Seroprevalence of *Brucella* infection in cattle and small ruminants in South Omo zone, southern Ethiopia

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Abstract

A cross-sectional study was conducted in selected districts of the South Omo Zone to estimate the seroprevalence of brucellosis and its associated risk factors. Additionally, the knowledge, attitude, and practices (KAP) of livestock keepers about the disease were also assessed. A total of 1349 sera samples were collected from 450 cattle and 899 small ruminants (450 goats and 449 sheep) kept under an extensive production system. Rose Bengal Plate Test was used for screening and ELISA as a confirmatory test for the detection of antibodies against *Brucella* species. Based on confirmatory tests, the overall seroprevalence of brucellosis was 2.2 % (95% CI: 1.1 – 4.1%) in cattle, 2.0% (95% CI: 0.9, 3.8%) in goats and 1.3% (95% CI: 0.5, 2.9%) in sheep with higher seropositivity in cattle compared to small ruminants. Seropositivity did not vary significantly (p> 0.05) with agroecology, age, and sex groups in cattle. However, a higher seroprevalence of 2.7% was detected in male cattle compared to 1.6% for females. Seroprevalence was higher in small ruminants from the lowland agroecology (3.0%) than those from the midlands (0.8%). Study respondents had a low level of knowledge on brucellosis with only 43% of them having some information about the disease. Most of the respondents have routinely engaged in practices that can expose them to infections such as assisted delivery (65%), contact with after-birth materials (50%), and handling aborted materials (15%) without any protection. High consumption of unpasteurized dairy products (93%) such as raw whole milk and traditionally fermented dairy product is also common. This study provides information on the occurrence

of brucellosis in major livestock species kept at cross-border marginal areas with limited disease information. The existence of various exposure practices implies the need for creating awareness among livestock keepers on general disease transmission and its zoonotic role.

Introduction

Brucellosis is an infectious disease of humans, livestock, and wildlife with public health and economic importance globally (Ducrotoyetal *et al.*, 2015). It is one of the re-emerging zoonotic diseases that pose public concerns, particularly for livestock keepers. The disease has complex epidemiology involving multi-species with the sources of infection being fetal membranes, aborted fetuses, discharge from aborted or delivered animals, and consumption of raw milk and meat from infected animals (Adugna *et al.*, 2013; Mangen *et al.*, 2015). The means of transmission in the animal is through contact with contaminated materials, inhalation of aerosols, ingestion, and mucous membranes (Radostits *et al.*, 2007).

Ruminant brucellosis is mainly caused by *B. abortus* and *B. melitensis;* the susceptibility of animals to brucella infection depends on various factors like natural immunity, environment, sex, and age (Kebede *et al.*, 2008). Predominant impacts on livestock include reproductive problems such as abortion, decrease milk production, culling of infected animals; weak offspring, infertility, and weight loss (Mangen *et al.*, 2015). In livestock and most wild ungulates, death is rare, except in fetuses and neonates, and the mortality rate ranges from 12% – 14% in sheep and 11% - 13% in goats (Behnke, 2010). The three species; *B. abortus, B. melitensis,* and *B. suis* have an essential zoonotic role with no pathognomonic symptoms in human which make them difficult to differentiate from febrile conditions including malaria and typhoid fever (Ducrotoy *et al.*, 2017). Thus, human brucellosis may be missed and undiagnosed by health professionals in developing countries and cases remain infected with consequent chronic disorders.

In developed countries, the disease has been controlled in animals and humans, while the re-emergence of the disease in humans is associated with travelers or immigrants coming from developing countries. On the other hand, a high

prevalence of *B. melitensis* in small ruminants has been reported from Middle Eastern countries with more than 100 cases per 100,000 herds. In Africa and South/Southeast Asia, the prevalence of brucellosis in livestock populations range from 0 to 68.8% in cattle, 0 to 88.8% in small ruminants, 0.4 to 20% in camels, and 0 to12.9% in other species (McDermott *et al*., 2013).

