ISSN: 2977-4047

Journal of Life Sciences Research and Reviews

SCIENTIFIC Research and Community

Research Article

Open Access

Epidemiological Study of Contagious Bovine Pleuropneumonia in Selected Districts of Western Amhara Region

Abebe AY* and Tsehay MT

Animal Health Department, South Achefer Livestock Office, Durbete, Ethiopia

ABSTRACT

A cross sectional and retrospective epidemiological study were conducted from November 2015 to March 2016 in five selected districts of Western Amhara Region, to estimate the seroprevalence of Contagious Bovine Pleuropneumonia, identify the predisposing factors for the occurrence of the disease and to describe the distribution of the disease. Systematic random sampling was used to sample individual animals. A total of 328 sera were tested for the presence of specific antibodies against Mycoplasma mycoides sub species mycoides small colony (Mmmsc), using competitive enzyme-linked immunosorbent assay. The risk factors that were evaluated in this study were location, agro ecology, age, sex, and body condition. The overall seroprevalence in this study was 21.04% (95% Confidence interval: 16.6, 25.5). The seroprevalence of Contagious Bovine Pleuropneumonia at the district level was 13.4%, 20%, 21.6%, 19.4% and 28.6% in West Belessa, Fogera, Mecha, Javie-Tenan, and Guangua districts, respectively. Seroprevalence variation was not statistically significant ($p > 0.05$) among the study districts. Significant variation was observed only between West Belessa and Guangua districts in univariable analysis. Among the putative host and environment related risk factors only body condition was found statistically significant ($P<0.05$). The outbreak record indicated that Contagious Bovine Pleuropneumonia outbreaks occurred each year in western Amhara Region with total outbreaks of 11 in the years 2010 to 2014. The highest number of outbreaks was reported in West Gojjam followed by Awi and East Gojjam zone and one outbreak was recorded in both North and South Gondar zones within the five years period. In conclusion, the serological findings and retrospective data analysis indicated that Contagious Bovine Pleuropnemonia is widely distributed and endemic in western Amhara Region and hence appropriate control measures including regular surveillance and vaccination to mitigate the problem should be implemented.

***Corresponding author**

Amare Yenew Abebe, Animal Health Department, South Achefer Livestock Office, Durbete, Ethiopia.

Received: August 18, 2025; **Accepted:** August 21, 2025; **Published:** August 31, 2025

Keywords: Cattle, Contagious Bovine Pleuropneumonia, Seroprevalence, Western Amhara Region

Introduction

Naturally endowed with different agro-ecological zones and suitable environmental conditions, Ethiopia is a home for many livestock species and suitable for livestock production. Ethiopia is believed to have the largest livestock population in Africa [1]. An estimate indicates that the country is a home for about 56 million cattle. From the total cattle population 98.6% are local breeds and the remaining are hybrid and exotic breeds [2].

Livestock plays vital roles in generating income to farmers, creating job opportunities, ensuring food security, providing services, contributing to asset, social, cultural and environmental values, and sustain livelihoods. The subsector contributes about 16.5% of the national gross domestic product and 35.6% of the agricultural GDP [3]. It also contributes 15% of export earnings and 30% of agricultural employment [4]. The livestock subsector currently support and sustain livelihoods for 80% of all rural population. The GDP of livestock related activities valued at birr 59 billion [3].

Despite high livestock population and existing favorable environmental conditions, the current livestock output of the country is little. This is associated with a number of complex and inter-related factors such as inadequate feed and nutrition, widespread diseases, poor genetic potential of local breeds, market problem, in efficiency of livestock development services with respect to credit, extension, marketing, and infrastructure. An improvement in this sector, therefore, has the potential to contribute significantly to national income and to the welfare of the majority of rural families [5-7].

Contagious Bovine Pleuropneumonia (CBPP) is a contagious disease of cattle caused by Mycoplasma mycoides subspecies mycoides small colonies (Mmmsc) [8]. It is a serious threat and obstacle to livestock production and development in Sub-Saharan Africa, some Asian countries, and still occurring in some European countries [9-11]. Wars, famine as well as inadequate financing of veterinary services have resulted in CBPP spreading widely in East and Central Africa [12]. With the imminent eradication of rinderpest, Contagious Bovine Pleuropneumonia (CBPP) has become the most important cattle disease that hinders livestock development in Ethiopia [13].

Contagious bovine pleuropneumonia is manifested by anorexia, fever and polypnoea, cough and nasal discharges. The mortality rate may be as high as 50% in the absence of antibiotic treatment. When an outbreak first occurs in an area, the mortality will be high but is often lower in the field following the primary outbreak. Clinical signs are not always evident; sub-acute or asymptomatic forms occur frequently as the clinical signs in affected animals subside with partial recovery in this case their lungs show typical

encapsulated lesions called 'Sequestra'. These animals may be responsible for unnoticed persistence of the infection in a herd or a region and play an important role in the epidemiology of the disease [12].

The losses due to CBPP (epidemic and endemic) are measured as the number of deaths that occur per class of animal, the quantity of beef lost for each class of animal, the quantity of milk lost from reproductive females and the loss in draft power from oxen. Previous studies conducted in Western Ethiopia, Northwest Ethiopia, Southern Ethiopia and different regions of the country revealed that CBPP is posing a major threat to cattle in many parts of the country thereby causing considerable economic losses through morbidity and mortality and warranting for serious attention [14-18]. In Ethiopia, the average physical losses from CBPP in terms of cattle deaths are 25,115 heads (8,372 in endemic and 16,743 in epidemic), 1,852 and 13,396 metric tons of beef and milk, respectively. Ethiopia experiences the largest number of cattle deaths, and reduction in cattle products compared to the other African countries, due probably to its large cattle population [19].

