Journal of American Science

Websites:
http://www.jofamericanscience.org
http://www.sciencepub.net

Emails:
editor@sciencepub.net
sciencepub@gmail.com

MARSLAND PRESS
Multidisciplinary Academic Journal Publisher

# Seroprevalence of Bovine Brucellosis under Extensive Production System in Wolaita Zone, Southern Ethiopia

Yohannes Hailemichael [1], Fufa Abunna [2], Buruk ushula [3]

[1] Assosa University, College of Agriculture and Natural Resource, Department of Veterinary Science, Western Ethiopia, P.O. BOX 18, Email Address: hmichaelyohannes123@gmail.com; Phone: +251-911-93-04-27
[2] Addis Ababa University, College of Veterinary Medicine and Agriculture, East Shoa, Ethiopia
[3] Jijiga University College of Veterinary Medicine, Eastern Ethiopia

**Abstract:** A cross-sectional epidemiological study was carried out in Sodo Zuria and Humbo districts of Wolaita zone southern Ethiopia from November 2016 to April 2017 to determine the seroprevalence and potential risk factors for bovine brucellosis in cattle under extensive production systems. The study populations comprised both indigenous and cross breed cattle were kept with other species such as sheep and goats. Serum samples were collected from 462 extensively managed cattle at least one year of age by using multistage sampling technique. All serum screened for Brucella antibodies by the Rose Bengal Plate Test and reactor sera were further tested by the Complement Fixation Test. Moreover, information was gathered on individual animal and herd level risk factors by using a structured questionnaire survey. The overall seroprevalence of brucellosis was 1.3% (95% CI: 0.5-3) and 5.8% (95% CI: 2-12) at both animal and herd level respectively. The result indicated that there was a statistically significant increase in seroprevalence of brucellosis in cow with history of abortion and retained placenta. Nevertheless, in the multivariable logistic regression analysis, herd size (p = 0.02, OR=13.7, CI: 1. 4 -29.7) and abortion (p = 0.01, OR=9.8, CI: 1.5 - 64.4) were statistically significant risk factors for individual animal seroprevalence. Control measures such as culling of aborted animal, proper disposal of aborted fetus, pasteurization or boiling of milk before consumption should be carried out to reduce risk of infection and transmission of the disease in livestock and human in the study area.
[Yohannes Hailemichael, Fufa Abunna Buruk ushula. **Seroprevalence of Bovine Brucellosis under Extensive Production System in Wolaita Zone, Southern Ethiopia.** *J Am Sci* 2020;16(10):7-20]. ISSN 1545-1003 (print); ISSN 2375-7264 (online). http://www.jofamericanscience.org. 2. doi:10.7537/marsjas161020.02.

***Key words***: Bovine brucellosis —Ethiopia — Risk factors—Seroprevalence —Wolaita

## 1. Introduction

Ethiopia maintains huge number of livestock population ranking first in Africa. A huge and diverse livestock species of Ethiopia is maintained under different agro-ecological zones, management, migration and animal health care system. Livestock represents a major national resource and form an integral part of the agricultural production system (IFPRI, 2006; Lobago *et al*., 2006).

Comparatively huge livestock resources of the country and the economic return gained from this subsector do not coincide. The main technical limitations on livestock development and that determine the biological efficiency of production in Ethiopia are inadequate feeding, poor animal health, low potential of the genotypes used for yield traits and the traditional low input livestock management practices (Shiferaw *et al*., 2003). Bovine brucellosis is one of these limiting factor and has been reported from several parts of the country (Bekele *et al*., 2000; Tolosa *et al*., 2008; Kebede *et al*., 2008; Asmare *et al*.,2010; Megersa *et al*., 2011; Adugna *et al*.,2013, Alemu *et al*., 2014, Bashitu *et al*., 2015; Asegdom *et al*., 2016).

Brucellosis is an infectious contagious bacterial disease usually caused by *Brucella abortus* in cattle, *B. melitensis* or *B. ovis* in small ruminants, *B. suis* in pigs and *B. canis* in dogs. It is slow-growing, Gram negative, small cocobacilli and intracellular bacteria that is capable to survive and multiply within epithelial cells, placental trophoblasts, dendritic cells and macrophages (Gorvel, 2008).

The disease is an important zoonosis that exists worldwide and is more or less endemic in most African countries (John *et al*., 2002). It causes significant reproductive losses in animals. Abortions, placentitis, stillbirth and birth of weak offspring in female and epididymitis and orchitis in male are the most common consequences (OIE, 2009). Bovine brucellosis is an infectious and contagious disease known for its impact on reproductive performance of cattle in Africa (McDermott and Arimi, 2002). The disease is primarily caused by *Brucella abortus* and occasionally by *Brucella melitensis* where cattleare

kept together with infected sheep or goats (OIE, 2009). Bovine brucellosis has been eradicated in most developed countries that have implemented a tight eradication program (Makita *et al*., 2008). Yet, it is prevalent in the Mediterranean basin, Middle East, Western and Central Asia, Latin America, Africa and India.

The disease has a considerable impact on animal and human health, as well as wide socio economic impacts, especially in countries in which rural income relies largely on livestock breeding and dairy products (Roth *et al*., 2003). It poses a barrier to trade of animals and animal products, an impediment to free animal movement. The economic and public health impact of brucellosis remains of concern in developing countries (Roth *et al*., 2003).

The epidemiology of brucellosis in livestock and cost-effective prevention measures are not well understood and available data are limited particularly in sub-Saharan countries (McDermott and Arimi, 2002). Hence, brucellosis remains widespread in livestock population and presents enormous economic and public health problems. It also causes losses due to abortion or breeding failure in the affected animal population, diminished milk production and causing reduced work capacity through sickness of the affected human (FAO, 2003).

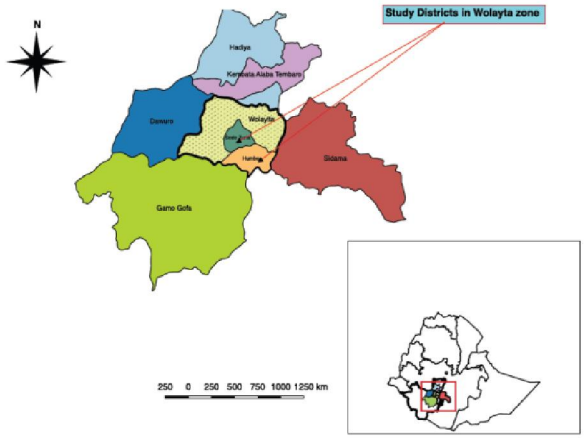
Brucellosis is endemic in Ethiopia since 1970. Since then, few fragmented studies have demonstrated thepresence of antibodies against Brucella in animals and humans in different parts of the country. The prevalenceof brucellosis has been found to range from 0.2% to 38% in cattle (Bekele *et al*., 2010; Ibrahim *et al*., 2011).

Though various prevalence studies of brucellosis were carried out in different agro-ecological zones of country, there is limited information on the status of bovine brucellosis in Wolaita zone of SNNP region.

In present study we determine the seroprevalence of bovine brucellosis and its associated risk factors in cattle under traditional extensive husbandry in Wolaita zone, Southern Ethiopia.

## 2. Materials and Methods

The present study was conducted in Sodo Zuria and Humbo districts of Wolaita zone southern Ethiopia. The study areas situated at6º35’ N 37º 50’ E to 6º53 N 37º 49’ E. Wolaita zone is one of the thirteen zones of the SNNPR region covering an area of 4471.3 km$^2$. It is located at a distance of 332 km. south of Addis Ababa and 157 km away from Hawassa town. It is one of the Omotic speaking people inhabiting the basins of Omo River and Lake Abaya. For administrative purpose the zone is divided in to twelve woredas or districts. Topographically it lies on an elevation ranging from 1200 to 2950 meters above sea level. The rainfall pattern is bimodal, a short rainy season runs from March to May and long rainy season runs from June to September. The mean annual temperature of the zone is about 19°C being maximum in February which is 29°C and minimum in August which is 15°C. Regarding the land utilization data, 261,000 hectares (ha) is used for cultivation, 5318 ha for grazing, 8261 ha for Bush- land and the remaining 35382.5 ha is a cultivable land. The farming system of the study area is largely characterized by mixed crop-livestock production system. Considerably, variable number and diversity of animal species are maintained under traditional extensive management system. Livestock production system is generally predominated by extensive system in which animals are allowed to forage freely during day time and kept in house during the night. (WZFEDD, 2013; CSA, 2008).




