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A Review On: Bovine Brucellosis and its Epidemiology in Ethiopia

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Abstract: Brucellosis is economically important zonootic bacterial disease caused by genus Brucella. It contains different species such as *B. abortus, B.melitensis, B.suis, B.ovis, B.canis, B.neotome, B. microti* that affect terrestrial animals and *B. ceti and B. pinnipedialis* affect marine mammals. The aim of this review is to summarize status of brucellosis in Ethiopia. Brucellosis occurs worldwide, except a few countries that have been successfully eradicated. The aborted fetus, fetal membrane and uterine discharges are considered as the major source of infection. Brucellosis is mainly transmitted to animals by ingestion of contaminated feed and water, by contact with infected aborted fetus, fetal membrane and genital discharges, and by artificial insemination from infected bulls. The bacteria are preferentially localized mainly in the reproductive tract of pregnant animals and consequently cause abortion (late abortion), retained fetal membrane and infertility, where as orchitis and epididimitis are seen in males. Among the serological tests, Rose Bengal plate test for screening and complement fixation testfor confirmatory are routinely used in Ethiopia. The disease also causes huge economic loses which arises from abortion culling of infected animal, hindering animal export trades of a country, treatment costs, time and costs allotted for research, and eradication programs. Formulating effective control strategies are needed that includes surveillance to identify infected animals, prevention of transmission to non infected animals and removal of the reservoir to eliminate the source of infection. In addition, vaccination of susceptible animals is also important in areas where high prevalence of brucellosis exists. In conclusions, Brucellosis has been widely reported from cattle as well as human cases in Ethiopia. This requires formulating effective control strategies are needed that includes surveillance to identify infected animals, prevention of transmission to non-infected animals and removal of the reservoir to eliminate the source of infection.

Keyords: Bovine · Brucellosis · Epidemiology · Ethiopia · Public Health

INTRODUCTION

Ethiopia has the largest cattle population in Africa. However, the country has not used this resource effectively owing to various limitations [1]. Animal disease, management problems, poor genetics, and nutritional deficiency are among the foremost impediments to cattle production in the country [2]. 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 [3, 4]. 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 [5, 6].

Brucellosis is a zoonotic disease that leads to considerable morbidity [7]. Also it was characterized by abortion in females and epididymitis and orchitisin males [8]. The economic and public health impact of brucellosis remains of concern in developing countries [9]. Tariku [10] reported that brucellosis contributed significant economic loss in dairy farm. In general, brucellosis can cause significant loss of productivity through abortion, still birth, low herd fertility and comparatively low milk production [11]. Inaddition, it poses a barrier to export and import of animals constraining livestock trade and is an impediment to free animal movement [12].

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Sources of infection include aborted fetuses, fetal membranes, vaginal discharges and milk from infected cows [13]. Primary clinical manifestations of brucellosis among livestock are related to the reproductive tract. In highly susceptible pregnant cattle, abortion after the five month of pregnancy is cardinal feature of the disease [14]. In humans, the disease is characterized by fever, sweating, anorexia, malaise, weight loss, depression, headache and joint pains and is confused with malaria and influenza [15].

Primary clinical manifestations of brucellosis among livestock are related to the reproductive tract. Inhighly susceptible pregnant cattle, abortion after the five month of pregnancy is cardinal feature of the disease [14]. 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,andbytest-and slaughter methods [16].

Brucellos is occurs worldwide and remains endemica mong Mediterranean countries of Europe, Northern and Eastern Africa, Near East countries, India, Central Asia, Mexico and Central and South America [17]. Also it is considered as a re-emerging problem in many countries such as Israel, Kuwait, Saudi Arabia, Brazil and Colombia, where there is an increasing incidence of *Brucella melitensis* or *Brucella suis* biovar$_1$ infection in cattle [18]. According to WHO [15] *B. melitensis*is considered to have the highest zoonotic potential, followed by *B.abortus*, and *B.suis* on those endemic regions. In Africa, bovine brucellosis was first recorded in Zimbabwe (1906), Kenya (1914) and in Orange Free State of South Africa in the year 1915 Chukuwu [19]. However, still the epidemiology of the disease in livestock and humans as well as appropriate preventive measures are not well understood and such information is inadequate particularly in sub-Saharan Africa. The surveillance and control of brucellosis in this region is rarely implemented outside South Africa [20]. In dairy production, the disease is a major obstacle to the importation of high yielding breeds and represents a significant constraint to the improvement of milk production through cross breeding.

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 [21, 22]. Seroprevalence rates of brucellosis ranging from 0.1% to 14.1% have beenreported in Ethiopia [23, 24]. Research from various parts of the country, published in 2016, Degefa *et al.* [24], Tsegaye *et al.* [25] and Pal *et al.* [26] 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 inEthiopia.

The objectives of this paper are

- ✓ To review epidemiology, diagnosis and control and prevention ofBrucellosis
- ✓ To review zoonotic importance of brucellosis
- ✓ To summarize status of brucellosis in Ethiopia.

Bovine Brucellosis

Etiology: The *Brucella* genus is composed of 12 recognized species after isolation and identification of novel species from the mandibular lymph nodes of the red fox [27]. There are six 'classical' species (Table 1): *Brucella abortus*, and *Brucella melitensis* are subdivided into biovar but *Brucella suis*, *Brucella ovis*, *Brucella canis* and *Brucella neotomae* are not and this division is based on cultural and serological properties [28]. They affect many animal species, but especially of those that produce food: sheep (especially milk Producing), goats, cattle and pigs and, on a more localized scale, camels, buffaloes, yaks and reindeer [29]. Bovine brucellosis is usually caused by *Brucella abortus*, less frequently by *B. melitensis*, and rarely by *B. suis*. In general, *brucella* have a predilection for both female and male reproductive organs in sexually mature animals and each *Brucella* species tends to infect a particular animal species. The target organs and tissues of *Brucella* species are placenta, mammary glands, and epididymis in animal reservoir host [30]. Persistent (life long) infection is a characteristic of its facultative intracellular organism, with shedding in reproductive and mammary secretions [31].

Characteristics of *Brucella* Organism: *Brucell a*species are facultative intracellular, gram negative, non-spore-forming and non-capsulated, partially acid-fast coccobacilli that lack capsules, endospores or native plasmids. They survive freezing and thawing but most disinfectants active against gram-negative bacteria kill *Brucella*. Pasteurization effectively kills *Brucella* in milk.

