

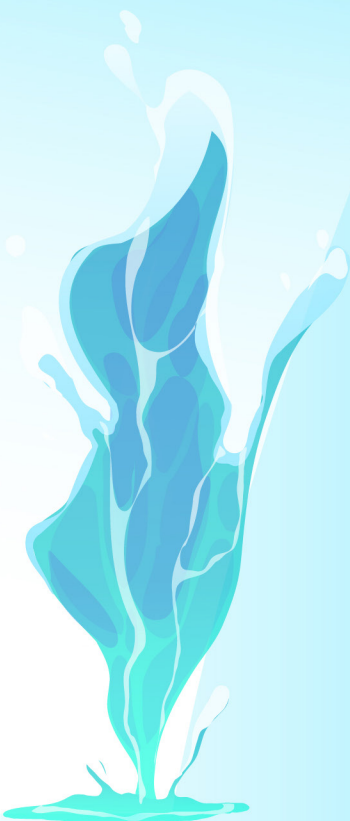
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Sero Epidemiology of Camel Brucellosis and its Public Health Significances at Three Selected Districts in Erer Zone, Somali Region

Ahmed Abdi Mohamed¹, Zakariye Abdifatah Ahmed^{2*}, Ali Abdullah Jabir³, Ahmed Abdullahi Salad⁴
Mokhtar omar Sheikh Mohamed⁵, Jeilani Bussuri Mio⁶, Sadam Addawe Jimale²

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ABSTRACT

Camel brucellosis is an infectious and zoonotic diseases caused by *Brucella abortus* and *Brucella melitensis*. A cross-sectional study was conducted on 450 camels from December, 2020 until August, 2021 with the aim of determining sero-prevalence and assessing the associated risk factors for camel brucellosis and its public health significances from purposively selected three districts namely (Fik, Hamaro and Laghida) of Erer zone, Somali Regional state, based on distribution of camel population and sampled using systematic random sampling. The overall sero-prevalence of *Brucella* in Erer zone was 4.8% (95% CI: 2.8-6.8). However, the Seroprevalence varied among the different districts with Laghida 10% (95% CI: 1.7-18.7), followed by Fik 5.7% (95% CI: 0.9-10.5) and Hamaro 1.9% (95% CI: 0.007-0.0522). By computing univariate logistic regression analysis risk factors such as; sex, age, districts, parity, herd sizes, camels that co-exist with other ruminants and reproductive disorder (abortion) ($p < 0.05$) were statistically significant as major risk factor for transmission of camel brucellosis. Furthermore, multivariable logistic regression analysis of the risk factors revealed that the age, herd size and camels that are kept closely together with other ruminants with adjusted odds ratio (OR) of 3.3 (95% CI: 1.58-6.74), 4.6 (95% CI: 2.66-8.10) and 11.4 (95% CI: 1.39-85.46), respectively were the major risk factors for the occurrence of camel brucellosis. Moreover, the questionnaire survey found common practices like lack of awareness about zoonotic diseases, raw milk consumption, and close contact with animals in pastoral communities. This highlights the need for further advanced epidemiological studies, herd health prevention, control strategies, and public health education to reduce brucellosis risk in both animals and pastoral communities.

INTRODUCTION

Background and Justifications of the Study

Camel is the integral part of livestock as a major source of livelihood for the pastoralists in the arid and semi-arid lands (Kagunyu & Wanjohi 2014). Eastern Africa is known to be the heartland for camel production as 80% and 63% of the Africa and world population, respectively produced in this region. Camels are subset of huge livestock resources in Ethiopia with the population estimated to be 2.3 million. This number ranks the country third in Africa after Somalia and Sudan and fourth in the world (CSA, 2007). Camel rearing is the most sustainable livestock production system, since camels (*Camelus dromedaries*) are species that are well adapted to a hot and arid environment of Ethiopian pastoralists (Tefera & Gebreah, 2001). All camels in Ethiopia are owned by pastoralists (MoARD, 2008).

Although camels are hardy and undemanding in their maintenance, they are not resistant to diseases affecting other livestock, as frequently assumed in the past. Camels are infected with different diseases including brucellosis, particularly when they are in contact with other infected ruminants. Brucellosis which caused by *Brucella* species

is an important zoonotic disease and has become a major worldwide human concern (Neta *et al.*, 2010). It is an infectious disease of domestic and wild animals. According to the Office International des Epizooties (OIE), it is the second most important zoonotic disease in the world, accounting for the annual occurrence of more than 500,000 human cases (Pappas *et al.*, 2006).

Brucellosis is considered by the Food and Agriculture Organization of the United Nations (FAO), the World Health Organization (WHO) and Office International des Epizooties (OIE) as one of the most widespread diseases that has still of veterinarian, public health and economic concern in many developing countries including Ethiopia (Hadush and Pal, 2013). The disease in dromedary camels can be caused by *B. abortus*, *B. melitensis* and *B. ovis* (Seifert, 1996). The organism can enter the body through the lungs; the digestive tract, mucous membranes and intact skin, where it is transmitted among animals from infected to susceptible individual animals. The disease spreads from camels to human through milk and/ or other infected animal products (Greenfield *et al.*, 2002).

Clinical signs of the disease in breeding Camelids are the same as those in bovines and small ruminants. The

¹ Department Veterinary Epidemiology, College of Veterinary Medicine, Jigjiga University, Ethiopia

² Dapartement of Epidemiology and Public Health, University of Veterinary and Animal Science, Lahore, Pakistan

³ Department of Clinical Medicine, University of Veterinary and Animal Science, Lahore, Pakistan

⁴ Department of Animal Nutrition, University of Veterinary and Animal Science, Lahore, Pakistan

⁵ Department of Clinics and Theriogenology, Faculty of Veterinary Medicine & Animal Husbandry, Somali National University, Somalia

⁶ Department of Infectious Diseases, Faculty of Veterinary Medicine & Animal Husbandry, Somali National University, Somalia

* Corresponding author's e-mail: Zakixaji7@gmail.com

disease is causing abortion and birth of non-viable offspring in female, and orchitis and epididymitis in male animals and infertility in both (Bati, 2004). In humans, the disease may occur acutely with mild flu like symptoms. While successful isolation of the agent can be achieved by sampling different body tissues, some classical serological tests for detecting antibodies against *Brucella* species, like Rose Bengal plate test (RBPT) and complement fixation test (CFT) are applicable (Musa *et al.*, 2008). Treatment of Brucellosis in animals is not as such effective when undertaken, while in humans the administration of effective antibiotics for an adequate length of time results successful (Corbel, 2006).

