


# Bovine Brucellosis: Epidemiology, Public Health Implications, and Status of Brucellosis in Ethiopia

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**Abstract:** Brucellosis is a globally distributed zoonotic disease that causes serious problems in developing countries such as Ethiopia. *Brucella abortus* is the primary cause of brucellosis in cattle, and *Brucella melitensis* and *Brucella suis* also occasionally cause *Brucella* infection in cattle. Abortion and the retained fetal membrane are typical signs in females, whereas orchitis and bursitis are the known signs in male cattle. Brucellosis is typically transmitted to healthy cattle by direct or indirect contact with diseased cattle or their discharges. Humans can acquire brucellosis through the consumption of unpasteurized milk or milk products, and through contact with diseased cattle or their discharges. The occurrence of bovine brucellosis is affected by different factors related to the management system, host, and environmental factors. In Ethiopia, the occurrence of brucellosis is high in pastoral and mixed cattle management systems, wherever humans live closely with cattle and so have a higher probability of picking up the *Brucella* organism. The most suitable technique in the management of *Brucella* infection is the vaccination of young female cattle. *Brucella abortus* can also be eradicated by the isolation of diseased cattle, administration of immunizing agents, and test-and-slaughter methods. Therefore, it is important to implement applicable management techniques and to increase public awareness about the transmission of brucellosis, and further research should be conducted on brucellosis in high-risk groups.

**Keywords:** brucellosis, cattle, epidemiology, public health, Ethiopia

## Introduction

Ethiopia has the largest cattle population in Africa. However, the country has not used this resource effectively owing to various limitations.<sup>1</sup> Animal disease, management problems, poor genetics, and nutritional deficiency are among the foremost impediments to cattle production in the country.<sup>2</sup> Among the infectious diseases, *Brucella* infection is widely prevalent and causes extensive economic losses, and brucellosis is one of the most serious zoonotic diseases in Ethiopia.<sup>3,4</sup> The introduction of higher-yielding cattle breeds is one of the major strategies to increase milk production in the country. However, brucellosis is the main challenge to the development of dairy farming in different parts of Ethiopia, since the disease causes reproductive inefficiency and pregnancy loss in cattle.<sup>5,6</sup>

*Brucella* infection causes huge financial losses and community health concerns in countries around the world, including Ethiopia.<sup>7-9</sup> *Brucella abortus*, *B. melitensis*, and *B. suis* are the major causes of bovine brucellosis. The disease is known to cause abortion in the last stage of pregnancy, followed by retention of the fetal membrane and infertility in succeeding pregnancies in cattle.<sup>10</sup> The *Brucella* organism spreads through interaction with aborting cattle and aborted

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materials or with contaminated fomites.<sup>11</sup> Herd size, age and sex of the cattle, management system, contact with wild animals, environmental factors, and herding different species in a herd are among the reported risk factors. Vaccination of calves or heifers is the most effective means of managing *Brucella* in an endemic area. Moreover, brucellosis can be controlled by quarantining infected cattle, and by test-and-slaughter methods.<sup>12–15</sup>

In Ethiopia, a number of reports have shown that *Brucella* infection is a widespread cause of disease in cattle. These investigations indicated that the highest seroprevalence of the disease occurs in areas where people live in very close proximity to cattle.<sup>16,17</sup> Seroprevalence rates of brucellosis ranging from 0.1% to 14.1% have been reported in Ethiopia.<sup>18,19</sup> Research from various parts of the country, published in 2016,<sup>9,20,21</sup> also showed that brucellosis was still a highly prevalent disease in Ethiopia, leading to high economic losses in cattle production. Nevertheless, there is limited evidence on the epidemiology and zoonotic implications of *Brucella* infection in cattle. Therefore, this article aims to review the epidemiology, zoonotic implications, and status of bovine brucellosis in Ethiopia.

