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Corresponding Author: Mr. Sintayehu Guta Debela

Corresponding Author's Institution: National Animal Health Diagnostic and Investigation Center (NAHDIC, Ethiopia); Centre Recerca en Sanitat Animal (CReSA -UAB, Spain).

First Author: Sintayehu Guta

Order of Authors: Sintayehu Guta; Melesse Balcha; Ignacio de Blas; Jordi Casal; Alberto Allepuz; Alehegne wubate; Ariadna García

The authors' email addresses are listed below:

G. Sintayehu: sintayehuguta_guta@yahoo.com

B. Melesse: melesse_balcha2000@yahoo.co.uk

W. Alehegne: walehegne@yahoo.com

I .De Blas : deblas@unizar.es

J .Casal **:** jori.casal@uab.es

A. Allepuz : Alberto.allepuz@uab.es

G. Sáenz **:** quiro3@msn.com

All the authors have read the manuscript and are in agreement that the work is ready for its submission. We also assure that the manuscript is not being considered for publication elsewhere.

With kind regards!

Sintayehu Guta Debela

Centre de Recerca en Sanitat Animals (CReSA)
Universitat Autònoma de Barcelona (UAB)
08193 Bellaterra (Barcelona), Spain.

Phone: +34 93 581 4089

Fax: 34 93 581 4490

Manuscript

Epidemiological survey of small ruminant brucellosis in selected pastoral zones of Ethiopia

G. Sintayehu* [a b], B. Melesse [a], W. Alehegne [a], de Blas I. [d], J. Casal [b,c], A. Allepuz [b,c], A. García-Sáenz [b]

a *National Animal Health Diagnostic and Investigation Center (NAHDIC),P.O. Box 04 Sebeta, Ethiopia.*

b *Centre de Recerca en Sanitat Animal (CReSA),UAB-IRTA, Campus de la Universitat Autónoma de Barcelona, Bellaterra, Barcelona, Spain.*

c *Departament de Sanitat i Anatomia Animals, Universitat Autònoma de Barcelona, 08193 Bellaterra, Barcelona, Spain.*

d *Faculty of veterinary Medicine, University of Zaragoza, Miguel Servet 177, 50013Zaragoza, Spain*

** Corresponding Author*

Phone: 34 93 581 4557
Fax: 34 93 581 4490
E-mail: sintayehuguta_guta@yahoo.com

Summary

A cross sectional study was conducted in selected pastoral zones of Ethiopia to determine prevalence and assess the spatial distribution of brucellosis in small ruminants. Between November 2004 and December 2006 a total of 6201 serum samples (3694 goats and 2507 sheep) was collected from 67 randomly selected Peasant associations (PAs), distributed in 25 districts and 8 zones located in Afar, Somali, Oromia and Southern Nations, Nationalities and Peoples (SNNP) Regional States of Ethiopia. Serological laboratory analyses, Rose Bengal Plate test (RBPT) as screening test and complement fixation test (CFT) as confirmatory test were used. The overall individual sero-prevalence of brucellosis in small ruminants in the pastoral areas was 5.2 % (n=320) by RBPT and 2.2% (n=134) by CFT. The PA/flock level sero-prevalence was 58.2 % (39/67). The study showed a statistically significant ($p<0.001$) higher seroprevalence of brucellosis in goats (3.1%) than in sheep (0.8%). There

was also a statistically significant (p<0.001) higher prevalence in males (3.8 %) compared to females (1.7%). All zones (8/8), 84% (21/25) of the districts and 58.2 % (39/67) of the (PA) were sero-positive for brucellosis. Differences in disease prevalence among zones, districts and villages were statistically significant (p<0.001).

There were no differences in prevalence among age groups in sheep, but an increase in prevalence with age was detected in goats (p=0.018): 1% in young animals (below 2 years), 3.5% in young adults (between 2- 4 years) and 2.5% in adults (>4years).

The proportion of affected flocks confirmed the widespread distribution of brucellosis in goats and sheep of the pastoral areas of Ethiopia. Therefore, urgent control measures should be taken to reduce the disease distribution and to minimize the economic losses and public health hazards.

Key words: Brucellosis, Complement Fixation Test, Ethiopia, Rose Bengal Plate Test, Small-ruminants, Pastoral area and Prevalence

1. Introduction

Brucella melitensis (biovars 1, 2 or 3) is the main causative agent of caprine and ovine brucellosis. It is recognized as a significant public health challenge, which imposes a major economic and financial burden in countries where the disease remains endemic (OIE, 2010). Economic losses from *B.melitensis* infections are significant and include decreased productivity as a result of abortion, weak offspring and decreased milk production, as well as lost trade opportunities (Moriyon *et al., 2004*).

Brucellosis is found worldwide in humans and animals. Clinical disease in animals is still common in the Middle East, Asia, Africa, South and Central America, the Mediterranean Basin and the Caribbean. *B. melitensis* is particularly common in the Mediterranean basin and it has also been reported from Africa, India and Mexico (http://www.cfsph.iastate.edu/Factsheets/pdfs/brucellosis.pdf).

In sub-Saharan Africa, little is known about its prevalence and most data is derived from small sero-epidemiological studies (Mc Dermot *and* Armi, 2002) with human cases reported in most of the

countries (Pappas *et al.,* 2006). The prevalence in small ruminants ranges from 3.6% in Uganda (Kabagambe *et al.,* 2000) to 17% in the Sudanese region of Kartum (Benkirane, 2006)

In Ethiopia, most of the research work has been focused on dairy intensive cattle herds in the urban and peri-urban areas. In 1987, the World Organization for Animal Health reported 20% infection rate, being higher around large towns than in rural areas (OIE 1987). In zebu cattle of the central highlands Tekleye *et al*., (1989) reported a prevalence of 4.2 %. Eshetu *et al*., (2005) found a prevalence of 10% in Addis Ababa, and in a study conducted in 2005 in smallholder farms of central Ethiopia (Wuchale-Jida district) Kebede *et al.,* (2008) reported a prevalence of 11%. In cattle under extensive management systems, studies conducted in different regions between 2003 and 2005 have reported animal prevalences of 0.8% and 3.2% and herd prevalence's of 2.9% and 42.3% (Tolosa *et al*., 2008; Berhe *et al.,* 2007). In other areas of Ethiopia, studies conducted between 2003 and 2004 have reported a prevalence of 1.6% and a herd level infection rate of 13.7 % (Kassahun *et al*., 2010).