Brucellosis is an endemic zoonotic disease in most developing countries including Ethiopia. Seroprevalence results have been documented in cattle and small ruminants across different production systems and regions of Ethiopia (Megersa *et al*., 2011; Tadess, 2016, Tesfaye *et al*., 2017; Edao *et al*., 2018; Gutema and Tesfaye, 2020, Wossene and Teshager, 2021). However, there are few seroprevalence reports of brucellosis in cattle (Megersa *et al*., 2011; Mekonnen, 2021) and in small ruminants (Feyera *et al*., 2020; Sintayehu *et al*., 2015) in the South Omo zone.

Nevertheless, the complexity of the disease occurrence, dynamic production system with high herd mobility, multi-species herding, and intermixing of the herds at communal grazing and water point, proximity interaction of people and animals, together with limited knowledge of zoonoses and consumption of raw animal products make brucellosis an important disease in the country. Therefore, understanding the magnitude of the disease and the level of awareness and exposure risks among herders is vitally important in any intervention measures. Hence, this study investigated the seroprevalence of the disease and associated risk factors and livestock keepers' knowledge and risky practices related to brucellosis in the South Omo Zone of Southern Ethiopia.

Materials and methods

Study area

The present study was conducted in three districts (Dasenech, BenaTsemay, and Debub Ari) of the South Omo Zone. The Zone is located in the Southwestern part of Ethiopia bordering Northwestern Kenya. The Zone has a total area of 243,780 hectares, which is subdivided into agroecological features of 93.4% lowland arid and semi-arid areas and 5.6% midland areas (SOZFED, 2017). South Omo Zone is characterized by pastoral, agro-pastoral, and mixed farming production systems. Livestock species like cattle, goats, sheep, and equine are kept in the area. The Zone is found between latitude ranging from 4° 43' N to 6° 46' N and longitude ranging from 35° 75' E to 37° 07' E (Figure 1). It

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receives 400-1600 mm of rainfall and has an average daily maximum temperature of 29.5^0C and a minimum of 12.3C^0 (NMA, 2018).
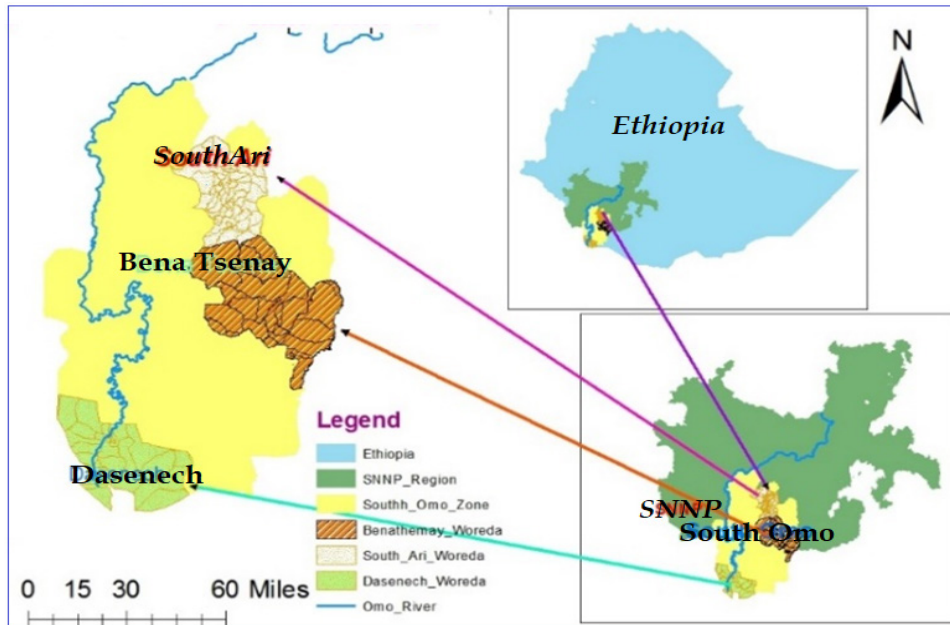

Figure 1. Map of Ethiopia showing the study area

Study design and study population

A cross-sectional study was carried out to assess the seroprevalence of brucellosis in cattle and small ruminants in three districts of the South Omo Zone. The study animals are indigenous cattle and small ruminants (both sex and above six months of age), which are kept under an extensive production system in Bena Tsemay, Debub Ari (south Ari), and Dasenech districts. The criteria for the selection of districts were based on complaints of ruminant abortion as a major problem in the areas during the animal disease surveillance by the Jinka Regional Veterinary Laboratory, in addition, to the large livestock population, and the diverse agro-ecology of the area.