Brucellosis has great losses in livestock of developing countries by causing tremendous economic losses due to abortion, premature birth, decreased milk production, reduced fertility, mortality and cost of treatments and cross transmission to other animal species. On the other hand it has an obvious impact on human health and environment. Since camels suffer from lack of attention and negligence in numerous countries, the control of brucellosis in camels is severely hampered. In Ethiopia, brucellosis in camels has not been extensively studied as compared to other species of animals.

Lack of awareness about zoonotic diseases, keeping different species of animals together at several conditions, existing habit of raw milk consumption and close contact with animals can serve as means of brucella infection to man. Moreover, the mixing of the different species during migration, at watering or in night enclosures (resting), between camels and small ruminants is visible. In fact, African pastoralists believe that camel milk has medicinal values only when it is drunk in raw status without heat treatment (Mammeri *et al.*, 2014).

In the Somali region pastoralists, it is not applicable at all to pasteurize camel milk and drink it instead they consume raw milk, raw liver and they did not use any protective material while handling parturient camels, removing placenta and/or other aborted materials since most of the people had poor knowledge about brucellosis. Most of the camel owners believed that camel milk to possess superior storage life, medicinal properties (against dropsy, jaundice, diabetes, glycaemia) and has an aphrodisiac effect. However, most of them did not have any knowledge about the transmission of brucellosis from consumption of raw milk. Hence the isolation of *B. abortus* and *B. melitensis* (Radwan *et al.*, 1992; Gameel *et al.*, 1993; Abou-Eisha, 2000) has certainly demonstrated the danger of camel milk to public health.

In spite of the existence of risk factors for camel Brucellosis in camel population and exposure of pastoral people for zoonotic brucellosis, very few information exists on the epidemiology and public health importance of camel brucellosis in the pastoral area of Ethiopia. Thus, there is a need for further study on the epidemiology of camel brucellosis and associated risk factors for zoonotic transmission and to design and implement control measures aiming at preventing further spread of the disease both in animal and pastoral communities.

Objectives

General Objectives

To estimate camel brucellosis prevalence, assess risk factors, public health significance, and awareness for zoonotic transmission from three selected districts; Fik, Hamero, and Lagehida districts of Erer zone, Somali regional state, Ethiopia;

Specific Objectives

To estimate the sero-prevalence of camel brucellosis in three selected districts of Fik, Hamero, and Lagehida in Erer Zone, Somali Region, Ethiopia.

To assess potential risk factors associated with the occurrence of camel brucellosis in the study areas.

To explore the public health significance, level of awareness, and risk factors for zoonotic transmission of camel brucellosis in the study areas.

To highlight control and preventive measures against the brucellosis risk and transmission in both animals and pastoral communities.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted in three purposively selected districts, namely, Fik, Hamero, and Lagehida of Erer zone, Somali regional state. Erer zone, previously known as Fik is one of the 11 Zones of the Somali Region of Ethiopia. It is bordered on the southwest by Afder Zone, on the west and northwest by the Oromia Region, on the north by Fafan, and on the east by Nogob zone. Erer River flows through this zone, it is about 630 km East of Addis Ababa. Currently Erer zone consists of Eight districts namely, Fik, Lagehida, Mayaa-muluqo, Qubi, Salahad, Waangaay, Hamaro and Yahob. It covers a total land area of 80.86 km² with altitude ranging from 500 to 1,650 meter above sea level (m.a.s.l) (Degefu *et al.*, 2011). It is characterized by a semi-arid climate with unreliable and erratic rainfall with a precipitation ranging from 300 to 600 mm per annum and an average daily temperature of 20°C to 27°C (Keskes *et al.*, 2013).

Erer zone is major pure pastoralists and minor agro pastoralists. The estimated livestock population of the zone includes 248,435 cattle, 866,130 sheep, 1, 203,881 goats 150,390 camels and 10,548 poultry (CSA, 2011/2012). According to the report of Birhan (2013), cattle, sheep, goats and camels are the main productive livestock reared in the area.

Fik district is located 8° 8' 16" N latitude and 42° 17' 36" E longitude. It has an altitude with an elevation of 1229 meters masl ([http:// population mongabay.com/](http://population.mongabay.com/)). and estimated a total populations were about 189,442 (<https://www.citypopulation.de/>) While, Hamaro district is located 7°27'0" N and 42°13'60" E It is located at an elevation of 640 meters above sea level ([https://www.getamap.net/maps/ethiopia/\(et07\)/_ hamarohedad/](https://www.getamap.net/maps/ethiopia/(et07)/_hamarohedad/)), and estimated total population 87,464 (<https://www.citypopulation.de/>) ([http:// population mongabay.com/](http://population.mongabay.com/)).