Table 1: The table below summarizes *Brucella*strains, hosts and transmission mode

Strain Symptoms	*Principle Host*	*Other Hosts*	*Symptoms*	*Transmission*	*Human Disease*
Brucellaabortus	Cattle	Sheep, goats, pigs, horses,dogs, humans, wild ungulates	Abortion after 5 months	Ingestion, some venereal	undulant fever-control with antibiotics
Brucellamelitensis	Sheep, goats.buffalo	cattle, pigs, dogs, humans,camels	Later term abortion, weak young, mastitis (goats)	Ingestion	Malta fever: can be fatal in human
Brucellaovis	Sheep		most often effects rams, rare abortions		
Brucellasuis	Pig	cattle, horses dogs, humans reindeer, caribou	Abortion and infertility	ingestion and venereal	extremely deadly in humans
Brucellacanis	Dogs	Humans	abortions at 40-60 days	Venereal	mild disease in humans

Sources: FAO, 2003

The bacterium is of 0.5-0.7ì in diameter and 0.6-1.5ì in length. They are oxidase, catalase and urease positive. Although *Brucella* species are described as non-motile, they carry all the genes except the chemotactic system necessary to assemble a functional flagellum [32]. The genomes of the members of *Brucella* are very similar in size and gene make up [33]. Each species within the genus of *brucella* has an average genome size of approximately 3.29Mb and consists of two circular chromosomes, those are Chromosome I, is approximately on average 2.11 Mb and Chromosome II is approximately1.18 Mb. The G + C content of all *Brucella* genome is 57.2% for Chromosome I and 57.3% for Chromosome II [34]. The *Brucella* have no classic virulence genes encoding capsules, plasmids, pili or exotoxins and compared to other bacterial pathogens relatively little is known about the factors contributing to the persistence in the host and multiplication within phagocytic cells. Also, many aspects of interaction between *Brucella*and its host remain unclear [35].

Geographical Distribution of Brucellosis Disease: The disease occurs worldwide, except in those countries where bovine brucellosis (*B.abortus*) has been eradicated which include Australia, Canada, Cyprus, Denmark, Finland, Netherlands, New Zealand, Norway, Sweden and the United Kingdom which has been reported as eradicated it. This is defined as the absence of any reported cases for at least five years. However, the Mediterranean Countries of Europe, Africa, Near East countries, India, Central Asia, Mexico, Central and South America are still not brucellosis free. Although in most countries brucellosis is a nationally notifyable disease and reportable to the local health authority, it is under reported and official numbers constitute only a fraction of true incidence of the disease [36].

Brucellosis is endemic in many developing countries and is caused by *Brucella* species that affect man, domestic and some wild animals, and marine mammals [37]. Ethiopia located in Eastern Africa, the country has diverse agro ecological zones, which have contributed to the evolution of different agricultural production systems. Animal husbandry forms an integral part of agricultural production in almost all ecological zones of the country [37]. In Ethiopia, brucellosis is endemic and the disease is highly susceptible more in cattle than in camels and small ruminants in pastoral and agro-pastoral areas. The highest prevalence is noticed in dairy cattle. It is more prevalent in developing countries and considered to be a serious health problem due to lack of effective public health measures, domestic animal health programs, and appropriate diagnostic facilities. Furthermore, the situation is also worsened by the resemblance of the disease with other diseases leading to misdiagnosis and under reporting [38].

Source of Infection and Mode of Transmission in Animals: In animals, the concentration of the bacteria is highest in pregnant uterus. The aborted fetus, placental membranes or fluids, and other uterine discharges were considered as major source of infection. Infected animals also shade organisms in milk which serve as source of infection for the new born. Contaminated feed can spread the infection from infected pasture over long distance during purchasing and selling activities. The disease is transmitted to susceptible animals by ingestion of contaminated feed and water, contact with aborted fetuses, fetal membrane and uterine discharges; infection by inhalation is also possible. The use of infected bull for artificial insemination also poses an important risk and spreads the infection to many herds [39].

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 [40]. Age has been stated as the intrinsic factor related to *Brucella* infection. A higher seroprevalence of *Brucella* organisms had been determined in adult cattle than in young cattle [41, 42]. Sexually mature and pregnant cattle are more prone to being infected with *Brucella*than sexually immature cattle.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. 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 positivecattle [43]

The effect of sex on the occurrence of *Brucella* infection in cattle has been stated previously [44]. Female cattle aremorelikelythanmalestohave *Brucella* infection [45] Although this is not easy to elucidate, it may be related to the biology of the *Brucella* organism and tropism to the fetal tissues.Because *Brucella* infection in males confers symptoms such as epididymitis and orchitis, the incidence in males may be lower than in females; asa result, they may be culled more quickly [46]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 [46]

Thereisdisagreementamonginvestigatorsoverwheth erparticular breeds are more prone to *Brucella* infection. Thus, a higher seroprevalenceof *Brucella* infection has been found in cross-breed than in local-breed (indigenous) cattle,while other reports indicated no association amongbreedsor a higher seroprevalenceof *Brucella* infection in indigenous than in cross-breedcattle [47]

Herd size is another risk factor for *Brucella* infection, with the risk being highest in large herds. 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. The low incidence of *Brucella infection* in small herds may be related to herd and/or arm management. Thus, small herds often graze nearby pastures, allowing interactions with other herds to be controlled, or using communal methods. 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 [47]

Herding several species within a herd has been characterized as a risk factor for brucellosis, Nahar and Ahmed [48] 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.

Pathogenesis: The ability of *Brucella* spp. to cause disease requires a few critical steps during infection. *Brucella* spp. can invade epithelial cells of the host, allowing infection through mucosal surfaces: M- cells in the intestine have been identified as a portal of entry for *Brucella* spp. Once *Brucella*spp. has invaded, usually through the digestive or respiratory tract, they are capable of surviving intra cellular within phagocytic or non-phagocytic host cells. Then replicate within the phagocyte, release to circulation and colonization of the bacteria in multiple tissues, like lymphoid tissues, mammary gland and reproductive tract [49].

Invading *Brucella* usually localize in the lymph nodes, draining the invasion site, resulting in hyperplasia of lymphoid and reticulo-endothelial tissue and the infiltration of inflammatory cells. Survival of the first line of defense by the bacteria results in local infection and the escape of *Brucella* from the lymph nodes in to the blood. During bacteraemic phase, bones, joints, eyes and brain can be infected, but the bacteria are most frequently isolated from supra-mammary lymph nodes, milk, iliac lymph nodes, spleen and uterus. In bulls, the predilection sites for infection are also the reproductive organs and the associated lymph nodes. During the acute phase of infection, the semen contains large number of *Brucella* but as the infection becomes chronic, the number of *Brucella*excreted decreases. However, it may also continue to be excreted for years or just become intermittent [39].

Clinical Signs: Brucellosis is a sub-acute or chronic disease which may affect many species of animals. In cattle, sheep, goats, other ruminants and pigs the initial phase following infection is often not apparent. In sexually mature animals the infection localizes in the reproductive system and typically produces placentitis followed by abortion in the pregnant female, usually during the last third of pregnancy, and epididymitis and orchitis in the male. According to WHO [15] *B. melitensis* is considered to have the highest zoonotic potential, followed by *B. abortus,* and *B. suis*on those endemic regions.

Although *B. abortus*is mainly associated with cattle, occasionally other species of animals such as sheep, swine, dogs and horses may be infected. In horses, *B. abortus* together with Actinomycesbovis may be present in poll evil and fistulous withers [50]. The mammary gland and regional lymph nodes can also be infected and bacteria can be excreted in milk [50].