In small ruminants, different studies have shown that prevalence was much higher in Afar than in the Somali region. A prevalence of 1.5% in sheep and 1.3% in goats was found in the central highlands by Tekleye and Kasali, (1990). However, in the Chifra Woreda of Afar region a prevalence of 18% was reported in goats by Abraham *et al.,* (2007). Prevalences of 5.6% in sheep and 13.2% in goats were reported by Teshale *et al.,* (2006) in the Afar and Somali regions and 3.2% of sheep and 5.8% of goats were detected as positive in Afar region by Ashenafi *et al*., (2007). Prevalence and community perception study conducted on brucellosis in 2008 in Jijiga district by Miheretab etal.,(2011) reported an overall prevalence of 1.5 %, and individual prevalence of 1.2% and 1.9% in sheep and goats respectively.

The objectives of this study were to determine the level and describe the spatial distribution of small ruminant brucellosis in the livestock export potential pastoral areas of Ethiopia.

2. Materials and methods

2.1 Description of Study Areas

Ethiopia's economy is mainly based on agriculture, which accounts for 45% of the national Gross domestic product (GDP) and 85% of total employment (CIA-The World Fact Book, 2011).

The country has one of the largest livestock populations in Africa (CSA, 2005). The small ruminant population is estimated to be 25 million heads of sheep and 22 million heads of goats (CSA, 2008). A 25% of the sheep and a 73% of the national goat population inhabit the lowlands, mostly pastoral areas.

The pastoral population of Ethiopia makes up roughly about 13.7% of the country's total population of 82.8 million (UNFPA, 2009). The pastoral population is heterogeneous in its ethnic composition and social structure, Livestock production, trading and take-a-chance crop farming (subsistence rain-fed farming) constitute the pastoral livelihood systems (PFE, 2009).

The Ethiopian low lands occur below 1500m elevations a.s.l and comprise 61% of the national land area. The lowlands are home for 12% of the human population and 26% of the livestock. Various forms of Pastoralism and Agro- Pastoralism dominate land use by the 29 ethnic groups of the lowland. Climate in the lowland include arid (64%), semi-arid (21%) and sub humid (15%). Defined by different temperature and rain fall regime, the Zones vary in terms of the number plant growing day per year, forage production, human and animal population, carrying capacities, and also in terms of livestock diseases (Desta and Coppock, 2004). Administrative regions and study area are shown in Figure 1.

These areas were selected for this study because:

- Pastoral areas have a large small ruminant population and supply more than 90% of the export animals
- Seasonal mixing of flocks/herds of different origin similarity in climate, vegetation, husbandry system.
- The traditional husbandry systems imply close contact between animals and humans, and entire dependence on livestock and its products for nutrition predispose pastoral communities for brucellosis.

2.2. Study animals

Sheep and goats are from the indigenous Ethiopian local breeds of Afar, Somali, Borana and S.Omo. Serum samples were collected from randomly selected sheep and goats. No Brucella vaccine has been used in the study area. Livestock population of the study area is shown in Table 1.

2.3. Study design

A cross-sectional study of small ruminant brucellosis was carried out between November 2004 and December 2006 in selected pastoral zones (Afar 1-5, Jijiga, Borana and S. Omo) located in Afar, Somali, Oromia and Southern Nations, Nationalities and Peoples (SNNP) Regional States of Ethiopia respectively (Figure 1).

For sample size calculations Win-Episcope 2.0 software was used (Thrusfield *et al.,* 2001). The study was initially designed to detect a 5% prevalence with an accepted error of 0.75% and a confidence interval of 95% (3245 animals), at last the sample size was increased to 6201. A two-stage cluster sampling at different hierarchical levels was used. Peasant Associations and villages /flocks were determined as primary and secondary sampling units, respectively. The sampling frame consisted of 51 districts and 513 PAs from which 25 districts and 67 PAS were randomly selected by lottery. Peasant association drawn by the random selection but found inaccessible were replaced by others that had similar ecology and were accessible. Villages and/or flocks within PAs were considered as cluster units and were randomly selected. Only sheep and goats above six months of age were sampled.

2. 4. Serum Sample Collection and Submission

A total of 6201 sera (3694 sheep and 2507 goats) was collected following standard procedures for brucellosis antibody detection. About 10ml of blood was collected from each animal using Vacutainer and needle. Sera were stored and tilted horizontally over night at room temperature to allow clotting. The serum was decanted into a single sterile cryogenic vial, labeled and transported to National Animal Health Diagnostic and Investigation Center (NAHRC) keeping at cold chain. Then the sera were stored at -20^{o}C until tested. Since *Brucella* is a zoonotic agent all the necessary hygienic measures were considered.

2.5. Serological Tests

In this study, Rose Bengal Plate Test (RBPT) was used as a screening test. All RBPT positive samples were retested with Complement Fixation Test (CFT) for confirmatory diagnosis at the National Veterinary Institute laboratory, Debre Zeit Ethiopia (NVI). The procedures described by Alton et al., (1988) and the world Health Organization for Animal Health (OIE, 2004) were followed respectively. The antigen used in RBPT was a suspension of *Brucella abortus* colored with Rose Bengal (Institute Pourquier 326, Rue de la Galera 34097 Montpellier Cedex 5, France). For CFT, Standard *Brucella abortus* antigen and control sera were obtained from the Bgvv, Berlin Germany, the complement from Biomerieux, France, and haemolysin o amboceptor from Institut Pourquier, France.