Lagehida district is located 7°44'59.99" N latitude

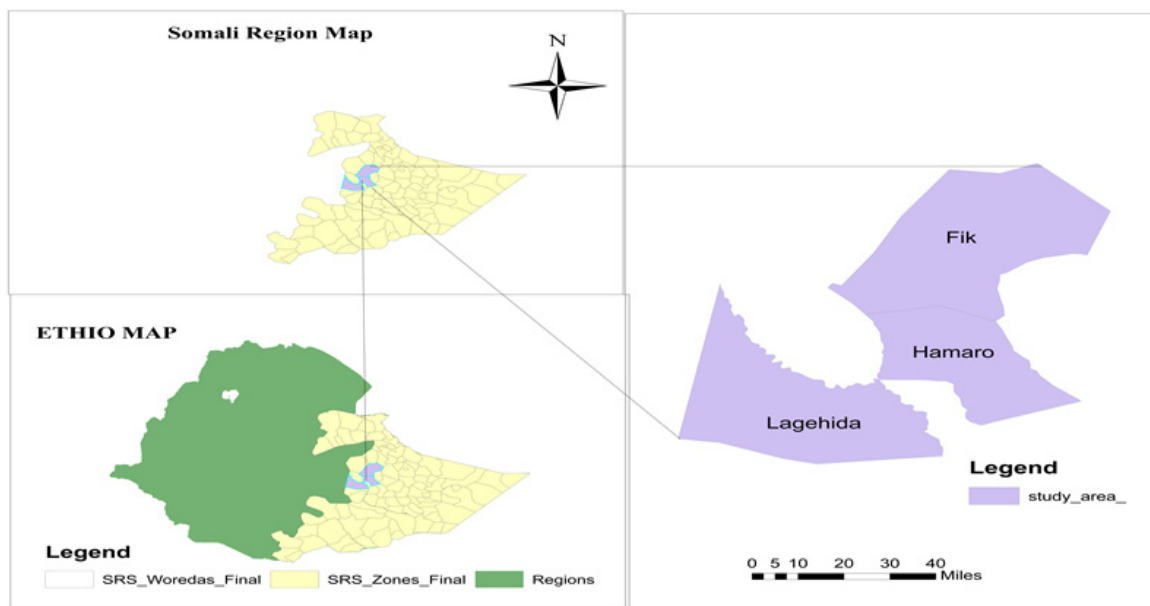


Figure 1: Map of the study areas

and 41° 14' 60.00" E longitude and has an elevation of 1,260 meters. mass above sea level (masl) (<http://populationmongabay.com/>). With estimated total population 65,469 <https://www.citypopulation.de/>).

Study Animal Population

The target study population was local Erer zone camels managed under extensive pastoral production system by the zone pastoralist. The three district, Fik, Hamaro and Laghida had an estimated camel population of 28,134 (CSA, 2011/2012). Based on camel population of the districts proportionally sample size was distributed. Camels aged two and above 2years old were included in this study. Those camels with above four years of age were considered matured (at age oandf puberty), while camels that were four and less than 4 years old were considered sexually immature. Herd consisting 3-15, 16-25 and >25 camels were also considered as small, medium and large herds, respectively.

Study Design

A cross-sectional study was conducted on 450 one humped camels, in selected pastoral and agro-pastoral residences of the Fik, Hamaro and Laghida districts of Erer zone, Somali region, from December, 2020, until August, 2021, to determine the sero-prevalence of Brucella infections with particular emphasis on potentially associated risk factors. The three districts were purposively selected based on their accessibility and distribution of camel population in the areas.

Among the districts, a total of 15 settlements or Kebeles (5 Kebeles from Hamaro, 6 Kebeles from Fik and 4 Kebeles from Laghida district) were purposively selected based on distribution of camel population. Camels found in these settlements were the study population, where individual animals have been sampled using systematic

random sampling. No camel was selected if a group contains less than three camels. Camels that were 2 years of age and above were sampled and included in this study. Moreover, 50 willingly selected camel owners (20 from Hamero, 15 from Fik and 15 from Laghida, districts), living in the selected villages, whose animals were tested for Brucellosis has been included in the questionnaire survey.

Sample Size Determination

Sample size was determined according to Thrusfield (2005) for random sampling and calculated using the expected prevalence of 2.43% (Tilahun *et al.*, 2013), 95% confidence interval and 5% absolute precision in the formula as follows: -

$$n = 1.96^2 \times P_{exp} (1 - P_{exp}) / d^2$$

Where n = sample size, d = desired absolute precision (0.05), P_{exp} = expected prevalence (2.43%); the minimum sample size calculated was 36 however; it was inflated to 450 for better precision. Proportional distribution of the sample was carried out depending on the camel population in the study areas.

Questionnaire Survey

In this study, two questionnaire formats (Annex 8.5 and 8.6) were generated in local Somali language and used: one for the individual animal history of the serum sampled animals and the other with a well-organized survey format for the herders on brucellosis perception and its zoonotic risk factors. The practices of feeding and housing animals, knowledge of zoonotic diseases, particularly brucellosis and its zoonotic risk factors, consumption habits of camel products, and handling and disposal practices for carcasses or aborted fetuses were all investigated in the questionnaire survey aimed to support the serological results.

Blood Sample Collection

Approximately 10ml of blood sample was collected from the jugular vein of each animal using plain vacutainer tubes, needles and needle holders. Each sample was labeled by using codes describing the specific animal. The blood samples were left at room temperature overnight, to allow clotting, for sera separation. Then, the sera were separated from the clotted blood by decanting to other tubes and were stored at -20°C until serologically tested. Modified Rose Bengal plate test (mRBPT) and complement fixation test (CFT) were used for screening and confirmatory test of sera respectively.

Serological Test

Rose Bengal Plate Test (RBPT)

The RBPT test was carried out according to the method recommended by (OIE, 2004). The antigen used for RBPT, was RBPT antigen (Institut Pourquier 325, rue de la galèra 34097 Montpellier cedex 5, France). This test was carried out at jigjiga regional diagnostics and research laboratory center in jigjiga city, somali regional state Ethiopia. Antigen and sera required for each day for serological testing was taken out from the cold storage (in refrigerator at -40C) and brought to room temperature for 30 minutes before testing takes place. Briefly 30 μl of stained rose Bengal antigen was dispensed on to card plate and then 30 μl of sera samples were dropped alongside the stained rose Bengal brucella antigen. By using the tip of the automatic micropipette tips, the sera and the stained rose Bengal brucella antigen were mixed and examined for agglutination. Positive and negative controls were employed for interpretation of the results. Agglutinations were recorded as 0, +, ++ and +++ according to the degree of agglutination (Nielson, 2002). A score of 0, +, ++ and +++ indicates the absence, barely visible, fine and coarse of agglutination, respectively. Then those samples with no agglutination (0) and with agglutination either +, ++ or +++ were recorded as negative and positive for brucella infection, respectively.

