female	310	81

3.2. Seroprevalence and Distribution of Camel Brucellosis in the Study Districts

Camel brucellosis antibodies were detected in 107 camels among 384 examined, giving an overall seroprevalence of 27.86% in RBPT. In addition, confirmatory test was conducted using cELISA, and 3.90% prevalence was found. According to study districts, the result showed that camel brucellosis was more prevalent in Dagahmadow district (4.2%) than in Dagahbur district (3.64%) (Table 2).

Table 2. *Serological prevalence of camel brucellosis in the selected districts of Jarar zone, 2025.*

District	No. examined	No. positive RBPT (%)	No. positive ELISA (%)
Dagahbur	192	70 (36.5)	7 (3.6)
Dagahmadow	192	37 (19.3)	8 (4.2)
Overall	384	107 (27.7)	15 (3.9)

All six villages/kebeles included in the study were found to have animals that were seropositive to camel brucellosis during screening and had a range between 3 and 54.7% seroprevalence rate (Table 3).

Table 3. *Seroprevalence of camel brucellosis by study Kebeles in Jarar Zone, Somali Region, Ethiopia using RBPT.*

District	Kebeles	No. examined Animals	No. positive in RBPT test	Prevalence (%)
Dagahbur	Bulale	64	35	54.7
	Sasamane	64	22	34.4
	Garawoo	64	13	20.3
	Gorayga	64	3	4.7
	Mudulka	64	18	28.1
Dagahmadow	Antenka	64	16	25.0

District	Kebeles	No. examined Animals	No. positive in RBPT test	Prevalence (%)
Overall		384	107	27.86

3.3. Associated Risk Factors for Brucellosis in Camels in Jarar Zone

The univariable logistic regression analysis identified reproductive health factors as significant predictors of camel brucellosis in Dagahbur and Dagahmadow districts. Camels with a history of abortion were over five times more likely to test positive for brucellosis (OR = 5.641, p = 0.002), while those with retained fetal membranes had an even higher likelihood, with over six times the odds (OR = 6.569, p = 0.001). Conversely, demographic factors such as sex, age, herd size, district, pregnancy status, and herd parity showed no significant association with infection risk.

Table 4. *Univariate Logistic Regression Analysis of Presumptive Risk Factors of Camel Brucellosis in Dagahbur and Dagahmadow Districts.*

Variables	Category	No. animals tested	ELISA Test Positive (%)	COR (95% CI)	P value
Sex	Male	74	2 (2.7)	Ref	
	Female	310	13 (4.2)	1.576 (0.348-7.139)	0.55
Age	Young	95	2 (2.1)	Ref	
	Adult	131	7 (5.3)	2.625 (0.533-12.928)	0.23
	Old	158	6 (3.8)	1.836 (0.363-2.284)	0.45
Herd size	<10 Animals	73	3 (4.1)	1.107 (0.269-4.555)	0.88
	10-50 Animals	150	6 (4.0)	1.076 (0.309-3.413)	0.90
	>50 Animals	161	6 (3.7)	Ref	
Parity	Nulliparous	126	2 (1.6)	Ref	
	Primiparous	111	7 (6.3)	4.173 (0.84-20.52)	0.07
	Multifarious	147	6 (4.1)	2.638 (0.52-13.31)	0.24
Districts	Dagahbur	192	7 (3.6)	1.14 (0.42-3.23)	0.79
	Dagahmadow	192	8 (4.2)	Ref	
Pregnancy	Yes	168	4 (2.4)	2.200 (0.688-7.036)	0.18
	No	216	11 (5.1)	Ref	
Abortion history	Yes	45	6 (1.3)	5.641 (1.906-16.694)	0.002*
	No	339	9 (2.7)	Ref	
Retained Fetal	Yes	40	6 (15.0)	6.569 (2.205-19.568)	0.001*
	No	344	9 (2.6)	Ref	

COR: Crude odds ratio, * Shows significance

The explanatory variables with $p \leq 0.25$ in univariable analysis with no multicollinearity were further analyzed using multivariable logistic regression. No significant interactions were detected between variables. The multivariable logistic regression analysis identified several key risk factors associated with camel brucellosis in the districts of Dagahmadow and Dagahbur. Animals with a history of abortion were significantly more likely to be seropositive, with an adjusted odds ratio (AOR) of 2.23 (95% CI: 1.906-16.694, p = 0.002). Similarly, camels that experienced retained fetal membranes showed a markedly increased risk, with an AOR of 6.27 (95% CI: 2.205-19,568, p = 0.001). Overall, the findings emphasize

that reproductive health issues, particularly abortion and retained fetal membranes, are strongly associated with increased susceptibility to brucellosis in camels, underscoring the importance of reproductive health management in controlling the disease within these districts (Table 5).