Sample size determination and sampling technique

A mix of purposive and random sampling methods was applied to select the study units. Hence, zone and districts were purposively selected while *kebeles*, the lowest administrative unit, were sampled randomly, taking 3 *kebeles* from

each district, making a total of nine *kebeles*. South Omo Zone was purposively selected based on the abortion complaints reports by the Jinka Regional Veterinary Laboratory while the three districts were sampled considering agro-ecology, livestock populations, and production systems.

The respondents for the questionnaire survey were selected randomly or subsampled. The required number of respondents (herders) for the questionnaire survey was estimated using the formula described by Arsham (2007) as N= 0.25/(SE)²; Where 0.25 is a constant value, SE refers to Standard Error (SE=0.05), N refers to the total number of respondents. Thus, 100 respondents were selected randomly for the questionnaire survey.

In selecting livestock for blood collection, as random sampling of herds was not feasible for the pastoral and agro-pastoral system, herds were selected through transect travel in the selected villages, and the encountered households were contacted for their willingness. If livestock keepers were willing, their animals were sampled until the required number of animals from a *kebele* was collected. If a contacted livestock keeper refused to cooperate, then the next household on the transect route was contacted to sample their animals. The livestock sample size was determined using the WinEpi formula (Universidad de Zaragoza©2010) with a 95% Confidence Interval (Z) and 5% marginal error (e), a design effect (deff) of 1.5%, and an expected prevalence (p) of 50% considering each species as an independent population.

An estimated designed effect of 1.5% was considered in the sample size estimation to cope with the expected sampling error resulting from the application of cluster sampling of animals from voluntary herders since the random sampling of herds and animals was not feasible. Thus, a total of 450 cattle and 900 small ruminants (450 goats and 450 sheep) were selected making a total sample size of 1350 animals. A total of 1,349 blood samples were processed and results were analyzed as a sheep sample was lost).

Questionnaire survey

The semi-structured questionnaire was administrated to livestock keepers to assess the knowledge and practices of herders toward brucellosis. The questionnaires focused on demographic variables including age, sex, education, knowledge of herders regarding the zoonotic nature of brucellosis, and expo-

sure practices of herders. The questionnaire covered also husbandry practices, livestock species composition, herd mobility, and consumption of animal products including dairy products. Local animal health workers were used to contact the owners of selected herds to explain the purpose of the study in the local language. Then, the interview was conducted in the local language of the herders, by translating the questionnaire originally developed in English to Dasenechigna, Benigna, Arigna, and Amharic languages.

Blood sample collection and testing procedure

After disinfecting the area of the jugular vein with alcohol, blood samples were collected from cattle (10 ml) and small ruminants (5 ml) using plain vacutainer tubes and disposable needles. The identity of each animal was marked on the corresponding vacutainer tubes. Then, tubes were kept tilted overnight at room temperature to separate the serum. The serum samples were harvested in cryo-tubes and transported on ice to Animal Health Institute at Sebeta, where they were stored at - 20°C until processed.

The Rose Bengal Plate Test antigen Kits (CACOGENICS Corporation, USA) were used for screening the presence of *Brucella* antibodies from sera. The test was carried out by adding an equal volume (25µl) of antigen and sera into each well in the direction from left to right as indicated in the laboratory protocol. Then the plate was agitated gently for 4 minutes. After 4 minutes of rocking the plate, the mixtures were observed for the formation of agglutination, and results were recorded.