2. 6. Data treatment and Analysis

The data collected from field was stored into an Excel spreadsheet and statistical analyses were carried out using SPSS version 15.0. Descriptive statistics and association of the categorical variables with risk factors was done using the chi square test or Fisher's exact test. For all analysis, a p value less than 0.05 was taken as significant. Administrative area shape files were downloaded from the GADM database of Global and Administrative Areas (http://www.gadm.org/). Maps were created with the free software Quantum GIS 1.6.Version (http://www.qgis.org/).

3. Results

A total of 6201 (3694 sheep and 2507 goats) serum samples were collected and tested; 4882 (78.73%) were females and 1319 (21.27%) males**.** The average age in goats and sheep were 3.2±1.7 years and 3.8 ± 2.0 years, respectively. On the other hand the mean age of females and males was (3.7 ± 1.9 and 2.3 ± 1.0) respectively. Of the 6201 sera tested, 320(5.2%; 95 %CI: 4.6-5.7) and 134 (2.2%; 95% CI: 1.83 - 2.55) were positive for brucellosis by RBPT and CFT respectively.

The sero-prevalences in Afar, Borana , S. Omo and Jijiga were 3.4%, 3.9%, 0.5% and 0.1%, respectively, there were statistically significant differences among the zones surveyed ($p<0.001$). The sero-prevalence in each administrative region and zone is summarized in Table 2. The zonal sero-prevalence is shown in Figure 2.

84% (21/25) of the districts surveyed presented at least one animal with anti-*Brucella* antibodies. The four negative districts were from Afar (Artuma-fursi) and Somali (Harshin, Medele and Obre) regional states. The higher sero-prevalences were observed in Amibarah, Awash Fentale, Semurobi and Yalo districts of Afar regional state with values of 11.7%, 10.3%, 8.0% and 7.1%, respectively.

94.4% (17/18) districts of Afar were seropositive for brucellosis and most of them had higher sero-prevalences than districts in other pastoral areas, except Borana. Low sero-prevalence was observed in all districts of Somali and SNNP regional states; all being below 0.5%. The district level sero-prevalence by species is shown on figure 3.

58.2% (39/67) of the PAs were sero-positive; since one flock from each PA has been sampled this prevalence is the same to the flock prevalence. In general most PAs of Afar has been found with higher prevalence by CFT reaching up to 23.3% Ambash in Amibarah and 20.7% in Daleti (Semurobi). Most PAs of Somali and SNNP were with low.

Goats presented a higher seroprevalence of brucellosis (3.1%, 95% CI: 2.58 - 3.69) than sheep (0.8 %, 95% CI: 0.52 - 1.23) ($p<0.001$; OR=3.96). The prevalence was also higher in males (3.8%, 95% CI: 2.9 – 5.0 %) than in females (1,7%, 95%CI : 1,39% - 2,13%) ($p<0,001$; OR=2.25).

While in sheep no significant differences were detected between ages, an increase of the prevalence with age was detected in goats (from 1% in young aged below 2 years ; 3.5% in young adult aged between 2- 4 years, and 2.5% in adults aged >4years ($p=0.018$) . Figure 4 shows the prevalence comparison between age groups.

4. Discussion

Vaccination against brucellosis has been never implemented in the country, therefore any sero-positivity was considered as to the result of natural infection. According to the result of the survey small ruminant brucellosis in Afar and Borana zones have higher prevalences (3.4% and 3.9% respectively) than Jijiga, and South Omo where the prevalences were lower than 0.5%. Differences in husbandry practices could be related with these values because in Afar and Borana flocks have more

contact with other flocks in communal grazing and watering point than in Jijiga and South Omo, where the contact between flocks is lower.

However, other epidemiological factors related to the pathogen, the host and the environment should be further studied and identified. Another aspect to be taken into account would be the proportion of sheep and goat in the flock was widely variable among zones. For instance sheep represented 80% of the sampled flocks in Jijiga zone whereas in Afar and Borana zones were of 27% and 22% respectively. Flocks of Afar and Borana zones having more goats generally showed higher prevalence than those with less number of goats in the flock. This is in agreement to that reported by Alton, 1985 who observed that breeds of goat were fully susceptible to infection but, different breeds of sheep had a great variation in susceptibility. The same holds true for the significant differences observed in the districts and PA's surveyed.

Abraham *et al.,* (2007) reported a prevalence of 18% in goats of the Afar region but other papers describe lower prevalences: 1.5% in sheep and 1.3% in goats was found in the central highlands by Tekleye and Kasali, (1990), 5.6% in sheep and 13.2% in goats of Afar and Somali region (Teshale *et al.,* (2006) and 3.2% of sheep and 5.8% of goats also in Afar region (Ashenafi *et al.*, 2007).

The disease prevalence observed in the Ethiopian pastoral areas in small ruminants was lower than most of the reported by other countries. This might be attributed to the low level of intensification, breed differences, the flock size and composition or the test used for the diagnosis. Teshale *et al*., (2006) detected prevalences 4-5 folds higher than us in Afar region using i-ELISA test. The present study included Borana and South Omo pastoral zones in addition to the repeatedly studied zones of Somali and Afar. Therefore covered more areas and processed larger sample size than previous studies, and provide better picture of the distribution of small ruminant brucellosis in the pastoral areas of Ethiopia.

Other authors describe also higher sero-prevalence in goats than in sheep: between 2 and 4 fold higher prevalences have been described in Eritrea (Omer et. al., 2000); East Morocco, Tunisia and Egypt (Benkirane, 2006) and Nigeria (Cadmus *et al.,* 2006) and between 1 and 2 fold in Sudan and United Arab Emirates (Benkirane, 2006) and in Kenya (Ndarathi and Waghela, 1991). In other countries

higher prevalence has been detected in sheep as in Somalia (Andreani *et al.,* 1983), Jordan (Benkirane, 2006) and Oman (Ismaily *et al.,* 1988).