Complement Fixation Test (CFT)

All sera which were tested positive by the RBPT were further retested, using the CFT, for confirmation and the CFT test was done at Jigjiga Regional Diagnostics and Research Laboratory Center. Standard B. abortus antigen for CFT (from the Veterinary Laboratories Agency,

Addle stone, United Kingdom), Amboceptor and sheep red blood cells (SRBCs), were used to detect the presence of brucella antibodies against brucella antigen in the sera. Similarly, the control sera and complement used in this test were also obtained from Jigjiga regional diagnostics and research laboratory center, Jigjiga city, Ethiopia. As an interpretation the test serum having SRBCs sedimentation at a dilution of $\geq 1:5$ were considered to be positive for the disease; camel Brucellosis.

Data Analysis

The generated data for each animal's serum sample and questionnaire was precisely recorded and placed into a database using a Microsoft Excel spreadsheet (Microsoft Corporation). The data on the individual animals whose serum had been sampled and placed into an Excel spreadsheet were then imported into STATA version 14.0 for Windows (Stata Corp. College Station, Texas 77845 USA) and appropriately analyzed. On the basis of combined RBPT and CFT positivity, the number of camels calculated to be seropositive for Brucella infection was divided by the total number of camels tested to determine the disease's Seroprevalence at the animal level. In order to ascertain the relationships between risk factors and the occurrence of camel brucellosis in the research areas, univariate logistic regression analysis was used. Odd ratio (OR) was utilized to indicate the degree of risk factor association with the disease occurrence signified by 95% confidence intervals.

In addition, to identify the primary risk variables, multivariable analysis using logistic regression was applied to all risk factors with $p > 0.2$ on univariate analysis. A P-value of less than 5% and a confidence level of 95% were regarded as significant for statistical inference. Using Microsoft Excel and Intercooled Stata 14.0, descriptive statistics have been utilized to analyze survey data.

RESULTS

Seroprevalence of Camel Brucellosis

Accordingly, in the current study, the overall seroprevalence of camel brucellosis was 4.8% (95% CI: 0.02–0.068) based on RBPT confirmed by CFT and by Rose Bengal plate test alone detected 56 (12.4 %, 95% CI: 0.093–0.155) of the samples as seropositive. Upon further testing by CFT only 22 (4.8 %, 95% CI: 0.02–0.068) sera were left positive.

Table 1: Camel brucellosis by RBPT and CFT

Location	N	RBPT		CFT		95%, CI
		No. positive	%	No. positive	%	
Hamaro	210	21	10	4	1.9	0.007-.052
Fik	140	18	12.8	8	5.7	0.92- 10.57
Laghida	100	17	17	10	10	1.7-18.7
Total	450	56	12.4	22	4.8	0.02–0.068

N = number of camels examined; No. = number

Table 2: Seroprevalence of Brucellosis in relation to different risk factors by univariate logistic regression analysis

Variables	Categories	No. sera Tested	No. sera Positive	Prevalence with 95%, CI	OR	P-value
Sex	Female	321	20	6.2 Ref	Ref	Ref
	Male	129	2	1.6 (0.05-1.02)	0.23	0.05*
Age	<4 years	154	2	1.3 Ref	Ref	Ref
	5-7years	187	12	6.4 (1.14- 23.65)	5.2	0.03*
	>7 years	109	8	7.3 (1.25- 28.92)	6.0	0.02*
Districts	Hamaro	210	4	1.9 Ref	Ref	Ref
	Fik	140	8	5.7 (0.9-10.5)	3.1	0.06
	Laghida	100	10	10 (1.7-18.7)	5.7	0.000**
Parity	No parturition	62	2	3.2 Ref	Ref	Ref
	Single parity	77	12	15.5 (1.2-26.1)	5.6	0.02*
	Mult parity	182	6	3.3 (0.2-5.2)	1	0.96
Herd size	Small herd	355	6	1.7 Ref	Ref	Ref
	Medium herd	38	6	15.7 (3.3-35.7)	10.9	0.000**
	Large herd	57	10	17.5 (4.3-35.6)	12.3	0.000**
ICWR	Yes	304	21	6.9 (1.43- 80.8)	10.7	0.02*
	No	146	1	0.68 Ref	Ref	Ref
AFAC	Yes	66	12	18.2 (2.67- 17.5)	6.86	0.000**
	No	255	8	3.23 Ref	Ref	Ref

No= Number; ICWR= Interaction of camels with Other Ruminants

AFAC= Abortion in Female Adult Camels; OR= Odds Ratio; CI= Confidence Interval

Results of univariate logistic regression analysis of potential risk factors at animal level in relation to Brucellosis revealed that all the variables investigated (except between Fik and Hamaro district ($p = 0.06$) and also multiparous adult female camels comparing to females with no history of parturition ($p=0.96$) had significant association with Brucella seropositivity ($P < 0.05$) (Table.2).

In this study, by manipulating a univariate logistic regression, the highest seroprevalence was found in females 6.2%, (CI: 4.2-10.4) (20 of 321) than males 1.6%, (CI: 0.054-1.029) (2 of 129) with statistically marginal significance ($p = 0.05$). Similarly, higher reactor rate was recorded in female animals with a single parity (15.58%, CI: 1.2-26.2) and there was statistically significance difference in univariate logistic regression. On the other hand, lower seroprevalence of (3.3%, CI: 2.03- 5.25) and (3.2%, CI: 0.008- 0.134) was observed in adult multiparous female camels and adult female camels with no history of parturition, respectively (Table.2). But,

multivariable logistic regression has showed that sex and parity had no effect for the occurrence of the disease in the area (Table.3).