The available major diagnostic assays are Serum Agglutination Slide Test (SAST), Complement Fixation Test (CFT) and Competitive Enzyme Linked Immunosorbent Assay (C-ELISA) which are used at herd level [20].

Serological analysis is the most important diagnostic tool for the control of CBPP, but it is significantly hampered by the relatively low sensitivity and specificity of the methods [10-22].

The control of CBPP can be achieved by restriction of animal movement, vaccination and stamping out of infected and exposed animals along with attendant zoo-sanitary measures.

This requires adequate financial, infrastructural, and human resources and adequate information system. The main problem in eradication is the frequent occurrence of sub-acute or asymptomatic infections and the persistence of chronic carriers after the clinical phase. Therefore, to carry out an effective control of CBPP through strategic vaccination the prerequisites are a thorough understanding of the epidemiology of the disease in the country [19].

Objectives

The general objective of the study was to investigate the epidemiology and putative risk factors associated with the occurrence of the disease in Western Amhara Region.

The specific objectives were;

1. To estimate the seroprevalence of CBPP in western Amhara Zones
2. To describe the distribution of the disease in the study area
3. To assess the potential predisposing factors associated with CBPP occurrence

Literature Review

Etiology

Contagious Bovine Pleuropneumonia (CBPP) is acontagious disease of cattle caused by *Mycoplasma mycoides* subspecies *mycoides* small colonies (*Mmmsc*) [8]. The *Mycoplasmas* (*Mollicutes*), formerly called PPLO (pleuropneumonia-like organisms), are non-sporulating, Gram-negative, non-motile bacteria, which do not possess a determined shape of the cell.

The Mollicutes are members of the order *Mycoplasmatales* and class Mollicutes (soft skin) and they are the smallest of the free-living prokaryotes. There are no internal membrane structures and no cell wall external to the plasma membrane; however, many strains possess surface structures equivalent to a capsule [23].

Epidemiology

Contagious bovine pleuropeumonia epidemiology is characterized by the following: (1) transmission by direct contact; (2) long incubation period; and (3) possibility of early excretion of mycoplasma (up to 20 days before apparition of clinical signs), during the course of the disease and after recovery in "lungers" (up to two years). The epidemiology of CBPP in Africa is dominated by different factors [24].

In groups of susceptible cattle, the morbidity approaches 90%, the case mortality may be as high as 50% and 25% of the infected ones remain as recovered carriers with or without clinical signs [12].

Host Susceptibility

Cattles and water buffalos are susceptible to CBPP, the African buffalo has been infected under experimental condition but, the same study found that natural transmission did not occur [25]. There is no difference in susceptibility of Bostaurus and Bosindicus cattle and both races respond equally to vaccination [26]. Under natural conditions, CBPP occurs in cattle of the species Bos and allied animals including yak, buffalo, bison and even reindeer [12].

Occurrence and Geographical Distribution

CBPP was first described in 1550 by Gallo, and with the exception of South America and Madagascar, has occurred throughout the world at some time or another [27]. According to, CBPP is eradicated from much of Europe, Australia, and North America at the beginning of 20th century where the last cases were observed in Portugal in 1999 [29]. CBPP is still an endemic disease in Africa, Asia, Eastern Europe, and the Iberian Peninsula [26-28].

Table 1: Cattle Population at Risk in Four CBPP Affected Areas of Ethiopia

Area	Administrative Zones	Cattle population	Livestock system
Western Ethiopia	Endemic Zones		
	-Western Wellega (Oromia)	1 005 500	Mixed Crop-livestock
	-Asosa (B. Gumuz)	84 200	Mixed Crop-livestock
	Epidemic Zones		
	-Part of W. Wellega (Oromia)	272 700	Mixed Crop-livestock
North western Ethiopia	Endemic Zones		
	-West Gojjam (Amhara)	1 188 000	Mixed Crop-livestock
	-Awi (Amhara)	470 000	Mixed Crop-livestock

North eastern Ethiopia	Endemic Zones -Afar zones (Afar) Epidemic Zones -Southern Tigray (Tigray) -North Wello (Amhara) -North Shoa (Amhara) -Eastern Shoa (Oromia) -Arsi (Oromia)	 768 000 450 000 620 000 1 018 000 1 019 000 2 509 000	 Nomadic Mixed Crop-livestock Mixed Crop-livestock Mixed Crop-livestock Mixed Crop-livestock Mixed Crop-livestock
Southern Ethiopia	Endemic Zones -Borena (Oromia) -South Omo (SNNP) -Konso (SNNP) -Derashe (SNNP) -Amaro (SNNP) Epidemic Zones (SNNP) -North Omo (SNNP) -Maji (SNNP)	 1 419 000 413 000 70 000 34 000 59 000 1 715 000 212 000	 Nomadic Mixed Crop-livestock Mixed Crop-livestock Mixed Crop-livestock Mixed Crop-livestock Mixed Crop-livestock Mixed Crop-livestock
Total	Endemic Zones Epidemic Zones	5 510 700 7 815 000	

Source: Cattle population in the zones: CSA (1998), Livestock and poultry and beehives population