Diagnosis: Diagnosis of brucellosis is the corner stone of any control and eradication program of the disease. Especially in humans due to its heterogeneous and poorly specific clinical symptoms, the diagnosis of brucellosis always requires laboratory conformation. It is made possible by direct demonstration of the causal organism using staining, immunoflorecent antibody, culture, and directly demonstration of antibodies using serological techniques [30,51].In cases of animal brucellosis diagnosis by cultural examination, the choice of samples usually depends on the clinical signs observed. The most valuable samples include vaginal secretions (swabs), aborted fetuses (stomach contents, spleen and lung), fetal membranes, and milk, semen and arthritis or hygroma fluids. From animal carcasses, the preferred tissues for culture are those of the reticulo-endothelial system (i.e. head, mammary and genital lymph nodes and spleen), the pregnant or early post-parturient uterus, and the udder. Growth normally appears after 3-4 days, but cultures should not be discarded as negative until 7-10 days have elapsed [52].

Rose Bengal Plate Test (RBPT): Often used as a rapid screening test; the sensitivity is very high (>99%) but the specificity is disappointingly as low as 68.8% . RBPT is a rapid, slide-type agglutination assay performed on serum. The general principle of this test is the agglutination of serum antibodies with Rose Bengal dye-stained *B. abortus*whole cells buffered at a pH of 3.65 to inhibit nonspecific agglutinins. Due to its simplicity and low cost, it is the most common test used for brucellosis screening purposes, especially in laboratories with limited resources. However, this is of value as a screening test in high risk rural areas where it is not always possible to perform the other tests [53].

Complement Fixation Test (CFT): This test detects specific antibodies of the IgM and IgG1 type that fix complement. The CFT is highly specific but it is laborious and requires highly trained personnel as well as suitable laboratory facilities that makes less suitable for use in developing countries. Although it specify is very important for the control and eradication of brucellosis, it may test false negative when antibodies of the IgG2 type hinder complement fixation. The CFT measures more antibodies of the IgG1 than antibodies of the IgM type, Since it usually appear after antibodies of the IgM type, control and surveillance for brucellosis is best done by CFT [52].

Public Health Importance of *Brucella*: Brucellosis (especially *B. melitensis*), remains one of the most common zoonotic diseases of worldwide with more than 50,000 human cases reported annually [54]. The significance of brucellosis as zoonotic has ever increased in recent times, due to the expansion of international commerce in animals and animal products, with increase urbanization, intensive farms and animal products, having nomadic animal husbandry [55]. Despite the advances made in surveillance and control, the prevalence of brucellosis is increasing in many developing countries due to various sanitary, socioeconomic, and political factors [56]. As compared to study of animal brucellosis, study of human brucellosis in Ethiopia is sparse with even less information on risk factors for human infection [57].

A study conducted in traditional pastoral communities by Ragassa *et al.* [58] using *B. abortus*antigen revealed that 34.1% patients with febrile illness from Borena, 29.4% patients from Hammer, and 3% patients from Metema areas were tested positive using *Brucella*IgM/IgG lateral flow assay. Studies conducted in high risk group such as farmers, veterinary professionals, meat inspectors and artificial insemination technicians in Amhara Regional State [50], Sidama Zone of Southern People Nations and Nationalities Sate [36]. In Addis Ababa, a seroprevalence of 5.30%, 3.78% and 4.8% by screening sera from 238, 38 and 336 individuals respectively were found [59]. The discrepancy between and others might be due to difference in milk consumption habits and sensitivity of test methods used [60,61].

Humans may become infected by ingestion of unpasteurized cheese or milk, by direct transmission through contact with infected animals or by handling specimens containing *Brucella* spp. in laboratory. It also transmitted to human by the consumption of raw dairy products and by direct contact with the skin or mucosa during parturition and abortion [62]. Cattle are natural hosts' for *Brucellaabortus*, and sheep *(Ovisaries*) and goats (*Capra hircus*) for *B melitensis*and*B ovis*, respectively. Humans are susceptible to *both B abortus*and*B melitensis,*the latter being most frequently reported in humans [63,64].

Human brucellosis is also known for complications and involvement of internal organs and its symptoms can be very diverse depending on the site of infection and include encephalitis, meningitis, spondylitis, arthritis, endocarditis, orchitis, and prostatitis [65]. Spontaneous abortions, mostly in the first and second trimesters of pregnancy, are seen in pregnant women infected with *Brucella* [66]. Symptoms and signs of brucellosis usually referred as fever of unknown origin can be confused with other diseases including enteric fever, malaria, rheumatic fever, tuberculosis, cholecystitis, thrombophlebitis, fungal infection, autoimmune disease and tumors [67]. Because of these rather non-specific signs, brucellosis is constantly mis-diagnosed as malaria, which is very prevalent in sub Saharan Africa [62].

Treatment, Prevention and Control: Due to the intracellular localization of *Brucella* and its ability to adapt to the environmental conditions encountered in its replicative niche e.g. macrophage [35], treatment of domestic animals with antibiotics is not usually successful. Even though, treatment failure and relapse rates are also high in humans, treatment depend on the drug combination of doxycycline with streptomycin which is currently the best therapeutic option with less side effects and less relapses, especially in cases of acute and localized forms of brucellosis [68]. A combination of doxycycline treatment (6 weeks duration) with parentally administered gentamicin (5 mg/kg) for 7 days is also considered an acceptable alternate regimen [69]. The initial aim of surveillance and control programs is the reduction of infection in the animal populations to reduce the effect of the disease on animal health and production, thus minimizing its impact on human health.

An effective control of animal brucellosis requires the following elements:

- Regular schedules of surveillance to identify infected animal that may causes herds infections,
- Prevention of transmission or spreads of infection to non-infected animal herds, and
- Eradication of the reservoir to eliminate the sources of infection in order to protect vulnerable animals or herds coupled with measures to prevent re-introduction of the disease [54].I n areas where a brucellosis free status has been established or where such a status is assumed from epidemiological data, the risk of importing the disease by means of animal movement must be protected. Movement of infected animals must be prohibited and import permissions should be given only to certified brucellosis-free farms or areas. This is also true for national and international transport of animal products, in accordance with the general principles and procedures specified in the International Zoo-Sanitary Code of the OIE. This code also describes the testing procedures for animals and quarantine measures [70].
- Suggested prevention and control strategies for livestock Brucellosis in Ethiopia

As the source of human brucellosis is direct or indirect exposure to infected animals or their products. Prevention must focus on various strategies that will mitigate infection risk. To our knowledge, there has been no national program proposed for prevention and control of brucellosis in Ethiopia. Similarly at regional levels, no strategy is in place to control brucellosis. This is largely a result of lack of facilities and budget to run such a program. Moreover, many responsible bodies may not recognize the significance of brucellosis given the contradictory and sometimes low prevalence data. However, at this time, it is crucial to define geographical extent of the problem and then allocate resources and funds to initiate prevention and control strategies in this country [70].