Likewise, camel brucellosis was statistically detected in all of the three districts and the highest sero-prevalence was recorded in Lagehida (10%, CI: 1.7-18.7) followed by Fik (5.7%, CI: 0.92- 10.57), while Hamero has got the lowest sero-prevalence of (1.90%, CI: 0.007-.052) in relation to the other two districts. Also, the observation shows that Seroprevalence of brucella in female camels with history of abortion was 18.2%, (CI: 2.7-17.6) whereas those without history of abortion was 3.1%, (CI: 1.6 - 6.5).

In univariate logistic regression analysis, the seroprevalence of brucella in relation to these two risk factors was statistically significance ($p < 0.05$) difference (Table.2). Nonetheless, similarly to sex and parity multivariable logistic regression has showed that location and abortion had no effect for the occurrence of camel Brucellosis in the study area (Table.3)

Table 3: Multivariable, stepwise approach logistic regression analysis of risk factors (sex, age, districts, herd size and ICOR) for Seroprevalence of camel Brucellosis

Variables		No. sera tested	No. sera positive	Crude OR	Adjusted OR	95%, CI	P-value
Sex	Female	321	20				
	Male	129	2	0.23	0.30	0.06-1.45	0.138
Age	<4 years	154	2	-	-	-	-
	5-7years	187	12	5.2	3.14	1.5-6.6	0.003*
	>7 years	109	8	6.0	-	-	-

Districts	Hamero	210	4	-	-	-	-
	Fik	140	8	3.1	1.02	0.4-2.1	0.952
	Lagehida	100	10	5.7	-	-	-
Herd size	Small herd	355	6	-	-	-	-
	Medium	38	6	10.9	4.37	2.1-8.9	0.000**
	Large herd	57	10	12.3	-	-	-
ICOR	Yes	304	21	10.7	11.8	1.4-93.7	0.020*
	No	146	1	-	-	-	-

No= Number; ICOR= Interaction of camels with Other Ruminants
OR= Odds Ratio; CI= Confidence Interval

Table 4: Multivariable, stepwise approach logistic regression analysis of risk factors (sex, age, herd size and ICWR) on seroprevalence of camel Brucellosis

Variables	Categories	No. sera tested	No. sera positive	Crude OR	Adjusted OR	95%, CI	P-value
Sex	Female	321	20	-	-	-	-
	Male	129	2	0.23	0.30	0.06-1.45	0.138
Age	<4 years	154	2	-	-	-	-
	5-7years	187	12	5.2	3.14	1.49- 6.61	0.003*
	>7 years	109	8	6.0	-	-	-
Herd size	Small herd	355	6	-	-	-	-
	Medium	38	6	10.9	4.44	2.54-7.74	0.000**
	Large herd	57	10	12.3	-	-	-
ICOR	Yes	304	21	10.7	11.74	1.48-92.61	0.019*
	No	146	1	-	-	-	-

Table 5: Putative effects of advance in age, herd size and ICOR on Seroprevalence of camel Brucellosis

Variables	Categories	No. sera tested	No. sera positive	Crude OR	Adjusted OR	95%, CI	P-value
Age	<4 years	154	2	-	-	-	-
	5-7years	187	12	5.2	3.27	1.58 - 6.74	0.001**
	>7 years	109	8	6.0	-	-	-
Herd size	Small herd	355	6	-	-	-	-
	Medium	38	6	10.9	4.64	2.66 - 8.10	0.000***
	Large herd	57	10	12.3	-	-	-
ICOR	Yes	304	21	10.7	11.46	1.39 - 85.46	0.023*
	No	146	1	-	-	-	-

In this study multivariable logistic regression analysis of risk factors was determined significantly, the age, herd size and keeping camels closely together with other ruminants as the major risk factors for the occurrence of seropositivity to Brucella infection in camels ($p < 0.05$) (Table.4). Advance in age, herd sizes and keeping camels together with other ruminants were significantly associated with infection rate ($p < 0.05$) when the putative effects of different factors subjected to step wise backward reduction method. Table.4, shows that increasing age and herd size together with keeping camels closely with other ruminants had significantly joint effect on seropositivity in dromedaries when other factors

removed ($p < 0.05$). Thus, they were found to be the risk factors for the occurrence of camel brucellosis in the study area (Table.4).

After computing both univariate and multivariable logistic regression analysis, statistically significance seroprevalence difference of 1.3%, (95%, CI: 0.003-0.053) 6.4%, (95%, 1.14 - 23.65) and 7.3% (95%, CI: 1.25-28.9) for Brucella infection were observed in the age groups of <4 years, 5-7 years and >7 years old, respectively. Animals within the age range of 5-7 had higher Brucella antibody distribution than young animals ($< Or = 4$ years) ($p < 0.05$) with odds ratio of 5.2 times higher risk for the likelihood disease occurrence in adult than young camels. Similarly

animals above 7 years of age had higher seroprevalence of camel brucellosis comparing to young camels where the odds ratio was indicating 6 times higher risk for the probability of disease occurrence in old than young camels (Table.2).

According to the result of this study Seroprevalence of brucellosis in relation to herd sizes were 1.7 %, (95%, CI: 0.007-0.0397), 15.7%, (95%, CI: 3. -35.) and 17.5%, (95%, CI: 4.-35.) in small, medium and large herd sizes, respectively. Correspondingly, significantly increasing positivity was recorded with respect to increasing herd sizes ($p < 0.05$) in both univariate and multivariable logistic regression analysis, where the risk for the occurrence of positivity being 10.9 times higher in medium and 12.4 times higher in large herds comparing to small sized herds (Table .2).

