The prevalence of camel brucellosis and associated risk factors: a global meta-epidemiological study

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REVIEW ARTICLE

Abstract

Camel brucellosis is a widespread and critical zoonotic infection caused by *Brucella abortus* and *Brucella melitensis* that negatively impact dairy and meat products. The current meta-analysis covers studies published over a course of 40 years, between 1 January 1980 and 1 April 2021, aiming to investigate the global prevalence of *Brucella* spp. in camels and related risk factors in different camel-keeping areas. Chi-squared test (I^2 index) was applied to evaluate the heterogeneity of studies. A random-effect model (REM) estimated the pooled prevalence among subgroups. The literature search on camel brucellosis was performed among the available databases, including CABI, PubMed, Embase, Web of Science, Cochrane, Scielo, Scopus, and Science Direct. A total of 56 publications, comprising 205 data reports, were evaluated. Our results showed that the overall prevalence of camel brucellosis in the world was 9.23%. The lowest and highest prevalence rates of *Brucella* spp. infections among camels were reported in Oman (0.34%, 95%CI: 0.18–0.55) and Sudan (37.41%, 95%CI: 25.27–50.31), respectively. According to different risk factors, subgroup analysis showed that the location, sex, herd size, age, and mixed rearing with other animals could be considered the main risk factors impacting the occurrence of brucellosis in camels. The reported *Brucella* spp. in dromedary camel was *Brucella melitensis* (Biovar 1, 2, and 3), *Brucella abortus* (Biovar 3, 5, and 6), and *Brucella suis*. Our study represented remarkable differences between the prevalence of *Brucella* spp. in male (6.83% in 41 studies) and female (9.64% among 62 studies) camels. However, the present meta-epidemiological study would help improve control and surveillance approaches to prevent the spread of camel brucellosis among herds.

Keywords: meta-epidemiology; brucellosis; camel; *Brucella abortus*; *Brucella melitensis*

Introduction

The Camelidae family comprises two genera comprising the genus *Camelus* and the genus of *lama* (also named Camelids). The old-world genus of *Camelus* is divided into two species of *Camelus dromedarius* (the one-humped camel) and the *Camelus bactrianus* (the two-humped camel). Dromedary camels occupy the West Central and Near East Asia, North Africa, and Ethiopia (Wardeh, 2004). The habitat of the *Camelus bactrianus* is the cold deserts of China, East-Central Asia, and Mongolia (Jasra and Mirza, 2004). It is estimated that the world population of camels is 25.89 million, composed of 11% two-humped and 89% of one-humped dromedary camels (Kula and Tegegne, 2016). More than 60% of the dromedary camel population is habited in the countries of North-East Africa, such as Sudan, Kenya, Ethiopia, and Somalia (Gizachew *et al*., 2014). As a vital source of subsistence and income, the camel has socioeconomic effects on the survival of the populations of the arid and semi-dry areas living in Asia and Africa (Ahmad *et al*., 2010; Aujla *et al*., 1998). As camels are still an important part of the nomadic and pastoral livelihoods and because of the lack of mandatory vaccination programs for camels, the precise size of their population worldwide is difficult to determine. Like other livestock species, Camels are susceptible to brucellosis (Abbas and Agab, 2002; Gwida *et al*., 2012).

Exposure to pathogenic bacteria and fungi can endanger human and animal health (Chinakwe *et al*., 2019; Lu *et al*., 2021; Sabrina Mahyuddin *et al*., 2020). Brucellosis is a zoonotic bacterial infection caused by gram-negative bacteria from the *Brucella* genus, classified as a risk group III pathogen by the WHO. The control of this widespread disease is of high economic importance in different camel-rearing countries (Abbas and Agab, 2002; Chinakwe *et al*., 2019; Gwida *et al*., 2012; Lu *et al*., 2021; Mahyuddin *et al*., 2020). Brucellosis in a camel through the *B. abortus* and *B. melitensis* has been documented in all camel-keeping countries except Australia (Alamian and Dadar, 2019; Wernery, 2014). Camel brucellosis can induce significant productivity loss by long calving interval time, low herd fertility, comparatively low milk production, and late first calving age. Other studies also reported that brucellosis is responsible for abortion, stillbirth, and decreased appetite in the camel population (Abdel Hafez *et al*., 2015; Warsame *et al*., 2020).

The disease also can play an important role in the import and export of animals constraining livestock trade. It has been estimated that the seroprevalence of brucellosis is low (2–5%) in camels reared under extensively or nomadic husbandry systems and relatively high (8–15%) in semi-intensively or intensively rearing husbandry systems (Abbas and Agab, 2002). However, despite the developments of surveillance and control programs for camel herds, the prevalence of brucellosis showed an increasing trend in different developing countries because of numerous socioeconomic, sanitary, and political risk factors (Corbel, 2006; Pappas, 2010). Therefore, the zoonotic threat of camel brucellosis should be considered a severe public health problem, particularly in camel-rearing areas (Sprague *et al*., 2012). Infected camels and their derived products could be a source of human brucellosis, leading to severe arthritis, fever, infertility, and in some cases, chronic infections following misdiagnosis (Corbel, 2006; Gutema Wegi, 2020).

For this reason, serological surveillance of camel brucellosis; isolation of infected camel; proper disposal of placental tissues, aborted fetus, and uterine discharge; and disinfecting of contaminated areas are of overwhelming importance for the successful prevention and control of camel brucellosis (Abbas and Agab, 2002; Sprague *et al*., 2012). However, no meta-analysis is available on the prevalence of camel brucellosis worldwide. The present meta-epidemiological study is aimed to evaluate the global prevalence of camel brucellosis and the associated risk factors impacting the transmission of *Brucella* infection.

Material and methods

Search strategy

The meta-analysis of published data on camel brucellosis was performed following the Cochrane protocol (Higgins and Green, 2011). The data were extracted and selected according to the PRISMA (Preferred Reported Items for Systematic Reviews and Meta-Analyses) method (Figure 1) (Liberati *et al*., 2009). Available databases were screened for all publications on camel brucellosis, including CABI, PubMed, Embase, Cochrane, Scielo, Scopus, Web of Science, and Science Direct to retrieve related papers on brucellosis in the camel population from 1 January 1980 to 1 April 2021. The Medical Subject Headings (MeSH) terms used in this study were "Malta Fever," "*Brucella* infection," "prevalence," OR "camel," OR "*Brucella* spp." *OR* "*B. melitensis*" OR "*B. abortus*" OR "*B. ovis*" OR "*brucellosis*" OR "seroprevalence" OR "*Camelus bactrianus*" OR "*Camelus dromedaries*." The selected articles were checked and cleaned in Endnote X7.8 for duplicates.

Inclusion and exclusion criteria

The inclusion criteria in this study were considered as follows: (1) full-text article in English; (2) related subjects to camel brucellosis like infertility, for example, (3) original and descriptive investigations by qualitative or quantitative data, as case-control, cohort, cross-sectional, case reports,

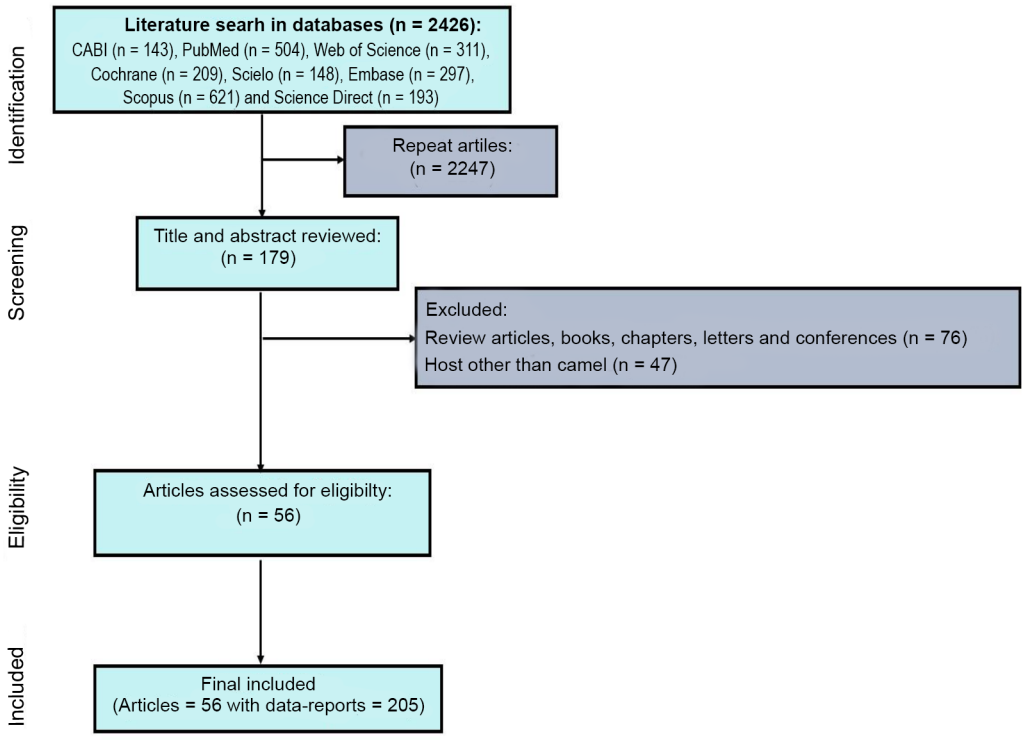

Figure 1. Flow chart of search processing based on Prisma.

and case series studies; (4) research study on camel brucelloses like positive results and total sample sizes. In addition, clinical trials, thesis, books, workshops, and hosts other than camel and review article were excluded (Dadar *et al*., 2020; De Souza *et al*., 2021; Mokhtarian *et al*., 2020).

Data extraction

The data associated with camel brucellosis were extracted from all related articles that comprised the first author, geographic location, study period, type of sample, positive samples, diagnostic tests, isolated *Brucella* species, biovars, gender, and symptoms (if any). Articles were sorted according to detection method classification (direct (D) and indirect (ID)). Indirect methods such as serological tests could detect anti-*Brucella* antibodies in serum and milk, such as the Rose Bengal Test (RBT), Rivanol Test, Serum Agglutination Test (SAT), Milk Ring Test (MRT), 2-Mercaptoethanol Test (2-ME), Complement Fixation Test (CFT), the Fluorescence Polarization Assay (FPA), Buffered Acidified Plate Antigen Test (BAPAT), Brucellosis Skin Test (BST), competitive Enzyme-Linked Immunosorbent Assay (c-ELISA), and indirect Enzyme-Linked Immunosorbent Assay (i-ELISA). The direct brucellosis diagnosis methods can be performed by bacterial culture and nucleic acid detection by molecular approaches such as Real-Time or Quantitative Polymerase Chain Reaction (RT- or QPCR) and Polymerase Chain Reaction (PCR).

Meta-epidemiological analysis of camel brucellosis

The prevalence of camel brucellosis was calculated as a ratio of positive *Brucella* specimens to the total sample size. Meta-analysis of prevalence was conducted by metaprop command. The I-squared test (I^2 index) evaluated the heterogeneity among different studies, and it was verified if the I^2 > 50% (Higgins and Thompson, 2002). Furthermore, a random-effects model (REM) calculated the pooled odds ratio (OR) in the studies to investigate the pooled prevalence of camel brucellosis in exanimated subgroups. Moreover, meta-regression analysis calculated the prevalence of camel brucellosis over time (Jackson *et al*., 2015; Stanley and Jarrell, 1989). Version 12.0 of the STATA software (STATA Corp, College Station, TX, USA) was used to evaluate the statistical analyses. The findings were investigated as significant when P-values were less than 0.05.

Results

Search results

Our results included 2426 studies dealing with camel brucellosis from different databases of CABI (n = 143), PubMed (n = 504), Web of Science (n = 311), Cochrane (n = 209), Scielo (n = 148), Embase (n = 297), Scopus (n = 621) and Science Direct (n = 193) (Figure 1). We analyzed 56 articles with 205 data reports based on the exclusion

and inclusion rules. Articles published between 1 January 1980 and 1 April 2021 were included in the analysis (Figure 2). A total of 56 articles were acceptable and complied with the selection criteria. All eligible data listed in the "data extraction" section are available in Supplementary file 1.

Geographical distribution of relevant studies in camel

The results of 56 articles (205 studies with a sample size of 134,949) (Figure 1) revealed that the number of studies investigating the occurrence of camel brucellosis in different regions varied from 46 studies in Egypt to one study in Niger (Table 1). In addition, the highest number of studies (n = 22) on camel brucellosis was observed in 2015 (Figure 2). However, no studies have focused on camel brucellosis in some countries such as Mauritania, Chad, Djibouti (countries with a high camel population), and Qatar and South Morocco (countries with an extremely high population of camels). The lowest and highest prevalence of camel brucellosis were observed in Oman (0.34%, 95%CI: 0.18–0.55) and Sudan (37.41%, 95%CI: 25.27–50.31), respectively (Table 1 and Figures 3 and 4).

Diagnostic methods

Table 2 showed that RBT (n = 50) and CFT (n = 43) were the most used tests for the diagnosis of camel brucellosis, followed by c-ELISA (n = 22), bacterial culture (n = 20), SAT (n = 19), PCR-based methods (n = 25), MRT (n = 5), 2-ME (n = 2), and i-ELISA (n = 2). The lowest and highest prevalence rates were reported by the MRT (3.46%) and the FPA (79.33%), respectively (Table 2). However, our results showed remarkable differences between the prevalence of camel brucellosis obtained through direct methods (15.08%) and indirect methods (8.49%) (Table 2).

Prevalence rates based on sample types and sampling methods

The biological specimens used for *Brucella* investigation in camels were, in the vast majority of cases, blood samples (n = 165 studies), followed by milk (n = 18 studies), lymph node (n = 13 studies), aborted fetus (n = 4 studies), vaginal swab (n = 3 studies), and semen (n = 1 study), while other samples, including abomasum contents (fetuses), and testes were not investigated (Table 2). Of

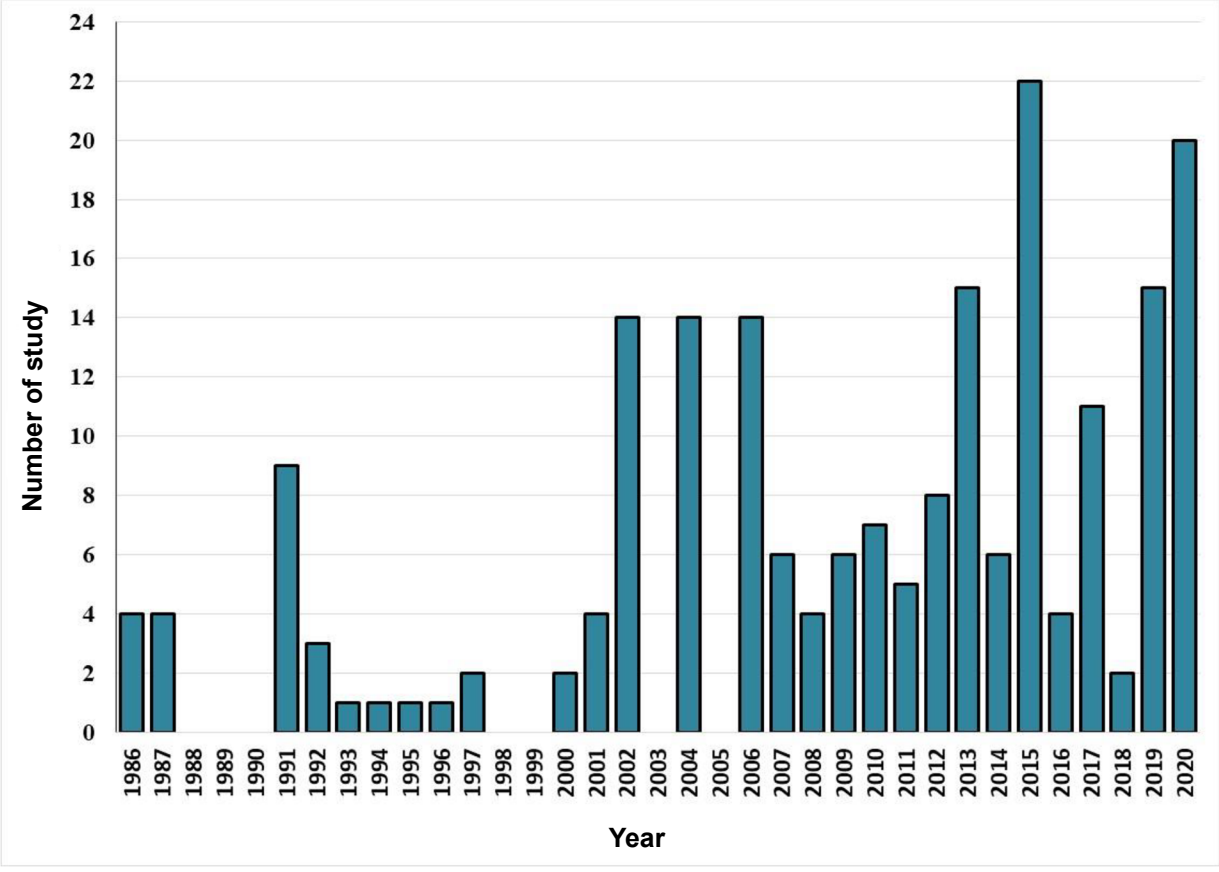

Figure 2. Distribution of the number of studies on the prevalence of *Brucella spp.* in camels over time.