A cross-sectional epidemiological study was carried out on both indigenous and cross breed cattle to determine seroprevalance of brucellosis and their association with different risk factors using two serological tests Rose Bengal Plate Test (RBPT) and Complement Fixation Test (CFT) and structured questionnaire survey from November 2016 to April 2017 in Wolaita zone, Southern Ethiopia.

In order to determine the desired sample size, there were no previous reports of prevalence of brucellosis in the present study area. Therefore, the average expected prevalence rate was assumed to be 50% for the area within 95% confidence interval (CI) at 5% desired precision as stated by Thrusfield (2007). Hence, using the formula, calculated sample for the current study becomes 384 heads of cattle; however, a total of 462 serum samples (234 from Humbo and 228 from Sodo Zuria districts) of both sexes having different ages were sampled to increase the precision of the result.

$$N = \frac{(1.96)^2 P (1-P)}{d^2}$$

Where
N= Total calculated sample size
P= expected prevalence
d= absolute precision

Data was collected and stored in Microsoft (MS) Excel Spread Sheet program and Categorical variables were summarized as frequency and percentages while continuous variables were summarized as mean ± standard deviation (SD). Descriptive statistical analysis of various risk factors and dependent variables were done using (STATA software version 13). The Fisher's exact test was used to test *Brucella* seroprevalence association with incriminated categorical risk factors. The total prevalence was calculated by dividing the number of RBPT- and CFT-positive animals by the total number of animals tested. Herd prevalence was calculated by dividing the total number of herds with at least one reactor in RBPT and CFT by the number of all herds tested. In these study a herd, defined as the total number of cattle belonging to the same household. Univariate logistic regression was used to test the significance of the effect of different risk factors on sero-prevalence of brucellosis. Odds ratio (OR) was utilized to measure the degree of association between risk factors and *Brucella* seropositivity. All risk factors that hadnon-collinear effect and p-value < 0.25 in the univariable logistic regression analysis were subjected to multivariable logistic regression analysis. Age of animals were categorized into <3, 3–6 and >6 years; herd size was categorized into<6, 6–10 and >10 heads of cattle and parity number 0,1 and >1was categorized as nullparous, monoparous and multiparous.

## 3. Results

A total of 462 animals, 105(22.7%) male and 357(77.3%) female animals above 1 year of age were sampled for *B. abortus* antibodies. Of which 10 (2.2%) (95% CI: 1-4) animals tested positive by RBT and 6 animals were confirmed positive by CFT, giving seroprevalence of 1.3% (95% CI: 0.5- 3) (Table 1).

The prevalence of bovine brucellosis was significantly higher in animals included in herd size greater than 10 (p = 0.009). Seroprevalence rate of 2.03% was observed in older animals (>6 years) and 1.23% in animals within 3-6 years old. No animal less than 3 years old was found to be seroreactive.

All seropositive animals were females and were either pregnant or lactating. Except for the cow with history of abortion and RFM, other variables did not significantly associate with animal level seropositivity in female animals. The seroprevalences of brucellosis were significantly associated with aborting cows (p=0.035) and cows with a history of RFM (p=0.011) (Tables 2, 3, 4).

Table 1: Brucellosis seropositivity at individual animal level

| Risk factors | No. Tested | RBPT positive (%) | CFT positive No. (%) | p-value |
|---|---|---|---|---|
| **Study districts** | | | | 0.216 |
| Humbo | 234 | 7 (2.99%) | 5 (2.13%) | |
| Sodo Zuria | 228 | 3(1.3%) | 1 (0.44%) | |
| **Age** | | | | 0.438 |
| <3 years | 103 | 0 (0%) | 0 (0%) | |
| 3-6 years | 162 | 2(1.23%) | 2 (1.23%) | |
| >6years | 197 | 8(4.06%) | 4 (2.03%) | |
| **Sex** | | | | 0.345 |
| Female | 357 | 10(2.8%) | 6 (1.68%) | |
| Male | 105 | 0(0%) | 0 (0%) | |
| **Breed** | | | | 1.00 |
| Local | 364 | 9(2.74%) | 5 (1.37%) | |
| Cross | 98 | 1(1.02%) | 1 (1.02%) | |
| **Herd size** | | | | 0.009 |
| <6 | 221 | 4(1.8%) | 1 (0.45%) | |
| 6-10 | 168 | 2 (1.19%) | 1 (0.59%) | |
| >10 | 73 | 4(5.48%) | 4 (5.48%) | |
| **Repro. Status** | | | | 0.530 |
| Heifer | 80 | 0(0%) | 0 (0%) | |
| Pregnant | 111 | 4(3.6%) | 2 (1.8%) | |
| Lactation | 140 | 5 (3.57%) | 4 (2.85%) | |

| | | | | |
|---|---|---|---|---|
| Dry | 26 | 1(3.85%) | 0(0%) | |
| **Mating system** | | | | 0.172 |
| Non | 79 | 0(0%) | 0(0%) | |
| Natural | 190 | 6(3.57%) | 3(1.57%) | |
| AI | 51 | 1(1.96%) | 1(1.96%) | |
| Mixed | 37 | 3(8.1%) | 2(5.4%) | |
| **Parity** | | | | 0.061 |
| Null parous | 115 | 0(0%) | 0(0%) | |
| Mono parous | 70 | 0(0%) | 0(0%) | |
| Multiparous | 172 | 10(5.8%) | 6(3.5%) | |
| **Abortion** | | | | 0.035 |
| Absent | 338 | 8(2.37%) | 4(1.18%) | |
| Present | 19 | 2(10.5%) | 2(10.5%) | |
| **RFM** | | | | 0.011 |
| Absent | 325 | 5(1.54%) | 3(0.9%) | |
| Present | 32 | 5(15.6%) | 3(9.37%) | |

Table 2: Individual animal level seroprevalence of brucellosis and associated risk factors

| Risk factors | No. Tested | CFT positive (%) | 95%CI | OR | P-value |
|---|---|---|---|---|---|
| **Study districts** | | | | | |
| Humbo | 234 | 5 (1.86%) | | | |
| Sodo Zuruia | 228 | 1 (0.44%) | 0.02, 1.74 | 0.20 | 0.14 |
| **Breed** | | | | | |
| Local | 364 | 5(1.37%) | | | |
| Cross | 98 | 1(1.02%) | 0.1, 6.4 | 0.74 | 0.78 |
| **Herd size** | | | | | |
| <6 | 221 | 1(0.45%) | | | |
| 6-10 | 168 | 1(0.59%) | 0.1, 21.2 | 1.32 | 0.85 |
| >10 | 73 | 4 (5.48%) | 1.4, 26.0 | 12.75 | 0.02 |
| **Abortion (n=357)** | | | | | |
| Absent | 338 | 4(1.18%) | | | |
| Present | 19 | 2(10.5%) | 1.7, 57.4 | 9.82 | 0.01 |
| **RFM (n=357)** | | | | | |
| Absent | 325 | 3(0.9%) | | | |
| Present | 32 | 3(9.37%) | 2.14, 57.52 | 11.10 | 0.00 |

Table 3: Herd level seroprevalence of brucellosis and associated risk factors

| Variables | No. herd tested | CFT Positive (%) | 95% CI | OR | p- value |
|---|---|---|---|---|---|
| **Study Districts** | | | | | |
| Humbo | 50 | 5 (10%) | | | |
| Sodo Zuria | 54 | 1 (1.85%) | 0.02, 1.5 | 0.17 | 0.11 |
| **Herd size** | | | | | |
| <6 | 55 | 2 (3.6%) | | | |
| 6-10 | 35 | 3 (8.6%) | 0.4, 15.7 | 2.48 | 0.33 |
| >10 | 14 | 1 (7.1%) | 0.2, 24. 2 | 2.04 | 0.57 |
| **Abortion** | | | | | |
| Present | 19 | 3 (15.8%) | 0.9, 27.7 | 5.12 | 0.06 |
| Absent | 85 | 3 (3.5%) | | | |
| **RFM** | | | | | |
| Present | 29 | 5(17.2%) | 1.7, 138.6 | 15.4 | 0.01 |
| Absent | 75 | 1(1.3%) | | | |