On the other hand, camel herds kept together with other ruminants were considered as one of the putative factor for dissemination of brucella infection. This was categorized based on the absence and presence of other ruminants together with the camel herds. The univariate and multivariable logistic-regression analysis indicated that, statistically a significant association exists between positive antibody status and keeping camels in close contact with other ruminants. A seroprevalence of 6.9%, (CI: 1.43- 8.7) and 0.68%, (CI: 0.001- 4.9) in animals kept close contact with other ruminants and those without contact with other ruminants, respectively was observed. According to multivariable logistic regression the likelihood of Brucellosis occurrence was 11.4 times higher in camels living with other ruminants than those camels kept without other ruminants (Table.4).

The questionnaire analysis indicated that an extensive management system was practiced in the current study area; where most of the camels were kept together with other species of animals and mainly reared for milk production, transport, cultural and social value. The highest proportion (82%) of the camel herds kept together with other species of animals while 8% of camel herds were kept alone. The camel rearing experience of pastoralists ranged from 7 to 45 years. According to camel herd composition pregnant and lactating female camels were quietly proportionate as 23.7% and 22% respectively.

Furthermore, non-lactating female adult camels were account 17.5%. Camel bulls in the herds of the study area were relatively quite low as 8.4% of the herd. Females were constituted about 63.2% of the entire herd while young immature camels of both sexes were account 28.3% of the herd. Similarly, pastoralists people in the study area were mainly keep camels for milk production (80%) where the rest particularly camel bulls were kept for draft power (10%) and other purposes like social value 4% and herd accumulation (6%).

In the study area, 75% of the total milk production from Hamaro and Fik, was sold to the small scale private milk collectors and then after transported to Hamaro and Fik towns to generate income. The remaining 25%

milk was used for home consumption. According to the respondents, all most all of the herders (100%) consumed fresh raw milk without any heat treatment. Also people in the study area consume milk after mixing with boiled tea so called “Caddeys” in Somali language. Camel meat was consumed as cooked. However, some of the respondents said that they consume hump of camel as raw.

In relation to the respondents, herding and watering were the activities done by young and adult males while adult and young males were belonging to the milking of camels in a proportion of 43% and 34% respectively. Likewise, females in the study area share same activity, with the males of both age groups, i.e. milking of camels as 23%. As per the respondents, during dry season, Camel owners in the study area were used traditional wells (71%) and ponds (29%) made by the Somali Regional Government Institutions, as the main water sources for their camels. Where as in rainy season, natural lakes and rivers were the main source of water for camels. According to the respondents, the prevalent camel diseases in the study area were included anthrax (92%), trypanosomosis (91%), pasteurellosis (85%), pneumonia (64%), camel pox (63%) and abortion (45%). People in the study area give local names for the above mentioned diseases as “Kud”, “Dbukaan”, “Cuna barar”, “Oof”, “Furuqa geela” and “Dbicis” respectively. Besides these localized abscess (48%), GIT parasites (51%), camel mange (61%), wound and tiger bite (19%) were declared by the respondents as commonly occurred diseases and events in the area. Additionally, trypanosomosis (48%), pasteurellosis (12%), camel pox (10%), Anthrax (21%), sunstroke (4%) and pneumonia (5%) were the diseases that respondent individuals in the questionnaire replied as the causes of abortion in camels.

The main responsibilities of adult men, which accounted for around (95%) of this family activity, included helping with delivery and mating of camels. While young males performed just (5%) regarding family activities. The majority of the respondents in this survey stated that aborted camels were primarily removed from the herd by sale, with the aborted fetus, placenta, and discharges either being left on the ground or being thrown to the herders’ dogs. Similar to this, approximately 35 percent of the herders practiced sharing the village bull among several herds, which was not uncommon. The other 65% of camel owners used a bull from their own herd for breeding. In the study area, camel owners grazed their animals separately and with other ruminants in proportions of 45% and 55%, respectively. Contrarily, in this study, 78% and 22% of camel herds had separate night resting area and camel herds shared night enclosures with other ruminants, respectively.

DISCUSSIONS

The overall Seroprevalence of camel brucellosis was found to be 4.8% when the RBPT and CFT tests were combined, as compared to 12.4% by the RBPT alone in study areas. This result was in agreement with earlier

findings of camels' brucellosis from the Abu Dhabi Emirate with weight losses of 4.1% (Hadush and Pal, 2013), 4.5% (Chauhan *et al.*, 2017), and 4.4% (Mohamed *et al.*, 2013) respectively. Furthermore, the current results were inconsistent with Habtamu and Fisseha's (2014) report of a Seroprevalence of 3.67% in camel brucellosis in the south-eastern Tigray region.

The current findings were also close those of Mohamed *et al.* (2015) and Bekele *et al.* (2013), who discovered that camels had Seroprevalence of 5.5% and 5.4% of *Brucella* seropositivity from Khartoum state, Sudan, and the Afar national region, respectively. Similarly, It is encouraging to the findings reported by Mohamed *et al.* (2014), who recorded 4.1% in Libya. In addition, The results of Abbas and Agab (2002), who observed low seroprevalence (5%) in nomadic or intensively managed camels, were also in agreement with this recent study.

However, the observed Seroprevalence of camel *Brucella* in this study was higher than the results, reported by Omer *et al.*, (2000), Robayo and Esubalew, (2017), Gumi *et al.*, (2013), Tilahun *et al.*, (2013) and Megersa *et al.*, (2011) who reported 3.1%, 1.5%, 0.9%, 2.4% and 1.8% in Eritrea, Ethiopian Somali region, in and around Dire Dawa, southeast Ethiopia, Somali region and Borana respectively. Correspondingly, the result of the recent study was higher than that of Mohamed *et al.*, (2011), who reported a lower Seroprevalence of 1.6% in camels from in and around Dire Dawa town. Furthermore, the observed Seroprevalence of this study was higher than that of Teshome *et al.*, (2003) and Dominech, (1977), who reported a lower seroprevalence of 1.2%, 1.7%, and 1.7% from camels in Borana zone, Tigray region and Hararghe region respectively.