Table 5. *Final Multivariable Logistic Regression Model for Potential Risk Factors of Camel Brucellosis in Dagahmadow and Dagahbur districts.*

Variables	Category	No. animals tested	ELISA Test Positive (%)	AOR (95% CI)	P value
Abortion history	Yes	45	6 (1.3)	2.23 (1.906-16.694)	0.002*
	No	339	9 (2.7)	Ref	
Retained Fetal	Yes	40	6 (15.0)	6.27 (2.205-19.568)	0.001*
	No	344	9 (2.6)	Ref	

AOR = Adjusted odds ratio, * Shows significance

4. Discussion

The present study revealed a camel brucellosis seroprevalence of 3.6% in Dagahbur and 4.2% in Dagahmadow districts, with an overall prevalence of 3.90% confirmed by cELISA. This prevalence aligns closely with findings from other regions in Somalia and Ethiopia. For instance, a study in Mogadishu reported a seroprevalence of 4.5% using ELISA [30], which corroborates our findings. Similar prevalence rates of 4.2% in Borena, Ethiopia [22], and 4.0% in Niamey, Niger [31], emphasize that camel brucellosis remains a relatively low but persistent health concern in East and West Africa. Additionally, Gizaw et al. [21] reported a prevalence of 4.1% in Afar, Ethiopia, further supporting the consistency across different pastoral regions. Conversely, Ghanem et al. [32] documented a slightly lower prevalence of 3.1% in Somaliland, while higher rates of 8.0% in Kenya [33] and 10.5% in Nigeria [34] highlight that prevalence can vary significantly depending on management practices, disease control measures, and regional factors. The observed variation in seroprevalence across different studies may be attributed to differences in diagnostic tests used, sample sizes, study designs, livestock management systems, and the level of awareness about brucellosis among pastoral communities [15, 35].

The relatively higher seroprevalence detected by RBPT (27.86%) compared to cELISA (3.90%) in this study is noteworthy and consistent with the known limitations of RBPT, which is recognized as a screening test with lower specificity due to its tendency to produce false-positive reactions from cross-reacting antibodies against other Gram-negative bacteria such as *Yersinia enterocolitica* O: 9, *Escherichia coli* O: 157, and *Salmonella* species [28, 29]. This finding underscores the importance of using confirmatory tests like cELISA, which offers higher specificity and is particularly valuable in endemic regions where cross-reactions are common [27, 36]. The cELISA has been recommended by the OIE as a confirmatory test for brucellosis diagnosis due to its ability to detect antibodies specifically directed against the smooth lipopolysaccharide (S-LPS) of *Brucella* species, minimizing cross-reactivity [29, 37]. The substantial discrepancy between RBPT and cELISA results observed in this study reinforces the recommendation that epidemiological surveys for brucellosis should employ confirmatory testing to avoid overestimation of true prevalence and to ensure accurate disease burden assessment [36, 38].

Regarding reproductive history, although no statistically significant association was observed between parity and seropositivity, seroprevalence was higher in pluriparous camels (5.97%) compared to primiparous ones (1.15%). This trend aligns with previous studies [9, 11], which suggest that repeated exposure during successive parturitions and physiological stress may increase the risk of infection. Pluriparous animals are exposed to multiple reproductive cycles, each presenting opportunities for exposure to *Brucella* organisms through infected birth materials, aborted fetuses, and contaminated vaginal discharges [12, 39]. The increased risk in older, multiparous animals may also be attributed to the cumulative probability of exposure over time and the potential for latent infections to become active during periods of physiological stress, such as pregnancy and lactation [13, 40]. Furthermore, the management practices in pastoral systems, where animals of different ages and reproductive statuses are often herded together, facilitate the transmission of *Brucella* organisms from infected aborting females to susceptible herdmates [14, 19].