Table 1. Meta-analysis of the prevalence of *Brucella* infection in camels by country.

Country	Number study	ES*	Lower	Upper	Weight (%)	Heterogeneity statistic	Degrees of freedom	P value	I^2
Sudan	23	37.41	25.27	50.31	10.61	7453.22	22	<0.001	99.70%
Saudi Arabia	9	13.32	9.24	17.97	4.40	89.05	8	<0.001	91.02%
Jordan	9	12.25	9.34	15.46	4.34	33.43	8	<0.001	76.07%
Nigeria	6	11.21	9.29	13.28	3.06	1.73	5	0.88	0.00%
Egypt	46	11.93	9.33	16.97	22.74	236.45	45	<0.001	94.32%
Kuwait	4	10.93	7.50	14.81	1.84	9.38	3	0.02	68.01%
Mongolia	3	9.24	1.18	23.51	1.55	.	2	.	.%
Kenya	4	8.29	5.76	11.21	2.03	4.25	3	0.24	29.49%
Iran	22	5.75	3.25	8.81	10.93	635.96	21	<0.001	96.70%
Iraq	9	5.20	1.19	11.18	4.33	102.9	8	<0.001	92.23%
United Arab Emirates	10	4.98	2.82	7.67	5.13	595.27	9	<0.001	98.49%
India	6	3.66	0.09	10.13	2.57	15.31	5	0.01	67.33%
Somaliland	2	3.52	2.83	4.28	1.04	.	1	.	.%
Yemen	3	3.02	0.00	10.41	1.46	.	2	.	.%
Ethiopia	26	2.84	2.17	3.60	13.42	210.69	25	<0.001	88.13%
Libya	5	2.64	1.08	4.69	2.44	7.43	4	0.11	46.14%
Somalia	2	0.97	0.65	1.36	1.04	.	1	.	.%
Niger	1	0.76	0.16	2.20	0.52	.	0	.	.%
Pakistan	11	0.43	0.00	1.73	5.01	33.12	10	<0.001	69.80%
Oman	3	0.34	0.18	0.55	1.56	.	2	.	.%
Overall	**64**	**9.23**	**7.24**	**11.41**	**100.00**	**30260.3**	**203**	**0**	**100.00%**

*Effect size (EF): Pooled prevalence of *Brucella* infection.

note, testes were analyzed after experimental infection with *B. abortus* wild-type (n = 1) and *B. abortus* S19) vaccine (n = 5) but no *Brucella* strain has been isolated from these samples (Damir *et al*., 1989). Not surprisingly, aborted fetuses showed a higher prevalence of *Brucella* spp. with 29.23% when compared to those reported in lymph nodes (21.45%), vaginal swabs (9.54%), blood samples (8.60%), milk (8.30%), and semen (2.13%). In most studies, sampling was done among apparently healthy camels (in 155 out of 195 studies). Coherently, the prevalence of camel brucellosis was higher in animals with apparent symptoms such as wry neck syndrome (50%), knee hygroma (37.17%), arthritis (33.33%), abortion (7.74%), and the lowest rates of brucellosis were showed among animals with infertility (1.54%) (Table 3).

Overall brucellosis prevalence according to the gender of camel

This meta-analysis reported remarkable differences between the prevalence of camel brucellosis in females (9.64% among 62 studies) and males (6.83% in 41 studies). The gender of exanimated camels was not reported in 102 studies (Table 2).

Most prevalent Brucella spp. infecting camel

Although the isolation of *B. melitensis* (n = 29), *B. abortus* (n = 22), and *Brucella suis* (n = 1) from camel was reported in different investigations, the species level of *Brucella* isolates was not reported in 153 studies. Among identified *Brucella* spp., *B. abortus* biovar 6 showed the highest prevalence rate (71.88%), followed by *B. abortus* biovar 3 (14.58%), *B. melitensis biovar 3* (12.06%), *B. melitensis* biovar 2 (8.92%), *B. melitensis* biovar 1 (3.4%), and *B. abortus* biovar 5 (3.13%). In some studies (n = 27), the biovar of *Brucella* spp. was not reported (prevalence rate of 10.26%)

Risk factor analysis of camel brucellosis

The risk factors, including geographical location, sex, herd size, age, and mixed rearing with other animals, can

Figure 3. Spatial distribution of the number of studies on the prevalence of *Brucella spp.* in camels.

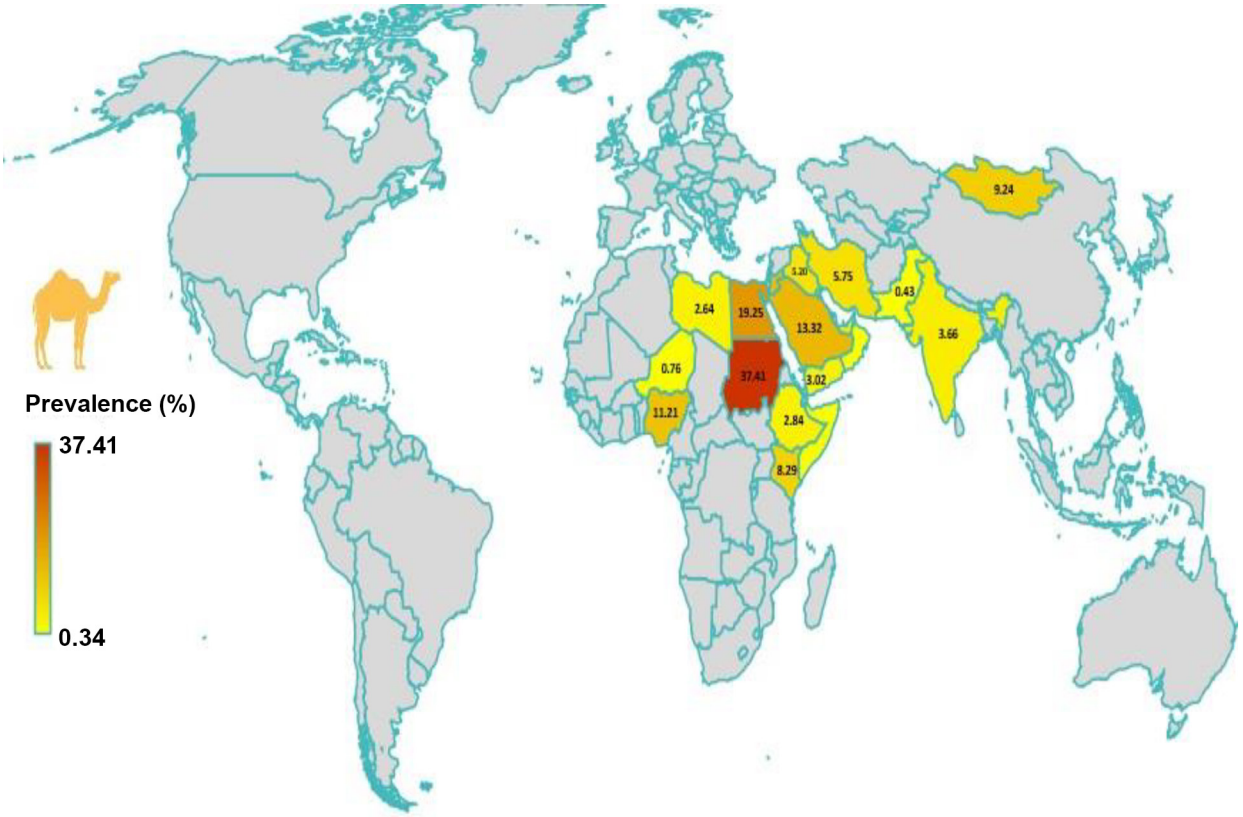

Figure 4. Spatial distribution of the prevalence of *Brucella spp.* in camels.

Table 2. Meta-analysis of the prevalence of *Brucella* infection in camels by Samples tissue, Gender, Biovar, Symptoms, and D/I Subgroups.

Subgroup		Number study	Pooled	Lower	Upper	Weight (%)	Heterogeneity statistic	Degrees of freedom	P value	I^2
Samples tissue	Fetus	4	29.23	0.67	71.25	1.59	42.69	3	<0.001	92.97%
	Lymph node	13	21.45	9.48	36.02	5.57	217.6	12	<0.001	94.49%
	Vaginal swab	3	9.54	0.00	30.71	1.37	.	2	.	.%
	Blood	165	8.60	6.51	10.92	82.57	29863.17	164	<0.001	99.45%
	Milk	18	8.30	5.12	12.04	8.41	74.88	17	<0.001	77.30%
	Semen	1	2.13	0.26	7.48	0.50	.	0	.	.%
Gender	Female	62	9.64	6.73	12.93	29.34	1489.83	61	<0.001	95.91%
	Male	41	6.83	3.86	10.39	19.12	1967.32	40	<0.001	97.97%
Biovar	B.m3	11	12.06	8.81	15.66	5.02	44.86	10	<0.001	77.71%
	B.m1	7	3.4	0.46	8.05	3.32	61.97	6	<0.001	90.32%
	B.m2	2	8.92	7.8	10.12	1.02	.	1	.	.%
	B.a6	2	71.88	34.68	98.58	0.55	.	1	.	.%
	B.a3	1	14.58	8.21	23.26	0.5	.	0	.	.%
	B.a5	1	3.13	0.65	8.86	0.5	.	0	.	.%
Symptoms	Wry neck syndrome	1	50	11.81	88.19	0.31	.	0	.	.%
	Knee hygroma	2	37.17	4.76	76.08	0.53	.	1	.	.%
	Arthritis	1	33.33	4.33	77.72	0.31	.	0	.	.%
	Orchitis	2	33.33	0.24	79.48	0.47	.	1	.	.%
	Healthy animal	155	9.92	7.6	12.49	77.63	23451.36	154	<0.001	99.34%
	Abortion	32	7.74	5.21	10.64	15.28	402.75	31	<0.001	92.30%
	Infertility	3	1.54	0.71	2.62	1.53	.	2	.	.%
D/I	D	37	15.08	5.93	26.88	16.84	2638.84	36	<0.001	98.64%
	I	167	8.49	6.5	10.7	83.16	26925.84	166	<0.001	99.38%

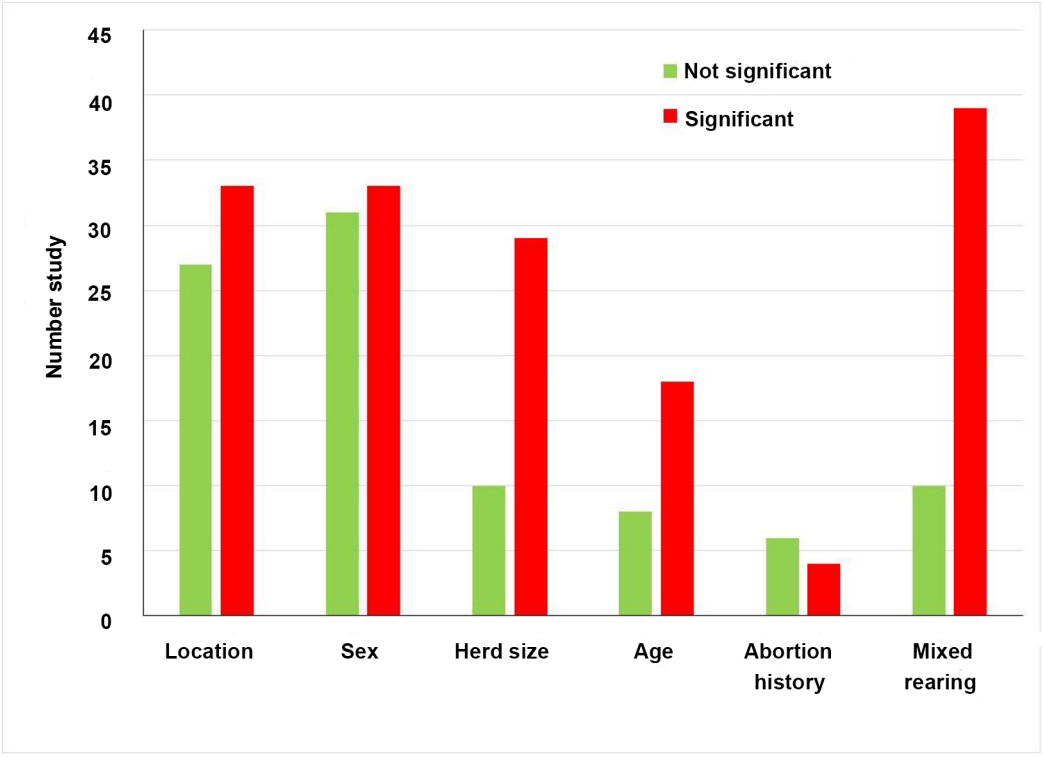

Figure 5. Effective risk factors of Brucellosis in camels that considered in research studies.

Table 3. Meta-analysis of the prevalence of *Brucella* infection in camels by the detection method.