Enzyme-linked Immunosorbent Assay (ELISA)

Positive reactor samples were tested by indirect ELISA (IDvet, 310, rue Louis Pasteur-Grabels-France) for antibodies to the *Brucella* species at the Animal Health Institute in Sebeta. In the 96 microplate wells, 190 µl of dilution buffer was added; then 10 µl of the positive, negative controls, and serum samples were added to their respective wells. Then the plates were incubated for 45 minutes at 21°C (+/- 5). Following incubation the contents were removed by flicking the plate over a sink, and the plate was washed three times with washing solution. Then, 100 µl of Conjugate 1x was added to each well; incubated for 30 minutes at 21°C (+/- 5) after which the plates were emptied and washed three times with washing solution. Then, 100 µl substrate solution was added to each well and incubated for 15 minutes at 21°C (+/- 5). Finally, 100 µl of the

Stop solution was added to each well to stop the reaction, and the plates were read by the microreader and their optical density (OD) values were recorded at 450 nm. The serum samples were considered positive if SP% > 120%.

Data management and analysis

Data were entered in the Microsoft Excel spreadsheet and analyzed using Stata version 14.2 (Stata Corp, College Station, Texas, USA). The data were carefully checked, cleaned, and imported from a Microsoft Excel Spreadsheet to Stata for further analysis. The seroprevalence was calculated by dividing the number of test-positive samples by the total number of samples multiplied by 100. The chi-square test was used to assess the association between seroprevalence and environmental and animal factors (species, sex, and age) and the statistical test was regarded as significant at $p < 0.05$.

Ethics statement

The ethical considerations (approval) for using study animals for the collection of blood samples was reviewed and approved by The College of Veterinary Medicine and Agriculture of Addis Ababa University and approval was given through a letter with Reference No VM/ERC/ 01/12/.11/2019. South Omo Zone and the selected district livestock offices were also consulted to carry out the study in selected areas. Informed consent was obtained from the participants after informing them about the purpose of the study and assuring them their identity would not be disclosed.

Results

Demographic and production system characteristics

Of the 100 respondents interviewed, 83% were male participants. Their age distribution showed 35% were from 18 to 35 years, 42% were from 36 to 45 years, and 23% were older than 46 years. Generally, most of the respondents (60%) were illiterate and 40% of them had some informal education, mostly elementary. A large proportion of the households (60%) had average family size below 7 persons and 40% of them had more than seven individuals per household. The respondents were engaged in agro-pastoral (22%), mixed farming (36%), and pastoralism (42%) production systems. Most of the respondents owned diverse species of livestock with 97% of them keeping cattle and small

ruminants, and few of them (3%) possessed other species such as donkeys and dogs.

Hygienic practices, attitudes, and awareness of respondents

Most of the respondents (65%) routinely assisted birth delivery and half of them (50%) had contact with after-birth materials, and some of them (15%) handled aborted fetus materials (Table 1). The majority of participants (58%) did not use any protection while assisting at birth. Knowledge about brucellosis is generally low and only 43% of them have some information about the disease, and only 27% of the respondents mentioned the correct route of transmission for the disease. They mentioned the main symptoms of the diseases to be abortion in cattle and small ruminants. Stillbirths, vaginal excretion, reduced milk production, and weakness were also mentioned as signs of the disease. Most of the respondents (93%) reported applying some disease prevention measures like isolation from other animals and culling. The respondents indicated that they believe that the disease is treatable by traditional medicine (15%) and modern medicine (66%), while a few of them (19%) did not know about the treatments. Study participants also reported that they do not prefer going to health institutions due to their dependence on traditional medicine (14%), remoteness (19%) from health centers, lack of awareness (28%), and cost of treatment (39%). The majority of respondents (93%) consume unpasteurized dairy products such as whole milk and traditionally fermented milk "Ergo" (yogurt) whereas very few individuals (7%) had no habit of consuming any raw dairy product (Table 1).