Reproductive disorders such as abortion and retained fetal membranes showed strong associations with seropositivity both in univariable and multivariable analyses in our study. Camels with a history of abortion had over twice the odds of being seropositive (AOR = 2.23, p = 0.002), and those with retained fetal membranes had markedly increased odds (AOR

= 6.27, p = 0.001). These findings reinforce the well-established role of reproductive health issues as primary indicators and risk factors for brucellosis, emphasizing the importance of reproductive health management in disease control. Our results are consistent with numerous studies that have documented the strong association between brucellosis and reproductive failures in camels and other livestock species [11, 15, 35]. *Brucella* organisms have a predilection for the reproductive tract, particularly the placenta and fetal tissues, where they can cause placentitis, abortion, and retained fetal membranes through the production of erythritol, a sugar that promotes bacterial growth in placental tissues [13, 40]. The abortion storm that typically follows the introduction of *Brucella* into a susceptible herd results in massive environmental contamination, further perpetuating the transmission cycle [19, 39]. The strong association between retained fetal membranes and brucellosis seropositivity observed in our study is particularly significant, as retention of fetal membranes can lead to secondary infections, reduced fertility, and increased veterinary treatment costs, contributing to substantial economic losses in camel production systems [6, 16].

Contrary to expectations, demographic factors such as sex, age, and herd size showed no significant association with brucellosis seropositivity in our study. The lack of association between sex and brucellosis is somewhat surprising given that female camels are generally considered at higher risk due to their reproductive functions and closer contact with infected birth materials [9, 11]. However, it is plausible that the limited number of male camels sampled (19%) may have reduced the statistical power to detect significant differences between sexes. Additionally, in pastoral management systems, male camels are often used for breeding and may have equal exposure to infected females during mating and herd mixing [15, 22]. The absence of a significant association between age and brucellosis in our study contrasts with some previous reports that have identified higher prevalence in older animals [21, 35]. However, our findings align with other studies that have found no age-related differences in seroprevalence [20, 33]. The lack of association with herd size may reflect the extensive pastoral management systems in the study area, where animals from different herds frequently mix at watering points, grazing areas, and markets, facilitating disease transmission regardless of herd size [8, 14].

The study's strengths include the use of a comprehensive methodology combining both RBPT and cELISA, which enhances the reliability of the seroprevalence estimates, along with an adequate sample size determined through statistical calculations and a multi-stage random sampling approach that improves representativeness. The identification of key reproductive health-related risk factors, such as abortion and retained fetal membranes, provides valuable insights for targeted control measures. Additionally, the research fills a regional knowledge gap by providing essential epidemiological data on camel brucellosis in the Somali Regional State of Ethiopia, highlighting its public health significance. The study also contributes to the growing body of evidence on camel brucellosis in the Horn of Africa, where camels play a critical role in the livelihoods of pastoral communities [1, 2]. The findings from this study can inform evidence-based policy decisions and guide the development of appropriate control strategies tailored to the local context, considering the unique socio-cultural and economic factors that influence livestock management practices in pastoral areas [16, 17].

However, the study has limitations, including its cross-sectional design, which restricts causal inference, and reliance solely on serological tests without bacteriological or molecular confirmation of active infections. Serological methods can also produce false positives due to cross-reactions, possibly overestimating prevalence. Recall bias from owner-reported reproductive histories and the absence of human health data further limit comprehensive understanding of the disease's impact and transmission risks. The cross-sectional nature of the study provides only a snapshot of the disease situation at a single point in time, and does not allow for the determination of temporal relationships between risk factors and infection [26, 41]. Additionally, while cELISA is highly specific, it cannot distinguish between antibodies resulting from natural infection and those produced following vaccination, although vaccination against brucellosis is not commonly practiced in the study area [36]. The lack of bacteriological isolation and molecular characterization of *Brucella* species limits our understanding of the circulating strains and their zoonotic potential [12, 39]. The reliance on owner-reported reproductive histories may introduce recall bias, as some herders may not accurately recall or report abortion events, particularly in pastoral settings where animals are often managed extensively [15, 22]. Furthermore, the absence of human serological data prevents assessment of the true zoonotic burden of brucellosis in the study communities, despite the known risks associated with consumption of raw camel milk and close contact with infected animals [16, 17]. Future studies should consider incorporating human health surveys, molecular characterization of circulating strains, and longitudinal designs to better understand the transmission dynamics and public health implications of camel brucellosis in this region [2, 19].