Table 4: Multivariable logistic regression analyses

| Risk factors | No. Tested | CFT Positive No. (%) | 95%CI | OR | P-value |
|---|---|---|---|---|---|
| **Herd size** | | | | | |
| <6 | 221 | 1 (0.45%) | | | |
| 6-10 | 168 | 1 (0.59%) | 3.9, 26.2 | 1.6 | 0.74 |
| >10 | 73 | 4 (5.48%) | 1.4, 29.7 | 13.7 | 0.02 |
| **Abortion** | | | | | |
| Absent | 338 | 4 (1.18%) | | | |
| Present | 19 | 2 (10.5%) | 1.5, 64.4 | 9.8 | 0.01 |

## 4. Discussion

Cross-sectional serological study, attempted to look the status of bovine brucellosis in two districts of Wolaita zone, southern Ethiopia. The study reveals that, the animal level prevalence of bovine brucellosis in extensive management system was found to be (1.3%). This relatively low prevalence might be attributable to extensive grazing conditions; these could reduce both animal to animal contact and the contamination of pastures under dry climatic conditions (Crawford *et al*., 1990; Adugna *et al*., 2013). Another explanation could be that, in the area studied, most of the farmers partly practice alternative farm products such as cash crops. Therefore, in the area small numbers of animals (on average five animals) are kept separately and free movement of animals were restricted and are tied around farmland specially during crop harvesting in order to feed on byproducts (post-harvest products) of the farms as reported by (Megersa *et al*., 2011). In the present study area, the majority of farmers replace their animals from their own stock instead of buying animals from markets.

Corresponding present study the low prevalence of bovine brucellosis has been reported in other studies on cattle under similar production systems in different parts of Ethiopia; 1.66% prevalence reported from Sidama zone (Asmare *et al*., 2010), 1% from Benshangul Gumuz (Adugna *et al*., 2013), 1.97% from East Wollega (Moti *et al*., 2012), 1.2% from Western Tigray (Haileselassie *et al*., 2010), 1.7% from Arsi Zone (Tsegaye *et al*., 2016) and3.3% from Alage district (Asgedom *et al*.,2016). It also agrees with 2% from Sudan (Senein and Abdelgadir, 2012), 2.77% from Eritrea (Scacchia *et al*., 2013). Lower prevalence of brucellosis also has been reported in intensive farms (Bashitu *et al*., 2015; Asgedom *et al*., 2016). On the contrary higher prevalence has been reported from the highland areas of Ethiopia among cattle in smallholder production systems based on the same diagnostic tests (Kebede *et al*., 2008). This variation is merely due to differences in cattle production systems (Mohan *et al*., 1996). Based on the same test, a higher prevalence was also reported in pastoral areas, compared with an extensive cattle production system (Dinka & Chala 2009; Tibesso *et al*., 2014).

The present study showed that there is non-significant difference in seroprevalence of brucellosis between the two districts (Sodo Zuria and Humbo). This finding is in agreement with the report of (Berhe *et al*., 2007; Ibrahim *et al*., 2009; Adugna *et al*., 2013). This could be due to similarity among traditional management systems in the two districts and where sedentary livestock raising is predominant. The study also revealed that all seropositive animals were females. This finding agrees with the reports by (Kebede *et al*., 2008; Tolosa *et al*., 2008; Dinka & Chala 2009; Adugna *et al*., 2013). However, Hailemelekot *et al*., (2007) reported 2.11% seroprevalence of brucellosis in male under extensive management system. Female animals are maintained in herds over extended time period thus, have ample time for exposure to the pathogen and being source of infection for other animals (Megersa *et al*., 2011; Adugna *et al*., 2013). Other explanation for this finding could be that the number of male animals in each herd was low and were mostly reared separately, thus the chance of exposure is lower for males.

Breed of animal was not significantly associated with brucellosis in this study. Breed differences in susceptibility have not been clearly documented in cattle, although genetically determined differences in susceptibility of individual animals have been demonstrated (Corbel, 2006). There is still argument among different authors on the issue of breed susceptibility to brucellosis. In this study, the seroprevalence was found to be higher in local breed animals (1.37%) than cross breed (1.02%). However, this difference was not statistically significant which is in agreement with the report of (Lidia, 2008) and (Moti *et al*., 2012) in central highland and East

Wollega zone of Ethiopia respectively. This could be due to, limited number of cross breed animals in this study because of their low number in extensive production system. On the contrary, (Jergefa *et al*., 2009) in their study found that breed of cattle has significant effect on the sero prevalence of brucellosis and is higher in crossbreed than in indigenous ones. This is due to the compounded effect of management systems in cross-breed and also the farmers who owned cross-bred tend to follow intensive management.

The present study also revealed that the seroprevalence of bovine brucellosis was not significantly associated with the age of the cattle. Brucellosis appears to be more associated with sexual maturity (Radostits *et al*., 2007), and higher seroprevalence is repeatedly reported in sexually matured animals. In this study, seropositive to brucellosis were insignificantly higher in age greater than three years including males. This agrees with the report of (Asfaw *et al*., 1998; Bekele *et al*., 2000; Omer *et al*., 2000; Jergefa *et al*., 2009; Asmare *et al*., 2010; Adugna *et al*., 2013). In this study, seropositivity occurred only in cow having mono parity. Similarly, higher seropositivity has been reported in other studies in animals older than five years, when compared with younger animals (Berhe *et al*., 2007; Dinka & Chala, 2009; Adugna *et al*., 2013). Seroprevalence may increase with age as a result of acquired immunity in infected animals and prolonged exposure to pathogen.

Herdsize remained independently and significantly associated with the animal level seropositivity to brucellosis in this study. This finding is in agreement with the reports (Asfaw *et al*., 1998; Tolosa *et al*., 2008; Asmare *et al*., 2010, Haileselassie *et al*., 2010; Ibrahim *et al*., 2010; Adugna *et al*., 2013;). An increase in herd size is usually accompanied by an increase in stocking density, as well as an increase in the risk of exposure to infection. Stocking density is an important determinant of the potential for transmission between susceptible and infected animals (Crawford 1990; Omer *et al*., 2000). In this study the number of animals per herd was generally low, with a maximum herd size of 18 animals, which is typical of mixed livestock and crop production. This would suggest that the risk of brucellosis increases with herd size. Similarly, the increased herd seropositivity has been reported in Zimbabwe (Matope *et al*., 2010). The result of present study indicates that bovine brucellosis should be considered in extensive production system as in intensive production in Ethiopia.

There was no seropositive reactor in nulliparous, monoparous as well as in animals less than 3 years of age. This finding correspondence with the report of 0.0% by (Ibrahim *et al*., 2009), 0.69% (Berhe *et al*., 2007), 1.4% (Kebede *et al*., 2008) for the same group of animals. This shows that brucellosis is highly related with age and sexual maturity of animals. The reproductive status did not significantly determine seropositivity in the present study. However, all seropositive animals were either pregnant or lactating. This agrees with the report of (Omer *et al*., 2000; Tolosa *et al*., 2008; Adugna *et al*., 2013). Sexually mature and pregnant cows are more susceptible to infection with *Brucella* than sexually immature cattle of either sex. This has been attributed to the affinity of these bacteria to the pregnant uterus and to erythritol in fetal tissue, possibly also to steroid hormones (Radostits *et al*., 2000).

Seroprevalence of brucellosis was significantly associated in cow with history of abortion and placenta retention in the current study. Thus the history of abortion and placenta retention were found to be 10 and 11times more likely to be seropositive when compared to no history of abortion and RFM respectively. Association between brucellosis seroprevalence and occurrence of abortion and placenta retention also reported (Berhe *et al*., 2007; Tolosa *et al*., 2008; Ibrahim *et al*., 2010; Adugna *et al*., 2013; Tsegaye *et al*., 2016). Due to its collinearity with history of abortion, history RFM was not included in the multivariable analysis. The reason is that, in most case the effects of abortion leads to placenta retention. This could be explained probably by the fact that abortion is the typical outcome of brucellosis infections (Schelling *et al*. 2003).