## Bovine Brucellosis

### Etiology and Clinical Signs

*Brucella abortus* causes disease mainly in cattle, and at least nine biotypes (1–9) are recognized, as well as several variants.<sup>22</sup> However, sheep, goats, and other domestic animals can also be infected. Cattle are also infected with *B. suis* and *B. melitensis* when they graze together with infected pigs, goats, or sheep.<sup>23,24</sup> *Brucella abortus* is a small, Gram-negative, and facultative intracellular bacterium.<sup>25,26</sup> The principal symptoms of *Brucella* infection are abortion in the last stage of pregnancy in female cattle, and orchitis and bursitis in male cattle.<sup>27,28</sup> *Brucella* infection is assumed in herds when abortion and retention of placental occur in the last gestational stage, in the absence of other disease.<sup>7,22</sup> *Brucella* infection results in abortion, stillbirths, retention of the placenta, and weak calves. Retention of the fetal membrane and endometritis are the outcomes of abortion. Female cattle generally abort just one, probably because of resistance. Hygromas on the leg joints of *Brucella*-infected cattle are a typical sign of the disease that results from chronic infection with *Brucella*.<sup>22,29</sup>

## Epidemiology of *Brucella* Infection in Cattle

### Transmission

Brucellosis is typically transmitted to other cattle by direct or indirect interaction with diseased cattle or their discharges.<sup>7</sup> The spread of brucellosis in cattle occurs through the ingestion of contaminated feed and drinking water contaminated by the bacteria that are present in massive amounts in birth products and uterine discharge.<sup>11</sup> Moreover, cattle typically lick their fetuses and newborn calves, which can have very high levels of bacteria and are the major source of infection.<sup>8</sup> *Brucella* infection can also be transmitted by feeding pooled colostrum to newborn calves. *Brucella* infection is rarely spread through sexual contact in cattle. However, artificial insemination has been shown to spread the infection from infected cattle to healthy cattle.<sup>30</sup> Humans typically acquire *Brucella* infection via the ingestion of unpasteurized milk or milk products. Interaction of the mucosa/abrasions with the fluid or tissues of aborted fetuses of diseased cattle can also be a source of disease in humans.<sup>26,31</sup> Work-related contact with cattle or their products is the major risk for human brucellosis. Abattoir, farm, and laboratory workers, as well as veterinarians, are known risk groups for *Brucella* infection.<sup>32</sup>

### Risk Factors for Bovine Brucellosis

The occurrence of *Brucella* infection is affected by a variety of factors associated with the management system, host, and environment. These include the age, sex, and breed of cattle, herd size and type, and agroecology.<sup>22,33,34</sup> Age has been stated as the intrinsic factor related to *Brucella* infection. A higher seroprevalence of *Brucella* organisms has been determined in adult cattle than in young cattle.<sup>35,36</sup> Sexually mature and pregnant cattle are more prone to being infected with *Brucella* than sexually immature cattle.<sup>13</sup> This is because the *Brucella* organism confers a response in the reproductive tract owing to the concentration of erythritol sugar, generated within the fetal tissues of cattle, which stimulates the growth of *Brucella* organisms.<sup>22</sup> However, the higher prevalence of *Brucella* in adults has also been related to longer interaction with diseased cattle. This could also be vital in the herd, while not culling the positive cattle.<sup>37</sup>

The effect of sex on the occurrence of *Brucella* infection in cattle has been stated previously.<sup>38</sup> Female cattle are more likely than males to have *Brucella* infection.<sup>39</sup>

Although this is not easy to elucidate, it may be related to the biology of the *Brucella* organism and tropism to the fetal tissues.<sup>22</sup> Because *Brucella* infection in males confers symptoms such as epididymitis and orchitis, the incidence in males may be lower than in females; as a result, they may be culled more quickly.<sup>40</sup> However, the absence of symptoms such as abortion or metritis in non-pregnant diseased females may also mean that there is a higher prevalence in females. Moreover, brucellosis becomes chronic in non-pregnant cattle. This has important epidemiological consequences as, after the initial immune response in cattle that are symptomless carriers, the antibodies disappear from the circulation, and it can be challenging to identify them with standard serological methods.<sup>7</sup>