Table 1. Socio-demographic and exposure practices of respondents (n=100) in the South Omo zone

Variables	Levels	Proportion (%)
Sex	Male	83
	Female	17
Marital status	Married	92
	Single	4
	Divorce /widow	4
Age (years)	18-35	35
	36-45	42
	>46	23
Education level	Illiterate	60

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Variables	Levels	Proportion (%)
	Literate	40
Production system	Agro-pastoral	22
	Mixed farming	36
	Pastoral	42
Heard about brucellosis	Yes	43
	No	57
Assist at birth	Yes	65
	No	35
Contact with birth material	Yes	50
	No	15
	Do not know	35
Use of protective materials	Yes	7
	No	58
	Do not know	35
Route of transmission	Contact	14
	Ingestion	9
	Inhalation	4
	Do not know	73
Raw milk intake	Yes	93
	No	7

Seroprevalence of brucellosis and the effect of risk factors

The results of the RBPT tests were 6.4% for cattle, 5.6% for goats, and 4.6% for sheep. Following confirmatory test by indirect ELISA, the overall seroprevalence of brucellosis was found to be 2.2 %; (95% CI: 1.1 − 4.1%) in cattle, and 1.7% (95% CI: 0.8 − 3.5%) in small ruminants. Seroprevalence of brucellosis was significantly higher in cattle than in small ruminants (p<0.001). Table 2 shows the summary of the seroprevalence of bovine brucellosis with potential risk factors. The results showed that the seroprevalence was not affected significantly by district, agroecology, sex, and age. However, the seroprevalence of bovine brucellosis was marginally higher in Bena Tsemay (3.3%) and lowest in Debub Ari (0.7%) district. The seropositivity was slightly higher in the lowland (2.7%) compared to the midland agroecology (2.0%). The seroprevalence also

did not differ significantly between female (2.7%) and male (1.6%) cattle young (0.9 %) and adult (2.7 %) cattle (p>0.05).

Table 2. Seroprevalence of brucellosis in cattle

Variables	Samples	Positive	Seroprevalence (%)	X^2	P-value
District					
Dasenech	150	4	2.7	2.7	0.265
BenaTsemay	150	5	3.3		
Debub Ari	150	1	0.7		
Agroecology					
lowland	150	4	2.7	0.2	0.651
midland	300	6	2.0		
Sex					
female	257	7	2.7	0.7	0.405
male	193	3	1.6		
Age					
young	115	1	0.9	1.3	0.254
adult	335	9	2.7		
Overall	450	10	2.2 (95% CI: 1.1, 4.1%)		

In small ruminants, brucellosis was prevalent in 2.0% (95% CI: 0.9, 3.8%) of the goats and 1.3% (95% CI: 0.5, 2.9%) of sheep with marginally higher seropositivity in Dasenech (3.0%) than other districts (χ^2= 5.3, p=0.072) based on ELISA results. There was also a significant difference in *Brucella* seropositivity with higher seroprevalence in lowland (3%) than midland (0.8%) agroecology (χ^2= 4.9, p=0.027). However, there was no significant effect on species (2.0% vs 1.3%, sex (1.8% vs 1.4%), and age (1.8% vs 1.6% of small ruminants (Table 3).

Table 3. Seroprevalence of Brucellosis in small ruminants

Variables	Samples	Positive	Prevalence (%)	X^2	P-value
District					
Dasenech	300	9	3.0	5.3	0.072
Bena Tsemay	299	2	0.7		
Debub Ari	300	4	1.3		
Agro-ecology					
lowland	300	9	3.0	4.9	0.027
midland	599	5	0.8		
Specie					
goats	450	9	2.0	0.6	0.437
sheep	449	6	1.3		
Sex					
female	611	11	1.8	0.2	0.653
male	288	4	1.4		
Age					
young	167	3	1.8		
adult	732	12	1.6	0.01	0.886
Overall	899	15	1.7(95% CI: 0.7, 3.5)		

Discussion

In the present study, we assessed the knowledge and risky practices of livestock keepers about brucellosis using a semi-structured questionnaire. In this result, a higher proportion of herders (65%) had exposure to *Brucella* infections through unprotected assistance of animals giving birth or aborting. This exposed the respondents to contaminated fetuses, afterbirth, and aborted fetus. They also mostly consume raw dairy products, suggesting high exposure risks among livestock keepers. A previous research finding demonstrated that the major means of brucellosis transmission is via exposure to aborted animals and assisting animals at birth (Kozukeev *et al*., 2006), which is in line with our findings.