Therefore, the agro-ecological characteristics of the study areas, sample size, animal management, and production techniques could all be contributing factors to the difference in seroprevalence between the current and previous studies. The prevalence of brucellosis might vary depending on geographic location, species, age, sex, and diagnostic procedures (Gul and Khan, 2007). As brucellosis transmitted from one herd to another due to the movement of an infected camel into a susceptible camel herd may deteriorate the epizootic conditions in the study areas. This is true for the Somali region pastoral community during prolonged dry seasons and drought, since camel herders move from one locality to another locality for long distances in search of forage and water sources for their animals. The increased seroprevalence that results from this study may potentially be a result of the applied test's differing in their specificity and sensitivity levels. Using tests with low specificity, a higher seroprevalence of camel brucellosis may be detected (Andreani *et al.*, 1982).

In combination with these, the comparatively higher prevalence of camel brucellosis in the area of study may be caused by a lack of hygienic precautions against disease occurrence and prevalence of reactor animals in the area, the virulence of the micro-organisms, the number of

susceptible camels, a shortage of veterinary services, and a lack of knowledge about the disease all contribute to an increase in brucellosis infection rates.

In contrast, the current study indicated that it is relatively lower than the seroprevalence of, 5.7%, 7.6%, and 5.4%, reported by Teshome *et al.*, (2003) Zewold and Haileselassie (2012), and Bekele *et al.*, (2013) in Afar region. This diversity may result from different herding practices. In the Afar region, mixing animals from different locations is widespread at communal grazing and watering places (Teshale *et al.*, 2006), however in the Somali region, only animals belonging to a certain clan are allowed to be mixed, and there is a heavy emphasis on clan-based division of animals as well as utilization of rangeland. Additionally, this condition might contribute the good practice of herders promptly removing non-conceiving and aborted females from the herds.

According to reports of Sadiq *et al.* (2011), Gameel *et al.* (1993), and Mohamed *et al.* (2014) records higher sero prevalence of camel brucellosis in Nigeria (9.4%), Kenya (5.8%), and Sudan (5.8%), respectively when compared to the current study. Additionally, Omer *et al.* (2007), Musa *et al.* (2008), and El-Boshy *et al.* (2009) reported higher seroprevalence of camel brucellosis in Sudan (30.5%), Darfur/Western Sudan (3.8%), and Egypt (7.3%) respectively. Differences in variations of camel brucellosis prevalence among countries may be responsible for difference in husbandry and management approaches. Serological results could potentially be influenced by sample selection bias.

Animals of all ages are susceptible to infection, however both sexes of sexually mature animals are frequently infected. According to the current study, there is a (6.4%) greater seroprevalence of camel brucellosis in adult age groups than in younger age groups (1.3%). In both univariate and multivariate logistic regression analysis, this higher seropositivity showed statistically significant differences between the two age groups, with animals aged 5-7 years having a 5.2 times higher risk of most likely disease emergence than animals aged 4 years. This is in agreement with the findings of Habtamu and Fisseha (2014), who from the Mehoni district in the south-eastern Tigray region of Ethiopia reported a marginally higher significant association with the occurrence of brucellosis in adult camels (>4 years) (6.5%) than in young camels (6 month to 4 years) (0%) with a likelihood odds ratio (OR) of 9.6. Similarly, the current study was in agreement with Madu *et al.*, (2016) who reported 16.7% in adult and 0.6% in young camels with $p < 0.05$, in three abattoirs from northern Nigeria.

Similar to this, the current study found that animals older than 7 years had higher seroprevalence of 7.3% compared to young camels, and this difference was statistically significant (Table 2). The odds ratio (OR) showed that older camels had a 6 times higher risk of disease occurrence than younger ones (Table 2). According to earlier studies by Radostits *et al.* (2006), infection may occur in animals of all age groups but persists frequently

in sexually mature animals. This greater Seroprevalence of brucellosis in older camels (7.3%) was corresponded with their findings.

According to Tefera and Gebreab (2001) reported that She-camel reached puberty at ages 4 and 5, respectively, while, males reached puberty at ages 5 years in eastern Ethiopia. Similarly, Wossene (1991) also documented the same age for puberty and the first calving in female Ogaden camel dromedaries. Sexually mature and pregnant animals are more likely to contract *Brucella* infection than sexually immature animals of either sex (Radostits *et al.*, 2007).

On the other hand, younger animals are more resistant to infection and typically recover from an existing infection, albeit latent infection is possible (Walker, 1999). Also, young camels might possess low Seroprevalence due to maternal immunization. This may be caused by the fact that erythritol and sex hormones, which promote *Brucella* organism development and multiplication, tend to concentrate more with age and sexual maturity (Radostits *et al.*, 2007).

Since brucellosis is regarded as a disease of particular concern to herds, a notably high level of 1.7%, 15.7%, and 17.5% *Brucella* seropositivity, respectively, was observed in small, medium, and large herd sizes. When compared to small herd sizes, the likelihood risk of *Brucella* positive incidence was 10.9 and 12.4 times greater in medium and large herds, respectively (Table.2). Thus, for, herd size was statistically determined to be one of the key risk variables for *Brucella* occurrences in the study areas ($p = 0.001$) for both univariate and multivariable logistic regression analysis. The likelihood of animal contact increases with herd size, increasing the likelihood of infection. This is particularly significant after calving or abortion, when most *Brucellosis* contamination occurs (Mohamed *et al.*, 2013).