There is disagreement among investigators over whether particular breeds are more prone to *Brucella* infection. Thus, a higher seroprevalence of *Brucella* infection has been found in cross-breed than in local-breed (indigenous) cattle,<sup>12</sup> while other reports indicated no association among breeds<sup>20</sup> or a higher seroprevalence of *Brucella* infection in indigenous than in cross-breed cattle.<sup>41,42</sup>

Herd size is another risk factor for *Brucella* infection, with the risk being highest in large herds.<sup>2,12</sup> This may be explained by the higher odds of identifying a minimum of one seropositive cattle, the rise of the spread of brucellosis by interaction among members of the herd, the use of common grazing lands, or inadequate cleaning and disinfection techniques on big farms.<sup>44</sup> The low incidence of *Brucella* infection in small herds may be related to herd and/or arm management.<sup>40</sup> Thus, small herds often graze nearby pastures, allowing interactions with other herds to be controlled, or using communal methods.<sup>45</sup> A small herd can be simply managed during delivery, and cattle are frequently removed from the herd throughout parturition. This is extremely important in the case of abortion, to prevent contamination of the pasture. In small herds, substitutions are typically made by relocating animals and economic trade is uncommon. Hence, the lower rate of cattle movement reduces the chances of disease transmission. In contrast, cattle movement in large herds is common, both for replacement and for trade, thus increasing the risk of *Brucella* infection.<sup>46</sup>

Herding several species within a herd has been characterized as a risk factor for brucellosis,<sup>24,37</sup> although there is no indication of the higher susceptibility of particular species to *Brucella* infection. As a result, the reason for the increased prevalence of brucellosis when various species

mix is unclear, but it may be related to a higher probability of being infected with brucellosis owing to various sources of the disease. *Brucella* infection is seldom spread from small ruminants to cattle.<sup>47</sup> Nevertheless, the threat to cattle on farms that also keep small ruminants suggests that some cases of bovine brucellosis may have originated from small ruminants, because *B. melitensis* biovar 3 has been isolated from cattle milk.<sup>48</sup>

Dairy cattle have a far greater probability of not only acquiring *Brucella* infection but also spreading it more rapidly than beef cattle. Cattle housed in small areas come into close contact with each other during feeding and milking.<sup>49</sup> Dairy cattle are exposed to additional stress on farms, causing conditions that are more conducive to *Brucella* infection.<sup>50</sup>

Cattle purchase is considered as a risk for brucellosis and will increase the chance of introducing diseased cattle into the herd.<sup>13</sup> Most infectious disease in previously brucellosis-free herds starts with the purchase of diseased cattle from unidentified sources.<sup>51</sup> The effect of agroecology is also recognized as a *Brucella* infection risk factor, with a higher prevalence in dry areas.<sup>52</sup> Because of a shortage of pasture in dry areas, cattle are put out to pasture over large areas, indicating uncontrolled cattle-to-cattle interaction with the potential risk of transmission. In addition, transmission through aerosol inhalation of contaminated dust from fetal discharges or abortions is likely.<sup>46</sup>

Large herd sizes are likely to be related to intensive management systems, which are generally tougher to manage and permit closer interactions between cattle and their surroundings, which can increase the probability of exposure to *Brucella* organisms.<sup>53</sup> In addition, the stressful conditions of an intensive production system may make cattle more prone to infections. However, an extensive production system may also increase the risk of *Brucella* infection. This may be related to the management of abortions, identification of diseased cattle, and interactions among cattle.<sup>40</sup> Since an extensive system implies rearing many cattle over a large area and sharing common pastures, the contamination of pastures with discharges from the reproductive tract may lead to brucellosis in the herds. Risk factors relating to farming and ecological conditions that affect the spread of brucellosis include giving birth, breeding in semi-dark settings, confined areas, and high cattle populations.<sup>53</sup> The intensive system is another risk factor for brucellosis. This may be related to airborne transmission of disease-causing

bacteria indoors.<sup>46</sup> Similarly, the seasons have an influence on animal husbandry and nutrition, principally in pastoral areas.<sup>44</sup> Rain influences the growth and nutritive status of animal feeds.