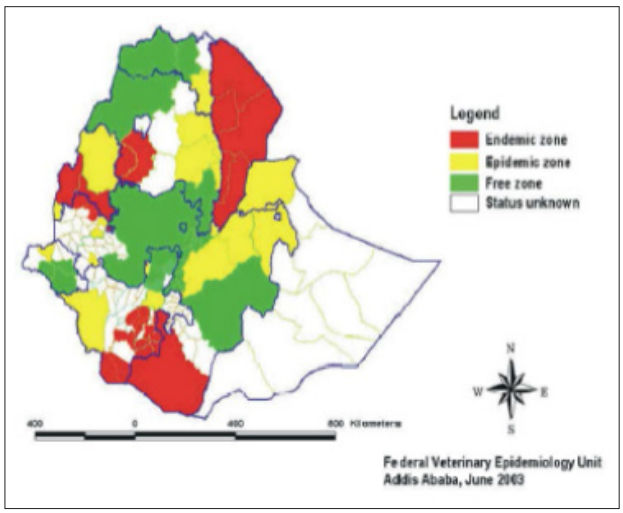

Figure 1: Map Showing the Different CBPP Zones in Ethiopia

Source: Federal Veterinary Epidemiology Unit Addis Ababa, June 2003

Source of Infection and Transmission

The main source of infection under natural condition is the excretion of flugge-type droplets by the coughing animal. Urine, fetal fluids and even nasal discharges can present sources of infection. The organism has been isolated from semen and preputial washings of two young bulls which were the result of frozen embryos implanted in to Portuguese cows [12]. *Mycoplasma mycoids sub species mycoids* small colony type remains viable in the sequestra for many years and under stress (e.g. starvation), the fibrous capsule may break down, and the mycoplasmas are released in to the airways and become a source of infection [30]. Such a mechanism accounts for epidemics in closed herds. As mycoplasma survives poorly in the environment, indirect methods of spread (e.g. by fomites) are unimportant [12].

Transmission occurs from direct and repeated contacts between sick and healthy animals. The principal route of infection is by inhalation of infective droplets from active or carrier cases of the disease or asymptomatic carriers [12-31].

Risk factors

Factors such as extremes of age, stress and inter current infections may predispose to tissue invasion [31].

Animal risk factors: CBPP occurs only in cattle although rare natural cases have been observed in buffalo, yak, bison, reindeer and antelopes, and the disease has been produced experimentally in captive African buffalo and white-tailed deer [24]. Age is determining factor, as calves are highly susceptible while yearling is more resistant. Cattle are again more susceptible in old age [32].

Management and environmental risk factors: Cattle movements are responsible for transmission of CBPP from one herd, region, and country to another [33]. Management practices that promote infection include kraaling animals at night and mixing of herds along stock routes and at watering points [34]. Environmental risk factors that include extremes of temperature, ventilation, dust, and overcrowding can cause the sequestrum to break down and convert the animal in to an active case [35].

Pathogen risk factor: *Mycoplasma mycoides* small colony type can be grouped in to two major epidemiologically distinct clusters. One cluster contains strains isolated from European countries since 1980 and the second cluster contains African and Australian strains collected over last 50 years [21]. Epidemiological and clinical observations indicate that European outbreaks of CBPP are less virulent than the disease encountered in Africa [12]. Mycoplasma mycoides subsp. mycoides is sensitive to all environmental influences, including disinfectants, heat and drying and do not ordinarily survive outside the animal body for more than a few hours [36].

Pathogenesis

Mycoplasmas adhere to host cells, an attribute essential for pathogencity, which facilitates toxic damage to host cells by soluble factors produced by the pathogen, often occurs on mucosal surfaces [31]. The organism becomes attached to the surface of cells and is not susceptible to removal by mucosal secretions. The pathogenesis of mycoplasmosis continues to be an area of active research, with most emphasis on further understanding of the mechanisms and significance of antigenic variation, the mechanisms involved in motility, the immune response to infection and mechanisms involved in adherence [37]. As indicated in

McGavin and Zachary the pathogenic mechanisms involve toxin production, unregulated production of TNF-α, ciliary dysfunction, immune suppuration, and immune mediated vasculitis [30].

Clinical Signs

There is considerable variation in severity of signs observed in cattle affected by CBPP, ranging from hyper acute through acute to chronic and sub-clinical forms [12]. Hyper acute form is much accelerated where affected animals may die within a week exhibiting classical respiratory signs [38]. In the acute form animals show dullness, anorexia, irregular rumination with moderate fever (sometimes up to 40-42). Coughing is usually persistent and is slight or dry and as the typical lung lesions develop, the signs become more pronounced with increased frequency of coughing and the animal becomes prostrate or stands with the back arched, head extended and elbows abducted. While classical respiratory signs may be evident in calves, articular localization of the causative agent with attendant arthritis usually predominates. In sub-acute form signs may be limited to a slight cough only noticeable when the animal is exercised. Cattle that recover naturally are extremely weak and emaciated. Many infected animals develop chronic or milder forms of the disease, which may be either symptomless or associated with only a slight temporary rise in body temperature, and some loss of condition [12].

Necropsy Findings

The characteristic post mortem findings in CBPP are localized in the chest cavity except in young calves where inflammation of the limb joints (usually the carpal and tarsal joints), with increased fluid, is sometimes seen. There is thickening and inflammation of the pleura often with heavy deposits of fibrin and large amounts of clear, serous effusion containing shreds of fibrin. A most striking feature of the acute disease is the very large volume of yellow fluid (up to 30 liters) containing clots, which can accumulate in the chest and therefore causing extremely difficult breathing [39].