Method of detection	Number study	Pooled	Lower	Upper	Weight (%)	Heterogeneity statistic	Degrees of freedom	P value	I^2
FPA	1	79.33	76.53	81.94	0.52	.	0	.	.%
BST	1	42.65	30.72	55.23	0.49	.	0	.	.%
Culture	20	17.04	9.14	26.42	8.53	246.24	19	<0.001	92.28%
RT-PCR	7	15.01	0	50.9	3.53	1327.15	6	<0.001	99.55%
c-ELISA	22	13.41	5.81	23.27	10.96	2894.43	21	<0.001	99.27%
BAPAT	5	10.65	9.22	12.17	2.54	4.04	4	0.4	0.97%
PCR	18	9.47	5.67	14.04	8.78	145.82	17	<0.001	88.34%
Rivanol Test	2	8.72	6.79	10.86	1.02	.	1	.	.%
RBT	50	8.57	5.44	12.24	24.45	6465.73	49	<0.001	99.24%
SAT	19	8.16	1.95	17.25	9.06	2630.17	18	<0.001	99.32%
i-ELISA	8	7.81	3.25	13.99	4.05	145.38	7	<0.001	95.18%
CFT	43	5.06	3.06	7.52	22.13	5227.08	42	<0.001	99.20%
2-ME	2	4.08	0	15.16	1.54	.	2	.	.%
MRT	5	3.46	0.9	7.16	2.38	8.91	4	0.06	55.08%

FPA: Fluorescence Polarization Assay; BST: Brucellosis Skin Test; RT-PCR: Real-Time Polymerase Chain Reaction; c-ELISA: competitive Enzyme-Linked Immunosorbent Assay; BAPAT: Buffered Acidified Plate Antigen Test; PCR: Polymerase Chain Reaction; RBT: Rose Bengal Test; SAT: Serum Agglutination Test; i-ELISA: indirect Enzyme-Linked Immunosorbent Assay; CFT: Complement Fixation Test; 2-ME: 2-Mercaptoethanol Test; Rivanol test; MRT: Milk Ring Test.

be considered the main risk factors for brucellosis in camels (Figure 5). Among data reports investigating the association between location and the occurrence of camel brucellosis, 60 reported a positive (n = 33) or negative (n = 27) association, whereas others found no evidence of a significant association (n = 145). Thirty-three studies have reported the effects of sex as a significant risk for brucellosis. Although the results of studies investigating the association between herd size and camel brucellosis were discording, most studies found a significant association (29 significant vs. 10 nonsignificant reports). Eighteen studies evaluating the effects of age reported an increased risk of brucellosis with greater age. Furthermore, several studies reported a significant association of mix herding/rearing with other livestock species and camel brucellosis (n = 39), although other studies showed a nonsignificant association (n = 10). Abortion history was only evaluated in 10 studies of the evaluated risk factors. Significant and insignificant associations were found in four and six studies, respectively.

Discussion

Brucellosis is a severe zoonotic disease in camel-rearing countries with serious economic consequences (Abbas and Agab, 2002; Gwida *et al*., 2012). Considering the close relationship between camels and humans, camel brucellosis should be an important public health issue (Alamian and Dadar, 2019; Dadar and Alamian, 2020; Sprague *et al*., 2012). Nevertheless, brucellosis in camels remains a neglected disease with low attention from health authorities and scientists. Since the first report of camel brucellosis in 1931 (Solonitsuin, 1949), the disease has been reported in all camel-raising areas worldwide. Although mixed herding with other livestock species was reported as a significant risk factor for camel brucellosis in 39 studies, no such association was seen in 10 studies. In this regard, Musa and his colleagues showed that cattle were a possible source of camel brucellosis because of the negative brucellosis results of all small ruminants screened in their study (Musa *et al*., 2008). In another study, close contact with small ruminants and cattle climbed to over 2.3 and 3.6 times the seropositivity of *Brucella* spp (Hadush *et al*., 2013). Our findings showed that the prevalence of camel brucellosis varied for different camel-rising countries over time. There are also significant differences in diagnostic tests, regional breeding technology, agro-ecology of camel-rising countries, husbandry and management systems, absence of adequate veterinary service, large-scale animal grazing, sharing of grazing pasture with other livestock species, lack of awareness about camel brucellosis, continuous movement of infected animals into a susceptible herd, cohabitation with other ruminants, as well as sanitation conditions (Abdelgawad *et al*., 2017; Gwida *et al*., 2012; Mokhtar *et al*., 2007; Sprague *et al*., 2012). In addition, illegal animal movement, unreported outbreaks, communal clashes,

and the absence of brucellosis control programs in different regions are often combined factors contributing to the maintenance and establishment of camel brucellosis.

In some developing countries, the proportion of camels infected by *Brucella* spp. is relatively large because camel herds suffer from a lack of appropriate surveillance programs. Furthermore, the control of camel brucellosis is severely hampered in camel-raising countries (Sprague *et al*., 2012). Therefore, several strategies should be used to improve the situation of camel brucellosis and significantly decrease the occurrence of the disease, including encouragement of animal keepers for closer interaction with the veterinary organization and awareness about camel brucellosis and sustainable control approaches. In some countries, no or only a few studies have been performed, thereby stressing the need for further investigation into camel populations.

Our analysis shows that geographical location, sex, herd size, age, and mixed rearing are important risk factors for brucellosis in camels. Several studies showed a higher prevalence of brucellosis among adult camels >4 years old compared to 6 months to 4-year-old animals (Dawood, 2008; Khan *et al*., 2020; Salisu *et al*., 2018). Among the risk factors evaluated in camel brucellosis in Ethiopia, body condition and abortion showed a statistically significant difference concerning the seropositivity of camel brucellosis (Waktole *et al*., 2022). The seroprevalence and associated risk factors for camel brucellosis in Algeria showed a higher seroprevalence in animals living in flocks with a history of abortion and females (P = 0.01) (Benfodil *et al*., 2022). Moreover, it has been shown that the seroprevalence of brucellosis obtained by i-ELISA was 22.9% in the age group lower than 8 years, 27.9% in animals aged 8–11 years, and 25.7% among camels aged 13–15 years (Khan *et al*., 2020). In another study, the seroprevalence of camel brucellosis using RBT was remarkably higher (29.4%) in the 5–9 year age group compared to 0–4 ones (8%) (Abebe *et al*., 2017). The seroprevalence in females (9.64%) was significantly higher than in males (6.83%). Previous data show that females with a history of abortion reported a higher prevalence of camel brucellosis followed by pregnant and nonpregnant females (Fatima *et al*., 2016). Other studies also showed the antibodies of *Brucella* as frequently detected in males (7%) compared to females (8.3%) (Kudi *et al*., 1997). Such high seropositive rates in males may be related to the fact that the main populations of imported camels for slaughter are males (Khan *et al*., 2020). Therefore, abattoir surveys may have an important selection bias, and inferences about the local population must be made with caution. It has been suggested that female camels can transmit the infection to other livestock species by vaginal mucous, aborted fetuses, and milk (Al-Majali *et al*., 2008; Dadar *et al*., 2020). Limited data on aborted fetuses showed a high prevalence (29.23%), suggesting high prevalence and transmission rates in pregnant animals during the last 4 months of pregnancy (Al-Majali *et al*., 2008). Another study also highlighted that rearing camels with other ruminants were significantly associated with camel brucellosis (Fatima *et al*., 2016). Moreover, camel herds with more than 30 animals were more sustainable for brucellosis seropositivity (Ghanem *et al*., 2009). Mixed husbandry systems were associated with seropositive brucellosis camel herds (Ghanem *et al*., 2009). However, some reported risk factors, such as age, sex, breed, mixed herds, and locality, were unrelated in some studies (Khan *et al*., 2020; Ullah *et al*., 2015). Therefore, there is high demand for enrolment in control programs and increasing public health knowledge to prevent camel brucellosis. The RBT is a cost-effective and easy-to-use test that shows specific specificity and sensibility values, especially in endemic areas for camel brucellosis (Gwida *et al*., 2011). However, some nonspecific agglutination could occur due to the interference with nonspecific antibodies reported in other livestock species (OIE) and humans in endemic areas (Díaz *et al*., 2011). The CFT was used in different studies and compared favorably with other serological tests like the SAT that the OIE approves for the serological identification of brucellosis in livestock (Gwida *et al*., 2011; Sprague *et al*., 2012). The c-ELISA and i-ELISA have also been applied to detect anti-*Brucella* antibodies in camels. According to Gwida *et al.* (2011), the c-ELISA detected the lowest number of positive cases (68.8%) compared to the RBT (70.7%), the SAT (70.6%), the CFT (71.4%), and the FPA (79.3%). Another study also showed seroprevalence of camel brucellosis in south Algeria as 5.3 and 1.4% through the ELISA test and RBPT, respectively (Benfodil *et al*., 2022). The tests of RBT and CFT were also used as screening and confirmatory methods of camel brucellosis seroepidemiology in Ethiopia (Waktole *et al*., 2022). Tests that are not widely used are the FPA and the BST, both reported in one study. Our results suggest fewer clinical signs in *Brucella*-infected camels than in other ruminant animals. Indeed, 155 studies reported camel brucellosis in apparently healthy animals, and only 32 studies reported an abortion history in the herd. Other signs such as wry neck syndrome, knee hygroma, arthritis, orchitis, and infertility were also reported in some studies (Gutema and Tesfaye, 2019; Hussein, 2021; Musa *et al*., 2008). However, Musa and his colleagues showed no significant link between the wry neck syndrome in camels with brucellosis, although repeated abortion, hygroma, and arthritis were associated with the disease occurrence (Musa *et al*., 2008). Raising public awareness and education about the zoonotic importance of camel brucellosis, proper hygienic practices, control of risk factors, and multidisciplinary work between health

and veterinary personnel should be improved (Admasu and Kaynata, 2017). Our research has limitations, such as a few studies on camel brucellosis in African countries such as Mauritania, Chad, and Djibouti (countries with a high population of camel livestock), Qatar, and South Morocco. The small sample size of camels in some studies made it difficult to determine the true prevalence of camel brucellosis in any specific locality.

Data related to the epidemiology of brucellosis in Bactrian camels have been reported infrequently in the international literature (Bayasgalan *et al*., 2018; Kim *et al*., 2016). Both studies were performed in Mongolia and suggested that Bactrian camels are secondary hosts for *Brucella* spp. A relevance between the seropositivity of cattle and camel, but not small ruminants, was described in different studies. The fact that *Brucella* isolates in camels were *B. abortus* further support an association between brucellosis in camels and cattle in Mongolia (Bayasgalan *et al*., 2018; Damir *et al*., 1989). Finally, it should be highlighted that there is an important knowledge gap related to anti-brucellosis vaccination in camels. Field data are sparse and often lack validation, while vaccine safety and efficacy have not been studied experimentally. Currently, there is no vaccine registered for use in camels, and thus vaccination is not recommended by the OIE.

Conclusion

Our knowledge of brucellosis in camels has increased over the last decade through comprehensive laboratory diagnosis, field analysis, and experimental infection trials. Infection with *B. abortus* and *B. melitensis* is frequent in different countries. The overall prevalence of camel brucellosis worldwide was 9.23%. The lack of prevention and control programs could make it a public health threat for the pastoral community. The highest incidence is when camels are kept together with infected small ruminants and bovines. A combination of direct methods and indirect methods can detect all positive reactors. However, isolation of the bacteria is still the golden test, although several molecular-based methods have been improved. Currently, no anti-brucellosis vaccine is recommended for use in camels by the OIE. Questions about the implementation of vaccination and the safety and efficacy of anti-*Brucella* vaccines in camels remain entirely open in endemic areas.

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References

Abbas, B. and Agab, H., 2002. A review of camel brucellosis. Preventive Veterinary Medicine 55: 47–56. https://doi.org/10.1016/S0167-5877(02)00055-7

Abdel Hafez, S.M., Ismael, AB ; Swelum, AA 2015. Development of a rapid and specific latex agglutination test for the serodiagnosis of camel brucellosis using a Brucella melitensis periplasmic protein antigen. Global Veterinaria 15: 260–267.

Abdelgawad, H.A., 2017. Serological and molecular detection of Brucella species in camels. Benha Veterinary Medical Journal. 33: 314–319.

Abdirahman, D.B., 2020. Camel Brucellosis: sero-prevalence and pathological lesions at slaughterhouses in Garissa County, Kenya. University of Nairobi.

Abebe, G., Worku, Y., Mamo, G., & Nazir, S. 2017. Sero-prevalence and associated risk factors of brucellosis in camel at Akaki Abattoir, Central Ethiopia. Journal of Animal Research, 7(4), 617–622. https://doi.org/10.5958/2277-940X.2017.00094.8

Admasu, P. and Kaynata, G., 2017. Seroprevalence of camel brucellosis in Yabello District of Borena Zone, Southern Ethiopia. Journal of Veterinary Medicine and Research 4: 1115.

Ahmed, M. O., Elmeshri, S. E., Abuzweda, A. R., Blauo, M., Abouzeed, Y. M., Ibrahim, A., ... & Elrais, A. 2010. Seroprevalence of brucellosis in animals and human populations in the western mountains region in Libya, December 2006–January 2008. Eurosurveillance, 15(30), 19625. https://doi.org/10.2807/ese.15.30.19625-en

Ahmad, S., Yaqoob, M., Hashmi, N., Ahmad, S., Zaman, M. A., & Tariq, M. 2010. Economic importance of camel: Unique alternative under crisis. Pakistan Veterinary Journal, 30(4), 191–197.

Al-Busadah, K. A., El-Bahr, S. M., & Khalafalla, A. I. 2017. Serum biochemical profile and molecular detection of pathogens in semen of infertile male dromedary camels (Camelus dromedarius). Animal reproduction science, 180, 58–65. https://doi.org/10.1016/j.anireprosci.2017.03.003

Al-Garadi, M.A., 2015. Bacteriological and serological study on brucellosis infection in camel (Camelus dromedaries), Al-Hodeida governorate, Yemen. International Journal of Advanced Research 3: 786–791.

Al-Khalaf, S. and El-Khaladi, A., 1989. Brucellosis of camels in Kuwait. Comparative Immunology, Microbiology and Infectious Diseases 12: 1–4. https://doi.org/10.1016/0147-9571(89)90002-7

Al-Majali, A.M., 2008. Risk factors associated with camel brucellosis in Jordan. Tropical Animal Health and Production 40: 193–200. https://doi.org/10.1007/s11250-007-9080-7

Al-Majali, A. M., Al-Qudah, K. M., Al-Tarazi, Y. H., & Al-Rawashdeh, O. F. 2008. Risk factors associated with camel brucellosis in Jordan. Tropical Animal Health and Production, 40(3), 193–200.

Alamian, S. and Dadar, M., 2019. Brucella abortus contamination of camel milk in two Iranian regions. Preventive Veterinary Medicine 169: 104708. https://doi.org/10.1016/j.prevetmed.2019.104708

Alatabi, A.C., 2020. Serodiagnosis for brucellosis in camels by rose Bengal and C-ELISA test in Iraq. Annals of Tropical Medicine & Public Health. 23(7): 20–32. https://doi.org/10.36295/ASRO.2020.23719

Alrawahi, A. H., Robertson, I., Hussain, M. H., & Saqib, M. 2019. A cross-sectional seroepidemiological study of camel (Camelus dromedarius) brucellosis and associated risk factors in the Sultanate of Oman. Open Veterinary Journal, 9(2), 133–139. https://doi.org/10.4314/ovj.v9i2.7

Aujla, K. M., Jasra, A. W., & Munir, M. 1998. Socioeconomic profile of camel herders in South-western mountainous areas of Pakistan. In Proceedings of the Third Annual Meeting for Animal Production under Arid Conditions, Al-Ain, United Arab Emirates. Vol. 2, 154–174.

Baumann, M. and Zessin, K., 1992. Productivity and health of camels (Camelus dromedarius) in Somalia: associations with trypanosomosis and brucellosis. Tropical Animal Health and Production 24: 145–156. https://doi.org/10.1007/BF02359606

Bayasgalan, C., 2018. Risk factors of brucellosis seropositivity in Bactrian camels of Mongolia. BMC Veterinary Research 14: 1–11. https://doi.org/10.1186/s12917-018-1664-0

Benfodil, K., 2022. Seroprevalence and associated risk factors for camel brucellosis in south Algeria. Veterinaria 71: 17–26. https://doi.org/10.51607/22331360.2022.71.1.17

Bornstein, S. and Musa, B., 1987. Prevalence of antibodies to some viral pathogens, Brucella abortus and Toxoplasma gondii in serum from camels (Camelus dromedarius) in Sudan. Journal of Veterinary Medicine, Series B 34: 364–370. https://doi.org/10.1111/j.1439-0450.1987.tb00409.x

Chinakwe, E., 2019. Microbial population changes in the rhizosphere of tomato Solanum Lycopersicum varieties during early growth in greenhouse. Malaysian Journal of Sustainable Agriculture (MJSA) 3: 23–27. https://doi.org/10.26480/mjsa.01.2019.23.27

Corbel, M.J., 2006. Brucellosis in humans and animals. World Health Organization.