Generally goats are more susceptible to *Brucella* infection than sheep, and partly it could be due to the fact that sheep excrete the organism for shorter periods than goats. Therefore this can reduce the potential of the spread of the disease among sheep flock (Radostits *et al*. 2000).

The higher apparent prevalence observed during the study in male than in female, was neither in accordance with Hirsh and Zee (1999) and Alton (1985) nor with Teshale *et al*., (2006) and Ashenafi *et al.*, (2007) that have reported less susceptibility to brucella infection in male and no observable variation in prevalence of brucellosis between the two sexes respectively. A possible reason for our findings is the sharing of males between villages which can be a source of infection for these animals and could explain the higher prevalence.

The statistically significant difference in prevalence among age groups of goats was not in agreement with the results of Jackson *et al.,* (2004). However in age groups of sheep our result was similar to the same authors that have detected no observable difference in prevalence. The even distribution of prevalences in groups of sheep of different ages was unexpected, because the prevalence of an infectious disease such as brucellosis would have been expected to increase with age. A lack of precision in recording the ages is one possible explanation.

B.melitensis infection causes disease only in adult (sexually mature) females and males. Young animals may be infected but do not show any clinical sign and generally show only a weak and transient serological response. However, susceptibility increases after sexual maturity and especially with pregnancy (Quinn, 1999; Walker, 1999).

A limited number of research works had been conducted on human brucellosis in Ethiopia. Evidence of exposure to brucellosis was found in abattoir workers of Addis Ababa (Kassahun *et al.,* 2006). Fifteen pastoralists (16.5%) were diagnosed positive for brucellosis among 91 pastoralists in Afar regional state during 2005-2006 (Ahmed *et al.,* 2008). A prevalence of 34.1% (30/88) in Borana, 29.4

%(5/17) in Hamer and 3% (3 /100) in Metema pastoral communities was reported by Genene *et al*., (2009).

The traditional husbandry systems, close contact animal-human lifestyle and entire dependence on livestock and its products for their nutrition predispose pastoral communities to be at high risk for brucellosis. Bbrucellosis impairs the export of live sheep and goats, as the importing countries strictly require *Brucella* free animals. The World Trade Organization Sanitary-Phytosanitary(WTO-SPS) agreements provide extra values to importing member countries. Ethiopia has appealed to be a member of this organization.

The over all individual prevalence of 2.2%, which apparently seems low, but 58% of the PAs, 85% of the districts and 100% of the zones surveyed were sero-positive for brucellosis. These findings imply that most parts and flocks of the pastoral areas are with high potential risk of brucellosis. Therefore this is clear evidence to timely start control measures to minimize economical losses and public health hazard.

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6. References

Abraham, A., Arthuro, M., Eshetu, Y., Asefa, D., and G. Tewodros, 2007: Seroprevalence of caprine brucellosis in Chifra Woreda, Afar Regional State, Ethiopia. Eth. J. Biolo. Sci., 6, 159-164.

Ahmed, E. Y., Abraham, A., Arthuro, M., Assefa, D., Tewodros, G., Inter-African Bureau for Animal Resources, 2008: Brucellosis as a zoonosis in Chifra district, Afar Regional State, Ethiopia. Bull. Anim. Health Prod. Afr., 56, 357-361

Alton, G.G., 1985: The epidemiology of *Brucella melitensis in* sheep and goats, In Verger, J. M., Plommet, M., eds : *Brucella melitensis*, a CEC seminar. Martinus Nijoff, Dordrecht-Boston-Lancaster, 187-196.

Alton, G.G., Jones, L.M., Angus, R.D., and J.M. Verger, 1988: Techniques for the Brucellosis Laboratory. INRA, Paris, France.

Andreani, E., Prosperi, S., Salim, A.H., and A.M. Arush, 1983: Serological and bacteriological investigation on *brucellosis* in domestic ruminants of the Somali Democratic Republic. *Revue d'Elevage et de Medecine Veterinaire des Pays Tropicaux*. 35, 329-333.

Ashenafi, F., Teshale, S., Ejeta, G., Fikru, R., and Y. Laikemariam, 2007: Distribution of brucellosis among small ruminants in the pastoral region of Afar, Eastern Ethiopia, Revue Scientifique et Technique Office International des Epizooties, 26, 731–739

Benkirane, A., 2006: Ovine and caprine brucellosis: world distribution and control/eradication strategies in West Asia/North Africa region. Small Rumin. Res., 62 , 19-25.

Berhe, G., Belihu, K., Y. Asfaw, 2007: Seroepidemiological investigation of bovine brucellosis in the extensive cattle production system of Tigray region of Ethiopia. *Inter. J. Appl. Res. Vet. Med*., *5*, *65-71*.

