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ORIGINAL RESEARCH

Seroprevalence of brucellosis and its contribution to abortion in cattle, camel, and goat kept under pastoral management in Borana, Ethiopia

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Abstract The involvement of *Brucella* infection in causing abortion was investigated in a breeding female subpopulation of 283 cattle, 756 camels, and 757 goats. Serum samples were serially tested using the Rose Bengal test and complement fixation test. The study showed that anti-*Brucella* antibodies were prevalent in 10.6% (95% confidence interval (CI), 7.4, 14.9), 2.2% (95%CI, 1.4, 3.7), and 1.9% (95%CI, 1.1, 3.2) of cattle, camel, and goats, respectively. Abortion was more commonly reported in camels (23.4%) than cattle (13.8%) and goats (12.4%). The results of this study suggested that *Brucella* infections contribute significantly to abortion in cattle (odds ratio (OR),=4.7; 95%CI, 2.0, 10.8) and goats (OR=6.9; 95%CI, 2.2, 21.7) but not in camels. The number of young animals produced by breeding females seems to be apparently reduced in seropositive groups. Keeping more than two animal species at household level was found to be the risk factor for cattle (OR=3.1; 95%CI, 1.2, 7.9) and camel (OR=5.3; 95%CI, 1.2–23.5) seropositivity to *Brucella* infection when compared to those animals from households that keep only two animal species. This may suggest a possibility of cross species transmission of *Brucella* infection under such mixed herding. Wet season (OR=4.8; 95%CI, 1.3, 18.1) was found to be associated with seropositivity in goats, linked to a coincidence of increased deliveries in flocks with possible excretion of *Brucella* organisms. The study results suggest that *Brucella* infection is the likely cause of abortion in cattle and goats while other causes largely outweigh brucellosis as a cause of abortion in camels in Borana, hence, contributing to reproductive loss.

Keywords Brucellosis · Seroprevalence · Abortion · Cattle · Camel · Goat · Ethiopia

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Introduction

The economic and public health impact of brucellosis remains of particular concern in developing countries. The disease poses a barrier to trade of animals and animal products, represents a public health hazard, and is an impediment to free animal movement (WHO 2006). The most common clinical manifestation of brucellosis in natural hosts is reproductive loss resulting from abortion, birth of weak offspring, or infertility. In particular, abortion, stillbirth or a weak, non-viable calf is the hallmark of brucellosis (Olsen and Tatum 2010). Loss of a calf or kid due to abortion and its sequelae frequently lead to infertility and reproductive losses. The role of specific etiologic agents such as *Brucella* species in causing abortion and reproductive loss has been well established, as documented by Radostits et al. (2000), but known causes of abortion and female infertility involve a wide range of etiologic agents.

Many developing countries with limited resources, including Ethiopia, are facing other priority diseases that are more spectacular and have not yet fully launched programs featuring any aspects of brucellosis intervention. Hence, brucellosis remains endemic and continues to be a major public and animal health problem in the developing regions of the world (Godfroid et al. 2005). The disease can generally cause significant loss of productivity through abortion, prolonged calving, kidding, or lambing interval, low herd fertility, and comparatively low milk production in farm animals (Radostits et al. 2000). The disease could seriously impair socio-economic development for livestock owners, which represent a vulnerable sector in rural populations in general and pastoral communities in particular. It has a significant public health implication for a pastoral community in consequence of lifestyles, feeding habits, close contact with animals, low awareness, and poor hygienic conditions which favor infections (Schelling et al. 2003).

The evidences of *Brucella* infections have been serologically demonstrated by different workers in sera of animals in Ethiopia. Seroprevalence was predominantly reported in cattle (Berhe et al. 2007; Kebede et al. 2008; Mekonnen et al. 2010) while the status of the disease in camels (Teshome et al. 2003; Megersa et al. 2005) and small ruminants (Teshale et al. 2006; Ashenafi et al. 2007) was not well documented. More importantly, the significance of animal brucellosis in causing abortion and reproductive loss in different livestock species was not substantially investigated. Therefore, the present study was intended to look into the role of *Brucella* infection in causing abortion and its contribution to reproductive losses in breeding females of cattle, camel and goat.

Materials and methods

Study area

The study was conducted in Yabello, a district found at 4° 53′ 24 N 38° 04′ 48 E in Borana, Southern Ethiopia. Generally, the Borana plateau represents a lowland area with semi-arid climate. The area has a bimodal rain pattern with annual average rainfall ranging from 300 mm to 700 mm. The main rainy season (65% of precipitation) extends from March to May, and there is a smaller rainy season between mid-September and mid-November. The main dry season extends from December to February (Coppock 1994). Livestock production system is generally predominated by extensive pastoral or agro-pastoral system in which indigenous animals are allowed to forage freely during daytime and kept in open enclosure during the night. The dynamic nature of this system is characterized by keeping diverse species of livestock with seasonal herd mobility. Breeding females are kept for milk production and so constitute the major proportion of pastoral herds or flocks.