The overall herd level seroprevalence of bovine brucellosis was 5.8%, which is comparable to herd level seroprevalence report of 3.3% (Haileselassie *et al*., 2010), 4.9% (Adugna *et al*., 2013) and 7.3% (Tsegaye *et al*., 2016) under extensive management systems. Nevertheless, higher herd level seroprevalences have been reported in other parts of Ethiopia in herds under extensive production systems (Berhe *et al*.,2007; Kebede *et al*., 2008; Tolosa *et al*., 2008; Dinka & Chala 2009; Jergefa *et al*., 2009; Asmare *et al*.,2010; Ibrahim *et al*., 2010; Asgedom *et al*., 2016). Similarly higher herd-level prevalence has also been reported in dairy cattle in other African countries (Matope *et al*., 2010). This inconsistency could be due to relatively larger herd sizes compared with herds in this study and different in management.

Cow with a history of RFM was significantly affects herd seropositivity. The herd seroprevalence of brucellosis was higher in herds that had a history of RFM (17.2%), compared with no history of RFM (1.3%). This could be explained by the fact that retained placenta is typical outcomes of brucellosis. On the contrary the presence of a cow with a history of abortion did not significantly affect herd

seropositivity. However, the herd seroprevalence of brucellosis was higher in herds that had history of abortion (15.8%) compared with non-aborted (3.5%). This could be due to the presence of other causes of abortion in herd. This finding is in agreement with a previous reports (Kebede *et al*., 2008; Adugna *et al*., 2013).

A total of 80 cattle owners and attendants were interviewed to assess their awareness levels regarding animal management, brucellosis and occupational risks using structured questionnaire. Knowledge of diseases is a crucial step in the development of prevention and control measures (Prilutski, 2010). Despite huge efforts of the government and non-government institutions to improve animal production in the areas, general knowledge of brucellosis among the farmers was still poor. The educational status attained by majority of the respondents was low which falls between illiterate and lower grades. This low level of educational status may lead to reduced production of dairy farms because of low use of dairy innovations such as cultivation of improved forages, breeding techniques and use of modern dairy farming. In addition to this, personal hygiene, proper disposal of aborted materials and the use of a separate parturition pen were not under consideration. These could have led high risks of transmitting the disease within and between the herds and human. This is in agreement with previous studies in extensive livestock production system (Ragassa *et al*. 2009; Megersa *et al*. 2011; Adugna *et al*., 2013). Likewise, mixing of different animal species having its own economic importance also increases the chances of transmission of brucellosis to the cattle.

The occurrence of brucellosis in humans is associated with contact with domestic animals (Alballa, 1995), exposure to aborted animals and assisting animal parturition (Cooper 1992; Kozukeev *et al*. 2006). In this study, the majority of the farmers have the habit of drinking raw milk and assisting parturition. This implies that little attention has been given to preventing brucellosis and that this, in turn, contributes to the spread and transmission of the infection to human in the area.

The present study has established that the bovine brucellosis persists at a low seroprevalence in Wolaita zone southern Ethiopia. The seroprevalence of bovine brucellosis was found to be 1.3% and 5.8% at animal level and herd level respectively. The low awareness of livestock owners on zoonotic importance of brucellosis and custom of consumption of raw milk, assisting parturition and handling of aborted materials were to be risk factors for human brucellosis. Therefore, the low prevalence of brucellosis in the present study area could serve as source of infection to other cattle of the different herd as there is free movement of animals between herds.

Community educational program should be carried out targeting brucellosis in the areas to aware livestock owners as well as general public in order to avoid direct or in direct contact with infected animals and their products.

**Acknowledgements**

We are grateful to Addis Ababa University College of Veterinary medicine for their help during my all academic years and express my deepest and sincere gratitude to my advisor Dr. Fufa Abunna Addis Ababa university (AAU), college of veterinary medicine and agriculture (CVMA) for his overall research guidance and taking his time to correct this manuscript.

**Corresponding Author:**
Dr. Yohannes Hailemichael
Department of Veterinary Science
Assosa, Ethiopia
Telephone: +251-911-93-04-27
E-mail: hmichaelyohannes123@gmail.com

**References**

1. Abernethy, D. A., Menzies, F. D., McCullough, S. J., McDowell, S. W. J., Burns, K. E., Watt, R., Gordon, A.W., Greiner, M. and Pfeiffer, D. U. (2012): Field trial of six serological tests for bovine brucellosis. *Vet. J.*, 191: 364–370.
2. Acha, N. & Szyfres, B. (2001): Zoonoses and communicable diseases common to man and animals, 3rd Ed. Vol I: Bacteriosis and mycosis. Scientific and technical publication No. 580. Pan American Health Organization, American Sanitary Bureau, Regional Office of the World Health Organization, Washington. DC, 40–62.
3. Acha, N., Szyfres, B. (2003): Zoonoses and Communicable Diseases Common to Man and Animals, 3rd ed., vol.1. Pan American Health Organization (PAHO), Washington, DC, 52-58.
4. Adone, R. & Pasquali, P. (2013): Epidemiosurveillance of brucellosis. *Rev. Sci. Tech. Offi. Inter. Epizo*., 32: 199–205.
5. Adugna, K., Agga, G. & Zewde, G. (2013): Seroepidemiological survey of bovine brucellosis in cattle under a traditional production system in western Ethiopia 32-3 of the Scientific and Technical Review.
6. Agasthya, S., Isloor, S., Krishnamsetty, P. (2012): Seroprevalence study of human brucellosis by conventional tests and indigenous