Cadmus, S.I.B., Ijagbone, I.F., Oputa, H.E., Adesokan, H.K., and J.A. Stack, 2006 : Serological survey of brucellosis in livestock animals and workers in Ibadan, Nigeria. Afr. J. Biomed. Res., 9, 163-168

Center for Food Security and Public Health.(CFSPH),2009: available at: *http://www.cfsph.iastate.edu/Factsheets/pdfs/brucellosis.pdf* (accessed 20 June 2011)

Central Statistical Agency of Ethiopia (CSA), 2005: Estimated number of cattle, sheep and goats by region: 2002/2003-2004/2005 (private peasant holdings for rural only). CSA, Addis Ababa

Central Statistical Agency of Ethiopia (CSA), 2008 : Federal Democratic Republic of Ethiopia Central Statistical Agency, agricultural sample survey, estimated number of cattle, sheep and goats by region

CIA-The World Fact Book Ethiopia World Bank, 2011: available at: http://www.cia.gov/cia/publications/factbook/geos/et.htm (accessed 12 May 2011)

Desta, S., and L.D. Coppock, 2004: Pastoralism under pressure tracking system change in southern Ethiopia . Human Ecology, 32, 465-487

Eshetu, Y., Kassahun, J., Abebe, P., Beyene, M., Zewdie, B., And A. Bekele, 2005: Seroprevalence Study of Brucellosis on Dairy Cattle in Addis Ababa, Ethiopia. Bull. Anim. Health Prod., 53, 211-214

Genene, R., Desalew, M., Lawrence, Y., Hiwot, T., Teshome, G., Asfawesen, G., Abraham, A., Abdoel, T.H., and L.S Henk, 2009 : Human Brucellosis in Traditional Pastoral Communities in Eth. Int. J. Trop. Med., 4 , 59–64

Hirsh, D.C., and Y.C. Zee, 1999: Veterinary microbiology. Blackwell Science, Cambridge, Massachusetts , 196-203.

Ismaily, S.I., Harby H.A., and P. Nicoletti, 1988: Prevalence of Brucella antibodies in four animal species in Sultanate of Oman. Trop. Anim. Health Prod., 20, 269-270.

Kabagambe, E. K., Okanga, K. O., Elzer, P. H., Opuda-Asibo, J., Scholl, D. T., Miller, J. E., Salman, M. D., Morley, P. S., Ruch-Gallie, R., International Society for Veterinary Epidemiology and Economics. Risk factors for *brucellosis* in *goats* in Eastern and Western Uganda, 2000: *Proceedings of the 9th Symposium of the International Society for Veterinary Epidemiology and Economics, Breckenridge, Colorado, USA, Aug. 6* **,** 2000, pp Id 454

Jackson, R., Pite, L., Kennard, R., Ward, D., Stack, J., Domi, X., Rami, A., and I. Dedushaj, 2004: Survey of the seroprevalence of brucellosis in ruminants in Kosovo. Vet. Rec., 154, 747-751.

Kassahun, A., Yilkal, A., Esayas, G. and A. Gelagay, 2010: Brucellosis in extensive management system of Zebu cattle in Sidama Zone, Southern Ethiopia. Afr. J. Agri. Res., 5, 257-263.

Kassahun, J., Yimer, E., Geyid, A., Abebe, P., Newayeselassie, B., Zewdie, B., Beyene, M., Bekele, A., Ethiopian Medical Association, 2006: Sero-prevalence of *brucellosis* in occupationally exposed people in Addis Ababa, *Ethiopia*. *Eth. Med. J., 44*, 245-52.

Kebede, T., Ejeta, G., Ameni, G., École Nationale Vétérinaire de Toulouse, 2008 : Seroprevalence of bovine *brucellosis* in smallholder farms in central *Ethiopia* (Wuchale-Jida district). *Rev. Méd. Vét.*. 159(1): 3-9.

McDermott, J.J., and S.M. Arimi, 2002: Brucellosis in sub-Saharan Africa: epidemiology, control and impact. Vet. Microbiol. , 90, 111–34.

Miheretab, B., Hassen, M., Mulugeta, T., and T. Tadele, 2011: Small ruminant brucellosis and community perception in Jijiga District, Somali Regional State, and Eastern Ethiopia. Trop. Anim. Health Prod. 43,893-98

Moriyon, I., Grillo, M.J., Monreal, D., Gonzalez, D., Marin, C., Goñi, I.L., Marinar-Jaime, R.C.,Moreno, E., and J. M. Blasco, 2004 : Rough vaccine in animal brucellosis : Structural and genetic basis and present status. Vet. Res., 35, 1-38

Ndarathi, C.M., and S. Waghela, 1991: *Brucellosis* in Maasai livestock in Kajiado district in *Kenya*. *Ind. J. Anim. Scie*. 61, 156-7.

Newcombe, R.G., and S.C. Merino, 2006 : Intervalos de confianza par alas estimaciones de proporciones y las diferencias entre ellas. Interdisciplinaria, 23, 141-51.

OIE, 1987: Bovine *brucellosis* and *brucellosis* of small ruminants.*Technical Series, Office International des Epizooties*, 6, 48-49.

OIE, 2004: Manual of Diagnostic Tests and Vaccines for Terrestrial Animals, Office International des Epizooties, Paris, France, 5th edition.

OIE, 2010 : Ovine and Caprine Brucellosis, Brucella melitensis Manual of Diagnostic Tests and Vaccines for Terrestrial Animals, Office international des Epizooties, Paris

Omer, M.K., Skjerve, E., Holstad, G.,Woldehiwet, Z., and A.P. Macmillan, 2000 : Prevalence of antibodies to *Brucella spp*. in cattle, sheep, goats, horses and camels in the State of Eritrea; influence of husbandry systems. Epidemiol. Infect., 125 , 447-453.

Pappas, G., Papadimitriou, P., Akritidis, N., Christou, L., and E.V. Tsianos, 2006: The new global map of human brucellosis. Lancet Infect. Dis., 6, 91-99.

PFE, 2009: Pastoralist perspectives of poverty reduction strategy program of Ethiopia: experiences and lesson from Afar Region of Ethiopia. PFE, Addis Ababa, Ethiopia.

Quinn, P.J., Carter, M.E., Markey, B., and G.R. Carter, 1999: Clinical veterinary microbiology, 1st edn. Mosby, Edinburgh, 367-420.

Radostits, O.M., Gay, C.C., Blood, D.C., and K.W. Hinchcliff, 2000: Veterinary Medicine A Textbook of the Diseases of Cattle, Sheep, Pigs, Goats and Horses. 9th ed. London, GB: WB Saunders Co.