## Diagnosis of Brucellosis

The isolation and identification of the *Brucella* organism offer a definitive diagnosis of brucellosis. This is important for epidemiology and to monitor the progress of vaccination programs in cattle.<sup>54</sup> The diagnosis can be made using direct or indirect techniques.

### Direct Diagnosis

*Brucella* infection can be confirmed by demonstration of the bacteria in smears with microscopic staining. The smears can be prepared from vaginal discharges, placenta, colostrum, fetal stomach fluid, the aborting cattle lochia, or the abomasum of the aborted fetus, with modified Ziehl-Neelsen (MZN) stain. Impression smears may be taken from freshly cut and blotted tissue surfaces, eg cotyledons, by firmly pressing the slide surface against the tissue. They are then allowed to air dry before heat fixation. Smears can also be prepared from fetal stomach fluid, cotyledons, or lochia, and stained with the improved Ziehl-Neelsen stain or stamp stain. In MZN-stained smears, the *Brucella* organism appears as red intracellular coccobacilli or rod shapes, whereas other bacteria stain blue.<sup>54</sup>

All *Brucella* strains are relatively slow growing, and as the isolated specimens are often heavily contaminated, the use of a selective medium, eg Farrell's medium, is advocated. Incubation usually continues for 72 hours, but a negative diagnosis can only be made after a week-long incubation. Samples that can be used for *B. abortus* isolation include fetal stomach fluid, spleen, liver, placenta, lochia, milk (especially colostrum or milk within a week of calving), semen, and lymph nodes (supramammary lymph nodes are favored for chronic and latent infections, and retropharyngeal for early infections, but iliac, prescapular, and parotid lymph nodes may also be used). If serological reactions are thought to be caused by the S19 vaccine strain, then prescapular lymph nodes must also be gathered. All *B. abortus* isolates should be sent to laboratories with biotyping facilities. Farrell's medium and *Brucella* albimi medium are selective enriched media for the isolation of *Brucella* species.<sup>7,54</sup>

### Indirect Diagnosis

In the absence of culture facilities, the diagnosis of *Brucella* infection is usually based on serological tests, with various agglutination tests such as the Rose Bengal plate test (RBPT), serum agglutination test, and antiglobulins.<sup>55</sup> Detection of antibodies (and to a lesser degree the measurement of cell-mediated immunity) against relevant *Brucella* epitopes is a more sensitive method.<sup>56</sup> Serology can be used for an apparent diagnosis of *Brucella* infection or to screen a herd. Indirect and competitive enzyme-linked immunosorbent assays (i-ELISA and c-ELISA) are also used.<sup>7,45</sup>

The RBPT is a very sensitive test used for screening serum samples. It does not distinguish between field and S19 vaccine strain reactions, but it is quick, inexpensive, and easy to implement.<sup>57</sup> False-negative reactions are rare but may sometimes be due to excessive heating in storage or in transit. The RBPT has a sensitivity of 96.10% and specificity of 99.30%.<sup>58</sup>

The diagnosis of brucellosis in cattle may be adversely affected by the presence of cross-reactions that give false-positive serological test results due to S19 vaccine or other Gram-negative bacteria that share similar epitopes, such as *B. abortus* O-chain polysaccharides.<sup>59,60</sup> Thus, *Yersinia enterocolitica* 0:9, *Escherichia coli* 0157:H7, *Salmonella* group N (0:30), *Francisella tularemia*, *Stenotrophomonas maltophilia*, *Pasteurella* species, and *Vibrio cholera* can react in serological tests for *Brucella* infections in cattle.<sup>60–62</sup> Therefore, the positive reaction should be investigated using appropriate confirmatory tests and/or epidemiological investigations. The RBPT appears to be adequate as a screening test for identifying diseased herds or to guarantee the absence of infection in *Brucella* infection-free herds.<sup>7</sup>