The lungs (almost always only one, the left) and pleura are affected and, in most cases, only the diaphragmatic lobe is involved. Affected lobules show various stages of gray and red hepatization and the interlobular septa are greatly distended with serofibrinous exudates-the classical 'marbled' lung of this disease [26]. In the recovered and chronic form, fluid is rarely seen in the pleural cavity but adhesions between lung lobes and between lungs and the chest wall are commonly found. Infarcts, varying in size from about 10-300 mm, are frequently preset in the affected lung tissue, which are the result from thrombosis of inter- or intra-lobular arteries and lymph vessels [39].

Lymph nodes in the chest may be enlarged and wet (edematous), with small necrotic foci and pinpoint hemorrhages. In the kidney cortex, white spots of dead tissue of variable size, called infarcts, can sometimes be seen [12].

Diagnosis

The diagnosis of CBPP is based on a history of contact with infected animals, clinical findings, immuno-diagnosis tests, necropsy findings and cultural examination [12].

Cultural Examination

Samples to be taken from live animals are nasal swabs and/or broncho-alveolar washings or pleural fluid obtained by puncture. Samples to be taken at necropsy are lung lesions, lymph nodes, pleural fluid and synovial fluid from those animals with arthritis. The causal organisms can be isolated culturally from animals during the febrile phase or shortly post mortem from blood, pleural exudates (chest fluid) and/or affected lung tissue and lymph nodes [40].

Biochemical Test

Mycoplasma mycoides sub species mycoides is sensitive to digitonin (like all members of the order Mycoplasmatales), does not produce 'film and spots', ferments glucose, reduces tetrazolium salts (aerobically or anaerobically), does not hydrolyse arginine, has no phosphatase activity, and has no or weak proteolytic properties. For routine field use, the immunological tests are sufficient, but where these give dubious results and in all cases of identification of first isolates, biochemical tests should be confirmed by a reference laboratory [40].

Serological Examination

To detect latently or chronically infected animals, almost all serological tests are suitable [27]. At present, the most reliable tests for detecting serum antibodies are C-ELISA and CFT. These tests are currently prescribed for international trade by the OIE [41]. The performance of this C-ELISA method has been validated by the French Committee for Accreditation in 2009. Compared with the CFT, the C-ELISA has equal sensitivity and greater specificity [29].

The rapid slide agglutination test with either whole blood or serum (better with serum) has been developed to detect specific agglutinins. Due to lack of sensitivity, the test detects only animals in the early stages (i.e. acute phases) of the disease and therefore, should be used only on a herd basis and applied on several animals of a given herd and to detect the presence of the disease (not to measure the quantity of disease) [42].

Differential Diagnosis

In carrying out a CBPP diagnosis, it is necessary to differentiate this disease from other diseases which may present similar clinical signs or lesions. The way the disease behaves in the herd is as important as the findings in a single animal when carrying out an investigation [12].

Diseases like; rinderpest (due to fever and discharges observed from the eyes, nose and mouth), Foot-and-mouth disease (due to salivation, lameness and fever), Bacterial or viral bronchopneumonia (due to clinical signs closely resembling closely those of acute CBPP), ephemeral fever (due to fever, discharges from the eye, dripping of saliva from the mouth, lameness nd swollen joints (but in animals of all age unlike CBPP), farcy (due to similar lymph node lesions and theileriosis (due to coughing, nasal and ocular discharge). Sequestra can mistake for the cysts of parasitic infestations, particularly echinococcus or aberrant liver flukes, actinobacillosis, tuberculosis and abscesses [12].

Treatment

Under practical field conditions, when the disease breaks out in a new area, treatment is not applicable and not recommended because of reasons of disease prevention [27]. Treatment is usually undertaken and indicated only in areas where the disease is endemic [26], but in practice farmers are treating their animals when they have no other alternative. Although the Mycoplasmas are susceptible to a number of antibiotics in vitro, treatment failures are common [23]

Commonly used antibiotics include tetracyclines, tylosin, erythromycin, lincomycin, spectinomycin, and tilmicosin[23]. Tylosin (10 mg/kg body weight every 12 hours for six injections) and spiramycin (10-50mg/kg body weight for 3 days) are effective in the control of excessive vaccination reactions and should be of value in the treatment of clinical cases [26]. Resistance to some of these antimicrobials has been noted. Animals that do not respond to treatment often become carriers. Penicillin is of little value where as streptomycine has some curative effect [23].

Control and Prevention

To make the most efficient use of the increasingly scarce resources, disease control programs must be tailored to the needs of particular communities and to high-priority cattle populations to ensure their efficacy, acceptance and sustainability and therefore economic evaluation should be generalized. In almost all African countries CBPP is notifiable disease and there are official controls on the import of cattle. However, in many countries there are nomadic people who have moved from country to country before the borders existed [24].

Control of Cattle Movement

In countries where cattle movement can readily be restricted, the disease can be eradicated by quarantine, blood testing and immunization with attenuated vaccine [43]. Cattle movement is of critical importance to the CBPP situation in Ethiopia. The persistence of the disease may well be connected with the complexity of cattle production movement in the country [44].

Uncontrolled animal movements during transhumance, trade, and cattle theft have facilitated the spread of the disease throughout Tanzania. Although the quarantine and checkpoints have been in place, weak legislation and a lack of means and resources to enforce control of livestock movements are making the situation worse [45].

Vaccination

In most African countries, for the time being, mass vaccination (or restricted to target key areas) and where possible controls of animal movement remain the most practical option. To obtain the desired results vaccination should endeavour to achieve high immunization coverage using high quality vaccines, which should be administered, at short intervals especially during the initial stages (90 – 92% of the population). Botswana is a typical example of African country in eradicating CBPP recently from the country [46].