Tekleye, B., Kassali, O.B., Mugurewa, M., Sholtens , R.G., and Y. Tamirat , 1989 : The prevalence of brucellosis in indigenous cattle in central Ethiopia, Bull. Anim. Health Prod. Afr., 37, 97–98.

Tekleye, B., and O.B. Kasali, 1990: Brucellosis in sheep and goats in Central Ethiopia, Bull. Anim. Health Prod. Afr., 38, 23–25

Teshale, S., Muhie, Y., Dagne, A., and A. Kidanemariam, 2006: Seroprevalence of small ruminant brucellosis in selected districts of Afar and Somali Pastoral Areas of Eastern Ethiopia: the impact of husbandry practice, Rev. Med. Vet., 157, 557–563

Tolosa, T., Regassa, F., Belihu, K., Inter-African Bureau for Animal Resources, 2008: Seroprevalence study of bovine brucellosis in extensive management system in selected sites of Jimma zone, Western Ethiopia. Bull. Anim. Health Prod., 56, 25-37.

Thrusfield, M., Ortega, C., de Blas, I., Noordhuizen, J.P.,and K. Franken, 2001: WIN EPISCOPE 2.0: improved epidemiological software for veterinary medicine. Vet. Rec., 148, 567-572.

UNFPA, 2009 : Demographic, Social and Economic Indicators, Available at *http://www.unfpa.org/swp/2009/images/e_indicator2.pdf* (accessed 12 may 2011)

Vikrant, J., Upadhyay, A.K., Mahesh, K., Indian Society for Veterinary Medicine, 2007: Comparative evaluation of sero-diagnostic tests for brucellosis. Izatnagar, India. *Ind. J. Vet. Med.*, 27, 43-4.

Walker, R.L., 1999: Veterinary microbiology. Black wells Science, Cambridge, Massachusetts, 196-203.

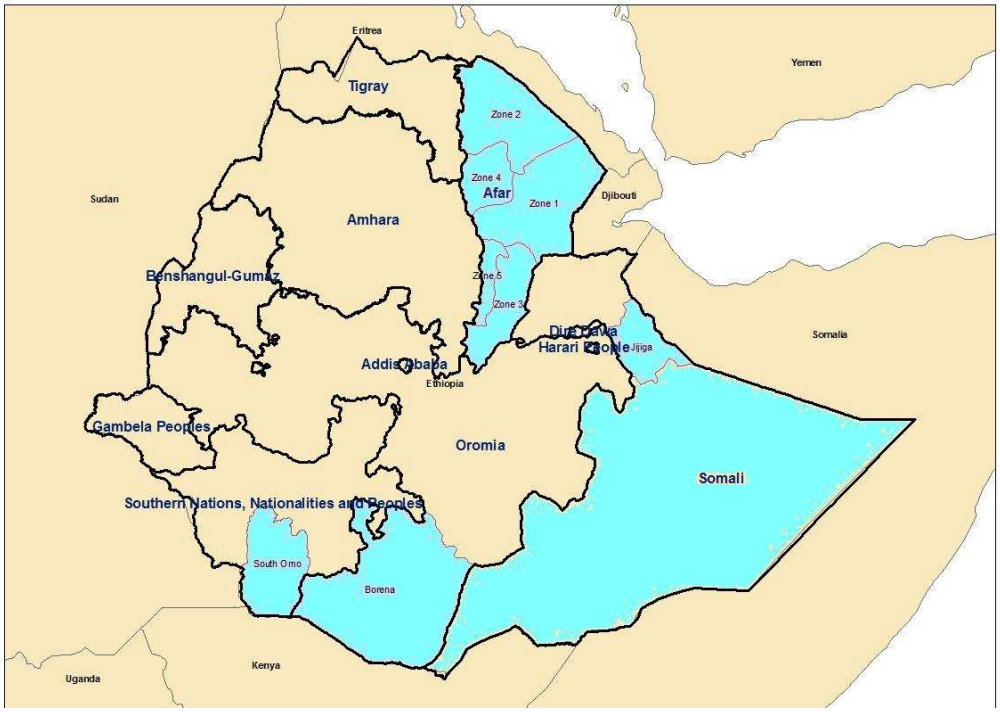

FIGURE 1 STUDY AREA
297x210mm (96 x 96 DPI)

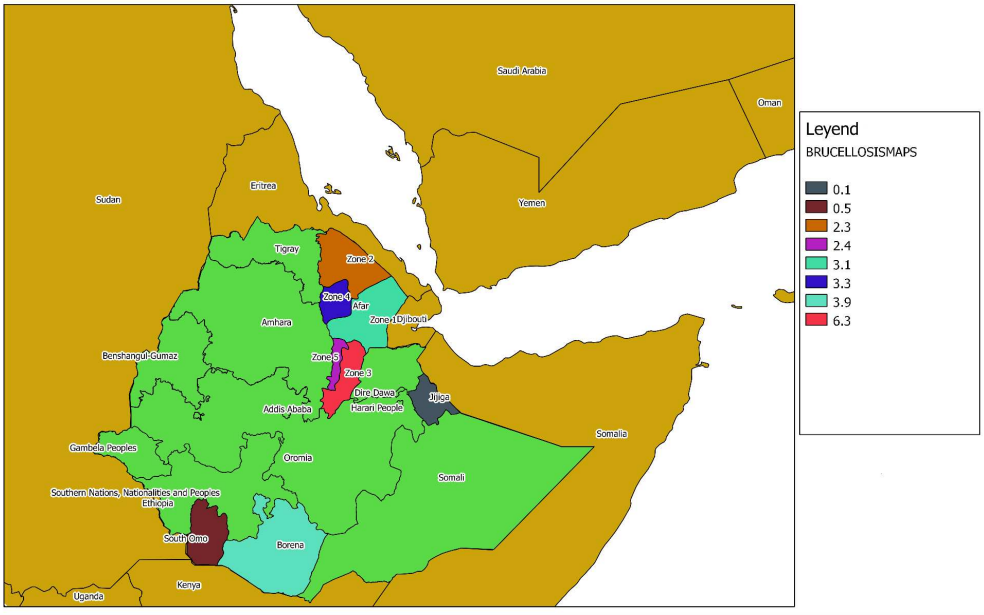

FIGURE 2 ZONAL PREVALENCE
1031x656mm (96 x 96 DPI)