The complement fixation test (CFT) is the most generally used test for serological confirmation of *Brucella* infection in cattle, and is recommended by the World Organisation for Animal Health (OIE).<sup>7</sup> The CFT is based on the detection of particular antibodies of type IgM and IgG<sub>1</sub> that fix complement.<sup>60</sup> The sensitivity and specificity of the CFT are acceptable in the hands of experienced users, and it can be used as a confirmatory blood test. Usually, the CFT is used on RBPT-positive sera, but similarly to the RBPT it is also influenced to a large extent by the misuse of S19 vaccine, mainly when recent or repetitive vaccinations have been carried out in sexually mature heifers and cows. It is almost impossible

to suggest a strict cut-off reading that shows brucellosis significantly once the S19 vaccine reaction is involved, because of its misuse. The CFT is a comparatively complex test. The reagents include *B. abortus* CFT antigen, complement, amboceptor (hemolysin), ovine erythrocytes, and test serum, with veronal buffer as the diluent.<sup>54</sup>

The c-ELISA is usually conducted by choosing monoclonal antibodies (mAbs) with slightly higher affinity for the antigen than the vaccine or cross-reacting antibody, but with lower affinity than the antibody arising from the infection.<sup>63</sup> The specificity of c-ELISA is very high and it is capable of identifying all antibody isotopes (IgM, IgG<sub>1</sub>, IgG<sub>2</sub>, and IgA).<sup>60</sup> The c-ELISA has high diagnostic specificity (100%) and a sensitivity of 98.8%, and it was observed to be the most specific test.<sup>64</sup> The high specificity of c-ELISA is a result of its using particular monoclonal antibodies as a conjugate, which have the ability to connect with other non-specific antibodies and fix to certain specific epitopes on the smooth lipopolysaccharides antigen.<sup>64,65</sup> The indirect ELISA (i-ELISA) has been also used for serological diagnosis of serum or milk from cattle.<sup>66</sup> The i-ELISA has been used for smooth lipopolysaccharide *Brucella* species, and it is sensitive and specific for *B. abortus* or *B. melitensis*, but it is not capable of differentiating antibodies induced by the vaccine strains S19 or Rev1.<sup>67</sup> The sensitivity of the i-ELISA varies from 96% to 100% and its specificity from 93.8% to 100%.<sup>68</sup>

The confirmatory test has to demonstrate a high level of diagnostic specificity and maintain effective sensitivity to reduce the number of false-positive reactions to a minimum.<sup>69</sup> The c-ELISA, in addition, is capable of reducing most reactions because of a residual antibody formed in reaction to vaccination with S19. The three OIE ELISA standard sera should be used by national reference laboratories worldwide to see or adjust the technique in question. The assay should be standardized, eg the optical density (OD) of the strongly positive OIE ELISA standard serum ought to be close to the highest level of inhibition.<sup>7</sup> The only limitation of the c-ELISA is that it is more complex and cost to conduct than the screening tests.<sup>70</sup> Weakly positive OIE ELISA common sera should provide a reaction that is moderate. The negative serum and the buffer or mAb control should give responses that are always less than the test population.<sup>7</sup>

## Occurrence of Brucellosis

Brucellosis has a worldwide distribution and is mainly a problem in developing countries such as Ethiopia.<sup>8</sup>