Study design and sample size determination

The data were collected as part of a study on the seroepidemiology of *Brucella* infection in multiple livestock species herding in the Borana pastoral production system. Briefly, a repeated cross-sectional study was carried out on cattle, camel, and goat brucellosis from December 2007 to October 2008. Sixteen villages from among all the villages in Yabello district were selected based on random sampling. An attempt was made to include at least three villages per Pastoral Association and three households per village whereas restrictions on the selections were imposed based on the accessibility of the villages by vehicle or the proximity to roads, and presence of the three livestock species per household. Subsequently, households keeping the three livestock species were given priority to sample the animals, if not at least two species were sampled from the same household.

The number of each animal species to be sampled per village was estimated taking the dynamic nature of pastoral herds (high herd mobility), presence of three animal species per household, willingness of herd owners to cooperate, and availability of herds during the visit into consideration. Within these constraints, we aimed at achieving at least 30 cattle in each village, corresponding to a 95% sensitivity of finding at least a positive animal in a finite population if the expected prevalence was 10%. Similarly, sampling of 60 animals each in cases of camels and goats was targeted from each village using expected prevalence of 5% (Dohoo et al. 2003). Subsequently, a total of 283, 757, and 756 breeding female (with primiparous and above) subpopulation of cattle, camels, and goats were sub-sampled from the data generated and analyzed, respectively.

Serum sample collection and testing

For ease of restraining, sample collection time was preferred to be early in the morning before animals were taken out for grazing. Blood samples of about 10 ml were aseptically collected using plain tubes from cattle and camels, and about 5 ml from goats through jugular venipuncture. Animals were sampled during the dry and major wet season to investigate seasonal differences. Serum samples were separated within 12 h of collection and transported to a laboratory using an ice box where they are stored at −20°C until tested. Information on potential risk factors such as environment, animal factors, and husbandry practices was filled out on a developed format during blood sampling. Additionally, questionnaire survey was administered to individual livestock owners to gather information on herd or flock managements, compositions, herd movement and type of water point used, reproduction history profile of breeding females, status of last offspring (viable birth, still birth, or abortion), and history of previous abortion.

Serum samples were serially tested by Rose Bengal test using RBT antigen as presumptive test and by compliment fixation test (CFT) as confirmatory test at the National Veterinary Institute, Debre Zeit, Ethiopia. An animal was considered positive if tested seropositive on both RBPT and CFT serial interpretation.

Data collection and analysis

Putative biological and environmental factors believed to be associated with *Brucella* infection were recorded. Additionally, information on reproductive data were collected on breeding females (primiparous and above) and used for subpopulation analysis. Reproductive history profiles of females include number of viable births (number of young produced), sex and status of last offspring (abortion or full-term), previous abortion (occurrence and number), and birth of a dead fetus (stillbirth) were recorded. However, due to its confusion with abortion, stillbirth was not considered in the analysis. All the necessary statistical analysis was performed using STATA version 10.0 for windows (Stata Corp. College Station, TX). Association of abortion as well as exposure variables with *Brucella* seropositivity was assessed using logistic regressions. The mean number of calves or kids (as viable birth) per breeding females was compared between seropositive and seronegative groups.

Result

Seropositive reactors were more frequently detected in cattle than in camels and goats, with 10.6%, 2.2%, and 1.9%, respectively. Table 1 displays brucellosis seropositivity, history of one or more abortions among the three animal species, and association of abortion with seropositivity.

Abortion was more commonly reported in camels than in cattle and goats. About 23.4% of dromedary females had history of one or more abortions compared to 13.8% and 12.4% in cattle and goats, respectively. Abortion was significantly associated with *Brucella* seropositivity in cattle (odds ratio (OR)=4.7) and goats (OR=6.9) but not in camels (OR=1.4).

The mean ages of breeding females and number of young animals produced by females with brucellosis status are shown in Table 2. The average age of sub-sampled females were 8.1 (range, 4 to 16), 10.2 (range, 5 to 22), and 3.1 years (range, 2 to 9) for cattle, camels, and goats, respectively. It appears that the number of young animals produced per breeding females was slightly reduced in seropositive groups. It is worth noting that the number of kids produced per goat per parity was regarded as single birth due to incomplete information on multiple births.