The major control method practiced in Ethiopia is Vaccination. The control of CBPP by vaccination has been carried out for the last 30 years in Ethiopia. Besides, the vaccination coverage was around 50% and did not reach the desired 80 – 100% level. Currently, CBPP control in Ethiopia was based on targeted and ring vaccination in the face of outbreaks [47].

Stumping Out

The ideal method to control a trans-boundary disease like CBPP is the application of the stamping out policy of complete elimination of infected and exposed animals along with attendant zoo-sanitary measures. However, this presupposes that there are adequate financial, infrastructural, and human resources to execute the task. Nevertheless, the current reality in sub-Saharan Africa is that these pre-requisites are either lacking or inadequate [48].

Materials and Methods

Study Area

The study was conducted on cattle located at selected districts of four Western Amhara zones (North Gondar, South Gondar, West Gojjam and Awi zone). Belessa district of North Gondar is located at 778 km from Addis ababa, the capital of Ethiopia. The district has an altitude ranging from 1200 meter above sea level (m.a.s.l) to 1800 m.a.s.l and 12013′ to12041′ N latitude and 37010′ to 3803′ E longitude. Fogera district of south Gondar is located at 619 km from Addis Ababa at 11049′ to 11059′ N latitude and 37°33′ to 37°52′ E longitudes. Altitude ranges from 1774 to 2410 m.a.s.l and the average minimum and maximum temperature of the district vary between 10.3 0C to 27.2 0C. According to fogera woreda agricultural and rular office report (2015) the district has about 266 448 cattle population. Mecha district of West Gojjam is located 525 km North west of Addis Ababa with an altitude ranging from 1800 to 2500 m.a.s.l and mean temperature ranging from 24-27 0C. The district is located at latitude 10o30′ N and longitude 37o29′ E and have about 192,556 cattle [49]. Javie Tenan district of West Gojjam located at 389 km from Addis Ababa at latitude and longitude of 10°42′N 37°16′E with an altitude of 1917 m.a.s.l. The temperature of the district varies from 15 0C- 27 0C and the district has about 238,021 cattle population [50]. Guangua district of Awi zone is located at 507 km from Addis Ababa. The district is located at 10057′ N latitude and 36030′ E longitude and the temperature of the area vary from 22 0C – 37 0C. The district has about 139,691 cattle population (GWARDO, 2014).

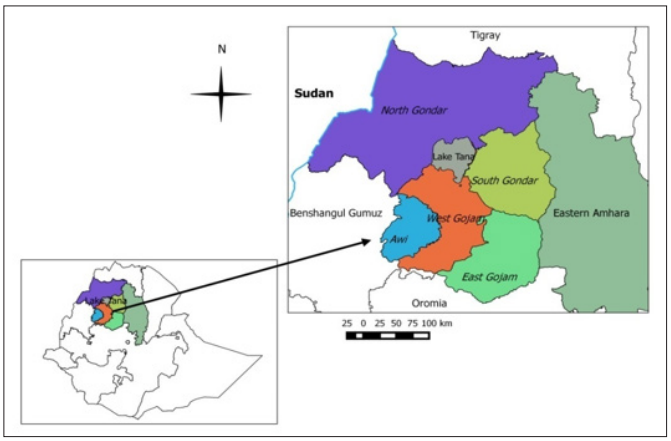

Figure 2: Map of the Study Area in Western Amhara Region

Study Population

The livestock population in Amhara Region is the largest next to Oromia region estimated at 13.8 million heads of cattle, 13.9 million sheep and goats, 2.95 million equines and 14.6 million poultry among which over half of the population is found in the western Amhara region [1]. In this study cattle kept under traditional smallholder farming system were included. Cattle considered for sampling were those with no history of vaccination against CBPP. This was to eliminate the possibility of seropositivity due to vaccinal antibodies. Also, in order to avoid seropositivity due to maternal antibodies, only cattle greater than 6 months old were considered for sampling. Cattle of both sexes were considered in the sampling.

Study Design

A cross-sectional and retrospective epidemiological study was conducted from October 2015 to March 2016. The cross-sectional study was to estimate the seroprevalence whilst the retrospective study to describe the frequency of occurrence and distribution of CBPP in selected districts of Western Amhara Region.

Sampling Method and Sample Size Determination

Systematic random sampling was used to sample among the study population. The sample size was determined according to for an infinite population with 95% confidence level, 5% desired absolute precision and considering 30.5%, expected prevalence as follows:

$$n = \frac{1.96^2 \, x Pexp \, (1-Pexp)}{d^2}$$

Where n = required sample size; Pexp= Expected Prevalence; d = Desired Absolute Precision

The calculated sample size for this study was therefore, 326 animals. Multistage sampling technique was applied for selecting study districts and kebeles. Systematic random sampling was used to sample individual animals. Five districts (one from North Gondar, one from South Gondar, two from west Gojjam and one from Awi zone) and three kebeles per district were selected for the study [15,28].

Sample Collection

Serum Sample Collection

Blood samples were collected from animals with no history of vaccinations to CBPP and apparently healthy. After proper restraining of the animal, the skin over the jugular vein was disinfected with 70% alcohol and about 5 ml of blood sample was collected from the jugular vein using vacutainer tubes. The blood samples were kept under the shade in a slant position for four hours and centrifuged to extract sera. The sera samples were transferred to serum tubes and kept at -200C in the laboratory of Faculty of Veterinary Medicine, University of Gondar until laboratory analysis. Corresponding to each sample, the age, sex and body condition of every animal and geo-reference information was collected and registered on a separate case sheet.