Dadar, M. and Alamian, S., 2020. Isolation of Brucella melitensis from seronegative camel: potential implications in brucellosis control. Preventive Veterinary Medicine 185: 105194. https://doi.org/10.1016/j.prevetmed.2020.105194

Dadar, M., 2020. Contamination of milk and dairy products by Brucella species: a global systematic review and meta-analysis. Food Research International 128: 108775. https://doi.org/10.1016/j.foodres.2019.108775

Damir, H.A., 1989. Isolation of Brucella abortus from experimentally infected dromedary camels in Sudan: a preliminary report. Veterinary Research Communications 13: 403–406. https://doi.org/10.1007/BF00402559

Dawood, H.A., 2008. Brucellosis in Camels (Camelus dromedorius) in the south province of Jordan. American Journal of Agricultural and Biological Sciences 3: 623–626. https://doi.org/10.3844/ajabssp.2008.623.626

De Souza, C., 2021. The occurrence of aflatoxin M1 in industrial and traditional fermented milk: a systematic review study. Italian Journal of Food Science 33: 12–23. https://doi.org/10.15586/ijfs.v33iSP1.1982

Díaz, R., 2011. The rose Bengal test in human brucellosis: a neglected test for the diagnosis of a neglected disease. PLoS Negl Trop Dis. 5: e950. https://doi.org/10.1371/journal.pntd.0000950

El-Sayed, A.M., 2017. Sero-prevalence of camel brucellosis (Camelus dromedarius) and phenotypic characteristics of Brucella melitensis biovar 3 in Shalateen City, Red Sea Governorate, Egypt. African Journal of Microbiology Research 11: 1259–1266. https://doi.org/10.5897/AJMR2017.8629

Fatima, S., 2016. Serological, molecular detection and potential risk factors associated with camel brucellosis in Pakistan. Tropical Animal Health and Production 48: 1711–1718. https://doi.org/10.1007/s11250-016-1148-9

Franck, S.V., Prevalence of brucellosis in camels (camelus dromedarius) in northern Niger.

Gameel, S., 1993. Prevalence of camel brucellosis in Libya. Tropical Animal Health and Production 25: 91–93. https://doi.org/10.1007/BF02236513

Gessese, A., 2014. Seroprevalence of brucellosis in camels (Camelus dromedaries) in South East Ethiopia. Journal of Veterinary Scientific Medical Diagnosis 3: 2.

Ghanem, Y.M., 2009. Seroprevalence of camel brucellosis (Camelus dromedarius) in Somaliland. Tropical Animal Health and Production 41: 1779. https://doi.org/10.1007/s11250-009-9377-9

Ghorbani, A., 2013. Comparison of serology, culture, and PCR for detection of brucellosis in slaughtered camels in Iran. Comparative Clinical Pathology 22: 913–917. https://doi.org/10.1007/s00580-012-1499-1

Gizachew, A., 2014. Review on medicinal and nutritional values of camel milk. Nature and Science 12: 35–41.

Gutema Wegi, F., 2020. Brucellosis in cattle, camel and human: seroprevalence and associated risk factors in Amibara district of Afar region, Ethiopia. Addis Ababa University.

Gutema, F. and Tesfaye, J., 2019. Review on camel brucellosis: public health importance and status in Ethiopia. Academic Research Journal of Agricultural Science and Research 7: 513–529.

Gwida, M., 2012. Brucellosis in camels. Research in Veterinary Science 92: 351–355. https://doi.org/10.1016/j.rvsc.2011.05.002

Gwida, M.M., 2011. Comparison of diagnostic tests for the detection of Brucella spp. in camel sera. BMC Research Notes 4: 1–7. https://doi.org/10.1186/1756-0500-4-525

Hadush, A., 2013. Sero-epidemiology of camel brucellosis in the Afar region of Northeast Ethiopia. Journal of Veterinary Medicine and Animal Health 5: 269–275.

Hamdy, M.E. and Amin, A., 2002. Detection of Brucella species in the milk of infected cattle, sheep, goats and camels by PCR. The Veterinary Journal 163: 299–305. https://doi.org/10.1053/tvjl.2001.0681

Hanon, B.M., 2017. Seroprevalence of brucellosis and toxoplasmosis in camels of Wasit Province, Iraq. AL-Qadisiyah Journal of Veterinary Medicine Sciences 16: 29–37. https://doi.org/10.29079/vol16iss2art440

Higgins, J.P. and Green, S., 2011. Cochrane handbook for systematic reviews of interventions. John Wiley & Sons.

Higgins, J.P. and Thompson, S., 2002. Quantifying heterogeneity in a meta-analysis. Statistics in Medicine 21: 1539–1558. https://doi.org/10.1002/sim.1186

Hosein, H., 2016. Seroprevalence of camel brucellosis and molecular characterization of Brucella melitensis recovered from

dromedary camels in Egypt. Res. J. Vet. Pract. 4: 17–24. https://doi.org/10.14737/journal.rjvp/2016/4.1.17.24

Hussein, M.F., 2021. Brucellosis (Brucella abortus and Br. melitensis). In: Infectious diseases of dromedary camels. Springer, pp. 89–94.

Ibrahim, M., 2020. Sero-prevalence of brucellosis, Q-fever and Rift Valley Fever in humans and livestock in Somali region, Ethiopia. bioRxiv. https://doi.org/10.1101/2020.01.31.928374

Ismail, W., 2012. Seroprevalence and associated risk factors of camel (Camelus dromedaries) brucellosis in and around Dire Dawa, Ethiopia. Global Veterinaria 8: 480–483.

Jackson, D., 2015. Approximate confidence intervals for moment-based estimators of the between-study variance in random effects meta-analysis. Research Synthesis Methods 6: 372–382. https://doi.org/10.1002/jrsm.1162

Jasra, A.W. and Mirza, M.A., 2004. Camel production systems in Asia. of the Series: ICAR Technical Series.

Khadjeh, G., 1999. Incidence of brucellosis in one-humped camels of Boushehr, Iran. Archives of Razi Institute 50: 83–86.

Khalafalla, A.I., 2017. A study on some reproductive disorders in dromedary camel herds in Saudi Arabia with special references to uterine infections and abortion. Tropical Animal Health and Production 49: 967–974. https://doi.org/10.1007/s11250-017-1284-x

Khalafalla, A.I., 2020. Preliminary comparative assessment of brucellergene skin test for diagnosis of brucellosis in dromedary camels (Camelus dromedarius). Vector-Borne and Zoonotic Diseases 20: 412–417. https://doi.org/10.1089/vbz.2019.2537

Khamesipour, F., 2015. Molecular study of Brucellosis in camels by the use of TaqMan® real-time PCR. Acta Microbiologica et Immunologica Hungarica 62: 409–421. https://doi.org/10.1556/030.62.2015.4.6

Khan, A.U., 2020. Seroprevalence and molecular identification of Brucella spp. in camels in Egypt. Microorganisms 8: 1035. https://doi.org/10.3390/microorganisms8071035

Kim, J.-Y., 2016. Distinctive phenotypic and molecular characteristics of Brucella abortus strains isolated from Mongolia. Turkish Journal of Veterinary and Animal Sciences 40: 562–568. https://doi.org/10.3906/vet-1511-75

Kudi, A., 1997. Brucellosis in camels. Journal of Arid Environments 37: 413–417. https://doi.org/10.1006/jare.1997.0277

Kula, J.T. and Tegegne, D., 2016. Chemical composition and medicinal values of camel milk. Int J Res Stud Biosci. 4: 13–25.

Liberati, A., 2009. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. PLoS Medicine. 6: 15–25. https://doi.org/10.1371/journal.pmed.1000100

Lu, H., 2021. A critical review on communication mechanism within plant-endophytic fungi interactions to cope with biotic and abiotic stresses. Journal of Fungi 7: 719. https://doi.org/10.3390/jof7090719

Mahyuddin, H.S., 2020. Using soxhlet and supercritical fluid (SFE) methods. Science 4: 9–12. https://doi.org/10.26480/gws.01.2020.09.12

Megersa, B., 2005. Seroprevalence of brucellosis in camels (Camelus dromedarius) in Borena Lowland, Southern Ethiopia Seroprevalence de la brucellose chez les dromadaires (Camelus dromedarius) dans la plaine de Borena au Sud de l'Ethiopie. Bulletin of Animal Health and Production in Africa 53: 252–257. https://doi.org/10.4314/bahpa.v53i4.32718

Megersa, B., 2011. Seroprevalence of brucellosis and its contribution to abortion in cattle, camel, and goat kept under pastoral management in Borana, Ethiopia. Tropical Animal Health and Production 43: 651–656. https://doi.org/10.1007/s11250-010-9748-2

Moghney, F., 2004. A preliminary study on brucellosis on camels at Behira province. Ass Univ Bull Environ Res. 7: 39–43. https://doi.org/10.21608/auber.2004.150592

Mohammed, M.A. and Shigidy, M.T., 2013. Sero-prevalence and epidemiology of brucellosis in camels, sheep and goats in Abu Dhabi Emirate. International Journal of Animal and Veterinary Advances 5: 82–86. https://doi.org/10.19026/ijava.5.5581

Mokhtar, M.O., 2007. Survey of Brucellosis among sheep, goats, camels and. Journal of Animal and Veterinary Advances 6: 635–637.

Mokhtarian, M., 2020. Aflatoxin B1 in the Iranian pistachio nut and decontamination methods: a systematic review. Quality Assurance and Safety of Crops & Foods 12: 15–25. https://doi.org/10.15586/qas.v12i4.784

Moustafa, T., 1998. Surveillance of Brucella antibodies in camels of the eastern region of Abu Dhabi, United Arab Emirates. Proceedings of the Third Annual Meeting for Animal Production under Arid Conditions 1: 160–166.

Musa, M. and Shigidi, M., 2001. Brucellosis in camels in intensive animal breeding areas of Sudan. Implications in abortion and early-life infection= La brucellose chez les dromadaires en zones d'élevage intensif au Soudan. Implications dans l'avortement et l'infection précoce= Brucelosis en camellos en areas de cria animal intensiva en Sudan: implicaciones para el aborto y las infecciones neonatales. Revue d'élevage et de médecine vétérinaire des pays tropicaux. 54. https://doi.org/10.19182/remvt.9799

Musa, M., 2008. Brucellosis in camels (Camelus dromedarius) in Darfur, western Sudan. Journal of Comparative Pathology 138: 151–155. https://doi.org/10.1016/j.jcpa.2007.10.005

Noor, M., 2020. Prevalence, risk factors associated with Brucellosis and presence of pathogenic bacteria isolated from camel milk in Garissa County, Kenya. South Asian Journal of Research in Microbiology 42–52. https://doi.org/10.9734/sajrm/2020/v6i430158

Omer, M., 2000. Prevalence of antibodies to Brucella spp. in cattle, sheep, goats, horses and camels in the State of Eritrea; influence of husbandry systems. Epidemiology & Infection 125: 447–453. https://doi.org/10.1017/S0950268899004501

Omer, M., 2010. Brucellosis in camels, cattle and humans: associations and evaluation of serological tests used for diagnosis of the disease in certain nomadic localities in Sudan. Revue scientifique et technique (International Office of Epizootics) 29: 663–669. https://doi.org/10.20506/rst.29.3.2003

Pappas, G., 2010. The changing Brucella ecology: novel reservoirs, new threats. International Journal of Antimicrobial Agents 36: S8–S11. https://doi.org/10.1016/j.ijantimicag.2010.06.013

Rabah, I., 2020. Serological and molecular epidemiological study on Brucellosis in camels and human in Matrouh Province. Damanhour Journal of Veterinary Sciences 4: 1–6.

Radwan, A., 1992. Serological and bacteriological study of brucellosis in camels in central Saudi Arabia. Revue Scientifique et Technique-Office International des Epizooties 11: 837–837. https://doi.org/10.20506/rst.11.3.612

Sabrina Mahyuddin, H., 2020. Antibacterial activity of compounds from azolla pinnata extracted using soxhlet and supercritical fluid (SFE) methods. Science Heritage Journal 4(1): 9–12. https://doi.org/10.26480/gws.01.2020.09.12

Salisu, U., 2018. Risk factors and knowledge of Brucella infection in camels, attitudes and practices of camel handlers in Katsina State, Nigeria. Nigerian Veterinary Journal 39: 227–239. https://doi.org/10.4314/nvj.v39i3.6

Shahzad, A., 2017. Seroprevalence and molecular investigation of brucellosis in camels of selected districts of Punjab, Pakistan. The Thai Journal of Veterinary Medicine 47: 207.

Shehzad, A., 2020. Seroprevalence and potential risk factors associated with brucellosis in the Desert Thal of Pakistan. Human and Veterinary Medicine 12: 47–52.

Shome, R., 2013. A report of seroprevalence of camel brucellosis in India. J Camel Pract Res. 20: 183–186.

Solonitsuin, M., 1949. Brucellosis in camels. Veterinarya, Moscow 26: 16–21.

Sprague, L.D., 2012. A review on camel brucellosis: a zoonosis sustained by ignorance and indifference. Pathogens and Global Health 106: 144–149. https://doi.org/10.1179/2047773212Y.0000000020

Stanley, T.D. and Jarrell, S.B., 1989. Meta-regression analysis: a quantitative method of literature surveys. Journal of Economic Surveys 3: 161–170. https://doi.org/10.1111/j.1467-6419.1989.tb00064.x

Teshome, H., 2003. A seroprevalence study of camel brucellosis in three camel-rearing regions of Ethiopia. Tropical Animal Health and Production 35: 381–390. https://doi.org/10.1023/A:1025874310261

Tilahun, B., 2013. Camel brucellosis and management practices in Jijiga and Babile districts, Eastern Ethiopia. Journal of Veterinary Medicine and Animal Health 5: 81–86.

Ullah, S., 2015. Prevalence of brucellosis among camels in district Muzaffargarh Pakistan. J Infec Mol Biol. 3: 52–56. https://doi.org/10.14737/journal.jimb/2015/3.2.52.56

Waktole, H., 2022. Seroepidemiology of camel brucellosis in and around Dire Dawa, Eastern Ethiopia. Veterinary Medicine International.

Wardeh, M., 2004. Classification of the dromedary camels. J. Camel Sci. 1: 1–7.

Warsame, I., 2020. Seroprevalence and associated risk factors of camel (Camelus dromedaries) Brucellosis in and around Dire Dawa, Ethiopia.

Wernery, U., 2014. Camelid brucellosis: a review. Rev sci tech. 33: 839–857. https://doi.org/10.20506/rst.33.3.2322

Yawoz, M., 2012. A serological study of brucellosis in camels south of Kirkuk, Iraq. Iraqi Journal of Veterinary Sciences 26: 105–107. https://doi.org/10.33899/ijvs.2012.67484

Zowghi, E. and Ebadi, A., 1989. Brucellosis in Camels in Iran. Archives of Razi Institute 40: 111–115.857. https://doi.org/10.20506/rst.33.3.2322

Supplementary file 1

Table S1. Main characteristic included in our study.