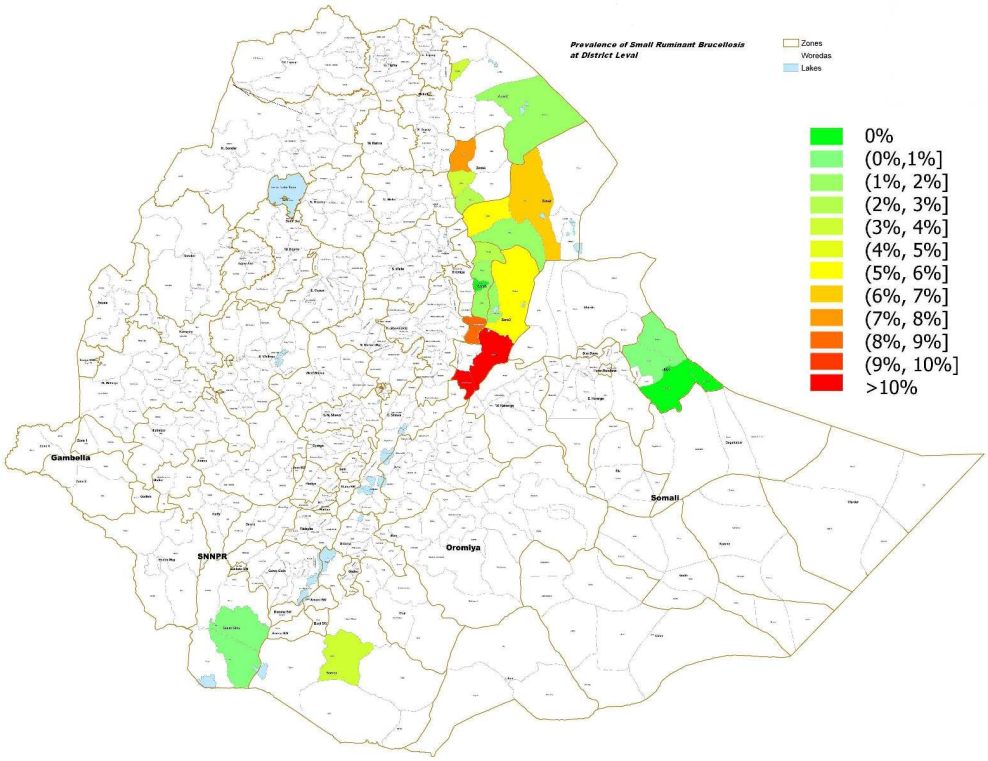

FIGURE 3 DISTRICT PREVALENCE
834x641mm (96 x 96 DPI)

LIST OF TABLES

Table1: *Livestock population of the Study Areas in (1000).*

Region/Zone	***Sheep***	***Goats***
Afar	*403.3*	*801.5*
Somalí	*1162.7*	*1374.5*
Borena	*1274.1*	*669.1*
South Omo	*323.8*	*505.1*

Source: (CSA, 2005)

***Table2**: Sero-Prevalence of Small Ruminant brucellosis in the studied zones*

Region	***Zone***	***Goats***		***Sheep***		***Total***	
		N	***Prev%.***	***N***	***Prev.%***	***N***	***Prev.%***
Afar	*1*	*1245*	*3,4%*	*215*	*1,4%*	*1460*	***3,1%***
	2	*79*	*2,5%*	*8*	*0,0%*	*87*	***2,3%***
	3	*331*	*7,6%*	*144*	*3,5%*	*475*	***6,3%***
	4	*156*	*3,8%*	*53*	*1,9%*	*209*	***3,3%***
	5	*483*	*3,1%*	*405*	*1,5%*	*888*	***2,4%***
	Subtotal	*2294*	*3,9%*	*825*	*1,8%*	*3119*	***3,4%***
Oromia	*Borena*	*474*	*4,4%*	*135*	*2,2%*	*609*	***3,9%***
Somali	*Jijiga*	*371*	*0,0%*	*1483*	*0,1%*	*1854*	***0,1%***
SNNP	*South Omo*	*555*	*0,5%*	*64*	*0,0%*	*619*	***0,5%***
Total		*3694*	*3,1%*	*2507*	*0,8%*	*6201*	***2,2%***
p		*<0,001* [a]		*<0,001* [b]		*<0,001* [a]	

TABLE: 3 SUMMARY OF THE STUDY AREA

REGION/ZONE	NO.ZONES	NO.DISTRICTS	NO.PAS	NO. DISTRICTS TESTED	NO.PAS TESTED
AFAR	5	33	353	18	45
BORENA	1	6	60	1	5
JIJIGA	1	6	60	5	12
S.OMO	1	6	40	1	5
TOTAL	8	51	513	25	67