Serological Testing

Competitive enzyme-linked immunosorbent assay (ELISA) for CBPP test was conducted as recommended by CIRAD-UMR15 (France) and it is based on a monoclonal anti-MmmSC antibody named Mab 177/5 as previously described [51]. The sensitivity and specificity of the diagnostic test used were 98% and 97%., respectively. Serum samples were mixed with specific monoclonal antibody (Mab 117/5) in a dilution plate and incubated with gentle agitation at 37 °C for 1 h, then transferred into the MmmSC-coated microplate. After washing, anti-mouse IgG serum–conjugated horse radish peroxidase was added. After a series of washings, the horse radish peroxidase substrate (TMB) was added forming a blue compound that turned yellow when the reaction was stopped. The optical density was read in an ELISA reader at 450 nm and the cut-off point was calculated to validate the results. All sera with percentage inhibition (PI) > 50% were considered positive. Sera with PI between 40% and 50% were considered doubtful and those sera with PI less than 40% were negative. All the serological analysis was conducted in the serology unit of National Veterinary Institute at Debre Zeit.

Secondary Data Collection

Five years retrospective data on CBPP outbreak was used in the present study. The secondary data was obtained from the National data base of the Federal Ministry of Livestock and Fisheries Resources (MoLFR), Epidemiology unit, to describe the frequency of CBPP outbreaks in the previous 5 years. Retrospective description of epidemiological data on number of CBPP outbreaks, sick and deaths, animals at risk were conducted for the period January 2010 to December 2014.

Methods of Data Management and Statistical Analysis

The collected data were entered to a Microsoft Office Excel 2007 spreadsheet. Statistical analyses were performed using STATA version 12 statistical package. Descriptive statistics was used to calculate means and confidence intervals for seroprevalence of CBPP. Seroprevalence was calculated by dividing the number of positive test results by the total number of animals tested. The univariable and multivariable logistic regression was used to determine the association between explanatory variables (risk factors) and the dependent variable (serological status of the animals). In all analyses, a confidence interval of 95% and p-value of ≤0.05 were applied to determine statistical significance.

Results

Seroprevalence

A total of 328 serum samples collected from the four zones of west Amhara were screened for specific antibodies against CBPP using c-ELISA kit. Out of the total number of the samples obtained, 69 sera tested positive, making the overall seroprevalence of CBPP in cattle 21.04% (95% CI=16.6, 25.5). District wise, the highest CBPP seroprevalence was observed in Guangua district (28.6%) and the lowest seroprevalence was recorded in west Belessa district (13.4%) (Table 2).

Table 2: Seroprevalence of Contagious Bovine Pleuropneumonia in Study Districts, Western Amhara Region

Zone	District	Number of cattle tested	No. animals positive	Prevalence (%)	95% Confidence Interval
North Gondar	West Belessa	52	7	13.4	3.9, 23.1
South Gondar	Fogera	65	13	20.0	10.0, 30.0
West Gojjam	Mecha	74	16	21.6	12.0, 31.2
	Jabitenan	67	13	19.4	9.7, 29.1
Awi	Guangua	70	20	28.6	17.7, 39.4
Total	328	69	21.04	16.6, 25.5	

As presented in Figure 3, the CBPP zonal prevalence distribution was higher in Awi zone (28.6%) followed by West Gojjam (20.6%) and South Gondar (20.0%). The least prevalence was reported in North Gondar (13.4%).

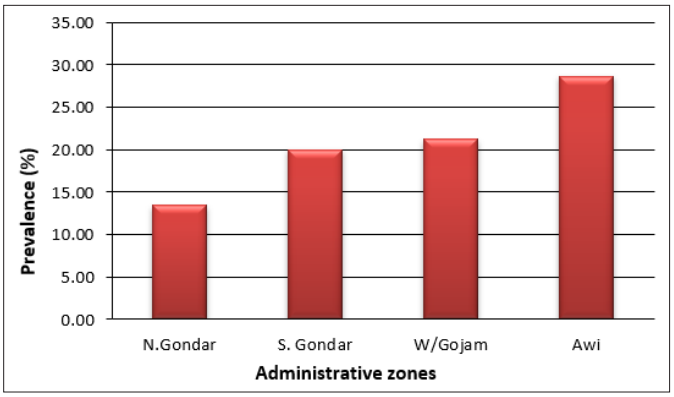

Figure 3: Seroprevalence Distribution of CBPP by Zone in Western Amhara Region

Risk Factors Associated with CBPP Seropositivity

Univariable analysis was undertaken to identify the effects of host and location on the prevalence of CBPP. The disease prevalence was not different between young and adult age group. However, the prevalence was slightly higher in adults (23.2%) compared to young cattle (17.65) and the odds of seropositivity was about 1.41. Sex related prevalence was slightly higher in male cattle (23.3%) compared to female (18.6%) with no significant variation. The effect of body condition on the seropositivty showed higher in poor condition animals (25.9%) than the medium (20.0%) and good body condition (13.7%). Among the environment related factors, agro-ecology and district/location was considered for analysis but both factors were not significant showing no effect on the occurrence of the disease.