Author	Start	End	Location	Animal species	No sample	Positive	Method	D/i	Sample
Zowghi	1986	1987	Iran	Camelus dromedarius	953	77	CFT	I	Blood
Zowghi	1986	1987	Iran	Camelus dromedarius	300	3	Culture	D	Lymph node
Al-Khalaf	1986	1986	Kuwait	Camelus dromedarius	698	104	CFT	I	Blood
Al-Khalaf	1986	1986	Kuwait	Camelus dromedarius	698	91	SAT	I	Blood
Al-Khalaf	1986	1986	Kuwait	Camelus dromedarius	209	17	MRT	I	Milk
Al-Khalaf	1986	1986	Kuwait	Camelus dromedarius	5	2	Culture	D	Fetus
Bornstein	1987	1987	Sudan	Camelus dromedarius	102	7	SAT	I	Blood
Bornstein	1987	1987	Sudan	Camelus dromedarius	102	7	CFT	I	Blood
Radwan	1989	1991	Saudi Arabia	Camelus dromedarius	2630	212	RBT	I	Blood
Radwan	1989	1991	Saudi Arabia	Camelus dromedarius	44	4	RBT	I	Blood
Radwan	1989	1991	Saudi Arabia	Camelus dromedarius	2283	195	RBT	I	Blood
Radwan	1989	1991	Saudi Arabia	Camelus dromedarius	100	26	Culture	I	Milk
Gameel	1990	1991	Libya	Camelus dromedarius	967	39	SAT	I	Blood
Gameel	1990	1991	Libya	Camelus dromedarius	124	5	Culture	D	Milk
Gameel	1990	1991	Libya	Camelus dromedarius	124	3	Culture	D	Fetus
Gameel	1990	1991	Libya	Camelus dromedarius	124	1	Culture	D	Vaginal swab
Moustafa	1990	1991	United Arab Emirates	Camelus dromedarius	1794	4	CFT	I	Blood
Moustafa	1991	1992	United Arab Emirates	Camelus dromedarius	11323	26	CFT	I	Blood
Moustafa	1992	1993	United Arab Emirates	Camelus dromedarius	1900	7	CFT	I	Blood

Isolate	Biovar	Gender	Symptom	Location	Sex	Herd size	Age	Abortion history	Mix rearing	Title
Brucella melitensis	3	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Brucellosis in camels in Iran (Zowghi and Ebadi, 1989)
Brucella melitensis	1	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Brucellosis in camels in Iran (Zowghi and Ebadi, 1989)
Brucella spp	ND	ND	Abortion	ND	ND	ND	ND	ND	ND	Brucellosis of camels in Kuwait (Al-Khalaf and El-Khaladi, 1989)
Brucella spp	ND	ND	Abortion	ND	ND	ND	ND	ND	ND	Brucellosis of camels in Kuwait (Al-Khalaf and El-Khaladi, 1989)
Brucella spp	ND	ND	Abortion	ND	ND	ND	ND	ND	ND	Brucellosis of camels in Kuwait (Al-Khalaf and El-Khaladi, 1989)
Brucella abortus	ND	ND	Abortion	ND	ND	ND	ND	ND	ND	Brucellosis of camels in Kuwait (Al-Khalaf and El-Khaladi, 1989)
Brucella abortus	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Prevalence of antibodies due to some viral pathogens, Brucella abortus, and Toxoplasma gondii in serum from camels (Camelus dromedarius) in Sudan (Bornstein and Musa, 1987)
Brucella abortus	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Prevalence of antibodies due to some viral pathogens, Brucella abortus, and Toxoplasma gondii in serum from camels (Camelus dromedarius) in Sudan (Bornstein and Musa, 1987)
Brucella melitensis	1	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Serological and bacteriological study of brucellosis in camels in central Saudi Arabia(Radwan et al., 1992)
Brucella melitensis	1	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Serological and bacteriological study of brucellosis in camels in central Saudi Arabia. (Radwan et al., 1992)
Brucella melitensis	2	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Serological and bacteriological study of brucellosis in camels in central Saudi Arabia (Radwan et al., 1992)
Brucella melitensis	2	Female	Healthy animal	ND	ND	ND	ND	ND	ND	Serological and bacteriological study of brucellosis (Gameel et al., 1993) in camels in central Saudi Arabia (Radwan et al., 1992)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Prevalence of camel brucellosis in Libya (Gameel et al., 1993)
Brucella melitensis	1	Female	Abortion	ND	S	ND	ND	ND	ND	Prevalence of camel brucellosis in Libya (Gameel et al., 1993)
Brucella melitensis	1	Female	Abortion	ND	S	ND	ND	ND	ND	Prevalence of camel brucellosis in Libya (Gameel et al., 1993)
Brucella melitensis	1	Female	Abortion	ND	S	ND	ND	ND	ND	Prevalence of camel brucellosis in Libya (Gameel et al., 1993)
Brucella spp	ND	ND	ND	ND	ND	ND	ND	ND	ND	Surveillance of Brucella antibodies in camels of the eastern region of Abu Dhabi, United Arab Emirates (Moustafa et al., 1998)
Brucella spp	ND	ND	ND	ND	ND	ND	ND	ND	ND	Surveillance of Brucella antibodies in camels of the eastern region of Abu Dhabi, United Arab Emirates (Moustafa et al., 1998)
Brucella spp	ND	ND	ND	ND	ND	ND	ND	ND	ND	Surveillance of Brucella antibodies in camels of the eastern region of Abu Dhabi, United Arab Emirates (Moustafa et al., 1998)

Table S1. Continued.

Author	Start	End	Location	Animal species	No sample	Positive	Method	D/i	Sample
Baumann	1992	1992	Somalia	Camelus dromedarius	1539	30	SAT	I	Blood
Baumann	1992	1992	Somalia	Camelus dromedarius	1539	5	CFT	I	Blood
Moustafa	1993	1994	United Arab Emirates	Camelus dromedarius	1433	3	CFT	I	Blood
Moustafa	1994	1995	United Arab Emirates	Camelus dromedarius	3145	3	CFT	I	Blood
Moustafa	1995	1996	United Arab Emirates	Camelus dromedarius	7899	8	CFT	I	Blood
Khadjeh	1997	1997	Iran	Camelus dromedarius	258	5	SAT	I	Blood
Khadjeh	1997	1997	Iran	Camelus dromedarius	5	3	Culture	D	Lymph node
Teshome	2000	2001	Ethiopia	Camelus dromedarius	1442	82	RBT	I	Blood
Teshome	2000	2001	Ethiopia	Camelus dromedarius	1442	60	CFT	I	Blood
Teshome	2000	2001	Ethiopia	Camelus dromedarius	282	12	CFT	I	Blood
Teshome	2000	2001	Ethiopia	Camelus dromedarius	1157	48	CFT	I	Blood
Omer	2000	2000	Ethiopia	Camelus dromedarius	98	3	CFT	I	Blood
Omer	2000	2000	Ethiopia	Camelus dromedarius	98	3	RBT	I	Blood
Hamdy	2002	2002	Egypt	Camelus dromedarius	12	1	RBT	I	Milk
Hamdy	2002	2002	Egypt	Camelus dromedarius	12	1	SAT	I	Milk
Hamdy	2002	2002	Egypt	Camelus dromedarius	12	1	MRT	I	Milk
Hamdy	2002	2002	Egypt	Camelus dromedarius	12	1	PCR	D	Milk

Isolate	Biovar	Gender	Symptom	Location	Sex	Herd size	Age	Abortion history	Mix rearing	Title
Brucella spp	ND	ND	Healthy animal	S	ND	S	ND	ND	S	Productivity and health of camels (Camelus dromedarius) in Somalia: associations with trypanosomosis and brucellosis (Baumann and Zessin, 1992)
Brucella spp	ND	ND	Healthy animal	S	ND	S	ND	ND	S	Productivity and health of camels (Camelus dromedarius) in Somalia: associations with trypanosomosis and brucellosis (Baumann and Zessin, 1992)
Brucella spp	ND	ND	ND	ND	ND	ND	ND	ND	ND	Surveillance of Brucella antibodies in camels of the eastern region of Abu Dhabi, United Arab Emirates (Moustafa et al., 1998)
Brucella spp	ND	ND	ND	ND	ND	ND	ND	ND	ND	Surveillance of Brucella antibodies in camels of the eastern region of Abu Dhabi, United Arab Emirates (Moustafa et al., 1998)
Brucella spp	ND	ND	ND	ND	ND	ND	ND	ND	ND	Surveillance of Brucella antibodies in camels of the eastern region of Abu Dhabi, United Arab Emirates (Moustafa et al., 1998)
Brucella spp	ND	ND	ND	ND	ND	ND	ND	ND	ND	Incidence of brucellosis in one-humped camels of Boushehr, Iran (Khadjeh et al., 1999)
Brucella melitensis	1	Female	ND	ND	ND	ND	ND	ND	ND	Incidence of brucellosis in one-humped camels of Boushehr, Iran (Khadjeh et al., 1999)
Brucella spp	ND	ND	Healthy animal	NS	NS	ND	ND	ND	ND	A seroprevalence study of camel brucellosis in three camel-rearing regions of Ethiopia (Teshome et al., 2003)
Brucella spp	ND	ND	Healthy animal	NS	NS	ND	ND	ND	ND	A seroprevalence study of camel brucellosis in three camel-rearing regions of Ethiopia (Teshome et al., 2003)
Brucella spp	ND	ND	Healthy animal	NS	NS	ND	ND	ND	ND	A seroprevalence study of camel brucellosis in three camel-rearing regions of Ethiopia (Teshome et al., 2003)
Brucella spp	ND	ND	Healthy animal	NS	NS	ND	ND	ND	ND	A seroprevalence study of camel brucellosis in three camel-rearing regions of Ethiopia (Teshome et al., 2003)
Brucella spp	ND	ND	Healthy animal	ND	ND	S	ND	ND	S	Prevalence of antibodies to Brucella spp. in cattle, sheep, goats, horses, and camels in the State of Eritrea; influence of husbandry systems (Omer et al., 2000)
Brucella spp	ND	ND	Healthy animal	ND	ND	S	ND	ND	S	Prevalence of antibodies to Brucella spp. in cattle, sheep, goats, horses, and camels in the State of Eritrea; influence of husbandry systems (Omer et al., 2000)
Brucella spp	ND	Female	Healthy animal	ND	ND	ND	ND	ND	ND	Detection of Brucella species in the milk of infected cattle, sheep, goats and camels by PCR(Hamdy and Amin, 2002)
Brucella spp	ND	Female	Healthy animal	ND	ND	ND	ND	ND	ND	Detection of Brucella species in the milk of infected cattle, sheep, goats, and camels by PCR (Hamdy and Amin, 2002)
Brucella spp	ND	Female	Healthy animal	ND	ND	ND	ND	ND	ND	Detection of Brucella species in the milk of infected cattle, sheep, goats and camels by PCR (Hamdy and Amin, 2002)
Brucella spp	ND	Female	Healthy animal	ND	ND	ND	ND	ND	ND	Detection of Brucella species in the milk of infected cattle, sheep, goats, and camels by PCR (Hamdy and Amin, 2002)

Table S1. Continued.

Author	Start	End	Location	Animal species	No sample	Positive	Method	D/i	Sample
FRANCK	2002	2002	Niger	Camelus dromedarius	395	3	c-ELISA	I	Blood
Musa	2002	2002	Sudan	Camelus dromedarius	4	1	SAT	I	Blood
Musa	2002	2002	Sudan	Camelus dromedarius	4	2	RBT	I	Blood
Musa	2002	2002	Sudan	Camelus dromedarius	17	3	SAT	I	Blood
Musa	2002	2002	Sudan	Camelus dromedarius	6	2	Culture	D	Lymph node
Musa	2002	2002	Sudan	Camelus dromedarius	6	3	Culture	D	Lymph node
Musa	2001	2002	Sudan	Camelus dromedarius	993	72	SAT	I	Blood
Musa	2001	2002	Sudan	Camelus dromedarius	2420	196	CFT	I	Blood
Musa	2001	2002	Sudan	Camelus dromedarius	306	51	CFT	I	Blood
Musa	2001	2002	Sudan	Camelus dromedarius	110	3	MRT	I	Milk
Megersa	2003	2004	Ethiopia	Camelus dromedarius	3218	58	CFT	I	Blood
Megersa	2003	2004	Ethiopia	Camelus dromedarius	3218	58	RBT	I	Blood
Moghney	2004	2004	Egypt	Camelus dromedarius	679	59	RBT	I	Blood
Moghney	2004	2004	Egypt	Camelus dromedarius	679	60	SAT	I	Blood
Moghney	2004	2004	Egypt	Camelus dromedarius	679	61	Rivanol test	I	Blood
Moghney	2004	2004	Egypt	Camelus dromedarius	679	55	2-ME	I	Blood
Moghney	2004	2004	Egypt	Camelus dromedarius	679	64	Buffered Acidified Plate Antigen Test	I	Blood
Moghney	2004	2004	Egypt	Camelus dromedarius	679	62	i-ELISA	I	Blood
Moghney	2004	2004	Egypt	Camelus dromedarius	87	8	RBT	I	Blood

Isolate	Biovar	Gender	Symptom	Location	Sex	Herd size	Age	Abortion history	Mix rearing	Title
Brucella spp	ND	ND	Healthy animal	S	ND	ND	S	ND	ND	Prevalence of brucellosis in camels (camelus dromedarius) in northern Niger (Franck et al.)
Brucella spp	ND	Male	Knee hygroma	ND	ND	ND	ND	ND	S	Brucellosis in camels (Camelus dromedarius) in Darfur, western Sudan (Musa and Shigidi, 2001)
Brucella spp	ND	Male	Knee hygroma	ND	ND	ND	ND	ND	S	Brucellosis in camels (Camelus dromedarius) in Darfur, western Sudan(Musa and Shigidi, 2001)
Brucella spp	ND	Female	Abortion	ND	ND	ND	ND	ND	S	Brucellosis in camels (Camelus dromedarius) in Darfur, western Sudan (Musa and Shigidi, 2001)
Brucella melitensis	3	Female	Arthritis	ND	ND	ND	ND	ND	S	Brucellosis in camels (Camelus dromedarius) in Darfur, western Sudan (Musa and Shigidi, 2001)
Brucella abortus	6	Female	Wry neck syndrome	ND	ND	ND	ND	ND	S	Brucellosis in camels (Camelus dromedarius) in Darfur, western Sudan (Musa and Shigidi, 2001)
Brucella spp	ND	Male	Healthy animal	ND	ND	ND	ND	ND	ND	Implications in abortion and early-life infection= La brucellose chez les dromadaires en zones d'élevage intensif au Soudan (Musa and Shigidi, 2001)
Brucella spp	ND	Female	Healthy animal	ND	ND	ND	ND	ND	ND	Implications in abortion and early-life infection= La brucellose chez les dromadaires en zones d'élevage intensif au Soudan (Musa and Shigidi, 2001)
Brucella spp	ND	Female	Abortion	ND	ND	ND	ND	ND	ND	Implications in abortion and early-life infection= La brucellose chez les dromadaires en zones d'élevage intensif au Soudan (Musa and Shigidi, 2001)
Brucella spp	ND	Female	Abortion	ND	ND	ND	ND	ND	ND	Implications in abortion and early-life infection= La brucellose chez les dromadaires en zones d'élevage intensif au Soudan(Musa and Shigidi, 2001)
Brucella spp	ND	ND	Healthy animal	ND	S	S	S	ND	ND	Seroprevalence of brucellosis in camels (Camelus dromedarius) in Borena Lowland, Southern Ethiopia (Megersa et al., 2005)
Brucella spp	ND	ND	Healthy animal	ND	S	S	S	ND	ND	Seroprevalence of brucellosis in camels (Camelus dromedarius) in Borena Lowland, Southern Ethiopia (Megersa et al., 2005)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	A preliminary study on brucellosis on camels at Behira province (Moghney, 2004)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	A preliminary study on brucellosis on camels at Behira province (Moghney, 2004)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	A preliminary study on brucellosis on camels at Behira province(Moghney, 2004)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	A preliminary study on brucellosis on camels at Behira province (Moghney, 2004)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	A preliminary study on brucellosis on camels at Behira province (Moghney, 2004)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	A preliminary study on brucellosis on camels at Behira province (Moghney, 2004)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	S	A preliminary study on brucellosis on camels at Behira province (Moghney, 2004)

Table S1. Continued.