The knowledge of herders on brucellosis and its means of transmission is vitally important in minimizing the risk of exposure to infection. A significant proportion of the livestock keepers (43%) had good knowledge about brucellosis whereas most of the respondents (57%) had no information about the

disease, which increases the likelihood of exposure of these respondents to infections. Similar survey findings were also reported from the Bench Maji zone in which most of the livestock keepers (72.7%) did not have information and basic knowledge about brucellosis (Kenea and Megersa, 2021). Additionally, others also reported low awareness among respondents of semi-intensive farms in and around the Alage district (Asgedom *et al.*, 2016) and Addis Ababa dairy cattle workers (Edao *et al.*, 2018). In the present study, the majority of respondents (93%) consumed unpasteurized milk and dairy products, which is one way of the transmission of brucellosis from animals to humans (Omore *et al.*, 1999).

In the present study, through RBPT 6.4%, and ELISA test the overall seroprevalence in cattle was found to be 2.2%. Such high variation between the tests might be related to the high sensitivity of RBPT particularly in chronic cases, and relatively low specificity in endemic areas (Díaz *et al.*, 2011). The observed prevalence is in agreement with the previous finding carried out in other parts of Ethiopia such as 2.2% (Gutema and Tesfaye, 2021) from Afar Region pastoral system where there is high livestock mobility, multi-species herding and livestock-dependent livelihood similar to the present study. Similar seroprevalence figures (2.1 to 2.4%) were reported by Tesfaye *et al.*, (2017) from Kombolcha, Asgedom, *et al.* (2016) from Alage district, and Yohannes *et al.* (2016) from Arsi Zone. Our seroprevalence result of cattle brucellosis is lower than the reports of other authors, which range from 5.2%-42.31% (Yohannes *et al.,* 2016; Mekonnen, 2021; Wossene and Teshager, 2021) which could be due to difference in the production system and agroecology.

In this study a higher seroprevalence of brucellosis was observed in cattle (2.2%) than in small ruminants (1.8%), which is similar to previous reports in Ethiopia (Megersa *et al.*, 2011) and other African countries; Tanzania (Assenga *et a*l., 2015), and Sudan (Mokhtar *et al.*, 2007). Seroprevalence variation might be due to prevailing *Brucella* species, as *Brucella abortus* infection is more prevalent in cattle than in small ruminants; also among different domestic ruminant cattle were the most infected with *Brucella* spp than other animals (James, 2012; Temba, 2012).

In the present study, seroprevalence was slightly higher (2.7%) in lowland than midland (2.0%) areas, though not statistically significant. Findings from several authors also revealed a higher seroprevalence in lowland pastoral production systems than in mid-altitude areas and crop-livestock mixed framing

practice (Megersa *et al*., 2011; Dinka and Chala, 2009; Omer *et al*., 2000). A possible reason might be the production system, composite of livestock species kept, and frequent migration of pastoral herds in search of pasture and water points due to conflicts.