**Table 1** Distribution of Brucellosis in Different African Countries

Location	Seroprevalence (%)	Number of Samples Tested	Type of Test Used	Reference
Kenya	4.9	–	ELISA	[71]
Kenya	3.9	–	MRT	[71]
Zambia	20.7	395	c-ELISA	[12]
Sudan	20.0	250	SAT	[72]
Sudan	2.0	250	c-ELISA	[72]
Sudan	8.4	250	RBPT	[72]
Nigeria	5.5	220	RBPT	[73]
Tanzania	5.3	655	RBPT	[74]
Eritrea	7.1	130	CFT	[75]
Uganda	5.0	423	c-ELISA	[76]
Gambia	1.1	465	RBPT	[77]
Gambia	1.1	465	CFT	[77]
Senegal	0.6	479	RBPT	[77]
Senegal	0.6	479	CFT	[77]
Guinea	7.8	3861	RBPT	[77]
Guinea	5.5	3861	CFT	[77]
Guinea Bissau	19.2	733	RBPT	[77]
Guinea Bissau	15.1	733	CFT	[77]
Ghana	2.9	444	RBPT	[78]
Cameron	4.9	840	RBPT	[79]
Cameron	9.6	840	i-ELISA	[79]
Angola	15.0	1344	RBPT	[80]
Nigeria	36.6	4745	RBPT	[41]
Nigeria	24.0	4745	c-ELISA	[41]
South Sudan	31.0	893	c-ELISA	[81]

This disease is economically important in cattle production in developing countries. Brucellosis has a significant influence on cattle and public health, as well as extensive socio-economic effects, particularly in countries with economies based on livestock production and dairy products (Table 1).



## Control and Eradication of *Brucella* Infection

Brucellosis treatment in animals is typically ineffective because of the intracellular nature of the organisms, which means that bacteria persist and multiply in the cells.<sup>22</sup> *Brucella* infection typically enters the herd via diseased cattle, as well as the disease being acquired from the semen of infected bulls or fomites.<sup>30</sup> Immunization of calves or heifers is the most effective means of managing *Brucella* in an endemic area. Newly introduced cattle should be free from *Brucella* and also come from disease-free areas. New animals must be quarantined and tested for *Brucella* infection before being introduced into the group.<sup>81,82</sup> Brucellosis can be eradicated by quarantining infected cattle, vaccination, and test-and-slaughter methods. Moreover, several forms of investigation and trace-backs are important in eradication programs.<sup>33</sup> *Brucella* organisms are killed by most typically available disinfectants.<sup>83</sup> Two *B. abortus* vaccines, strain 19 and RB51, are used to manage brucellosis in common areas and as part of the eradication approach.<sup>45,82</sup>

## Public Health Significance of Brucellosis

*Brucella abortus* causes serious zoonotic disease and is an invasive *Brucella* species in humans. Occupational contact is seen in people who have interacted with infected cattle or their tissues. *Brucella* infection is among the principal easily acquired laboratory infections. Humans can also contract the disease by consuming unpasteurized milk or milk products.<sup>84</sup> The strain 19 *B. abortus* vaccine can also affect humans unless it is handled carefully. Adverse events have been reported with the RB51 vaccine, although it seems to be safer than strain 19.<sup>45</sup>

The prevalence of *Brucella* infection in humans is associated with the prevalence in nearby cattle.<sup>85</sup> Brucellosis is a comparatively common disease among animals and humans in developing countries, and several cases of brucellosis occur each year.<sup>54</sup> Symptoms of brucellosis in humans include fever, sweat, anorexia, malaise, weight loss, depression, headache, and joint pain. This disease may be confused with other diseases such as malaria and influenza.<sup>83,86,87</sup> The highest seroprevalence of human brucellosis was reported in the Afar region (12%), whereas low seroprevalence was reported in the Fafan zone (0.4%) in Ethiopia using the CFT (Table 2).