Author	Start	End	Location	Animal species	No sample	Positive	Method	D/i	Sample
Moghney	2004	2004	Egypt	Camelus dromedarius	87	8	SAT	I	Blood
Moghney	2004	2004	Egypt	Camelus dromedarius	87	7	Rivanol test	I	Blood
Moghney	2004	2004	Egypt	Camelus dromedarius	87	7	2-ME	I	Blood
Moghney	2004	2004	Egypt	Camelus dromedarius	87	9	Buffered Acidified Plate Antigen Test	I	Blood
Moghney	2004	2004	Egypt	Camelus dromedarius	87	9	i-ELISA	I	Blood
Al-Majali	2004	2006	Jordan	Camelus dromedarius	412	47	RBT	I	Blood
Al-Majali	2004	2006	Jordan	Camelus dromedarius	412	39	CFT	I	Blood
Al-Majali	2004	2006	Jordan	Camelus dromedarius	7	4	Culture	D	Fetus
Mokhtar	2004	2006	Sudan	Camelus dromedarius	14372	2605	RBT	I	Blood
Tilahun	2005	2006	Ethiopia	Camelus dromedarius	822	28	RBT	I	Blood
Tilahun	2005	2006	Ethiopia	Camelus dromedarius	822	20	CFT	I	Blood
Tilahun	2005	2006	Ethiopia	Camelus dromedarius	641	15	CFT	I	Blood
Tilahun	2005	2006	Ethiopia	Camelus dromedarius	181	5	CFT	I	Blood
Dawood	2006	2007	Jordan	Camelus dromedarius	640	91	RBT	I	Blood
Dawood	2006	2007	Jordan	Camelus dromedarius	640	79	CFT	I	Blood
Dawood	2006	2007	Jordan	Camelus dromedarius	30	13	Culture	D	Fetus
Dawood	2006	2007	Jordan	Camelus dromedarius	26	2	Culture	D	Milk
Dawood	2006	2007	Jordan	Camelus dromedarius	147	11	CFT	I	Blood
Dawood	2006	2007	Jordan	Camelus dromedarius	493	68	CFT	I	Blood
Junaidu	2006	2006	Nigeria	Camelus dromedarius	141	18	c-ELISA	I	Blood

Isolate	Biovar	Gender	Symptom	Location	Sex	Herd size	Age	Abortion history	Mix rearing	Title
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	S	A preliminary study on brucellosis on camels at Behira province (Moghney, 2004)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	S	A preliminary study on brucellosis on camels at Behira province (Moghney, 2004)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	S	A preliminary study on brucellosis on camels at Behira province (Moghney, 2004)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	S	A preliminary study on brucellosis on camels at Behira province (Moghney, 2004)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	S	A preliminary study on brucellosis on camels at Behira province (Moghney, 2004)
Brucella spp	ND	ND	Healthy animal	ND	ND	S	ND	ND	S	Risk factors associated with camel brucellosis in Jordan (Al-Majali et al., 2008)
Brucella spp	ND	ND	Healthy animal	ND	ND	S	ND	ND	S	Risk factors associated with camel brucellosis in Jordan (Al-Majali et al., 2008)
Brucella melitensis	3	Female	Abortion	ND	S	S	ND	ND	S	Risk factors associated with camel brucellosis in Jordan (Al-Majali et al., 2008)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Survey of Brucellosis among Sheep, Goats, Camels (Mokhtar et al., 2007)
Brucella spp	ND	ND	Healthy animal	NS	NS	NS	ND	ND	NS	Camel brucellosis and management practices in Jijiga and Babile districts, Eastern Ethiopia (Tilahun et al., 2013)
Brucella spp	ND	ND	Healthy animal	NS	NS	NS	ND	ND	NS	Camel brucellosis and management practices in Jijiga and Babile districts, Eastern Ethiopia (Tilahun et al., 2013)
Brucella spp	ND	Female	Healthy animal	NS	NS	NS	ND	ND	NS	Camel brucellosis and management practices in Jijiga and Babile districts, Eastern Ethiopia (Tilahun et al., 2013)
Brucella spp	ND	Male	Healthy animal	NS	NS	NS	ND	ND	NS	Camel brucellosis and management practices in Jijiga and Babile districts, Eastern Ethiopia (Tilahun et al., 2013)
Brucella spp	ND	ND	Healthy animal	NS	NS	ND	ND	ND	ND	Brucellosis in Camels (Camelus dromedorius) in the south province of Jordan (Dawood, 2008)
Brucella spp	ND	ND	Healthy animal	NS	NS	ND	ND	ND	ND	Brucellosis in Camels (Camelus dromedorius) in the south province of Jordan(Dawood, 2008)
Brucella melitensis	3	Female	Abortion	NS	NS	ND	ND	ND	ND	Brucellosis in Camels (Camelus dromedorius) in the south province of Jordan (Dawood, 2008)
Brucella melitensis	3	Female	Abortion	NS	NS	ND	ND	ND	ND	Brucellosis in Camels (Camelus dromedorius) in the south province of Jordan (Dawood, 2008)
Brucella spp	ND	Male	Healthy animal	ND	ND	ND	ND	ND	ND	Brucellosis in Camels (Camelus dromedorius) in the south province of Jordan (Dawood, 2008)
Brucella spp	ND	Female	Healthy animal	ND	ND	ND	ND	ND	ND	Brucellosis in Camels (Camelus dromedorius) in the south province of Jordan (Dawood, 2008)
Brucella spp	ND	Female	Healthy animal	ND	ND	ND	ND	ND	ND	Brucellosis in camels (Camelus dromedaries) slaughtered in Sokoto, northwestern Nigeria (Dawood, 2008)

Table S1. Continued.

Author	Start	End	Location	Animal species	No sample	Positive	Method	D/i	Sample
Junaidu	2006	2006	Nigeria	Camelus dromedarius	141	18	RBT	I	Blood
Junaidu	2006	2006	Nigeria	Camelus dromedarius	141	18	SAT	I	Blood
Junaidu	2006	2006	Nigeria	Camelus dromedarius	188	19	RBT	I	Blood
Junaidu	2006	2006	Nigeria	Camelus dromedarius	188	19	SAT	I	Blood
Junaidu	2006	2006	Nigeria	Camelus dromedarius	188	19	c-ELISA	I	Blood
Ahmed	2006	2008	Libya	Camelus dromedarius	14	2	RBT	I	Blood
Omer	2007	2010	Sudan	Camelus dromedarius	489	138	c-ELISA	I	Blood
Omer	2007	2010	Sudan	Camelus dromedarius	1736	697	c-ELISA	I	Blood
Omer	2007	2010	Sudan	Camelus dromedarius	2000	797	RBT	I	Blood
Omer	2007	2010	Sudan	Camelus dromedarius	2000	809	c-ELISA	I	Blood
Omer	2007	2010	Sudan	Camelus dromedarius	3	3	Culture	D	Lymph node
Megersa	2007	2008	Ethiopia	Camelus dromedarius	756	17	CFT	I	Blood
Ghanem	2008	2008	Somaliland	Camelus dromedarius	1246	49	RBT	I	Blood
Ghanem	2008	2008	Somaliland	Camelus dromedarius	1246	39	i-ELISA	I	Blood

Isolate	Biovar	Gender	Symptom	Location	Sex	Herd size	Age	Abortion history	Mix rearing	Title
Brucella spp	ND	Female	Healthy animal	ND	ND	ND	ND	ND	ND	Brucellosis in camels (Camelus dromedaries) slaughtered in Sokoto, northwestern Nigeria (Dawood, 2008)
Brucella spp	ND	Female	Healthy animal	ND	ND	ND	ND	ND	ND	Brucellosis in camels (Camelus dromedaries) slaughtered in Sokoto, northwestern Nigeria (Dawood, 2008)
Brucella spp	ND	Male	Healthy animal	ND	ND	ND	ND	ND	ND	Brucellosis in camels (Camelus dromedaries) slaughtered in Sokoto, northwestern Nigeria (Dawood, 2008)
Brucella spp	ND	Male	Healthy animal	ND	ND	ND	ND	ND	ND	Brucellosis in camels (Camelus dromedaries) slaughtered in Sokoto, northwestern Nigeria (Dawood, 2008)
Brucella spp	ND	Male	Healthy animal	ND	ND	ND	S	ND	ND	Brucellosis in camels (Camelus dromedaries) slaughtered in Sokoto, northwestern Nigeria (Dawood, 2008)
Brucella spp	ND	Male	Healthy animal	ND	ND	ND	ND	ND	ND	Seroprevalence of brucellosis in animal and human populations in the western mountains region in Libya, December 2006–January 2008 (Ahmed et al., 2010)
Brucella spp	ND	Male	Healthy animal	ND	ND	ND	ND	ND	ND	Brucellosis in camels, cattle, and humans: associations and evaluation of serological tests used for the diagnosis of the disease in certain nomadic localities in Sudan (Omer et al., 2010)
Brucella spp	ND	Female	Healthy animal	ND	ND	ND	ND	ND	ND	Brucellosis in camels, cattle, and humans: associations and evaluation of serological tests used for the diagnosis of the disease in certain nomadic localities in Sudan (Omer et al., 2010)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Brucellosis in camels, cattle, and humans: associations and evaluation of serological tests used for diagnosis of the disease in certain nomadic localities in Sudan (Omer et al., 2010)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Brucellosis in camels, cattle and humans: associations and evaluation of serological tests used for diagnosis of the disease in certain nomadic localities in Sudan(Omer et al., 2010)
Brucella abortus	6	Female	Abortion	ND	ND	ND	ND	ND	ND	Brucellosis in camels, cattle, and humans: associations and evaluation of serological tests used for the diagnosis of the disease in certain nomadic localities in Sudan (Omer et al., 2010)
Brucella spp	ND	ND	Abortion	ND	ND	ND	ND	ND	S	Seroprevalence of brucellosis and its contribution to abortion in cattle, camel, and goat kept under pastoral management in Borana, Ethiopia (Megersa et al., 2011)
Brucella spp	ND	ND	Healthy animal	ND	ND	S	ND	ND	S	Seroprevalence of camel brucellosis (Camelus dromedarius) in Somaliland (Ghanem et al., 2009)
Brucella spp	ND	ND	Healthy animal	ND	ND	S	ND	ND	S	Seroprevalence of camel brucellosis (Camelus dromedarius) in Somaliland (Ghanem et al., 2009)

Table S1. Continued.

Author	Start	End	Location	Animal species	No sample	Positive	Method	D/i	Sample
Gwida	2008	2009	Sudan	Camelus dromedaries	895	633	RBT	I	Blood
Gwida	2008	2009	Sudan	Camelus dromedaries	895	632	SAT	I	Blood
Gwida	2008	2009	Sudan	Camelus dromedaries	895	639	CFT	I	Blood
Gwida	2008	2009	Sudan	Camelus dromedaries	895	616	c-ELISA	I	Blood
Gwida	2008	2009	Sudan	Camelus dromedaries	895	710	Fluorescence Polarization Assay	I	Blood
Gwida	2008	2009	Sudan	Camelus dromedaries	895	759	rt-PCR	D	Blood
Mohammed	2009	2010	United Arab Emirates	Camelus dromedaries	1008	56	RBT	I	Blood
Mohammed	2009	2010	United Arab Emirates	Camelus dromedaries			c-ELISA	I	Blood
Warsame	2010	2011	Ethiopia	Camelus dromedaries	285	4	CFT	I	Blood
Bayasgalan	2010	2011	Mongolia	Camelus dromedaries	1822	37	RBT	I	Blood
Bayasgalan	2010	2011	Mongolia	Camelus dromedaries	250	37	Culture	D	Milk
Bayasgalan	2010	2011	Mongolia	Camelus dromedaries	250	37	PCR	D	Milk
Mohammed	2010	2011	Ethiopia	Camelus dromedaries	361	6	CFT	I	Blood
Ghorbani	2011	2012	Iran	Camelus dromedarius	310	39	RBT	I	Blood
Ghorbani	2011	2012	Iran	Camelus dromedarius	310	7	SAT	I	Blood
Ghorbani	2011	2012	Iran	Camelus dromedarius	100	39	Culture	I	Lymph node
Ghorbani	2011	2012	Iran	Camelus dromedarius	100	9	PCR	I	Blood

Isolate	Biovar	Gender	Symptom	Location	Sex	Herd size	Age	Abortion history	Mix rearing	Title
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Comparison of diagnostic tests for the detection of Brucella spp. in camel sera. (Gwida et al., 2011)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Comparison of diagnostic tests for the detection of Brucella spp. in camel sera. (Gwida et al., 2011)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Comparison of diagnostic tests for the detection of Brucella spp. in camel sera. (Gwida et al., 2011)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Comparison of diagnostic tests for the detection of Brucella spp. in camel sera. (Gwida et al., 2011)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Comparison of diagnostic tests for the detection of Brucella spp. in camel sera. (Gwida et al., 2011)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Comparison of diagnostic tests for the detection of Brucella spp. in camel sera. (Gwida et al., 2011)
Brucella spp	ND	ND	Healthy animal	S	S	S	ND	ND	ND	Sero-prevalence and epidemiology of brucellosis in camels, sheep and goats in Abu Dhabi Emirate(Mohammed and Shigidy, 2013)
Brucella spp	ND	ND	Healthy animal	S	S	S	ND	ND	ND	Sero-prevalence and epidemiology of brucellosis in camels, sheep, and goats in Abu Dhabi Emirate (Mohammed and Shigidy, 2013)
Brucella spp	ND	Male	infertility	S	S	S	ND	ND	ND	Seroprevalence and associated risk factors of camel (Camelus dromedaries) brucellosis in and around Dire Dawa, Ethiopia (Ismail et al., 2012)
Brucella abortus	ND	ND	Healthy animal	S	NS	NS	NS	NS	S	Risk factors of brucellosis seropositivity in Bactrian camels of Mongolia (Bayasgalan et al., 2018)
Brucella abortus	ND	Female	Healthy animal	S	NS	NS	NS	NS	S	Risk factors of brucellosis seropositivity in Bactrian camels of Mongolia (Bayasgalan et al., 2018)
Brucella abortus	ND	Female	Healthy animal	S	NS	NS	NS	NS	S	Risk factors of brucellosis seropositivity in Bactrian camels of Mongolia (Bayasgalan et al., 2018)
Brucella spp	ND	Female	infertility	S	S	S	ND	ND	ND	Seroprevalence and epidemiology of brucellosis in camels, sheep, and goats in Abu Dhabi Emirate (Mohammed and Shigidy, 2013)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Comparison of serology, culture, and PCR for the detection of brucellosis in slaughtered camels in Iran (Ghorbani et al., 2013)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Comparison of serology, culture, and PCR for the detection of brucellosis in slaughtered camels in Iran (Ghorbani et al., 2013)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Comparison of serology, culture, and PCR for the detection of brucellosis in slaughtered camels in Iran (Ghorbani et al., 2013)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Comparison of serology, culture, and PCR for the detection of brucellosis in slaughtered camels in Iran (Ghorbani et al., 2013)

Table S1. Continued.