indirect enzymelinked immunosorbent assay. *Sci. Wrld. J*., 1: 1-5.
7. AHA (2005): Disease strategy: Bovine brucellosis (version 3.0). Australian Veterinary Emergency Plan (AUSVETPLAN), Edition 3, Primary Industries Ministerial Council, Canberra, ACT.
8. Ahmed, A. M. (2009): Seroprevalence of cattle brucellosis in Gabiley District, Somaliland, Thesis research submitted to STVS as a partial fulfillment of requirements for the award of the Diploma in Livestock Health Sciences (DLH), Somaliland, Somalia.
9. Al Dahouk, S., Tomaso, H., Nöckler, K., Neubauer, H., Frangoulidis, D. (2003): Laboratory-based diagnosis of brucellosis--a review of the literature. Part I: Techniques for direct detection and identification of *Brucella* spp. *Clin. Lab*., 49: 487-505.
10. Alballa, S.R. (1995): Epidemiology of human brucellosis in southern Saudi Arabia. *J. Trop. Med. Hyg*., 98:185–189.
11. Alem, W. & Solomon, G. (2002): A retrospective sero-epidemiology study of bovine Brucellosis in different production systems in Ethiopia. In: Proceeding of 16th Annual Conference, Addis Ababa, Ethiopia. Pp 53-57.
12. Alemu, F., Admasu, P. Feyera, T. & Niguse A. (2014): Seroprevalence of Bovine brucellosis in Eastern Showa, Ethiopia. *Acd. J. Anml. Dis*., 3(3): 27-32.
13. Anonymous, (2000): Brucellosis. Iowa State Department of Public Health. http://idph.state.ia.us/adper/common/pdf/epi_manu al/brucellosis.pdf accessed on May 16, 2007.
14. Araj, G. F. (2010): Update on laboratory diagnosis of human brucellosis. *Int. J. Antimicr. Agnts*., 36 Suppl, 1: S12-17.
15. Asfaw, Y., Molla, B., Zessin, K. H. & Tegegne, A. (1998): A cross-sectional study of bovine brucellosis and test performance in intra-and peri-urban production systems in and around Addis Ababa, Ethiopia. *Bull. anim. Hlth. Prod. Afr*., 46: 217–224.
16. Asgedom, H., Damena, D. & Duguma, R. (2016): Seroprevalence of bovine brucellosis and associated risk factors in and around Alage district, Ethiopia. *Sprin. Plus*., 5:851.
17. Asmare, K., Asfaw Y., Gelaye, E. & Ayelet, G. (2010): Brucellosis in extensive management system of zebu cattle in Sidama zone, southern Ethiopia. *Afr. J. agric. Res*., 5 (3): 257–263.
18. Aulakh, H. K., Patil, P. K., Sharma, S., Kumar, H., Mahajan, V. & Sandhu, K. S. (2008): A Study on the Epidemiology of bovine brucellosis in Punjab (India) using milk-ELISA. *Acta. Vet. Brno*., 77: 393–399.
19. Bashitu, L. Afera, B. Tuli, G. & Aklilu, F. (2015): Sero-Prevalence Study of Bovine brucellosis and its Associated Risk Factors in Debrebirhan and Ambo Towns. *J. Adv. Dairy Res*., 3:1-4.
20. Bekele, A., Molla, B., Asfaw, Y. & Yigezu, L. (2000): Bovine brucellosis in ranches and farms in southeastern Ethiopia. *Bull. anim. Hlth. Prod. Afr*., 48: 13–17.
21. Bekele, M., Biffa, D., Abunna, F., Regassa, A., Godfroid, J. and Skjerve, E. (2011): Seroprevalence of brucellosis and its contribution to abortion in cattle, camel and goat kept under pastoral management in Borana, Ethiopia. Tropical Animal Health and Production, 43(3): 651-656.
22. Berhe, G., Belihu, K. & Asfaw, Y. (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.
23. Blasco, J. M., Garin, B., Marin, C. M., Gerbier, G., Fanlo, J., Bagues, M. P. & Cau, C. (1994): Efficacy of differentiating Rose Bengal and Complement Fixation antigen for diagnosis of *Brucella melitensis* in sheep and goats. *Vet. Rec*., 134: 415–420.
24. Boschiroli, M. L., Foulongne, V., O'Callaghan, D. (2001): Brucellosis: a worldwide zoonosis. *Curr. Opin. Microbiol*., 4: 58-64.
25. Bricker, B. J. (2002): Diagnostic strategies used for the identification of *Brucella*. *Vet. Microbiol*., 90: 433-434.
26. Bwala, D. G., McCrindle, C., Fasina, O. F. & Ljagbone, L. (2015): Abattoir characteristics and sero-prevalence of bovine Brucellosis in cattle slaughtered at Bodija Municipal Abattoir, Ibadan, Nigeria. *J. Vet. Med. Anim. Hlth*., 7(5):164-168.
27. Central Statistical Agency (CSA) (2008): Agricultural sample survey 2007/08: report on livestock and livestock characteristics (private peasant holdings). Statistical bulletin No. 417, Vol. II. Federal Democratic Republic of Ethiopia, Addis Ababa.
28. CFSPH (2009): Bovine Brucellosis: *Brucella abortus*. College of Veterinary Medicine, Iowa State University, Ames, Iowa.
29. Chain, E., M. E. Tolmasky & Garcia, E. (2005): Whole genome analyses of speciation events in pathogenic *Brucella*. *Infec. Immun*., 73: 8353-8361.
30. Cheville, N. F., Olsen, S. C., Jensen, A. E., Stevens, M. G., Palmer, M. V. & Florance, A.

M. (1996): Effects of age at vaccination on efficacy of *Brucella abortus* strain RB51 to protect cattle against brucellosis. *Am. J. Vet. Res*., 57: 1153–1156.
31. Christopher, S., Umapathy, B. L., Ravikumar, K. L. (2010): Brucellosis: review on the recent trends in pathogenicity and laboratory diagnosis. *J. Lab. Physic*., 2: 55-60.
32. Chukwu, C.C. (1985): Brucellosis in Africa, Part I. The prevalence. *Bull. Anim. Hlth. Prod. Afr*., 35:92-98.
33. Colibaliy, N. D. & Yamego, K. R. (2005): Prevalence and control of Zoonotic disease: collaboration between public health workers and veterinarians in Burkina Faso. *Acta. Tropica.*, 76: 53-57.
34. Cooper, C. W. (1992): Risk factors in transmission of brucellosis from animals to humans in Saudi Arabia. *Trans. R. Soc. Trop. Med. Hyg*., 86: 206–209.
35. Corbel, M. J. (2006): Brucellosis in humans and animals. Produced by the, WHO in collaboration with the, FAO and OIE, Geneva.
36. Crawford, R. P., Huber, J. D., Adams B. S. (1990): Epidemiology and Surveillance. In Animal brucellosis. Edited by: Nielsen K, Duncan *J.R. CRC Press Inc.,* Florida; 131-148.
37. De Miguel, M. J., Marín, C. M., Muñoz, P. M., Dieste, L., Grilló, M. J., *et al.* (2011) Development of a selective culture medium for primary isolation of the main *Brucella* species. *J. Clin. Microbiol*., 49: 1458-1463.
38. De-Lahunta, A., Habel, R. (1986): Applied Veterinary Anatomy. USA: WB Saunders Company Pp 4-12.
39. Degefa, T., Duressa, A. & Duguma, R. (2011): Brucellosis and some reproductive problems of indigenous Arsi cattle in selected Arsi Zone's of Oromia Regional State, Ethiopia. *Glob. Vet*., 7 (1): 45-53.
40. Degefu, H., Mohamud, M., Hailemelekot, M. & Moti, Y. (2011): Seroprevalence of bovine brucellosis in agro pastoral areas of Jijjiga zone of Somali National Regional State, Eastern Ethiopia, Ethiopian. *Vet. J*., 15 (1): 37-47.
41. Delrue, R. M., Lestrate, P., Tibor, A., Letesson, J. J. & Bolle, X. (2004): *Brucella* pathogenesis, genes identified from random large-scale screens. *FEMS. Microbiol. Lett*., 231: 1–12.
42. Deselgn, T. B. & Gangwar, S. K. (2011): Seroprevalence study of bovine brucellosis in Assela government dairy farm of Oromia Regional State, Ethiopia. Short communication, *Int. J. Sci. Natr*., 2(3): 692- 697.
43. Di Febo, T., Luciani, M., Portanti, O., Bonfini, B., Lelli, R., *et al.* (2012): Development and evaluation of diagnostic tests for the serological diagnosis of brucellosis in swine. *Vet Ital*., 48: 133-156.
44. Díaz, R., Casanova, A., Ariza, J., Moriyón, I. (2011): The Rose Bengal Test in human brucellosis: a neglected test for the diagnosis of a neglected disease. *PLoS. Negl. Trop. Dis*., 5: 950.
45. Dinka, H. & Chala, R. (2009): Seroprevalence study of bovine brucellosis in pastoral and agro-pastoral areas of east Showa zone, Oromia regional state, Ethiopia. *Am. Eurasian J. agric. environ. Sci*., 6 (5):508–512.
46. Dohoo, L., Martin, W., & Stryhn, H. (2003): Veterinary Epidemiologic Research. AVC Inc., University of Prince Edward Island, 550 University Avenue, Charlottetown, Prince Edward Island, Canada. Pp. 335-60.
47. Donde, B. G. (2013): Mycobacteria and zoonoses among pastoralists and their livestock in South-East Ethiopia. PhD Thesis, Basel University, Switzerland.
48. FAO (2003): Guidelines for coordinated human and animal brucellosis surveillance. FAO Animal Production and Health Paper 156, Rome, Italy, Pp. 1–45.
49. FAO, OIE and WHO (2006): Bucellosis in human and animals. Geneva, Switzerland. Pp. 10-35.
50. Farrell, I. D. (1974). The development of a new selective medium for the isolation of *Brucella abortus* from contaminated sources. *Res. Vet. Sci*. 16:280-286.
51. Folitse, R. D., Boi-Kikimoto, B. B., Emikpe, B. O. & Atawalna, J. (2014): The prevalence of Bovine tuberculosis and Brucellosis in cattle from selected herds in Dormaa and Kintampo Districts, Brong Ahafo region, Ghana. *Clin. Microbiol*., 5 (2):1-5.
52. Foster, R. A. & Ladds, P. W. (2007): Male genital system, In: Maxie MG, Ed. Pathology of Domestic Animals. 5th (ed). Elsevier Saunders: Philadelphia, Pp. 565–619.
53. Gall, D., Nielsen, K. (2004): Serological diagnosis of bovine brucellosis: a review of test performance and cost comparison. *Rev. Sci. Tech*., 23: 989-1002.
54. Gall, D., Nielsen, K., Forbes, L., Cook, W., Leclair, D., *et al.* (2001): Evaluation of the fluorescence polarization assay and comparison to other serological assays for detection of brucellosis in cervids. *J. Wildlife Dis*., 37: 110-118.
55. Gall, D., Nielsen, K., Vigliocco, A., Smith, P., Perez, B., *et al.* (2003): Evaluation of an indirect-linked immunoassay for presumptive