TABLE:4 NUMBER OF SAMPLES BY REGION ZONE DISTRICT AND PAS

Region	Zone	District	PAS	N° Samples	Caprine	Ovine	F	M
Afar	Zone1	Chifra	Gerirona Wekelu	69	67	2	8	61
Afar	Zone1	Chifra	Jarana Contola	72	55	17	2	70
Afar	Zone1	Chifra	Tiberchamana Hafuma	139	106	33	2	137
Afar	Zone1	Dubti	Beyahle Sahl	61	41	22	2	61
Afar	Zone1	Dubti	Debelna Hemaleysen	71	64	7	5	66
Afar	Zone1	Mille	Ashada na Dinto	284	282	2	269	15
Afar	Zone1	Mille	Bekeridearna	80	78	2	80	0
Afar	Zone1	Mille	Daylena Giraro	199	103	96	173	26
Afar	Zone1	Mille	Gessiyo Laas	160	146	14	156	4
Afar	Zone1	Mille	Giraro na Anikyol	132	130	2	121	11
Afar	Zone1	Mille	Yahilu	188	173	15	175	13
Afar	**Zone2**	Afdera	**Aligenda**	29	29	0	26	3
Afar	Zone2	Afdera	Kosorawda	29	27	2	29	0
Afar	Zone2	Koneba	Alhiena	29	23	6	26	3
Afar	Zone3	Amibarah	Ambash	30	15	15	2	28
Afar	Zone3	Amibarah	Bonta	30	22	8	0	30
Afar	Zone3	Awash Fentale	Deho	58	39	19	50	8
Afar	Zone3	Awash Fentale	Duddub	29	19	10	24	5
Afar	Zone3	Bure Mudaitu	Debel	29	24	5	28	1
Afar	Zone3	Bure Mudaitu	Denaligitira	29	17	12	29	0
Afar	Zone3	Bure Mudaitu	Tuli	29	17	12	26	3

Afar	Zone3	Gewane	Beyeda	**73**	43	30	10	63
Afar	Zone3	Gewane	Biliforo	**79**	58	21	4	75
Afar	Zone3	Gewane	Gebeya Bora	**50**	48	2	2	48
Afar	Zone3	Gewane	Geleladura	**68**	48	20	12	56
Afar	Zone4	Ewa	Bilu	**51**	36	15	6	45
Afar	Zone4	Ewa	Bolotomu	**78**	72	6	11	67
Afar	Zone4	Golina	Amedona Fokis	**29**	18	11	27	2
Afar	Zone4	Golina	Bohalina Muli	**29**	14	15	29	0
Afar	Zone4	Yalo	Harmelena Rekub	**28**	19	9	24	4
Afar	Zone5	Artuma	Atayena Dulaela	**29**	20	9	27	2
Afar	Zone5	Daliphagi	Fenheyruna Gewane	**107**	0	107	100	7
Afar	Zone5	Daliphagi	Hado Bidare	**157**	75	82	131	26
Afar	Zone5	Daliphagi	Kedelaf	**149**	133	16	140	9
Afar	Zone5	Daliphagi	Kerbeti	**153**	102	51	144	9
Afar	Zone5	Dewey	Kilentina Derseda	**30**	21	9	23	7
Afar	Zone5	Dewey	Wediragi	**28**	1	27	17	11
Afar	Zone5	Fursi	Derela Godor	**30**	19	11	27	3
Afar	Zone5	Fursi	Meraktuma	**27**	11	16	22	5
Afar	Zone5	Semurobi	Bohalina Amaruma	**30**	22	8	30	0
Afar	Zone5	Semurobi	Daleti	**29**	18	11	27	2
Afar	Zone5	Semurobi	Fentagerem	**29**	19	10	29	0
Afar	Zone5	Telalak	Amedidas	**29**	7	22	25	4
Afar	Zone5	Telalak	Hemaleysen	**29**	16	13	26	3
Afar	Zone5	Telalak	Waydelelena Yahilu	**29**	16	13	26	3
Total	**5**	**18**	**45**	**3119**	**2294(73.55)**	**825(26.45)**	**2122(68)**	**997(32)**
Oromia	**Borana**	**Yabelo**	**5**	**609**	**474(77.8)**	**135(22.2)**	**550(90.3)**	**59(9.7)**
Oromia	Borana	Yabelo	Dairuto	121	103	18	105	16
Oromia	Borana	Yabelo	Didharra	121	93	28	109	12
Oromia	Borana	Yabelo	Dtadim	123	110	13	122	1
Oromia	Borana	Yabelo	Hadagelchat	125	87	38	112	13
Oromia	Borana	Yabelo	Haramayu	119	81	38	102	17
Somali	Jijiga	Awabere	Rufish	**236**	39	197	217	19
Somali	Jijiga	Harshin	Harshin	**79**	12	67	67	2
Somali	Jijiga	Jijiga	Abbatoire	**50**	13	37	44	6
Somali	Jijiga	Jijiga	Akorder	**185**	2	183	182	3
Somali	Jijiga	Jijiga	Degehayat	**171**	70	101	149	22
Somali	Jijiga	Jijiga	Gebededer	**218**	92	126	200	18
Somali	Jijiga	Jijiga	Getefercot	**143**	8	135	112	31
Somali	Jijiga	Jijiga	Karamara	**110**	56	54	107	103
Somali	Jijiga	Jijiga	Lambarga	**198**	30	168	180	18
Somali	Jijiga	Medele	Medelle	**60**	1	59	59	1
Somali	Jijiga	Obre		**230**	24	206	224	6
Total	1	5	12	**1854**	**371(20)**	**1483(80)**	**1706(92)**	**148(8)**
SNNP	S.Omo	Bensa tsemay	Alduba	**123**	109	14	97	26
SNNP	S.Omo	Bensa tsemay	Shaba	**124**	121	3	104	20
SNNP	S.Omo	Bensa	Luka	**124**	102	22	99	25

		tsemay						
SNNP	S.Omo	Bensa	Enchete	**124**	110	14	105	19
		tsemay						
SNNP	S.Omo	Bensa	Goldia	**124**	113	11	99	25
		tsemay						
	1	1	5	**619**	**555(89.7)**	**64(10.3)**	**504(81)**	**115(19)**
G. Total		**25**	**67**	**6201**	**3694**	**2507**	**4882**	**1319**

GRAPH 1: COMPARISON OF SEROPREVALENCE AMONG AGE GROUPS IN SHEEP AND GOATS