Author	Start	End	Location	Animal species	No sample	Positive	Method	D/i	Sample
Gessese	2011	2012	Ethiopia	Camelus dromedarius	1500	11	RBT	I	Blood
Gessese	2011	2012	Ethiopia	Camelus dromedarius	1501	8	CFT	I	Blood
Yawoz	2012	2012	Iraq	Camelus dromedarius	60	2	RBT	I	Blood
Yawoz	2012	2012	Iraq	Camelus dromedarius	6	0	RBT	I	Blood
Hadush	2013	2013	Ethiopia	Camelus dromedarius	1152	58	RBT	I	Blood
Hadush	2013	2013	Ethiopia	Camelus dromedarius	342	14	CFT	I	Blood
Hadush	2013	2013	Ethiopia	Camelus dromedarius	810	33	CFT	I	Blood
Khamesipour	2013	2013	Iran	Camelus dromedarius	123	5	PCR	D	Blood
Khamesipour	2013	2013	Iran	Camelus dromedarius	123	3	PCR	D	Blood
Khamesipour	2013	2013	Iran	Camelus dromedarius	123	4	PCR	D	Lymph node
Khamesipour	2013	2013	Iran	Camelus dromedarius	123	2	PCR	D	Lymph node
Khamesipour	2013	2013	Iran	Camelus dromedarius	78	14	PCR	D	Lymph node
Khamesipour	2013	2013	Iran	Camelus dromedarius	45	16	PCR	D	Lymph node
Shome	2013	2013	India	Camelus dromedarius	78	3	SAT	I	Blood
Shome	2013	2013	India	Camelus dromedarius	78	3	RBT	I	Blood
Shome	2013	2013	India	Camelus dromedarius	5	0	SAT	I	Blood

Isolate	Biovar	Gender	Symptom	Location	Sex	Herd size	Age	Abortion history	Mix rearing	Title
Brucella spp	ND	ND	Healthy animal	NS	ND	ND	NS	ND	S	Seroprevalence of brucellosis in camels (Camelus dromedaries) in South East Ethiopia (Gessese et al., 2014)
Brucella spp	ND	ND	Healthy animal	NS	ND	ND	NS	ND	S	Seroprevalence of brucellosis in camels (Camelus dromedaries) in South East Ethiopia (Gessese et al., 2014)
Brucella spp	ND	Female	Healthy animal	ND	ND	ND	ND	ND	ND	A serological study of brucellosis in camels south of Kirkuk (Yawoz et al., 2012)
Brucella spp	ND	Male	Healthy animal	ND	ND	ND	ND	ND	ND	A serological study of brucellosis in camels south of Kirkuk (Yawoz et al., 2012)
Brucella spp	ND	ND	Healthy animal	NS	NS	S	ND	ND	S	Seroepidemiology of camel brucellosis in the Afar region of Northeast Ethiopia (Hadush et al., 2013)
Brucella spp	ND	Male	Healthy animal	NS	NS	S	ND	ND	S	Sero-epidemiology of camel brucellosis in the Afar region of Northeast Ethiopia (Hadush et al., 2013)
Brucella spp	ND	Female	Healthy animal	NS	NS	S	ND	ND	S	Seroepidemiology of camel brucellosis in the Afar region of Northeast Ethiopia (Hadush et al., 2013)
Brucella abortus	ND	Female	Healthy animal	ND	ND	ND	ND	ND	ND	Molecular study of the prevalence of Brucella abortus and Brucella melitensis in the blood and lymph node samples of slaughtered camels by polymerase chain reaction (PCR) in Iran (Khamesipour et al., 2015)
Brucella melitensis	ND	Male	Healthy animal	ND	ND	ND	ND	ND	ND	Molecular study of the prevalence of Brucella abortus and Brucella melitensis in the blood and lymph node samples of slaughtered camels by polymerase chain reaction (PCR) in Iran (Khamesipour et al., 2015)
Brucella abortus	ND	Female	Healthy animal	ND	ND	ND	ND	ND	ND	Molecular study of the prevalence of Brucella abortus and Brucella melitensis in the blood and lymph node samples of slaughtered camels by polymerase chain reaction (PCR) in Iran (Khamesipour et al., 2015)
Brucella melitensis	ND	Male	Healthy animal	ND	ND	ND	ND	ND	ND	Molecular study of the prevalence of Brucella abortus and Brucella melitensis in the blood and lymph node samples of slaughtered camels by polymerase chain reaction (PCR) in Iran (Khamesipour et al., 2015)
Brucella abortus	ND	Male	Healthy animal	ND	ND	ND	ND	ND	ND	Molecular study of the prevalence of Brucella abortus and (Shome et al., 2013) Brucella melitensis in the blood and lymph node samples of slaughtered camels by polymerase chain reaction (PCR) in Iran (Khamesipour et al., 2015)
Brucella melitensis	ND	Female	Healthy animal	ND	ND	ND	ND	ND	ND	Molecular study of the prevalence of Brucella abortus and Brucella melitensis in the blood and lymph node samples of slaughtered camels by polymerase chain reaction (PCR) in Iran (Khamesipour et al., 2015)
Brucella spp	ND	Female	Healthy animal		ND	ND	ND	ND	ND	A report of seroprevalence of camel brucellosis in India (Shome et al., 2013)
Brucella spp	ND	Female	Healthy animal		ND	ND	ND	ND	ND	A report of seroprevalence of camel brucellosis in India (Shome et al., 2013)
Brucella spp	ND	Male	Healthy animal		ND	ND	ND	ND	ND	A report of seroprevalence of camel brucellosis in India (Shome et al., 2013)

Table S1. Continued.

Author	Start	End	Location	Animal species	No sample	Positive	Method	D/i	Sample
Shome	2013	2013	India	Camelus dromedarius	5	4	RBT	I	Blood
Shome	2013	2013	India	Camelus dromedarius	78	3	i-ELISA	I	Blood
Shome	2013	2013	India	Camelus dromedarius	78	3	i-ELISA	I	Blood
Khamesipour	2013	2014	Iran	Camelus dromedarius	135	3	rt-PCR	D	Blood
Khamesipour	2013	2014	Iran	Camelus dromedarius	135	4	rt-PCR	D	Lymph node
Abdel Hafez	2013	2014	Saudi Arabia	Camelus dromedarius	53	11	Culture	D	Milk
Khalafalla	2013	2014	Saudi Arabia	Camelus dromedarius	182	48	c-ELISA	I	Blood
Khalafalla	2013	2014	Saudi Arabia	Camelus dromedarius	11	4	Culture	D	Vaginal swab
Khalafalla	2013	2014	Saudi Arabia	Camelus dromedarius	88	13	PCR	D	Blood
Al-Garadi	2014	2015	Yemen	Camelus dromedarius	56	6	Culture	D	Vaginal swab
Al-Garadi	2014	2015	Yemen	Camelus dromedarius	100	2	RBT	I	Blood
Al-Garadi	2014	2015	Yemen	Camelus dromedarius	39	0	MRT	I	Milk
Fatima	2014	2015	Pakistan	Camelus dromedarius	3	1	RBT	I	Blood
Fatima	2014	2015	Pakistan	Camelus dromedarius	3	1	c-ELISA	I	Blood
Fatima	2014	2015	Pakistan	Camelus dromedarius	47	0	c-ELISA	I	Blood

Isolate	Biovar	Gender	Symptom	Location	Sex	Herd size	Age	Abortion history	Mix rearing	Title
Brucella spp	ND	Male	Healthy animal		ND	ND	ND	ND	ND	A report of seroprevalence of camel brucellosis in India (Shome et al., 2013)
Brucella spp	ND	Female	Healthy animal		ND	ND	ND	ND	ND	A report of seroprevalence of camel brucellosis in India (Shome et al., 2013) (Admasu and Kaynata, 2017)
Brucella spp	ND	Male	Healthy animal		ND	ND	ND	ND	ND	A report of seroprevalence of camel brucellosis in India (Shome et al., 2013)
Brucella abortus	ND	Male	Healthy animal	ND	ND	ND	ND	ND	ND	Molecular study of Brucellosis in camels by the use of TaqMan® real-time PCR(Khamesipour et al., 2015)
Brucella melitensis	ND	Female	Healthy animal	ND	ND	ND	ND	ND	ND	Molecular study of Brucellosis in camels by the use of TaqMan® real-time PCR (Khamesipour et al., 2015)
Brucella melitensis	3	Female	Abortion	ND	ND	ND	ND	ND	ND	Development of a rapid and specific latex agglutination test for the serodiagnosis of camel brucellosis using a Brucella melitensis periplasmic protein antigen (Abdel Hafez et al., 2015)
Brucella spp	ND	Female	Abortion	ND	ND	ND	ND	ND	ND	A study on some reproductive disorders in dromedary camel herds in Saudi Arabia with special references to uterine infections and abortion (Khalafalla et al., 2017)
Brucella spp	ND	Female	Abortion	ND	ND	ND	ND	ND	ND	A study on some reproductive disorders in dromedary camel herds in Saudi Arabia with special references to uterine infections and abortion (Khalafalla et al., 2017)
Brucella spp	ND	Female	Abortion	ND	ND	ND	ND	ND	ND	A study on some reproductive disorders in dromedary camel herds in Saudi Arabia with special references to uterine infections and abortion (Khalafalla et al., 2017)
Brucella spp	ND	Female	Abortion	ND	ND	ND	ND	ND	ND	Bacteriological and serological study on brucellosis infection in camel (Camelus dromedaries), Al-Hodeida governorate, Yemen (Al-Garadi et al., 2015)
Brucella spp	ND	Female	Abortion	ND	ND	ND	ND	ND	ND	Bacteriological and serological study on brucellosis infection in camel (Camelus dromedaries), Al-Hodeida governorate, Yemen (Al-Garadi et al., 2015)
Brucella spp	ND	Female	Healthy animal	ND	ND	ND	ND	ND	ND	Bacteriological and serological study on brucellosis infection in camel (Camelus dromedaries), Al-Hodeida governorate, Yemen (Al-Garadi et al., 2015)
Brucella spp	ND	Male	Orchitis	S	S	S	ND	ND	S	Serological, molecular detection, and potential risk factors associated with camel brucellosis in Pakistan. Tropical animal health and production(Fatima et al., 2016)
Brucella spp	ND	Male	Orchitis	S	S	S	ND	ND	S	Serological, molecular detection, and potential risk factors associated with camel brucellosis in Pakistan. Tropical animal health and production (Fatima et al., 2016)
Brucella spp	ND	Male	Healthy animal	S	S	S	ND	ND	S	Serological, molecular detection, and potential risk factors associated with camel brucellosis in Pakistan. Tropical animal health, and production (Fatima et al., 2016)

Table S1. Continued.

Author	Start	End	Location	Animal species	No sample	Positive	Method	D/i	Sample
Fatima	2014	2015	Pakistan	Camelus dromedarius	47	0	rt-PCR	I	Blood
Fatima	2014	2015	Pakistan	Camelus dromedarius	140	9	RBT	I	Blood
Fatima	2014	2015	Pakistan	Camelus dromedarius	140	3	c-ELISA	I	Blood
Fatima	2014	2015	Pakistan	Camelus dromedarius	140	3	rt-PCR	I	Blood
Hosein	2014	2015	Egypt	Camelus dromedarius	965	37	RBT	I	Blood
Hosein	2014	2015	Egypt	Camelus dromedarius	170	10	RBT	I	Blood
Hosein	2014	2015	Egypt	Camelus dromedarius	965	32	c-ELISA	I	Blood
Hosein	2014	2015	Egypt	Camelus dromedarius	170	10	c-ELISA	I	Blood
Hosein	2014	2015	Egypt	Camelus dromedarius	26	2	Culture	D	Milk
Hosein	2014	2015	Egypt	Camelus dromedarius	26	2	PCR	D	Milk
Admasu	2014	2015	Ethiopia	Camelus dromedarius	384	14	RBT	I	Blood
Admasu	2014	2015	Ethiopia	Camelus dromedarius	91	4	CFT	I	Blood
Admasu	2014	2015	Ethiopia	Camelus dromedarius	293	8	CFT	I	Blood
El-Sayed	2014	2015	Egypt	Camelus dromedarius	801	103	RBT	I	Blood
El-Sayed	2014	2015	Egypt	Camelus dromedarius	802	93	Buffered Acidified Plate Antigen Test	I	Blood

Isolate	Biovar	Gender	Symptom	Location	Sex	Herd size	Age	Abortion history	Mix rearing	Title
Brucella spp	ND	Male	Healthy animal	S	S	S	ND	ND	S	Serological, molecular detection, and potential risk factors associated with camel brucellosis in Pakistan. Tropical animal health, and production(Fatima et al., 2016)
Brucella spp	ND	Female	Abortion	S	S	S	ND	ND	S	Serological, molecular detection, and potential risk factors associated with camel brucellosis in Pakistan. Tropical animal health and production (Fatima et al., 2016)
Brucella spp	ND	Female	Abortion	S	S	S	ND	ND	S	Serological, molecular detection, and potential risk factors associated with camel brucellosis in Pakistan. Tropical animal health and production (Fatima et al., 2016)
Brucella spp	ND	Female	Abortion	S	S	S	ND	ND	S	Serological, molecular detection, and potential risk factors associated with camel brucellosis in Pakistan. Tropical animal health and production (Fatima et al., 2016)
Brucella spp	ND	Male	Healthy animal	ND	ND	ND	ND	ND	ND	Seroprevalence of camel brucellosis and molecular characterization of Brucella melitensis recovered from dromedary camels in Egypt (Hosein et al., 2016)
Brucella spp	ND	Female	Healthy animal	ND	ND	ND	ND	ND	ND	Seroprevalence of camel brucellosis and molecular characterization of Brucella melitensis recovered from dromedary camels in Egypt (Hosein et al., 2016)
Brucella spp	ND	Male	Healthy animal	ND	ND	ND	ND	ND	ND	Seroprevalence of camel brucellosis and molecular characterization of Brucella melitensis recovered from dromedary camels in Egypt (Hosein et al., 2016)
Brucella spp	ND	Female	Healthy animal	ND	ND	ND	ND	ND	ND	Seroprevalence of camel brucellosis and molecular characterization of Brucella melitensis recovered from dromedary camels in Egypt (Hosein et al., 2016)
Brucella melitensis	3	Female	Healthy animal	ND	ND	ND	ND	ND	ND	Seroprevalence of camel brucellosis and molecular characterization of Brucella melitensis recovered from dromedary camels in Egypt(Hosein et al., 2016)
Brucella melitensis	3	Female	Healthy animal	ND	ND	ND	ND	ND	ND	Seroprevalence of camel brucellosis and molecular characterization of Brucella melitensis recovered from dromedary camels in Egypt (Hosein et al., 2016)
Brucella spp	ND	ND	Abortion	S	S	NS	ND	ND	NS	Seroprevalence of camel brucellosis in Yabello District of Borena Zone, Southern Ethiopia (Admasu and Kaynata, 2017)
Brucella spp	ND	Male	Abortion	S	S	NS	ND	ND	NS	Seroprevalence of camel brucellosis in Yabello District of Borena Zone, Southern Ethiopia (Admasu and Kaynata, 2017)
Brucella spp	ND	Female	Abortion	S	S	NS	ND	ND	NS	Seroprevalence of camel brucellosis in Yabello District of Borena Zone, Southern Ethiopia(Admasu and Kaynata, 2017)
Brucella melitensis	3	Male	Healthy animal	ND	ND	ND	ND	ND	ND	Seroprevalence of camel brucellosis (Camelus dromedarius) and phenotypic characteristics of Brucella melitensis biovar 3 in Shalateen City, Red Sea Governorate, Egypt (El-Sayed et al., 2017)
Brucella melitensis	3	Male	Healthy animal	ND	ND	ND	ND	ND	ND	Seroprevalence of camel brucellosis (Camelus dromedarius) and phenotypic characteristics of Brucella melitensis biovar 3 in Shalateen City, Red Sea Governorate, Egypt (El-Sayed et al., 2017)

Table S1. Continued.