Epidemiology of Brucellosis in Ethiopia: Ethiopia, located in Eastern Africa, is predominantly an agrarian country with over 85% of its population engaged in agricultural activity. Since the first report of brucellosis in the 1970s in Ethiopia, the disease has been noted as one of the important livestock diseases in the country [71, 72]. A large number of studies on bovine have been reporting individual brucellosis seroprevalence ranging from 1.1% to 22.6% in intensive livestock management systems [72] and 0.05% -15.2% in extensive (Table 2) management systems [73,74]. Both husbandry systems as well as environmental conditions greatly influence the spread of *Brucella* infection [75]. Most brucellosis study report for

Table 2: List of Prevalence of Bovine brucellosis in intensive and semi-intensive management systems in Ethiopia

prevalence	*Management system*	*Diagnostic test*	*Authors*
2.5	Semi-Intensive and Intensive	RBPT,CFT	[81]
1.9	Semi-Intensive and Intensive	RBPT,CFT	[82]
10	Semi-Intensive and Intensive	RBPT,CFT	[83]
3.4	Semi-Intensive and Intensive	RBPT,CFT	[84]
7.7	Semi-Intensive	RBPT,CFT	[85]
1.9	Semi-Intensive	RBPT,CFT	[86]
4.5	Semi-Intensive	RBPT,CFT	[87]
12.4	Semi-Intensive	RBPT,CFT	[72]
1.5	Intensive	RBPT,CFT	[76]
3.6	Semi-Intensive	RBPT,CFT	[88]

Table 3:.List of the studies of Brucellaseroprevalence in the extensive management system in Ethiopia

Prevalence	*Management system*	*Diagnostic test*	*Authors*
1.7	Extensive	RBPT,CFT	[81]
3.2	Extensive	RBPT,CFT	[89]
0.5	Extensive	RBPT,CFT	[74]
11.2	Extensive	RBPT	[90]
1.4	Extensive	RBPT,CFT	[79]
1.2	Extensive	RBPT,CFT	[85]
3.6	Extensive	RBPT,CFT	[71]
2.2	Extensive	RBPT,CFT	[87]
9.7	Extensive	RBPT,CFT	[72]
10.6	Extensive	RBPT,CFT	[73]
0.8	Extensive	RBPT,CFT	[91]
1.7	Extensive	RBPT,CFT	[88]

Table 4: Seroprevalenceof bovine brucellosis in Ethiopia in different geographical areas under different production systems

Study areas	N. animal tested (Prevalence)	Type of test	Authors	System
Jimma zone	1,813 (0.61)	RBPT, SAT	[91]	Extensive & intensive
Tigray	1,951 (1.49)	RBPT, SAT	[89]	Extensive & intensive
Bahr Dar	1,944 (4.63)	RBPT, SAT	[84]	Extensive & intensive
Cent. Oromia	1,238(2.99)	RBPT, SAT	[87]	Extensive & intensive
AA &Suluta	1,501 (1.3)	RBPT, SAT	[92]	Extensive & intensive
Tigray	1,968 (4.9)	RBPT, SAT	[85]	Semi-intensive & extensive
East Shewa	1,106 (11.5)	RBPT	[90]	Pastoral & agro-pastoral
Sidama zone	1,627 (1.66)	RBPT, SAT	[79]	Extensive
Jijjiga	435 (1.38)	RBPT, SAT	[74]	Agro-pastorals
South & East Ethiopia	1,623 (3.5)	RBPT, SAT	[83]	Extensive

Remark: AA (Addis Ababa), Eth(Ethiopia), N (number)

highland agro-ecology was concentrated at urban and pre urban dairy farms. According to different authors herd level seroprevalence ranged between 2.9% and 45.9% [76].

Over half of the cattle are farmed under extensive lowland pastoralist and agro-pastoralist production system, *brucella*sero-prevalence within extensive cattle rearing systems (Table 3) is lower than that of intensive systems (Table 4). The highest seroprevalence (50%) was documented using ELISA in Didituyura Ranch [77], 2.91% in indigenous Borena breed cows in Borena zone in Southern Ethiopia [78]. In South Eastern Ethiopian pastoral zones of the Somali and Oromia regional state herds, sero-prevalence per species which were 1.4% were reported [79]. The same study in the area showed that anti-*Brucella* antibodies were prevalent in 10.6% [73]. In general accordingly to region-based meta-analysis,

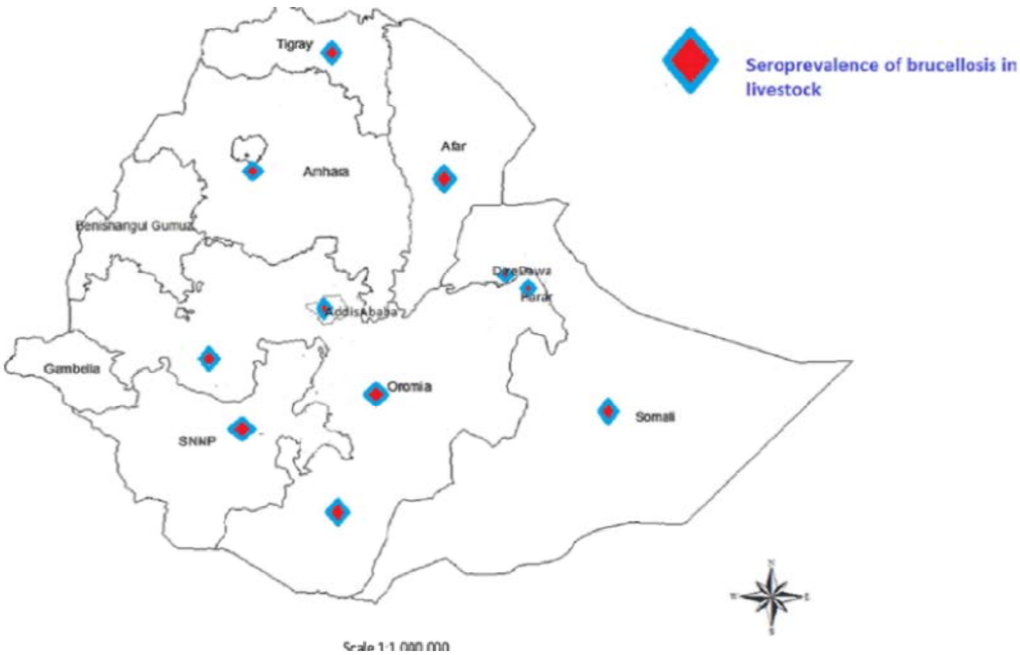

Fig. 1: Geographical location for studied report on the brucellosis in Ethiopia (Adopted from [82].

forest plot revealed the highest prevalence in central Ethiopia followed by the southern part Figure 1). The lowest prevalence estimate was observed in the western part of the country [80]. The prevalence of disease in country ranged from 15% [41] to 12% [80].

The management systems as well as ecological conditions greatly influence the spread of *brucella* infection [85]. Ethiopia has several institutionally owned commercial dairy farms, mostly situated in and around Addis Ababa and in some regional towns. These farms have been the focus of most of *Brucella* surveys, potentially producing a bias in reported findings. These prevalence reports below have been systematically reviewed as semi-intensive and extensive management systems of various regions in Ethiopia.