Table 3: Risk Factors Associated with CBPP Seropositivity Using Univariable Logistic Regression Analysis

Variables	Risk factor Category	Tested samples	Prevalence (%)	Odds Ratio	[95% Conf. Interval]	P-value
Age	Young	125	17.6	1.0	-	-
	Adult	203	23.2	1.41	0.80, 2.48	0.23
Sex	Male	172	23.26	1.0	-	-
	Female	156	18.6	0.75	0.44, 1.29	0.30
Bodycondition	Good	95	13.7	1.0	-	-
	Medium	75	20	1.58	0.70, 3.56	0.32
	Poor	158	25.9	2.21	1.11, 4.38	0.02
Agro ecology	Lowland	122	22.13	1.0	-	-
	Mid-highland	206	20.39	0.90	0.52, 1.55	0.71
District	W. Belesa	52	13.4	1.0	-	-
	Fogera	65	20.0	1.61	0.59, 4.38	0.35
	Mecha	74	21.6	1.77	0.67, 4.68	0.25
	Javie-Tenan	67	19.4	1.55	0.57, 4.21	0.39
	Guangua	70	28.6	2.57	1.0, 6.65	0.05

Assumed risk factors having p-value <0.30 in univariable analysis were fitted to multivariable logistic regression analysis model. Host related factors; age, sex and body condition and environment related factor; location was considered in the analysis. As a result, only body condition was identified as a risk factor for the occurrence of high seroprevalence of CBPP.

Table 4: Multivariable Logistic Regression Analysis of Risk Factors Associated with CBPP Seropositivity

Variables	Risk Category	Odds Ratio	(95%(OR)	P-value
Age	Young	1.00	-	-
	Adult	1.56	0.14, 2.85	0.86
Sex	Male	1.00	-	-
	Female	0.69	0.19, 1.20	0.39
Body condition	Good	1.00	-	-
	Medium	1.50	0.65, 3.49	0.34
	Poor	2.42	1.17, 5.00	0.02
District	W. Belesa	1.00	-	-
	Fogera	1.72	0.62-4.81	0.30
	Mecha	2.22	0.81-6.05	0.12
	Javi-Tenan	1.60	0.57-4.47	0.37
	Guangua	2.43	0.92-6.41	0.07

Occurrence and Distribution of CBPP

Five years (between 2010 and 2014) retrospective CBPP outbreak data was obtained from the database of MoLFR. The retrospective data indicated that outbreaks of CBPP were occurred every year except 2013, with a total of 11 outbreaks in 5 zones and different districts of the western Amhara Region. During the five years period, the highest number of outbreaks was reported in the year 2014

(6) followed by 2010 (3) and only one outbreak during 2011 and 2012 (Figure 4).

The highest outbreak during 2014 was reported in West Gojjam (3) and East Gojjam (2). The outbreak was frequent in Awi zone during the year 2010 and 2011. In North Gondar and South Gondar, single outbreak of CBPP was reported only in 2010 and 2014, respectively.

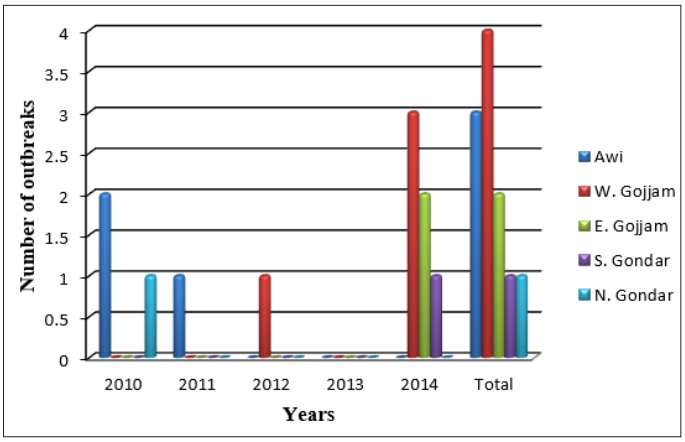

Figure 4: Distribution of CBPP Outbreaks in Western Amhara Region Between 2010-2014

Discussion

Based on the findings of the serological analyses of this study, CBPP was a major cattle health problem and endemic in west Amhara Region. The overall seroprevalence of CBPP in the study region was reported 21.04% (95%CI; 16.6, 25.5%). This result was in agreement with previous studies conducted in different parts of Ethiopia in cattle under extensive production system; 18.9% in West Gojjam and Awi, 15.2% in Raya Azebo district of Tigray region and 19% in Bako Tibbe district of western Shoa zone, Oromia and 16% report in Kenya [52-54]. However, the present sero-prevalence finding is lower than the reports of Dejene, 48% in Western Wollega Desta, 56% in North Omo, western Ethiopia, Gedlu which was reported 30.4% in Somali region of Ethiopia, 30.2% in agro-pastoral areas of Nigeria [14-16,55,56].

In contrast the seroprevalence report in this study was higher than others' reports; 9.4% in Borena, 4% in and around Adama, central Ethiopia, 10.65% in Kwara State, Nigeria, 0.54% in Senegal, 0.29% in Northern Nigeria and 9.7% in the Maasai ecosystem of South-western Kenya [57-62]. The variation in seroprevalence reports in this study compared to others could be due to differences in year and season of studies, agro-ecological systems, cattle management and production systems, population density and the types of tests used to determine the seroprevalence. The serological test used in this study, competitive ELISA, is more sensitive for detecting chronically infected cattle than other tests. Thus, it is unlikely that individual animals at the early stage of infection can be missed by this test [63,64].

The highest seroprevalence observed in Guangua district (Awi zone) compared to other study districts in the western Amhara could be due to presence of larger herds and communal grazing practices and frequent animal movement to border regions with pastoral production system such as Benshangul Gumuz,. Similar justifications were also given by Teshale et al. in a study in Southern zone of Tigray region; where the highest herd seroprevalence was observed in Raya Alamata district (28%), followed by Raya Azebo (15.2%) districts adjacent to Afar Region [52]. High district level seroprevalences were reported previously in Banja (66.3%) and Dangila (41.7%) districts of Awi zone and Denbecha (33.3%) district of West Gojjam [15]. High herd level seroprevalences were observed in Mieso (100%) followed by Qabribeyah (75%), and Afdem (71.4%) districts of Somali region with pastoral production system [55].