Author	Start	End	Location	Animal species	No sample	Positive	Method	D/i	Sample
El-Sayed	2014	2015	Egypt	Camelus dromedarius	803	92	CFT	I	Blood
Abdelgawad	2015	2016	Egypt	Camelus dromedarius	112	16	RBT	I	Blood
Abdelgawad	2015	2016	Egypt	Camelus dromedarius	112	17	Buffered Acidified Plate Antigen Test	I	Blood
Abdelgawad	2015	2016	Egypt	Camelus dromedarius	112	18	CFT	I	Blood
Abdelgawad	2015	2016	Egypt	Camelus dromedarius	21	12	PCR	D	Lymph node
Hanon	2016	2017	Iraq	Camelus dromedarius	237	51	RBT	I	Blood
Hanon	2016	2017	Iraq	Camelus dromedarius	28	1	CFT	I	Blood
Hanon	2016	2017	Iraq	Camelus dromedarius	209	38	CFT	I	Blood
Hanon	2016	2017	Iraq	Camelus dromedarius	237	7	PCR	D	Blood
Hanon	2016	2017	Iraq	Camelus dromedarius	237	5	PCR	D	Blood
Al-Busadah	2016	2017	Saudi Arabia	Camelus dromedarius	94	2	PCR	D	Semen
Shahzad	2016	2017	Pakistan	Camelus dromedarius	761	26	RBT	I	Blood
Shahzad	2016	2017	Pakistan	Camelus dromedarius	761	26	c-ELISA	I	Blood
Abdirahman	2017	2017	Kenya	Camelus dromedarius	160	15	RBT	I	Blood
Abdirahman	2017	2017	Kenya	Camelus dromedarius	160	16	SAT	I	Blood
Abdirahman	2017	2017	Kenya	Camelus dromedarius	160	15	c-ELISA	I	Blood
Alamian	2018	2018	Iran	Camelus dromedarius	96	14	PCR	D	Milk

Isolate	Biovar	Gender	Symptom	Location	Sex	Herd size	Age	Abortion history	Mix rearing	Title
Brucella melitensis	3	Male	Healthy animal	ND	ND	ND	ND	ND	ND	Seroprevalence of camel brucellosis (Camelus dromedarius) and phenotypic characteristics of Brucella melitensis biovar 3 in Shalateen City, Red Sea Governorate, Egypt (El-Sayed et al., 2017)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Serological and molecular detection of Brucella species in camels (Abdelgawad et al., 2017)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Serological and molecular detection of Brucella species in camels (Abdelgawad et al., 2017)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Serological and molecular detection of Brucella species in camels (Abdelgawad et al., 2017)
Brucella melitensis	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Serological and molecular detection of Brucella species in camels (Abdelgawad et al., 2017)
Brucella spp	ND	ND	Healthy animal	ND	S	ND	NS	ND	ND	Seroprevalence of brucellosis and toxoplasmosis in camels of Wasit Province, Iraq (Hanon, 2017)
Brucella spp	ND	ND	Healthy animal	ND	S	ND	NS	ND	ND	Seroprevalence of brucellosis and toxoplasmosis in camels of Wasit Province, Iraq (Hanon, 2017)
Brucella spp	ND	ND	Healthy animal	ND	S	ND	NS	ND	ND	Seroprevalence of brucellosis and toxoplasmosis in camels of Wasit Province, Iraq(Hanon, 2017)
Brucella abortus	ND	Female	Healthy animal	ND	ND	ND	ND	ND	ND	Seroprevalence of brucellosis and toxoplasmosis in camels of Wasit Province, Iraq (Hanon, 2017)
Brucella melitensis	ND	Male	Healthy animal	ND	ND	ND	ND	ND	ND	Seroprevalence of brucellosis and toxoplasmosis in camels of Wasit Province, Iraq (Hanon, 2017)
Brucella melitensis	ND	Male	infertility	ND	ND	ND	ND	ND	ND	Serum biochemical profile and molecular detection of pathogens in semen of infertile male dromedary camels (Camelus dromedarius) (Al-Busadah et al., 2017)
Brucella spp	ND	ND	Abortion	S	S	ND	S	S	ND	Seroprevalence and molecular investigation of brucellosis in camels of selected districts of Punjab, Pakistan (Shahzad et al., 2017)
Brucella spp	ND	ND	Abortion	S	S	ND	S	S	ND	Seroprevalence and molecular investigation of brucellosis in camels of selected districts of Punjab, Pakistan (Shahzad et al., 2017)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Camel Brucellosis: Seroprevalence and pathological lesions at slaughterhouses in Garissa County, Kenya (Abdirahman, 2020)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Camel Brucellosis: Seroprevalence and pathological lesions at slaughterhouses in Garissa County, Kenya (Abdirahman, 2020)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Camel Brucellosis: Sero-prevalence and pathological lesions at Slaughterhouses in Garissa County, Kenya (Abdirahman, 2020)
Brucella abortus	3	Female	Healthy animal	ND	ND	ND	ND	ND	ND	Brucella abortus contamination of camel milk in two Iranian regions (Alamian and Dadar, 2019)

Table S1. Continued.

Author	Start	End	Location	Animal species	No sample	Positive	Method	D/i	Sample
Alamian	2018	2018	Iran	Camelus dromedarius	96	3	Culture	D	Milk
Khan	2017	2019	Egypt	Camelus dromedarius	295	52	RBT	I	Blood
Khan	2017	2019	Egypt	Camelus dromedarius	86	7	RBT	I	Blood
Khan	2017	2019	Egypt	Camelus dromedarius	295	71	i-ELISA	I	Blood
Khan	2017	2019	Egypt	Camelus dromedarius	86	16	i-ELISA	I	Blood
Khan	2017	2019	Egypt	Camelus dromedarius	295	66	c-ELISA	I	Blood
Khan	2017	2019	Egypt	Camelus dromedarius	86	11	c-ELISA	I	Blood
Khan	2017	2019	Egypt	Camelus dromedarius	295	66	CFT	I	Blood
Khan	2017	2019	Egypt	Camelus dromedarius	86	11	CFT	I	Blood
Khan	2017	2019	Egypt	Camelus dromedarius	295	101	rt-PCR	I	Blood
Khan	2017	2019	Egypt	Camelus dromedarius	86	15	rt-PCR	I	Blood
Alatabi	2018	2019	Iraq	Camelus dromedarius	172	6	RBT	I	Blood
Alatabi	2018	2019	Iraq	Camelus dromedarius	172	4	c-ELISA	I	Blood
Alrawahi	2019	2019	Oman	Camelus dromedarius	2250	9	RBT	I	Blood
Alrawahi	2019	2019	Oman	Camelus dromedarius	252	0	CFT	I	Blood
Alrawahi	2019	2019	Oman	Camelus dromedarius	1998	9	CFT	I	Blood
Wegi	2019	2020	Ethiopia	Camelus dromedarius	250	19	RBT	I	Blood

Isolate	Biovar	Gender	Symptom	Location	Sex	Herd size	Age	Abortion history	Mix rearing	Title
Brucella abortus	5	Female	Healthy animal	ND	ND	ND	ND	ND	ND	Brucella abortus contamination of camel milk in two Iranian regions (Alamian and Dadar, 2019)
Brucella abortus	ND	Male	Healthy animal	NS	NS	ND	ND	ND	ND	Seroprevalence and molecular Identification of Brucella spp. in camels in Egypt (Khan et al., 2020)
Brucella abortus	ND	Female	Healthy animal	NS	NS	ND	ND	ND	ND	Seroprevalence and molecular identification of Brucella spp. in camels in Egypt (Khan et al., 2020)
Brucella melitensis	ND	Male	Healthy animal	NS	NS	ND	ND	ND	ND	Seroprevalence and molecular identification of Brucella spp. in camels in Egypt (Khan et al., 2020)
Brucella abortus	ND	Female	Healthy animal	NS	NS	ND	ND	ND	ND	Seroprevalence and molecular identification of Brucella spp. in camels in Egypt (Khan et al., 2020)
Brucella abortus	ND	Male	Healthy animal	NS	NS	ND	ND	ND	ND	Seroprevalence and molecular identification of Brucella spp. in camels in Egypt(Khan et al., 2020)
Brucella abortus	ND	Female	Healthy animal	NS	NS	ND	ND	ND	ND	Seroprevalence and molecular identification of Brucella spp. in camels in Egypt(Khan et al., 2020)
Brucella spp	ND	Male	Healthy animal	NS	NS	ND	ND	ND	ND	Seroprevalence and molecular identification of Brucella spp. in camels in Egypt(Khan et al., 2020)
Brucella spp	ND	Female	Healthy animal	NS	NS	ND	ND	ND	ND	Seroprevalence and molecular identification of Brucella spp. in camels in Egypt(Khan et al., 2020)
Brucella suis	ND	Male	Healthy animal	NS	NS	ND	ND	ND	ND	Seroprevalence and molecular identification of Brucella spp. in camels in Egypt(Khan et al., 2020)
Brucella abortus	ND	Female	Healthy animal	NS	NS	ND	ND	ND	ND	Seroprevalence and molecular identification of Brucella spp. in camels in Egypt(Khan et al., 2020)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	S	ND	S	Serodiagnosis for brucellosis in camels by rose Bengal and C-ELISA test in Iraq (Alatabi et al., 2020)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	S	ND	S	Serodiagnosis for brucellosis in camels by rose Bengal and C-ELISA test in Iraq (Alatabi et al., 2020)
Brucella spp	ND	ND	Healthy animal	S	S	S	S	NS	NS	A cross-sectional seroepidemiological study of camel (Camelus dromedarius) brucellosis and associated risk factors in the Sultanate of Oman (Alrawahi et al., 2019)
Brucella spp	ND	ND	Healthy animal	S	S	S	S	NS	NS	A cross-sectional seroepidemiological study of camel (Camelus dromedarius) brucellosis and associated risk factors in the Sultanate of Oman (Alrawahi et al., 2019)
Brucella spp	ND	ND	Healthy animal	S	S	S	S	NS	NS	A cross-sectional seroepidemiological study of camel (Camelus dromedarius) brucellosis and associated risk factors in the Sultanate of Oman (Alrawahi et al., 2019)
Brucella spp	ND	ND	Abortion	ND	ND	ND	S	S	ND	Brucellosis in cattle, camel, and human: seroprevalence and associated risk factors in amibara district of afar region, Ethiopia (Gutema Wegi, 2020)

Table S1. Continued.

Author	Start	End	Location	Animal species	No sample	Positive	Method	D/i	Sample
Wegi	2019	2020	Ethiopia	Camelus dromedarius	250	8	CFT	I	Blood
Rabah	2019	2020	Egypt	Camelus dromedarius	100	10	RBT	I	Blood
Rabah	2019	2020	Egypt	Camelus dromedarius	100	10	Buffered Acidified Plate Antigen Test	I	Blood
Rabah	2019	2020	Egypt	Camelus dromedarius	100	9	CFT	I	Blood
Rabah	2019	2020	Egypt	Camelus dromedarius	100	9	PCR	I	Blood
Ibrahim	2020	2020	Egypt	Camelus dromedarius	272	11	RBT	I	Blood
Ibrahim	2020	2020	Egypt	Camelus dromedarius	272	10	c-ELISA	I	Blood
Ibrahim	2020	2020	Egypt	Camelus dromedarius	115	21	c-ELISA	I	Blood
Ibrahim	2020	2020	Ethiopia	Camelus dromedarius	141	1	i-ELISA	I	Blood
Dadar	2020	2020	Iran	Camelus dromedaries	2854	10	RBT	I	Blood
Dadar	2020	2020	Iran	Camelus dromedarius	2854	7	SAT	I	Blood
Dadar	2020	2020	Iran	Camelus dromedarius	2854	6	2-ME	I	Blood
Dadar	2020	2020	Iran	Camelus dromedarius	40	9	PCR	D	Lymph node
Khalafalla	2020	2020	United Arab Emirates	Camelus dromedarius	68	36	RBT	I	Blood
Khalafalla	2020	2020	United Arab Emirates	Camelus dromedarius	68	36	c-ELISA	I	Blood

Isolate	Biovar	Gender	Symptom	Location	Sex	Herd size	Age	Abortion history	Mix rearing	Title
Brucella spp	ND	ND	Abortion	ND	ND	ND	S	S	ND	Brucellosis in cattle, camel, and human: seroprevalence and associated risk factors in amibara district of afar region, Ethiopia (Gutema Wegi, 2020)
Brucella spp	ND	ND	Healthy animal	S	S	ND	S	ND	ND	Serological and molecular epidemiological study on Brucellosis in camels and humans in Matrouh Province (Rabah et al., 2020)
Brucella spp	ND	ND	Healthy animal	S	S	ND	S	ND	ND	Serological and molecular epidemiological study on Brucellosis in camels and humans in Matrouh Province(Rabah et al., 2020)
Brucella spp	ND	ND	Healthy animal	S	S	ND	S	ND	ND	Serological and molecular epidemiological study on Brucellosis in camels and human in Matrouh Province(Rabah et al., 2020)
Brucella abortus	ND	ND	Healthy animal	S	S	ND	S	ND	ND	Serological and molecular epidemiological study on Brucellosis in camels and humans in Matrouh Province(Rabah et al., 2020)
Brucella spp	ND	ND	Healthy animal	S	NS	ND	ND	ND	ND	Serological, molecular detection, and potential risk factors associated with camel brucellosis in Pakistan. Tropical animal health and production (Ibrahim et al., 2020)
Brucella spp	ND	ND	Healthy animal	S	NS	ND	ND	ND	ND	Serological, molecular detection, and potential risk factors associated with camel brucellosis in Pakistan. Tropical animal health and production (Ibrahim et al., 2020)
Brucella spp	ND	Female	Abortion	S	NS	ND	ND	ND	ND	Serological, molecular detection, and potential risk factors associated with camel brucellosis in Pakistan. Tropical animal health and production (Ibrahim et al., 2020)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Sero-prevalence of brucellosis, Q-fever and Rift Valley Fever in humans and livestock in the Somali region, Ethiopia (Ibrahim et al., 2020)
Brucella spp	ND	Male	Healthy animal	ND	ND	ND	ND	ND	ND	Isolation of Brucella melitensis from seronegative camel: potential implications in brucellosis control(Dadar and Alamian, 2020)
Brucella spp	ND	Male	Healthy animal	ND	ND	ND	ND	ND	ND	Isolation of Brucella melitensis from seronegative camel: potential implications in brucellosis control(Dadar and Alamian, 2020)
Brucella spp	ND	Male	Healthy animal	ND	ND	ND	ND	ND	ND	Isolation of Brucella melitensis from seronegative camel: potential implications in brucellosis control (Dadar and Alamian, 2020)
Brucella melitensis	ND	Male	Healthy animal	ND	ND	ND	ND	ND	ND	Isolation of Brucella melitensis from seronegative camel: potential implications in brucellosis control (Dadar and Alamian, 2020)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Preliminary Comparative Assessment of Brucellergene Skin Test for Diagnosis of Brucellosis in Dromedary Camels (Camelus dromedarius)(Khalafalla et al., 2020)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Preliminary Comparative Assessment of Brucellergene Skin Test for Diagnosis of Brucellosis in Dromedary Camels (Camelus dromedarius) (Khalafalla et al., 2020)

Table S1. Continued.

Author	Start	End	Location	Animal species	No sample	Positive	Method	D/i	Sample
Khalafalla	2020	2020	United Arab Emirates	Camelus dromedarius	68	29	Brucellergene skin test	I	Blood
Noor	2020	2020	Kenya	Camelus dromedarius	104	4	MRT	I	Milk
Shehzad	2020	2020	Pakistan	Camelus dromedarius	214	7	RBT	I	Blood
Shehzad	2020	2020	Pakistan	Camelus dromedarius	214	0	c-ELISA	I	Blood

Isolate	Biovar	Gender	Symptom	Location	Sex	Herd size	Age	Abortion history	Mix rearing	Title
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Preliminary Comparative Assessment of Brucellergene Skin Test for Diagnosis of Brucellosis in Dromedary Camels (Camelus dromedarius) (Khalafalla et al., 2020)
Brucella spp	ND	Female	Healthy animal	S	S	S	S	ND	S	Prevalence, Risk Factors Associated with Brucellosis and Presence of Pathogenic Bacteria Isolated from Camel Milk in Garissa County, Kenya(Noor et al., 2020)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Seroprevalence and potential risk factors associated with brucellosis in the Desert Thal of Pakistan (Shehzad et al., 2020)
Brucella spp	ND	ND	Healthy animal	ND	ND	ND	ND	ND	ND	Seroprevalence and potential risk factors associated with brucellosis in the Desert Thal of Pakistan (Shehzad et al., 2020)