As a result, according to Abbas and Agab (2002), the infection rate has a strong association with the size of the herd, the density of the animal population, and inadequate management. According to Radostits *et al.* (2000), the size of the herd is a key element in the spread of the *Brucella* infection. According to Mohamed *et al.* (2013), who observed a 4.4% ($p = 0.000$) seroprevalence of camel *Brucellosis* in Abu Dhabi, the likelihood of animal contact increases with herd size, increasing the likelihood of infection. Similarly, Zewold and Hailleselassie (2012) reported a strong correlation between herd size and the occurrences of *brucella* among camels in the area.. According to these authors, there was a statistically significant difference in the incidence of the disease depending on herd size (small: 14–20, medium: 21–40, and large: > 40 camels; $2 = 8.47$, $P = 0.004$). The same effect of herd size on the prevalence of camel *brucellosis* was noted by Mohamed *et al.* (2015) in Khartoum State, Sudan. They stated that multivariable analysis revealed that herd sizes with more than 20 camels were significantly associated with the prevalence of camel *brucellosis* by logistic regression analysis (OR=5.7) with

P0.05. Similar associations have been reported by Bekele *et al.* (2013) in the Afar region of northeastern Ethiopia and by Adamu *et al.* (2014) in the northeastern part of Nigeria.

Regarding camel herds' interactions with other ruminants in the study areas (Table. 2), the Seroprevalence rates were 6.9% and 0.68%, respectively, in animals who had regular contact with other ruminants and those with no contact with animals. This illustrates the real condition of *Brucellosis* among the two groups that focus on studying how ruminants, such as sheep, goats, and cattle, spread the disease from camels to humans and vice versa. The majority of *Brucella* species tend to be related to certain hosts, although infections can also happen in other species, especially if they are kept in close proximity to one another. Most of the pastoral communities in the study area keep camels and other ruminants together during browsing, watering, in night enclosures, and during migration, which could present a chance for the disease to spread between species. According to Mohamed *et al.* (2011), in camels raised in eastern Ethiopia without ruminants, with small ruminants, and with large ruminants, the Seroprevalence of *Brucellosis* was 1%, 4.3%, and 5.3%, respectively. Additionally, Chauhan *et al.* (2017) noted that raising multiple species in the same herd may result in intimate animal interaction, which may enable the interchange between various pathogenic microbes. Similarly, Abou-Eisha (2000), observed high Seroprevalence in camels with a history of sheep and goats being kept together (with the camels). This may have shown comparable results had it been included in this study about the comparison of the species Seroprevalence. Factors that contribute to this high prevalence rate in camels may be related to the extensive management system livestock prevailing in the study area. According to the current result of the questionnaire survey 82% (37/45), of the respondents keep camels closely together with other ruminants.

The interaction of the various species among camels and other ruminants during migrating, while watering, or in night enclosures (resting) was also observed. The movement of animals for grazing and watering may contribute to the spread of camel *Brucellosis* since grouping the animals around watering areas may increase contact between sick and healthy animals and so facilitate the disease's spread.

In accordance with the above discussion, this study highlights the need to include camels in Ethiopia's national program for the prevention and control of *Brucellosis* on the basis that, in cases where the disease affects stock animals, it poses a risk to the health of laboratory, veterinary, farm, and abattoir workers. In addition, there are risks to the public's health and high-risk individuals beyond occupational contractors, particularly for pastoral households. These households are at a high risk of contracting the disease due to deliberate handling of potentially infected animals, such as when grooming animals or assisting she camels for parturition process.

According to survey results, camel owners in the study area consume raw milk, assist with deliveries, groom livestock, clean newborns, help with nursing, and move the young from the field to the house without wearing any protective gear or materials. In addition to these, herdsman have no awareness of Brucellosis. Similar findings were made by Tilahun *et al.* (2013), who documented that 100% of the herders in the Jigjiga and Babile districts drank fresh raw milk. without any heat treatment. Similarly, Habtamu and Fisseha (2014) stated that the majority of animal owners were unaware of the zoonotic nature of brucellosis since they drank raw milk and did not take measures when handling aborted fetuses in the Mehoni area in the south-eastern section of Tigray region. These could threaten the region's public health. Zewold and Haileselassie (2012) added that individuals who owned milking camels and lived in the pastoral and agro-pastoral communities of the Afar Region helped animals during parturition and grooming in addition to maintaining close contact with other livestock. Therefore, these contribute as potential risk factors for brucellosis in humans. According to Zewold and Haileselassie (2012) reported 15% (30 out of 200) *Brucella* seropositivity in clinical patients from two health centers of Awash-Fentale and Amibara districts in Afar region, north east Ethiopia.

CONCLUSION

The result of the present study revealed a Seroprevalence of 4.8% and this was moderately higher in relation to other previous studies, which have been done so far in the study region. Multivariable logistic regression analysis of presumed risk factors indicated that age, herd size and camels closely kept with other ruminants were the key associated risk factors for the likelihood occurrence and transmission of camel Brucellosis in the study areas. The existence of the disease together with the extensive production systems and practices, including livestock movements, sharing of grazing grounds and watering points, and mixing and trading of animals that were prevailing in the study area will intensify the condition and increase the prevalence of Brucellosis. On the other hand, there is a possible risk of *Brucella* spreading to people in the area, since the livelihood of pastoral community mainly depends on camel species, providing milk and meat. Furthermore, lack of awareness about zoonotic diseases, the habit of raw milk consumption and close contact with animals was highly common in the study area. Therefore, the results of the current study provide the importance of camel Brucellosis in study areas and the risk factors that had potentially contributed to the occurrence of the disease in camels and also the possible zoonotic significances in human beings.

RECOMMENADITIONS

Therefore, based on the above conclusion the following recommendations were forwarded: -

- Advanced research on isolation and identification of the *Brucella* biotypes circulating in camels should be

implemented to design effective herd health control and preventive strategies.

- Comprehensive epidemiological research should be carried out with a particular emphasis on other ruminants' involvement in the occurrence of camel brucellosis infection and its spread in pastoral areas.
- Public health education should be undertaken to promote awareness levels of livestock owners on animal husbandry practices, disease management protocols, and zoonotic infections prevention and control measures.

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