Table 3 shows the associations of potential risk factors with seropositivity to *Brucella* infections among breeding females based on multivariable logistic regression analysis. The exposure variables identified for cattle was keeping more than two livestock species (OR=3.1) compared to keeping two species at household levels. Similarly, the same scenario as in cattle was also observed for camels, with increased risk of seropositivity in camels kept with more species of animals (OR=5.3). In goats, wet season (OR=4.8) was found to be associated with seropositivity to *Brucella* infections. The wet season is probably linked to coincidence of increased deliveries in flocks with excretion of *Brucella* organisms, which is the actual risk factor for infection.

Discussion

Seropositivity to *Brucella* infection was significantly higher in cattle (10.6%) compared to camels (2.2%) and goats

Table 1 Prevalence and association of abortion with brucellosis seropositivity in breeding females of the three animal species

Animal species	Brucellosis		Abortion		*P* value
	Status	No	*N* (%)	OR (95% CI)	
Cattle	Negative	253	28 (11.1)		
	Positive	30	11 (36.7)	4.7 (2.0, 10.8)	<0.001
	Prevalence	10.6%	13.8%		
Camel	Negative	739	172 (23.3)		0.501
	Positive	17	5 (29.4)	1.4 (0.5, 4.1)	
	Prevalence	2.2%	23.4%		
Goat	Negative	744	62 (8.3)		<0.001
	Positive	13	5 (38.5)	6.9 (2.2, 21.7)	
	Prevalence	1.9%	12.4%		

Table 2 Mean (95% CI) age and number of young animals (YA) produced by breeding females

Animal species	Brucellosis status	*N*	Mean age (95% CI)	Mean YA (95% CI)
Cattle	Negative	253	8.0 (7.7, 8.4)	3.8 (3.5, 4.0)
	Positive	30	8.3 (7.6, 9.0)	3.4 (3.0, 3.9)
Camel	Negative	739	10.2 (10.0, 10.5)	3.4 (3.2, 3.5)
	Positive	17	10.4 (8.4, 12.4)	3.1 (2.2, 3.9)
Goat	Negative	743	3.1 (3.0, 3.2)	2.5 (2.4, 2.6)
	Positive	14	4.1 (2.9, 5.3)	2.5 (1.7, 3.3)

(1.9%), which is consistent with the serosurvey findings of brucellosis in different ruminant species sharing the same ecosystem in Chad (Schelling et al. 2003). Cadmus et al. (2006) also reported higher seroprevalence to *Brucella* species from Nigerian cattle than goats while the seroprevalence was higher in Sudanese cattle and camels compared to sheep and goats (Mokhtar et al. 2007). Conversely, records of higher seroprevalence were documented in camels and goats in the Middle East areas (Abbas and Agab 2002; Al-Majali 2005; Al-Majali et al. 2008; Dawood 2008).

In classical brucellosis epidemiology (i.e., *Brucella abortus* in cattle, *Brucella melitensis* in sheep and goats, and *Brucella suis* in pigs) where control measures are not in place, a state of endemicity is reached in the maintenance host species which is characterized by a high seroprevalence at both the herd and individual animal levels. Animals are infected early in their life, and females are likely to abort at their first pregnancy. In the Middle East, *B. melitensis* is endemic in small ruminants, and seropositivity is detected in the vast majority of flocks with individual prevalence reaching 27.7% (Al-Majari et al. 2005). In cases of spillover from the preferential host to an accidental host, such a state of endemicity is not reached in the accidental host species which is characterized by low serological prevalence. In this regard, *B. abortus* infection in sheep as well as *B. melitensis* infection in cattle have been described in Nigeria (Ocholi et al. 2004) and France (Verger et al. 1989) and were linked to the presence of pathogen in its cattle and small ruminant reservoirs, respectively. In Denmark, *Brucella suis* biovar 2 has been isolated in cattle and was linked to its presence in the hare (*Lepus europeanus*) reservoir (Andersen and Pedersen 1995). These studies suggest that infection with *Brucella* spp. in a non-preferential host is not sustainable, and a state of endemicity is not reached. Similarly, the occurrence of *B. melitensis* or *B. abortus* in camels was found to be linked to their presence in their livestock reservoir, i.e., small ruminants and cattle, respectively (Abbas and Agab 2002; Al-Majali et al. 2008; Dawood 2008). Accordingly, higher brucellosis seroprevalence in cattle than camel and goats in the present study may suggest spillover of infection from cattle to the latter species.