In general, at the country level brucellosis prevalence studies have been conducted in different localities of the country. But, there is little information on specific transmission dynamics within different agro-ecology in the country. Since prevalence studies in animals and human were largely confined to serological surveys and commonly targeted bovine brucellosis, occasionally sheep and goats and rarely camels. Also attempts to identify*Brucella* species in the country were unsuccessful, the distribution and proportion of their natural hosts were also not studied exhaustively [88]. This is largely attributed to the degree of laboratory development and lack of consumables for laboratory tests [79].

Human Brucellosis: The true incidence of brucellosis in human and animals worldwide is obscure and the occurrence is expanding in low and middle income nations like Ethiopia. The bacterial pathogen is considered by US Centers for Disease Control and Prevention (CDC) as a category (B) pathogen that has potential for improvement as a bio-terrorism weapon with a capability of airborne transmission [63].The incidence of human brucellosis is correlated with the level of incidence in domestic animals [17]. Human cases occur after ingesting raw milk and milk products and coming into close contact with infected animals. Human brucellosis can be a very debilitating disease, although the case fatality rate is generally low [17].

Brucellosis primarily affects livestock, but can be transmitted to humans (Figure 1) by ingestion, close contact, inhalation or accidental inoculation. The prevalence of human brucellosis differs between areas and has been reported to vary with standards of personal and environmental hygiene, animal husbandry practices and species of the causative agent and local methods of food processing [64]. In Ethiopia according to Regassa *et al.* [58] the major risks for brucellosis in the pastoral community are living in close proximity of livestock, milking and consuming raw milk and fresh dairy product.

As compared to study of animal brucellosis, study of human brucellosis in Ethiopia is sparse with even less information on risk factors for human infection. For instance, (3.6%) were reported to be positive for

Table 5: Summary of humans tested for brucellosis in Ethiopia and its prevalence

Study Area	*Prevalence*	*Reference*
Hawassa	3.78	[94]
Addis Ababa	4.8	[81]
Borena	34.1	[58]
Amhara region	5.3	[90]
South Gonder	3.0	[58]
Yabellooromia	10.0	[88]
Hammer	29.4	[58]
Jimma zone	2.1	[65]

Source: Robinson, A., 2003

*B. abortus*antibodies by RBPT and CFT [91]. A study conducted in traditional pastoral communities by Regassa (Table 5) *et al.* [58] using *B. abortus*antigen revealed that 34.1% patients with febrile illness from Borena, 29.4% patients from Hammer and 3% patients from Metema areas were tested positive using *Brucella* IgM/IgG. The seroprevalence studies conducted in high risk group such as farmers, veterinary professionals, meat inspectors and artificial insemination technicians were reported 5.30% by Mussie *et al.* [93], 3.78% and 4.8% by Kassahun *et al*. [94] and Asmare *et al*. [36] in different region of Ethiopia from individuals humans.

CONCLUSION AND RECOMMENDATIONS

Brucellosis is worldwide disease and has high prevalence in many African countries. Brucellosis affected both animals and humans, has a very high economic and public health impact. Its impact on Public health is very well related to the infected animal species from which human transmission occurs. The disease transmits from infected animals to human beings through several routes; it can be transmitted via consumption of unpasteurized milk and cheese, direct contact with infected animal and handling of specimen that contaminated with *Brucella* species. It is special hazard to occupational groups. It causes considerable losses in cattle as a result of abortion and reduction in milk yield. Even though the disease is prevalent in Ethiopia, few reports in human are available. This may be due to absence of appropriate diagnostic facilities. Based on the above concluding remarks, the following recommendations are forwarded:

- ✓ In order to reduce the economic losses and public health impact of the brucellosis disease, control and eradication of disease of animals should be prepared or designed at the national and regional level.
- ✓ To convince the decision makers, prevalence, distribution and public health impact of the disease should be further studied and well documented.
- ✓ Suitable laboratories for study of the disease have to be established at national and regional level.
- ✓ Public education on the transmission and source of infection of the disease as well as control and prevention method should be taught or awareness creation should be applied.
- ✓ For both human and animal brucellosis, extension services should include emphasis on addressing the impacts of risk factors for the occurrence of brucellosis.
- ✓ Avoid eating or drinking unpasteurized milk, cheese, or ice cream.
- ✓ The necessary precautions should be taken to reduce occupational risks. Aware people to use Pasteurized milk widely practiced to prevent human infections.
- ✓ Eradication of the reservoir to eliminate the sources of infection in order to protect vulnerable animals or herds coupled with measures to prevent re-introduction of the disease.

REFERENCES

1. Central Statistical Authority, 2017. Livestock and livestock characteristics, agricultural sample survey. Addis Ababa, Ethiopia. Stat Bull., 2(583): 9-13.
2. Ibrahim, N., K. Belihu, F. Lobago and M. Bekana, 2010. Sero-prevalence of bovine brucellosis and its risk factors in Jimma zone of Oromia Region, South-western Ethiopia. Trop. Anim. Health Prod., 42: 35-40.doi:10.1007/s11250-009-9382-z
3. Jergefa, T., B. Kelay, M. Bekana, S. Teshale, H. Gustafson and H. Kindahl, 2009. Epidemiological study of bovine brucellosis in three agro-ecological areas of central Oromia, Ethiopia. Rev. Sci. Tech., 28(3): 933-943. doi:10.20506/rst.28.3.1939
4. Asgedom, H., D. Damena and R. Duguma, 2016. Seroprevalence of bovine brucellosis and associated risk factors in and around Alage dis- trict, Ethiopia. Springer Plus., 5(851): 1-8. doi:10.1186/s40064-016-2547-0
5. Asmare, K., Y. Asfaw, E. Gelaye and G. Ayelet, 2010. Brucellosis in extensive management system of Zebu cattle in Sidama Zone, Southern Ethiopia. Afr J. Agric. Res., 5(3): 257-263.
6. Tulu, D., B. Deresa, F. Begna and A. Gojam, 2018. Review of common causes of abortion in dairy cattle in Ethiopia. J. Vet. Med. Anim . Health, 10(1): 1-13. doi:10.5897/JVMAH2017.0639
7. Smits, H.L. and S.M. Kadri, 2005. Brucellosis in India: a deceptive infectious disease. Indian J. Med. Res., 12(2): 375-384.