In this study, seroprevalence did not vary with animal factors such as age and sex of animals unlike most of previous reports which showed adults were more affected than young animals (Godfroid *et al.,* 2010). A similar finding has been also documented in Tanzania by Shafee *et al*. (2012) in which there was no variation of the brucella seroprevalence between sex groups. Nevertheless, findings of other studies reported from Tanzania, Nigeria, Pakistan, and Ethiopia (Megersa *et al*., 2011; Mai *et al*., 2012; Shafee *et al*., 2012; Assenga *et al.,* 2015) showed a significant difference between male and female animals. A possible reason could be due to sample size, the number of positive reactors in which few male animals are often tested, in addition to the effect of the age difference between male and female animals in which females are more aged than their male counterparts, (Godfroid *et al*., 2010). Likewise, a study by Akinseye *et al*. (2016) also indicated age of cattle did not have a significant effect on the seropositivity of brucellosis. Most of the previous studies in Ethiopia and other African countries (Megersa *et al.,* 2011; Assenga *et al*., 2015; Mekonnen, 2021) reported a significant association of age with Brucella seropositivity with higher seroprevalence in adults than in young animals. Age-related seroprevalence is ascribed in literature to the availability of erythritol hormones in mature animals that stimulated the multiplication of Brucella organisms and concentration in the reproductive organs (Radostits *et al.,* 2007). Additionally, increasing the age of the animals also increases the risk of exposure associated with longer contact with infected animals or with the environment.

The finding of 1.8% seroprevalence of brucellosis in small ruminants is similar to the findings of Mohammed *et al*. (2017) who reported 1.72% prevalence from the Somali Region, Ethiopia; Sintayehu *et al*. (2015) recorded seroprevalence of 1.9% in pastoral and agro-pastoral lowlands of Ethiopia, and Teshale *et al*. (2006) reported 1.9% seroprevalence from Afar and Jijiga areas in Ethiopia. The current study area has many similarities with the study areas of the aforementioned findings in terms of animal husbandry practices, population density, use of communal grazing lands and water points, and high mobility of herds that facilitate the transmission of the disease within the livestock population. But a significantly higher seroprevalence (21%) was reported from 124 female small ruminants with an abortion history in the same study area (Feyera *et al*.,

2020). The variation could be due to sample size, sampling techniques i.e. considering of flock with abortion history, and types of tests used. Another study in the Borana area also showed a higher seroprevalence (9.11%) of the disease compared to our findings (Yohannes *et al.,* 2013). The study area shared the same production system but, showed different seroprevalence results possibly due to differences in sample size, the test used, and *Brucella* species circulating in the area.

In this study, seropositivity to *Brucella* infection in small ruminants is significantly higher in the lowland than in the midland area, which is in accordance with the findings of Aloto *et al.* (2022) in Southern Ethiopia. The higher prevalence in the lowland areas could be related to the livestock husbandry practice in lowland areas, where different livestock species are kept together and large flocks can come into contact at communal grazing and water points which could facilitate *Brucella* infection in small ruminants.

We did not find a significant difference in the seropositivity of *Brucella* infection between sheep and goats unlike most of the previous study findings in which higher seroprevalence was reported in goats than sheep (Teshale *et al.*, 2006; Ashenafi *et al.,* 2007; Tesfaye *et al.,* 2012; Kelkay *et al.,* 2017; Aloto *et al.*, 2022). This result is in line with the report of Deddefo *et al.* (2015) in Arsi and East Shewa which reported seroprevalence of brucellosis in goats (4.9%) and sheep (4.4%) was not statistically different. The variation in seroprevalence between the species of animals could be due to the different sample proportions between species and the size of the flock and their management. In general, a wide range of seroprevalence of *Brucella* infection; ranging from 1.9% to 15.4% was previously reported (Teshale *et al.,* 2006; Ashenafi *et al.,* 2007; Tesfaye *et al.*, 2012; Wedajo *et al.*, 2015; Teshome *et al.*, 2018; Aloto *et al.,* 2022; Dosa *et al.*, 2022) in goats and sheep in Ethiopia.

Conclusions

The present study showed that antibodies against *Brucella* species are prevalent in cattle and small ruminants in southern Ethiopia where flock mobility and cross-border movement of animals are also high. The results provide baseline information on brucellosis occurrence in livestock in cross-border marginal areas with limited disease information. Agroecology was an important risk factor for brucellosis occurrence in small ruminants in that higher seroprevalence

was recorded in the lowland pastoral production system than midland area. The existence of various practices which expose people and animals to brucella infection implies the need to create awareness among livestock keepers about the general nature of the disease and the zoonotic role it plays.

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