serodiagnosis of *B. ovis* in sheep. *Small Rum. Res*., 48: 173-179.
56. Gebretsadik, B., Kelay, B. & Yilkal, A. (2007): Seroepidemiological investigation of bovine brucellosis in the extensive cattle production system of Tigray region of Ethiopia. *Inter. J. App. Res. Vet., Med*., 5 (2): 65–71.
57. Godfroid, J, Scholz, H. C, Barbier, T. (2011): Brucellosis at the animal/ ecosystem/human interface at the beginning of the 21st century. *Prev. Vet. Med*. 102: 118-131.
58. Gorvel, J. P. (2008): *Brucella*: Mr "Hide" converted into Dr Jekyll. *Microb. Infect*. 10: 1010–1013.
59. Gumi, B., Firdessa, R., Yamuah, L., Sori, T. & Tolosa, T. (2013): Seroprevalence of brucellosis and Q-fever in Southeast Ethiopian Pastoral Livestock. *J. Vet. Sci. Med. Diag*., 2: 1.
60. Habtamu, T., Richard, B., Dana, H. & Kassaw, A. T. (2015): Camel brucellosis: Its Public Health and Economic Impact in Pastoralists, Mehoni District, Southeastern Tigray, Ethiopia. *J. Microbiol*., Res., 5 (5): 149–156.
61. Hadush, A., Pal, M. (2013): Brucellosis: An infectious re-emerging bacterial zoonosis of global importance. *Int. J. Liv. Hlth*., 3: 28-34.
62. Hailemelekot, M., Kassa, T. & Assfaw, Y., (2007): Seroprevalence study of bovine brucellosis in Bahir Dar milk shed, Northwestern Amhara Region. Eth., *Vet. J*. 11 (1): 49-65.
63. Haileselassie, M., Kalayou, S. & Kyule, M. (2010): Serological survey of bovine brucellosis in barka and arado breeds (Bos indicus) of Western Tigray, Ethiopia. *Prev. Vet. Med*., 94 (1–2):28–35.
64. Her, M., Cho, D. H., Kang, S. I., Cho, Y. S., Hwang, I. Y., *et al*. (2010): The development of a selective medium for the *Brucella abortus* strains and its comparison with the currently recommended and used medium. *Diagn. Microbiol. Infect. Dis*., 67: 15-21.
65. Hoover, D. and Friedlander, A. (1997): Brucellosis: Medical aspects of chemical and biological warfare. Textbook of Military Medicine Pp: 5013-5021.
66. IBM (2013): Interim Manual for Brucellosis in Cattle. Department of Agriculture, Fisheries and Forestry, Republic of South Africa.
67. Ibrahim, N., Belihu, K., Lobago, F. & Bekana, M. (2010): Sero-prevalence of bovine brucellosis and its risk factors in Jimma zone of Oromia region, south-western Ethiopia. *Trop. anim. Hlth. Prod*., 42 (1): 35–40.
68. IFPRI (2006): Atlas of the Ethiopian Rural Economy. International Food Policy Research Institute (Washington, DC), Central Statistical Agency (Addis Ababa), Ethiopian Development Research Institute (Addis Ababa).
69. Jergefa, T., Kelay B., Bekana, M., Teshale, S., Gustafson H. & Kindahl H. (2009): Epidemiological study of bovine brucellosis in three agro-ecological areas of central Oromiya, Ethiopia. *Rev. sci. tech. Off. int. Epiz*., 28 (3): 933–943.
70. John, J. M. & Arimi, S. M. (2002): Brucellosis in sub-Saharan Africa: epidemiology, control and impact. *Vet. Microbiol*., 90: 11-134.
71. Kang'ethe, E. K., Ekuttan, C. E., Kimani, V. N., Kiragu, M. W. (2007): Investigations into the prevalence of bovine brucellosis and the risk factors that predispose humans to infection among urban dairy and non-dairy farming households in Dagoretti Division, Nairobi, Kenya. *East Afr. Med. J.,* 84: 96-100.
72. Kattar, M., Zalloua, A., Araj, F., Samaha, K., foury, J., *et al*., (2007) Development and evaluation of real-time polymerase chain reaction assays on whole blood and paraffin-embedded tissues for rapid diagnosis of human brucellosis. *Diagn. Microbiol. Infect. Dis*., 59: 23-32.
73. Kebede, T., Ejeta, G. & Ameni, G. (2008): Sero-prevalence of bovine brucellosis in smallholder farms in central Ethiopia (Wuchale–Jida district). *Rev. Méd. vét*., 159:39.
74. Kho, J. & Splitter, G. A. (2003): Molecular host-pathogen interaction in brucellosis: Current understanding and future approaches to vaccine development for mice and humans. *Cli. Microbiolo. Rev*., 1: 65–78.
75. Ko, K. Y., Kim, J. W., Her, M., Kang, S. I., Jung. S. C., *et al*. (2012): Immunogenic proteins of *Brucella abortus* to minimize cross reactions in brucellosis diagnosis. *Vet. Microbiol*., 156: 374-380.
76. Kozukeev, T. B., Ajeilat, S., Maes, E., Favorov, M. (2006): Centers for Disease Control, Prevention (CDC). Risk factors for brucellosis, 1: 31–34.
77. Kubuafor, D. K., Awumbila, B., Akanmori, B. (2000): D. Seroprevalence of brucellosis in cattle and humans in the Akwapim-south district of Ghana: Public health implication. *Acta. Trop*., 76: 45-48.
78. Kunda, J., Fitzpatrick, J., Kazwala, R., French, N.P. and Shirima, G. (2007): Health-seeking behaviour of human brucellosis cases in rural Tanzania. *BMC Publ. Hlth*.,7: 315.
79. Lage, P., Poester, P., Paixão, A., Silva, A., Xavier. N., *et al*. (2008): Brucelose bovina: uma atualização. Revista Brasileira de Reprodução Anim. *Vet. Sci. J*., 4: 46-60.