**Table 2** Occurrence of Human *Brucella* Infection in Ethiopia

Study Area	Seroprevalence (%)	Type of Test Used	Reference
Jimma zone	3.2	RBPT	[88]
Jimma zone	2.4	CFT	[88]
Addis Ababa	10.4	CFT	[89]
West Tigray	1.2	CFT	[90]
Afar Region	16.0	RBPT	[91]
Afar Region	12.0	CFT	[91]
Adami Tulu	2.2	RBPT	[92]
Adami Tulu	2.2	CFT	[92]
Central Ethiopia	4.7	RBPT	[20]
Central Ethiopia	1.3	CFT	[20]
Fafan zone	2.4	RBPT	[93]
Fafan zone	0.4	CFT	[93]

## Status of *Brucella* Infection in Ethiopia

Various investigations have shown that *Brucella* infection in cattle is common in Ethiopia, particularly in pastoral areas.<sup>16</sup> Brucellosis has been assessed serologically in various locations around the country.<sup>5,94,95</sup> A higher seroprevalence of *Brucella* infection was reported in intensive than in extensive production systems. The highest (50%) seroprevalence of *Brucella* was recorded in the Borena zone.<sup>96</sup> In addition, a seroprevalence of 0.77% was reported in the Jimma zone<sup>94</sup> and a prevalence of 1.7% was reported in an extensive production system.<sup>5,90</sup> Another investigation, carried out in south and east Ethiopia, indicated that 3.5% of cattle were positive for *Brucella* antibodies.<sup>37</sup> Several reports have shown that *Brucella* infection is prevalent in Ethiopia,<sup>9,20,21</sup> as presented in Table 3.

## Conclusion

*Brucella* infection is the major cause of production constraints in cattle and brucellosis is a serious zoonotic disease in Ethiopia. The occurrence of brucellosis in cattle is influenced by age, herd size, production system, and the agroecology of the area. Consumption of unpasteurized milk or its products and contact with infected cattle are

**Table 3** Occurrence of *Brucella* Infection in Ethiopia

Study Area	Number of Cattle Tested	Breed	Prevalence (%)	Type of Test Used	Reference
Central	1136	Mixed	11	CFT	[97]
Central	1136	Mixed	12.5	RBPT	[97]
West	1152	Local	1	CFT	[95]
West	1152	Local	1.2	RBPT	[95]
North	1968	Local	4.9	CFT	[90]
Assela	304	Mixed	14.1	RBPT	[18]
Central	1238	Mixed	4.9	RBPT	[3]
Central	1238	Mixed	2.9	CFT	[3]
Ambo	169	Cross	0.2	RBPT	[98]
Ambo	169	Cross	0	CFT	[98]
South East	862	Local	1.4	RBPT	[99]
South East	862	Local	1.4	CFT	[99]
Southern	1627	Local	1.7	CFT	[5]
Southern	811	Cross and exotic	2.5	CFT	[5]
East Showa	1106	Local	11.2	RBPT	[100]
Eastern	435	Local	1.8	RBPT	[19]
Eastern	435	Local	1.4	CFT	[19]
East Wollega	406	Mixed	3.0	RBPT	[43]
East Wollega	406	Mixed	2.0	CFT	[43]
Aris zone	370	Local	0.1	RBPT	[19]
Aris zone	370	Local	0.1	CFT	[19]
Debrezeit	300	Mixed	3.0	RBPT	[101]
Debrezeit	300	Mixed	2.0	CFT	[101]
Jimma zone	1595	Mixed	3.3	RBPT	[2]
Jimma zone	1595	Mixed	3.1	CFT	[2]
Jimma zone	423	Mixed	4.3	CFT	[24]
Borana	283	Local	10.6	CFT	[37]
Jimma zone	348	Mixed	1.4	RBPT	[102]
Jimma zone	348	Mixed	0.3	CFT	[102]
Aris zone	756	Mixed	2.6	CFT	[20]
North Shewa	384	Cross	0.8	RBPT	[21]

the major methods of transmission of *Brucella* infection to humans. Brucellosis is a herd disease. The most suitable technique for managing *Brucella* infection is the

vaccination of young female cattle. Therefore, it is important to implement applicable management methods and to increase public awareness about the transmission of

brucellosis, and further research should be conducted on brucellosis in high-risk groups.

## Disclosure

The author declared no conflicts of interest for this work.

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