Cattle, camels, and goats, to some extent, sheep, are the principal livestock species that are kept in Borana lowland. Herding of these animals together, which is the normal practice of the traditional pastoral people, is one of the putative factors to increase transmission of *Brucella* infection. Keeping more animal species at household level may increase animal density and chance of contact between

Table 3 Multivariable analysis of potential risk factors for seropositivity to *Brucella* infections in the breeding females

Species	Variables	Levels	*N*	Prevalence (%)	OR (95% CI)	*P* value
Cattle	Age category	Younger	61	1.6	1.0	–
		Middle	175	14.9	9.9 (1.3, 74.7)	0.027
		Older	47	6.4	3.8 (0.4, 38.0)	0.257
	Species composition[a]	2 species	119	5	1.0	–
		>2 species	164	14.6	3.1 (1.2, 7.9)	0.019
Camel	Species composition	2 species	324	0.6	1.0	–
		>2 species	432	3.5	5.3 (1.2, 23.5)	0.028
	Season	Dry	499	1.6	1.0	–
		Wet	257	3.5	1.9 (0.7, 4.9)	0.209
Goat	Season	Dry	551	0.7	1.0	–
		Wet	206	4.4	4.8 (1.3, 18.1)	0.020
	Age category	Younger	191	2.1	1.0	–
		Middle	526	1.0	0.4 (0.1, 1.4)	0.149
		Older	40	10.0	1.9 (0.4, 9.2)	0.434

[a] Household level livestock species composition (presence of cattle, camel, goats, or sheep) ranges from two to four animal species

animals, thus, facilitating exposure to infectious agents and increasing chance of acquiring infection. Likewise, mixed herding was reported by different authors to be a risk factor for *Brucella* transmission between different animal species (Musa et al. 2008; Al-Majali et al. 2008; Kaoud et al. 2010). Musa and his co-workers (2008) reported higher seroprevalence of brucellosis in camels kept mixed with cattle, sheep, and goat in Sudan. The authors subsequently isolated both *B. melitensis and B. abortus* (*B. melitensis* biovar 3, *B. abortus* biovar 6) from camels of the area. This may substantiate the existence of cross species transmission of *Brucella* infection under such composite holdings. Wet season has coincidence with delivery; thus, it is linked to increased deliveries with excretion of *Brucella* organisms that could facilitate transmission and exposure to pathogen.

The most common clinical manifestation of brucellosis in natural hosts is reproductive loss resulting from abortion, birth of weak offspring, or infertility. In particular, abortion, stillbirth or a weak, non-viable calf is the hallmark of brucellosis (Olsen and Tatum 2010). Abortion in farm animals (Oloffs et al. 1998; Verma et al. 2000; Kabagambe et al. 2001; Schelling et al. 2003; Ocholi et al. 2004; Muma et al. 2007; Musa et al. 2008) represents the major complaint attributed to *Brucella* infections. In the present study, seropositive cattle (OR=4.7) and goats (OR=6.9) were much more likely to have had an abortion experience in the past years compared to non-reactors. This is comparable to the results of Kabagambe et al. (2001) and Oloffs et al. (1998) from Uganda and Schelling et al. (2003) from Chad, who reported that *Brucella* seropositive animals were three to five times more likely to have had an abortion compared to seronegative groups.

Association of seropositivity with abortion was not observed in camel unlike other study findings which documented the contribution of *Brucella* infections to camel abortion (Musa and Shigidi 2001; Musa et al. 2008). Known causes of abortion in camels are many and involve a wide range of etiologic agents, both specific and nonspecific. A thorough literature review by Tibary et al. (2006) demonstrated that abortion rates due to infectious diseases vary from 10% to more than 70% in some areas and a wide range of infectious causes of abortion were identified. Thus, our results suggest that brucellosis is the likely cause of abortion in cattle and goats while other causes largely outweigh brucellosis as a cause of abortion in camels in Borana.

The occurrence of abortion and number of young animals produced per breeding female have been regarded as reasonable indicators for productivity in livestock (McDermott et al. 1987). Consequent to abortion, the number of young animals and total milk production are the two important products affected most (Olsen and Tatum 2010). In the present study, an attempt was made to generate data on reproductive history profile of breeding females to look into the role of *Brucella* infection in reducing the number of young animals produced. The mean number of young animals produced by breeding females has been slightly reduced in seropositive groups. In goats, however, the mean number of kids produced by both positive and negative group is similar, which is attributable to higher mean age in positive than negative group. It is important to note that information based on a cross-sectional study which has weak causal inference ability may not provide a quantitative impact estimate and may have limitations, but the only possible information available for pastoral production system where more extensive studies are not feasible.

In conclusion**,** the study showed that antibodies to *Brucella* organisms were prevalent in breeding females, and a likely contribution of *Brucella* infection to abortion was observed in cattle and goats. The study showed that animal brucellosis is important in impacting livestock productivity, thus, suggesting the need for designing a feasible control intervention.

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