8. Debassa, G., M. Tefera and M.Addis, 2013. Small ruminant brucellosis: serological survey in Yabello District, Ethiopia. Asia J. Anim. Sci. 7 (1), 14-21
9. Roth, F., J. Zinsstag, D. Orkhon, G. Chimed-Ochir and G. Hutton, 2003. Human health benefits from livestock vaccination for brucellosis: case study. Bull. World Health Organ., 8(1): 867-876.
10. Tariku, S., 1994. The Impact of Brucellosis on Productivity in an Improved Dairy Herd of Chaffa State Farm, Ethiopia.
11. Gessese, A.T., B. Mulate, S. Nazir and A. Asmare, 2014. Seroprevalence of brucellosis in camels (Camelus dromedaries) in South East Ethiopia. J. Vet. Sci. Med. Diagn., 3(1): 1-10.
12. Zinsstag, J., E. Schelling, J. Solera, J.M. Blasco and I. Moriyon, 2011. Brucellosis: Oxford Textbook of Zoonoses: Biology, Clinical Practice and Public Health Control.second ed. Oxford University Press.
13. Adugna, K.E., G.E. Agga and G. Zewde, 2013. SeroepidemiologicalsurveyofbovinebrucellosisincattleunderatraditionalproductionsysteminwesternEthiopia.Rev.Sci.Tech. Off. Int. Epiz., 32(3): 1-20.
14. Radostits, O.M., C.C. Gay, C.D. Blood and K.W. Hinchcliff, 2000. Veterinary Medicine, Text book of the Disease of Cattle, Sheep, Pigs, Goats and Horses. ninethed. W.B. Saunders Company Ltd, New York, pp: 867-882.
15. WHO, 1997. Emerging and other communicable diseasesurveillance and control. The development of new/ improved brucell osisvaccines. Reports of the WHO Meet-ings, Geneva, pp:1-37.
16. Muma, J.B., K.L. Samui, J. Oloya, M. Munyeme and E. Skjerve, 2007. Risk factors for brucellosis in indigenous cattle reared in livestock- wildlife interface areas of Zambia. Prev. Vet. Med., 2007; 80: 306-317. doi:10.1016/j.prevetmed. 03.003
17. FAO, 2003. Guidelines for coordinated human and animal brucellosis surveillance. Proceedings of Animal Production and Health Conference Paper, 156. FAO, Rome, Italy, pp: 1-45.
18. Cutler, S.J., A.M. Whatmore and N.J. Commander, 2005. Brucellosisnewaspectsof anolddisease. J. Appl. Microbiol., 9(8): 1270-1281.
19. Chukwu, C.C., 1985. Brucellosis in Africa, Part I. The prevalence.Bull. Anim. Hlth. Prod. Afr., 35: 92-98.
20. McDermott, J.J. and S.M. Arimi, 2002. Brucellosis in Sub-Saharan Africa: epidemiology, control and impact. Veterinary Microbiology, 20: 111-134.
21. Berhe, G., K. Belihu and Y. Asfaw, 2007. Seroepidemiological investigation of bovine brucellosis in the extensive cattle production system of Tigray Region of Ethiopia. Int. J. Appl. Res Vet. Med., 5(2): 65-71.
22. Tulu, D., B. Deresa and F. Begna, 2020. Case-control study on risk factors associated with brucellosis in aborted cattle of Jimma zone, Ethiopia. Iran. J. Vet. Sci. Technol., 11(2): 27-36.
23. Deselegn, T.B. and S.K. Gangwar, 2011. Seroprevalence study of bovine brucellosis in Assela government dairy farm of Oromia Regional State, Ethiopia. Int. J. Sci. Nature., 2(3): 692-697.
24. Degefa, T., A. Duressa and R. Duguma, 2011. Brucellosis and some reproductive problems of indigenous Arsicattle inselected Arsizones of Oromia Regional State, Ethiopia. Global Veterinary, 7: 45-53.
25. Tsegaye,Y., M. Kyule and F. Fikrelobago, 2016. Seroprevalence and risk factors of bovine brucellosis in Arsi Zone, Oromia Regional State, Ethiopia. Am Sci Res. J. Eng. Technol. Sci., 24(1): 16-25.
26. Pal, M., D. Lemu, S. Worku and G. Desta, 2016. Sero-prevalence study of bovine brucellosis and reproductive problems in small-scale dairy farms of North Shewa, Ethiopia. Int. J. Livestock Res., 6(9): 1-10. doi:10.5455/ijlr.20160922081855.
27. Scholz, H.C., S. Revilla-Fernández, S. Al Dahouk, J.A. Hammerl and M.S. Zygmunt, 2016. Brucellavulpes sp. nov., isolated from mandibular lymph nodes of red foxes (Vulpesvulpes). Int. J. Syst. Evol. Microbiol., 66: 2090-8.
28. Office International des Epizooties (OIE), 2013. Bovine brucellosis: Manual of diagnostic tests and vaccines for terrestrial animals OIE, Paris, pp: 409-435.
29. World Health Organization (WHO), 2006. Brucellosis in Humans and Animals. Geneva, Switzerland: WHO Press.
30. Quinn, P.J., B.K. Markey, M.E. Carter, W.J. Donnelly and F.C. Leonard, 2002. Veterinary Microbiology and Microbial diseases. Great Britain. Blackwell., pp: 162-166.
31. Radostits, O.M., C.C. Gay, K.W. Hinchcliff and P.D. Constable, 2007. A Textbook of the Diseases of Cattle, Horses, Sheep, Pigs and Goats. 10th edition. Spain: Saunders Elseier, pp: 963-993.
32. Fretin, D., A. Fauconnier, S. Kohler, S. Halling, S. Leonard, C. Nijskens, J. Ferooz, P. Lestrate, R.M. Delrue, I. Danese, J. Vandenhaute, A. Tibor,

X. DeBolle and J.J. Letesson, 2005. The sheathed flagellum of Brucellamelitensis is involved in persistence in a murine model of infection. Cell Microbiol., 7: 687-698.