Despite these limitations, the study provides important baseline data for the development of integrated brucellosis control programs in the Somali Region. Control strategies should focus on improving reproductive health management, enhancing disease surveillance, and promoting public awareness about the risks associated with brucellosis and the importance of pasteurizing camel milk [6, 13]. One Health approaches that involve collaboration between veterinary, medical, and environmental sectors are essential for effective brucellosis control, given the zoonotic nature of the disease [19, 36]. The importance of a One Health approach is further underscored by the parallel public health threat posed by bacterial contamination of animal-source foods in this region, as evidenced by studies highlighting poor hygiene practices and the isolation of pathogenic *E. coli* along the beef value chain

in Eastern Ethiopia [42]. This reinforces the need for integrated food safety surveillance and hygiene interventions that address multiple zoonotic and foodborne pathogens simultaneously. Community engagement and education are critical components of any control program, as pastoral communities often have traditional beliefs and practices that may influence disease transmission and control [16, 35]. The involvement of local leaders, pastoral development offices, and livestock marketing institutions is crucial for the successful implementation of control measures [8, 14]. Additionally, the development of affordable and accessible diagnostic services, improved veterinary healthcare infrastructure, and effective vaccination programs could significantly reduce the disease burden in camel populations and protect human health [6, 21].

In conclusion, camel brucellosis remains a prevalent disease in the Dagahbur and Dagahmadow districts of Jarar zone, with reproductive disorders identified as key risk factors. The strong association between brucellosis and reproductive health issues underscores the importance of reproductive health management in disease control. Coordinated efforts among stakeholders, including veterinary services, public health institutions, pastoral development offices, and community leaders, are needed to implement preventive and control measures. Public awareness campaigns should emphasize the importance of pasteurizing camel milk, proper handling of aborted materials, and seeking veterinary care for reproductive problems. Future research should focus on molecular characterization of circulating *Brucella* strains, assessment of human brucellosis burden, and evaluation of the effectiveness of different control interventions in pastoral settings. Furthermore, integrated surveillance systems that monitor both zoonotic and foodborne pathogens in livestock products are essential to safeguard public health in these pastoral communities.

5. Conclusions

The current study has shown the distribution of *Brucella* antibodies in 3.9% of the tested camels in Dagahmadow and Dagahbur districts, in Jarar zone, Somali Regional State of Ethiopia. The risk factors identified for the presence and transmission of the disease from animal to animal were reproductive health factors including history of abortion and retained fetal membranes. The finding of positive serological reactors does not only imply the presence of the disease in the camel population but also indicates the presence of *Brucella* infection that could serve as a source of infection for the spread of the disease into unaffected animals and herds. This implies that the infected herds' animals and family members are at risk.

Based on the above conclusions, the following recommendations are forwarded to control further spread of the disease:

1) Targeted Control Strategies: There is a pressing need to develop and implement targeted control strategies focusing on reproductive health management to curb the spread of camel brucellosis in this study area. Special attention should be given to the isolation and management of animals with a history of abortion or retained fetal membranes.
2) Regular Screening: Regular screening of camel populations is essential to monitor and control the disease. Early detection through routine testing can prevent further spread.
3) Public Awareness Campaigns: An awareness campaign should be carried out to educate camel owners, herdsmen, and milk consumers about the risks of brucellosis and the health hazards associated with consuming unpasteurized camel milk and its products. The risks of handling aborted materials without protection should also be emphasized.
4) Further Epidemiological Investigations: Further epidemiological investigations are essential, focusing on identifying the specific *Brucella* species and biotypes responsible for infections in the area. Molecular studies should be conducted to characterize the circulating strains.
5) One Health Approach: Collaborative efforts between veterinary and human health sectors should be strengthened to effectively address the zoonotic implications of camel brucellosis in the region.

Abbreviations

AOR	Adjusted Odds Ratio
cELISA	Enzyme-Linked Immunosorbent Assay
CI	Confidence Interval
COR	Crude Odds Ratio
CSA	Central Statistical Agency (of Ethiopia)
ELISA	Enzyme-Linked Immunosorbent Assay
FAO	Food and Agriculture Organization
IGAD	Intergovernmental Authority on Development
m.a.s.l.	Meters Above Sea Level
NGO	Non-Governmental Organization
OIE	World Organisation for Animal Health
OR	Odds Ratio
PA	Pastoral Association
PBS	Phosphate-Buffered Saline
RBPT	Rose Bengal Plate Test
rpm	Revolutions Per Minute
S-LPS	Smooth Lipopolysaccharide
SPSS	Statistical Package for the Social Sciences
WHO	World Health Organization

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Author Contributions

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Data Availability Statement

The data is available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest.

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