80. Lapaque, N., Moriyon, I., Moreno, E., Gorvel, J. P. (2005): *Brucella* lipopolysaccharide acts as a virulence factor. *Curr. Opin. Microbiol.,* 8: 60–66.
81. Le Flèche, P., Jacques, I., Grayon, M., Al Dahouk, S., Bouchon, P., *et al*. (2006): Evaluation and selection of tandem repeat loci for a *Brucella* MLVA typing assay. *BMC Microbiol*., 6: 9.
82. Lidia, B. (2008): Seroprevalence study of bovine brucellosis in Central High Land of Ethiopia, DVM Thesis, Jimma University, Jimma, Ethiopia.
83. Lilenbaum, W., De Souza, G. N., Ristow, P., Moreira, M. C., Fraguas, S., Cardoso Vda, S. and Oelemann, W. M. (2007): A serological study on *Brucella* abortus, caprine arthritis-encephalitis virus and Leptospira in dairy goats in Rio de Janeiro. *Braz. Vet. J*., 173: 408–412.
84. Lim, J. J., Kim, D. H., Lee, J. J., Kim, D. G., Min, W., *et al*. (2004): Evaluation of recombinant 28 kDa outer membrane protein of *Brucella abortus* for the clinical diagnosis of bovine brucellosis in Korea. *J. Vet. Med. Sci*., 74: 687-691.
85. Lobago, F., Bekana, M., Gustafsson, H. & Kindahl, H. (2006): Reproductive performances of dairy cows in smallholder production system in Selalle, Central Ethiopia. *Trop. Anim. Health. Prod*., 38: 333-342.
86. Lopes, L. B., Nicolino, R., Haddad, J.P. A. (2010): Brucellosis risk factors and prevalence: a review. *Open Vet. Sci. J*. 4: 72–84.
87. López-Goñi, I., García-Yoldi, D., Marín, M., De-Miguel, J., Muñoz, M., *et al*. (2008): Evaluation of a multiplex PCR assay (Bruce-ladder) for molecular typing of all *Brucella* species, including the vaccine strains. *J. Clin. Microbiol*., 46: 3484-3487.
88. López, G., García, Y. & Marín, C. (2011): "Evaluation of multiplex PCR assay (Bruceladder) for molecular typing of all Brucella species, including the vaccine strains," *J. Cli. Microbiol*., 46(10): 3484–3487.
89. Makita, K. E., Fèvre, M., Waiswa, C., Kaboyo, W., De Clare Bronsvoort, B. M., Eisler, M. C., Welburn, S. C., (2008): Human brucellosis in urban and peri-urban areas of Kampala, Uganda. Animal biodiversity and emerging diseases. *Acad. Sci*. Int J Health.
90. Makita, K., Fèvre, E. M., Waiswa, C., Eisler, M. C., Thrusfield, M. and Welburn, S. C. (2011): Herd prevalence of bovine brucellosis and analysis of risk factors in cattle in urban and peri-urban areas of the Kampala economic zone, Uganda. *Vet. Res.*, 7: 60.
91. Mangen, M. J., Otte, J., Preiffer, D., Chilonda, P. (2002): Bovine Brucellosis in Sub Saharan Africa Estimation of Sero-prevalence and impact on meat and milk off take potential FAO, Livestock Information and policy branch. AGAL. Livestock policy discussion paper, 8: 12-18.
92. Maríapía, F., Maximilian, M., Gilman, R. and Smits, H. (2007): Human brucellosis, Review. *Lanc. Infect. Dis*., 7(7): 75–86.
93. Marín, C. M., Jimenez de Bagüés, M. P., Barberán, M., Blasco, J. M. (1996): Comparison of two selective media for the isolation of *Brucella melitensis* from naturally infected sheep and goats. *Vet. Rec.* 138: 409-411.
94. Matope, D. G., Bhehe, E., Muma, J. B., Land, A., Skjerve, E. (2010): Risk factors for *Brucella* spp. infection. *Epidemiol. Infect.,* 39: 157–164.
95. McDermott, J. J. & Arimi, S. M. (2002): Brucellosis in sub-Saharan Africa: Epidemiology, control and impact. *Vet. Microbiol*., 90: 111–156.
96. McGiven, J. A., Tucker, J. D., Perrett, L. L. & Stack, J. A. (2003): "Validation of FPA and cELISA for the Detection of Antibodies to *Brucella abortus* in Cattle Sera and Comparison to SAT, CFT, and iELISA," *J. Immunol. Methds*, 278 (1-2): 171-178.
97. Megersa, M., Biffa, D., Niguse, F., Rufael, T., Asmare, K. & Skjerve, E. (2011): Cattle brucellosis in traditional livestock husbandry practice in Southern and Eastern Ethiopia, and its zoonotic implication. *Acta. Vet. Scand.,* 53: 24.
98. Megid, J., Mathias, A. & Carlos, R. (2010): Clinical manifestations of brucellosis in domestic animals and humans. *OpenVet. Sci. J*., 4: 119–126.
99. Mitka, S., Anetakis, C., Souliou, E., Diza, E., Kansouzidou, A. (2007): Evaluation of different PCR assays for early detection of acute and relapsing brucellosis in humans in comparison with conventional methods. *J. Clin. Microbiol*., 45: 1211-1218.
100. Mohan, K., Makaya, P. V., Muvavarirwa, P., Matope, G., Mahembe, E. & Pawandiwa, A. (1996): Brucellosis surveillance and control in Zimbabwe: bacteriological and serological investigation in dairy herds. *Onderstepoort J. vet. Res*., 63: 47–51.
101. Moreno, E., Moriyon, I. (2002): *Brucella* melitensis: a nasty bug with hidden credentials for virulence. *Proc. Natl. Acad. Sci. U.S.A.,* 99: 1–3.
102. Moti, Y., Mersha, T., Degefu, H., Tolosa, T. and Woyesa, M. (2012): Bovine brucellosis: serological survey in Guto-Gida District, East

Wollega Zone, Ethiopia. *Glob. Vet*., 8 (2): 139-143.
103. Muma, J. B., Syakalima, M., Munyeme, M., Zulu, V. C., Simuunza, M. and Kurata, M. (2013): Bovine tuberculosis and brucellosis in traditionally managed livestock in Selected Districts of Southern Province of Zambia. Veterinary Medicine International, Hindawi Publishing Corporation.
104. Munoz, P., Marin, C., Monreal, D., Gonzales, D., Garin-Bastuji, B., Diaz, R., Mainar-Jaime, R., Moriyon, I., Blasco, J. (2005): Efficacy of several serological tests and antigens for the diagnosis of bovine brucellosis in the presence of false positive serological results due to *Yersinia enterocolitica* O:9. *Clin. Diagn. Lab. Immunol*., 12: 141-151.
105. Musa, M. T., Eisa, M. Z., El Sanousi, E. M., Abdel Wahab, M. B., Perrett, L. (2008): Brucellosis in camels (*Camelus dromedarius*) in Darfur, Western Sudan. *J. Comp. Pathol.*, 138: 151–155.
106. Nielsen K: (2002) Diagnosis of brucellosis by serology. *Vet. Microbiol*., 90: 447-459.
107. Nielsen, H., Ewalt, R. (2004): Bovine brucellosis: In manual of standards for diagnostic tests and vaccines, (5th Edn) OIE, Paris, France, Pp: 328-345.
108. OIE (2000): Bovine brucellosis Diagnostic Technique. Manual of Standard for Diagnostic Tests and Vaccines. (4thedn), Paris, pp. 1-37.
109. OIE World Organisation for Animal Health (2004): Bovine brucellosis. In: Manual of Standard for Diagnostic Tests and Vaccines. 5th edition. Paris: OIE, 242-262.
110. OIE, (2012): Manual of Diagnostic Tests and Vaccines for Terrestrial Animals. http://www.oie.int/. Retrieved on May 19, 2014.
111. OIE. (2009): Bovine Brucellosis; caprine and ovine brucellosis and procine brucellosis in: World assembly of delegates of the OIE Chapter 2.4.3. OIE Terrestrial Manual. Paris, Pp 1–35.
112. Olsen, S. & Tatum, F. (2010): Bovine brucellosis. *Vet. Clin., North American F. A. Prac*., 26: 15–27.
113. Omer, M. K., Asfaw, T., Skjerve, E., Teklegiorgis, T., Woldehiwot, Z. (2002): Prevalence of antibodies to *Brucella* species and risk factors related to high risk occupational groups in Eritrea. *Epidemiol. Infect*. 129: 85 – 91.
114. Omer, M. K., Skjerve E., Woldehiwete Z. & Holstad G. (2000): Risk factors for *Brucella* species infection in dairy cattle farms in Asmara, state of Eritrea. *Prev. vet. Med.*, 46: 257–265.
115. Oyedipe, E. A., Bavanendran, V. and Eduvie, L. O. (1981): Factors affecting the reproductive performance of Fulani cattle. National Animal Production Research Institute, NAPRI, Shika, ABU, Zaria.
116. Park, M. Y., Lee, C. S., Choi, Y. S., Park, S. J., Lee, J. S., & Lee, H. B. (2005): A sporadic outbreak of human brucellosis in Korea. *J. Korean Med. Sci*., 20: 941-946.
117. Perrett, L. L., McGiven, J. A., Brew, S. D., Stack, J. A. (2010): Evaluation of competitive ELISA for detection of antibodies to *Brucella* infection in domestic animals. *Croat. Med. J*., 51: 314-319.
118. Poester, F. P., Gonçalves, V. S., Paixão, T. A., Santos, R. L., Olsen, S. C., *et al*. (2006): Efficacy of strain RB51 vaccine in heifers against experimental brucellosis Vaccine, 24: 5327-5334.
119. Poester, P. P., Nielsen, K., Samartino, L. E. and Yu, W. L. (2010): Diagnosis of brucellosis. *The Open Vet. Sci. J*., 4: 46–60.
120. Prilutski, M. A (2010): A brief look at effective health communication strategies in Ghana. *Elon. J. Undergra. Res*., 1: 51–58.
121. Radostits, O. M., *et al*. (2007): Veterinary Medicine, Text Book of Cattle, Horses, Sheep, Pig and Goats, 11th edn. London: WB Saunders Company Ltd.
122. Radostits, O. M., Gay, C. C., Blood C. D. & Hinchcliff, K. W. (2000): Veterinary medicine: a textbook of the diseases of cattle, sheep, pigs, goats and horses, 9th Ed. W. B. Saunders Ltd., New York, 867–882.
123. Ragan, V. E. (2002): The animal and plant Health Inspection Services (APHIS) brucellosis eradication program in the United States. *Vet. Med*., 90: 11–18.
124. Ragassa, G., Mekonnen, D., Yamuah, L., Tilahun, H., Guta T., Gebreyohannes, A., Aseffa, A., Abdoel, T. H., Smits, H. L. (2009): Human brucellosis in Traditional pastoral communities in Ethiopia. *Int. J. Trop. Med*., 4: 59–64.
125. Rahman, M. S., Uddin, M. J., Park, J., Chae, J., Rahman, M. B. and Islam, M. A. (2006): A Short history of Brucellosis: special emphasis in Bangladesh, *J. Vet. Med*., 4: 1–6.
126. Redkar, R., Rose, S., Bricker, B., Del Vecchio, V. (2001): Real-time detection of *Brucella abortus*, *Brucella melitensis* and *Brucella suis*. *Mol. Cell Probes*., 15: 43-52.
127. Robinson, A. (2003): Guidelines for coordinated human and animal brucellosis surveillance. In: FAO animal production and health paper, 156.
128. Roth, F., Zinsstag, J., Orkhon, D., Chimed-Ochir, G. & Hutton, G. (2003): Human health