33. Sriranganathan, N., M.N. Seleem, S.C. Olsen, L.E. Samartino, A.M. What more, B. Bricker, D. Callaghan, S.M. Halling, O.R. Crasta, R.A. Wattam, A. Purkayastha, B.W. Sobral, E.E. Snyder, K.P. Williams, X. Yu G.T.A. Fitch, R.M. Roop, P. de Figueiredo, S.M. Boyle, Y. He and R.M. Tsolis , 2009. Genome mapping and genomics in animal-associated microbes. In: Brucella Springer (Chapter 1).
34. Halling, S.M., B.D. Peterson-Burch, B.J. Bricker, R.L. Zuerner, Z. Qing, L.L. Li, V. Kapur, D.P. Alt and S.C. Olsen, 2005. Completion of the genome sequence of Brucellaabortus and comparison to the highly similar genomes of Brucellamelitensis. I.J. Bacteriol., 187: 2715-2726. Health significance in western Tigray, northern Ethiopia. SAGE-Hindawi Vet. Med. Int. Id. 354943, 7.http://dx.doi.org/10.4061/2011/354943.
35. Seleem, M.N., S.M. Boyle and N. Sriranganathan, 2008. Brucella: a pathogen without classic virulence genes. Vet. Microbiol., 129, 1-14. A Review on Bovine Brucellosis: Epidemiology, Diagnosis and Control Options ARC Journal of Animal and Veterinary Sciences (AJAVS) pp: 10.
36. Robinson, A., 2003. Guidelines for coordinated human and animal brucellosis surveillance In: FAO Animal Production and Health Pape., pp: 156. Schelling, E., Diguimbaye, C., Daoud, S., Nicolet, J., P. Boerlin, M. Tanner and J. Zinsstag, 2003. Brucellosis and Q-fever sero prevalence of nomadic pastoralists and their livestock in Chad. Preventive Veterinary Medicine., 61: 279 293.
37. Molla, B., 1989. Sero epidemiological survey of bovine brucellosis in Arsi Region. DVM thesis, Faculty of Veterinary Medicine, Addis Ababa University, Debrezeit, Ethiopia.
38. Aworh, M.K., E. Okolocha, J. Kwaga, F. Fasina, D. Lazarus and I. Suleman, 2013. Human brucellosis: sero-prevalence and associated exposure factors among abattoir workers in Abuja, Nigeria-2011. Pan Afr. Med. J., 17: 103.
39. Acha, P.U. and B. Szyfers, 2001. Zoonosis and Communicable Diseases Common to man and Animals.3rd ed. Pan America Health Organization. Washington, D.C., pp: 40-296.
40. Gul, S.T. and A. Khan, 2007. Epidemiology and epizootology of brucellosis: A review. Pak Vet. J., 27: 145-151.
41. Ashagrie, T., Y, Deneke and T. Tolosa, 2011. Seroprevalence of caprinebru-cellosis and associated risk factors in South Omo Zone of Southern Ethiopia., 5: 1682-1685.
42. Borba, M.R., M.A. Stevenson and V.S. Goncalves, 2013. Prevalence and risk-mapping of bovinebrucellosis in Maranhao State, Brazil. Prev Vet Med. 2013; 110: 169-176. doi:10.1016/ j.prevetmed.2012.11.013.
43. Megersa, B., D. Biffa, F. Abunna, A. Regassa, J. Godfroid and E. Skjerve, 2011. Seroprevalence of brucellosis and its contribution to abortion in cattle, camel, and goat kept under pastoral management inBorana, Ethiopia. Trop Anim Health Prod. 2011;43:651-656. doi:10.1007/s11250-010-9748-2.
44. Munoz, P.M., M. Boadella and M. Arnal, 2010. Spatial distribution and risk factors of Brucellosis in Iberian wild ungulates. BMC Infect Dis. 2010; 10: 46. doi:10.1186/1471-2334-10-46.
45. Talukder, B.C., M.A. Samad and A.K. Rahman, 2012. Comparative evaluation of commercial serodiagnostic tests for the seroprevalence study of brucellosis in stray dogs in Bangladesh. Bangladesh J. Vet. Med., 2012; 9: 79-83.doi:10.3329/bjvm.v9i1.11217.
46. Coelho, A.M., J.G. Díez and A.C. Coelho, 2013. Brucelosis en pequeñosrumiantes: efecto de la aplicacióndeunprograma especial de vacunación en masa con REV-1. REDVET. Rev Electron de Vet., 14: 1-16.
47. Mai, H.M., P.C. Irons, J. Kabir and P.N. Thompson, 2012. A large seropreva- lence survey of brucellosis in cattle herds under diverse produc- tion systems in northern Nigeria. BMC Vet. Res., 8(144): 1-14.doi:10.1186/1746-6148-8-144.
48. Nahar, A. and M.U. Ahmed, 2009. Sero-prevalence study of brucellosis in cattle and contact human in Mymensingh district. Bangladesh J. Vet. Med., 7: 269-274.doi:10.3329/bjvm.v7i1.5071
49. Carvalho Neta, A.V., J.P. Mol, M.N. Xavier, T.A. Paixao, A.P. Lage and R.L. Santos, 2010. Pathogenesis of bovine brucellosis.Veterinary Journal, 184: 146-155.
50. Gul, S.T. and A. Khan, 2007. Epidemiology and epizootology of brucellosis: a review. Pak. Vet. J., 27(3): 145-151.

51. Walker, R.L., 1999. Brucella. In: Dwight C. Hirsh and Yuang Chung Zee (ED.): Veterinary Microbiology. USA: Blackwell Science Inc, pp: 196-203.
52. Office International des Epizooties, 2016. Terrestrial Manual; Brucellosis Infection; Adopted by the World Assembly of Delegetes of the OIE, 2: 1-14.
53. Mantur, B.G., M.S. Birada, R.C. Bidri M.S. Mulimani and P. Kariholu, 2006. Protean clinical manifestations and diagnostic challenges of human brucellosis in adults: 16 years' experience in an endemic area. J. Med. Microbiol., 55: 897-903.
54. Gwida, M., S. Al Dahouk F. Melzer, U. Rösler, H. Neubauer and H. Tomaso, 2010. Brucellosis regionally emerging zoonotic disease. Doi: 10.3325/cmj.2010.51.289.
55. Bayeleyegn, M., 2007.Advanced veterinary public health lecture note. FVM, AAU, Debre- zeit, Ethiopia, pp: 10-32.
56. Pappas, G., P. Panagopoulou, L. Christou and N. Akritidis, 2006. Brucella as a biological weapon. Cell Mol. Life Sci., 63: 2229-2236.
57. Mekonnen, H., K. Shewit, K. Moses, A. Mekonnen and K. Belihu, 2011. Effect of Brucella infection on reproduction conditions of female breeding cattle and its public
58. Ragassa, G., D. Mekonnen, L. Yamuah, H. Tilahun, T. Guta, A. Gebreyohannes, A. Aseffa, T.H. Abdoel and H.L. Smits, 2009. Human brucellosis in Traditional pastoral communities in Ethiopia. Int. J. Trop. Med., 4: 59-64.
59. Kassahun, J., E. Yimer, A. Geyid, P. Abebe, B. Newayeselassie, B. Zewdie , M. Beyene and A. Bekele, 2006. Sero-prevalence of brucellosis in occupationally exposed people in Addis Ababa, Ethiopia.
60. Khan, M.Y., M.W. Mah and Z.A. Memish, 2001. Brucellosis in pregnant women. Clin. Infect. Dis, 32: 1172-1177.
61. Mantur, B.G. and S.S. Mangalgi, 2007. Evaluation of conventional Castaneda andlysis centrifugation blood culture techniques for diagnosis of human brucellosis. J. Clin. Microbiol., 42: 4327-4328.
62. Maichomo, M.W., J.J. Maichomo, S.M. McDermott, P.B. Arimi, T.J. Gathura and S.M. Mugambi, 2009. Study of brucellosis in a pastoral community and evaluation of the usefulness of clinical signs and symptoms in differentiating it from other flu-like diseases. Afr. J. Health Sci., pp: 114-119.
63. Seleem, M.N., S.M. Boyle and N. Sriranganathan, 2010. Brucellosis: A Re-emergingZoonosis. Veterinary Microbiology, 140: 392-398.
64. Chugh, T.D., 2008. Emerging and re-emerging bacterial diseases in India. J. Biosci., 33: 549-555.
65. Bekele, M., H. Mohammed, M. Tefera and T. Tolosa, 2011. Small Ruminant Brucellosis and Community Perception in Jijiga District, Somali Regional State, Eastern Ethiopia. Tropical Animal Health and Production, 43: 893-898.
66. Lita, E.P., J. Erume, G.M. Nasinyama and E.B. Ochi, 2016. A Review on Epidemiology and Public Health Importance ofBrucellosis with Special Reference to Sudd Wetland Region SouthSudan.Intern. J. Rese. Stud. in Bioscie., 4(12): 7-13.
67. Garin-Bastuji, B., 2014. Brucellosis: An emerging disease with public health implications?. Httpt: //www. Slues.org.centrb.cgd (accessed on 31 may 2018).
68. Seleem, M.N., N. Jain, N. Pothayee, A. Ranjan, J.S. Riffle and N. Sriranganathan, 2009. Targeting Brucellamelitensis with polymeric nanoparticles containing streptomycin and doxycycline. FEMS Microbiol. Lett., 294: 24-31.
69. Glynn, M.K. and T.V. Lynn, 2008. Brucellosis. J. Am. Vet. Med. Assoc., 233: 900-908.
70. Food and Agriculture Organization of the United Nations,World Organization for Animal Health Organization (WHO), 2006. Brucellosis in human and animals. Principleauthor:M.J.Corbel.WHO,Geneva.
71. Ibrahim, N., K. Belihu, F. Lobago and M. Bekana, 2010. Sero-prevalence of bovine brucellosis and its risk factors in Jimma zone of Oromia region, South-western Ethiopia. Trop. Anim. Health Prod., 42: 35-40.
72. Kebede, T., G. Ejeta and G. Ameni, 2008. Sero Prevalence of Bovine Brucellosis in Small holder Dairy farms in Central Ethiopia (Wuchale-Jida district). The Journal of Livestock and Veterinary Medicine in Tropical Countries, 159: 3-9.
73. Megersa, B., D. Biffa, F. Niguse, T. Rufael, K. Asmare and E. Skjerve, 2011. Cattle brucellosis in traditional livestock husbandry practice in Southern and Eastern Ethiopia, and its zoonotic implication. In: Acta Veterinaria Scandinavica., 53: 24, http:// www.actavetscand.com/ content/53/1/24 ; Accessed date on September 13/2011.
74. Degefa, T., A. Duressa and R. Duguma, 2011. Brucellosis and Some Reproductive Problems of Indigenous Arsi Cattle in selected Arsizone’s of Oromia Regional State, Ethiopia. Global Veterinaria, 7: 45-53.

75. World Health Organization (WHO), 1997. Emerging and other communicable disease surveillance and control.The development of new/improved brucellosis vaccines.Reports of the WHO Meetings, Geneva, pp: 1-37.
76. Tesfaye, G., W. Tsegaye, M. Chanie and F. Abinet, 2011. Sero-prevalence and Associated Risk Factors of Bovine Brucellosis in Addis Ababa dairy farms. Tropical Animal Health and Production, 43: 1001-1005.
77. Alem, W. and G. Solomon, 2002. A retrospective sero-epidemiology study of bovine brucellosis in different production systems in Ethiopia.Proceeding of Sixtieth Annual Conference. June 5-6, 2001. Addis Ababa, Ethiopia, pp: 53-57.
78. Benti, A.D. and W. Zewdie, 2014. Major reproductive health problems of indigenous Borena cows in Ethiopia. J. Adv. Vet. Anim. Res., 1(4): 182-188.
79. Gumi, B., R. Firdessa, L. Yamuah, T. Sori and T. Tolosa, 2013. Sero-prevalence of brucellosis and Q-fever in southeast Ethiopian pastoral livestock. J. Vet. Sci. Med. Diagn., 2(1): 1-5.
80. Asmare, K., I.R. Krontveit, G. Ayelet, B. Sibhat, J. Godfroid and E. Skjerve, 2014. Meta analysis of Brucellasero-prevalence in dairy cattle of Ethiopia.Trop.Anim. Health Prod., Article Id. Doi.http://dx.doi.org/10.1007/s11250-014-0669-3.
81. Asmare, K., Y. Asfaw, E. Gelaye and G. Ayelet, 2010. Brucellosis in extensive management system of Zebu cattle in Sidama Zone, Southern Ethiopia. Afr. J. Agric. Res., 5: 257-263.
82. Asmare, K., B. Megersa, Y. Denbarga, G. Abebe, A. Taye, J. Bekele, T. Bekele, E. Gelaye, E. Zewdu, A. Agonafir, G. Ayelet and E. Skjerve, 2013a. A study on sero-prevalence of caprine brucellosis under three livestock production systems in southern and central Ethiopia. Trop. Anim. Health Prod., 45: 555-560.
83. Abebe, A., M. Yalemtsehay, S. Damte and E. Eden, 2009. Febrile illnesses of different etiology among outpatients in four health centers in northwestern Ethiopia. Jpn. J. Infect. Dis., 62: 107-110.
84. Hadush, A. and M. Pal, 2013. Brucellosis-An infectious re-emerging bacterial zoonosis of global importance. Int. J. Livest Res., 3: 28-34.35.
85. Haileselassie M., K. Shewit and K. Moses, 2010. Serological survey of bovine brucellosis in barka and arado breeds (Bosindicus) of Western Tigray, Ethiopia. Preventive Veterinary Medicine, 94(1-2): 28-35.
86. Ibrahim, N., K. Belihu, F. Lobago and M. Bekana, 2010. Sero-prevalence of bovine brucellosis and its risk factors in Jimma zone of Oromia region, South-western Ethiopia. Trop. Anim. Health Prod., 42: 35-40.
87. Jergefa, T., B. Kelay, M. Bekana, S. Teshale, H. Gustafson and H. Kindahl, 2009. Epidemiological study of bovine brucellosis in three agroecological areas of central Oromiya, Ethiopia. Rev. Sci Tech Off. Int. Epiz., 28: 933-943.
88. Yohannes, M., H. Degefu, T. Tolosa, K. Belihu, R. Cutler and S. Cutler, 2013. Brucellosis in Ethiopia. Afr. J. Microbiol. Res., 7(14): 1150-1157.
89. Berhe G., K. Belihu and Y. Asfaw, 2007. Seroepidemiological investigation of bovine brucellosis in the extensive cattle production system of Tigray region of Ethiopia. Int.J. Appl. Res. Vet. Med., 5(2): 65-71.
90. Dinka, H. and R. Chala, 2009. Sero prevalence study of bovine brucellosis in pastoral and agro-pastoral areas of East Showa zone, Oromia Regional State, Ethiopia.American-Eurasian Journal of Agricultural and Environmental Science, 6: 508-512.
91. Tolosa, T., F. Ragassa, K. Belihy and G. Tizazu, 2007. Brucellosis among patients with fever of unknown origin in Jimma University Hospital South Western Ethiopia. Ethiop. J. Health Sci., 7: 1153-1154.
92. Tesfaye, G., W. Tsegaye, M. Chanie and F. Abinet, 2009. Sero-prevalence and Associated Risk Factors of Bovine Brucellosis in Addis Ababa dairy farms. Tropical Animal Health and Production, 43: 1001-1005.
93. Mussie, H., K. Tesfu and A. Yilkal, 2007a. Sero-prevalence study of bovine brucellosis in Bahir Dar Milk shed, Northwestern Amhara Region. Ethiop. Vet. J., 11(1): 42-49.
94. Kassahun, A., P. Shiy, A. Yilkal, G. Esayas, A. Gelagaye and Z. Aschalew, 2007. Sero-prevalence of brucellosis in cattle and high risk professionals in Sidama Zone, Southern Ethiopia.Ethiop. Vet. J., 11: 69-84.