benefits from livestock vaccination for brucellosis: case study. *Bull. W. Hlth. Organ.*, 81: 867–876.
129. Ruiz-Mesa, D., Sanchez-Gonzalez, J., Reguera, M., Martin, L., Lopez-Palmero, S. (2005): Rose Bengal test: Diagnostic yield and use for the rapid diagnosis of human brucellosis in emergency departments in endemic areas. *Clin. Microbiol. Infect*., 11: 221-225.
130. Samui, K. L, Oloya, J, Munyeme, M, Skjerve, E. (2007): Risk factors for brucellosis in indigenous cattle reared in livestock-wildlife interface areas of Zambia. *Prev. Vet. Med.*, 80: 306-317.
131. Sathyanarayan, S., Suresh, S., Krishna, S., Mariraj, J. (2011): A comparative study of agglutination tests, blood culture and ELISA in the laboratory diagnosis of human brucellosis. *Int. J. Biol. Med. Res*., 2: 569-572.
132. Scacchia, M., Di provvido, A., Ippoliti, C., Kefle, U., Sebhatu T., D'Angelo, A., De Massis, F. (2013): Prevalence of brucellosis in dairy cattle from the main dairy farming regions of Eritrea. *J. vet. Res*., 80 (1): 448.
133. Schelling, E., Diguimbaye, C. and Daoud, S. (2003): Brucellosis and Q-fever seroprevalences of nomadic pastoralists and their livestock in Chad. *Prev. Vet. Med.*; 61: 279–93.
134. Seifert, H. S. H. (1996): Diseases caused by aerobic rods. I. Brucellosis. In: Tropical Animal Health. *Klu. Acad. Puprs., Doch*., Pp. 356–367.
135. Seleem, M. N., Boyle, S. M., Sriranganathan, N. (2008): *Brucella*: a pathogen without classic virulence genes. *Vet. Microbiol.,* 129: 1–14.
136. Seleem, M. N., Boyle, S. M., Sriranganathan, N. (2010): Brucellosis: a reemerging zoonosis. *Vet. Microbiol*., 140: 392-398.
137. Senein, M. & Abdelkadir, A. (2012): Serological survey of cattle brucellosis in Eldein, eastern Darfur, Sudan. *Acad. J.*, 6 (31): 6086-6090.
138. Shey-Njila, O., Daouda., Nya, E., Zoli, P. A., Walravens, K., Godfroid, J., Geerts, S. (2005): Serological survey of bovine brucellosis in Cameroon. Revue d'Elevage et de Medicine Vétérinaire des Pays Tropicaux, 58 (3): 139-143.
139. Shiferaw, Y., Tenhagen, B. A., Bekena, M. & Kassa, T. (2003): Reproductive performance of crossbred dairy cows in different production systems in central high lands of Ethiopia. *Trop. Anim. Hlth. Prod.*, 25: 551–561.
140. Sintaro, T. (1994): The impact of brucellosis on productivity in an improved dairy herd of Chaffa state farm, Ethiopia. Master of Science Thesis. Faculty of Veterinary Medicine, Free University of Berlin, Germany.
141. Sriranganathan, N., Mohamed, N. S. & Stephen, M. B. (2010): Brucellosis: A re-emerging zoonosis. *Vet. Microbiol.,* 140: 392–398.
142. Swai, E. S. and Schoonman, L. (2010): The Use of Rose Bengal Plate Test to assess cattle exposure to *Brucella* infection in traditional and smallholder dairy production systems of Tanga Region of Tanzania. Veterinary Medicine International, Hindawi Publishing.
143. Tabak, F., Hakko, E., Mete, B., Ozaras, R., Mert, A., & Ozturk, R. (2008): Is family screening necessary in Brucellosis Infection? *J. Sys. Microbiolo*., 58: 173–178.
144. Thrusfield, M. (2007): Sampling in Veterinary Epidemiology. 3rd ed. Black Well Science Ltd, London. 46-65: 228-242.
145. Tibesso, G., Ibrahim, N. and Tolosa, T. (2014): Sero-Prevalence of Bovine and Human Brucellosis in Adami Tulu, Central Ethiopia. Wrld. App. Sci. J., 31 (5): 776-780.
146. Tolosa, T. (2004): Seroprevalence study of bovine brucellosis and its public health significance in selected sites of Jimma Zone, Western Ethiopia. MSc Thesis. Addis Ababa University, Faculty of Veterinary Medicine, Debre Zeit.
147. Tolosa, T., Regassa, F. & Belihu, K. (2008): Seroprevalence study of bovine brucellosis in extensive management system in selected sites of Jimma zone, western Ethiopia. *Bull. anim. Hlth. Prod. Afr*., 56: 25–37.
148. Tsegaye, Y. Kyuleb, M. & Lobagob, F. (2016): Seroprevalence and Risk Factors of Bovine brucellosis in Arsi Zone, Oromia Regional State, Ethiopia. *American Sci. Res. J. Engin., Technol. Sci.*,24*: 16-25.*
149. Unger, F., Münstermann, S., Goumou, A., Apia, C. N., Konte, M. & Hempen, M. (2003): Risk associated with bovine brucellosis in selected study herds and market places in four countries of West Africa animal health working paper 2. International *Trypanotolerance* Centre, Banjul, The Gambia.
150. Walker, R. (1999): *Brucella*. In: Dwight C. Hirsh & Yuang Chung Zee (ed): Veterinary Microbiology. USA: *Blackwell Sci. Inc*., Pp. 196–203.
151. Warner, D. (2001): Brucellosis in animals and man. In: Zoonosis: animal disease that affect man by D.E Goodman (ed). Christian Vet. Miss. Seattle., Pp.23–32.
152. WHO (2006): Brucellosis in humans and animals. Geneva, Pp: 27–66.
153. WHO/FAO/OIE (2004): Report of the WHO/FAO/OIE Joint Consultation on Emerging Zoonotic Diseases, Geneva, Switzerland.

154. World Organisation for Animal Health (OIE) (2012): Bovine brucellosis. In Manual of Diagnostic Tests and Vaccines for Terrestrial Animals. Available at: www.oie.int/fileadmin/Home/eng/Health_standards/tahm/2.04.03_BO VINE_BRUCELL.pdf (accessed on 26 August 2012).
155. WZFEDD (Woliata Zone Finance and Economic Development department), (2013): Socioeconomic profile, 2012/13. Woliata Sodo, Ethiopia.

10/2/2020