The age specific seroprevalence in this study was reported 17.6% in young and 23.2% in adult cattle. Although there was not statistically significant difference, the seroprevalence was relatively higher in adults. This finding is similar with previous reports by Swai et al., Matua-Alumira et al. and Teshale et al. that sero-positivity in adults was a bit higher than that in young animals [52,54,65]. The small difference in sero-prevalence between the two age categories can be attributed to the fact that young animals do not move far away from houses; therefore, there is less chance to come into contact with infected animals. In addition, Masiga and Domenech reported that young animals are more susceptible to acute forms of CBPP than adult cattle and thus acutely infected young animals may die of CBPP and not be available for testing [32].

The seroprevalence difference among sex groups is controversial. In this study the seroprevalence was 23.26% in male and 18.6% in female animals and there was no statistically significant difference ($P > 0.05$) in the occurrence of the disease. This result is in agreement with the previous reports by Teshale et al. and Daniel et al. who reported a relatively high prevalence in male than female animals with not statistically significant ($P > 0.05$) [52,53]. The difference of seroprevalence among sex groups may be due to similar exposure of animals to the disease since the disease is contagious that all susceptible cattle in the herd can be affected and chronically diseased animals can serve as a continuous source of infection to the herd. In contrast to our finding, Schnier et al. reported significantly higher prevalence in female animals than males [62].

The body condition was found significantly ($P < 0.05$) associated with the occurrence of the disease in which high seroprevalence was recorded in animals with poor body condition (25.9%) than medium (20.0%) and good body condition (13.7%). This finding is parallel to the previous finding by Biruhtesfa , who reported as body condition was significantly associated with the occurrence of the disease [66]. The higher seroprevalence in poor conditioned animals could be explained by the chronic nature of the disease that animals can loss their body condition as a result of infection. Agro-ecology and location of this study were not significantly associated with seroprevalence of CBPP. The seroprevalence was 22.13% in low land and 20.39% in mid highland and the overall distribution among districts was not significant with the exception in Guangua district in Awi zone. The absence of statistically significant association of the disease with agro-ecology is parallel with the study by Biruhtesfa in Adama conducted on animals of different origin. This finding contradict with that of Gedlu and Teshale et al. who reported a significantly higher prevalence in low land agro-ecology [52-66]. This variation in seroprevalence reports may be due to differences in study location and production system where most of previous reports were from lowland and pastoral areas, endemic for CBPP.

Even if the disease reporting and surveillance system in the country particularly in the Amhara region is passive, the outbreak data documented in this study provide information about the endemicity

of CBPP that can help to formulate control strategy in the region.

The study of annual occurrence of CBPP in West Amhara Region showed that the highest number of outbreaks was occurred in 2014 followed by 2010 and no record was found in the year 2013. The geographical distribution of the CBPP revealed high frequency of outbreaks in West Gojjam (4), Awi (3) and East Gojjam (2) zones and single outbreak was recorded in north and South Gondar within the five years period. Outbreaks were reported from Womberma (1 outbreak in 2012) and Quarit (3 outbreaks in 2014) districts of West Gojjam; from Fugta-lekoma (2 outbreaks in 2010) and Guangua (1 outbreak in 2011) districts of Awi zone; Machakel and Debay Tilatgen districts (1 outbreak each in 2014) in East Gojjam; Dera district (S. Gondar) and Metema of North Gondar reported 1 outbreak each in 2014 and 2010, respectively.

During this period of outbreak a total of 765 cases and 87 deaths of cattle were reported about 71,860 cattle were exposed in the western Amhara region. In order to contain these outbreaks vaccination was delivered to about 40,000 cattle. The high frequency of CBPP outbreak in all zones of western Amhara indicates that the disease is endemic.

Conclusion and Recommendations

This study documented high seroprevalence of CBPP and large number of outbreaks of the disease in cattle in the West Amhara Region with relative variations in study location, suggesting the disease is endemic and could cause considerable economic losses through morbidity and mortality. Therefore, based on the above conclusion the following recommendations are suggested;

- Control measures including regular surveillance and vaccination against CBPP should be implemented to mitigate the problem.
- Proper management of cattle especially during outbreaks should be undertaken on movement practices for grazing, watering and marketing.
- Awareness creation among the farmers about the means of prevention and control of the disease.
- Further epidemiological study on the isolation and molecular characterization of CBPP is required at a regional and national level.

References

1. Central Statistical Authority (CSA) (2013) Agricultural Sample Survey, 2012/13, Volume II: Report on Livestock and livestock characteristics (Private peasant holdings). Statistical bulletin 570. Central Statistical Agency (CSA), Federal Democratic Republic of Ethiopia, Addis Ababa.
2. Central Statistical Authority (CSA) (2014) Central statistics for livestock population in Ethiopia. Addis Ababa, Ethiopia 578: 9-15.
3. Metaferia F, Cherenet T, Gelan A, Abnet F, Tesfay A, et al. (2011) A Review to Improve Estimation of Livestock Contribution to the National GDP. Ministry of Finance and Economic Development and Ministry of Agriculture. https://hdl.handle.net/10568/24987.
4. Behnke R (2010) The Contribution of Livestock to the Economies of IGAD Member States: Study Findings, Application of the Methodology in Ethiopia and Recommendations for Further WORK. ODESSA CENTRE, IGAD Livestock Policy Initiative, Great Wolford, UK. https://hdl.handle.net/10568/24968.
5. Benin S, Ehui S, Pender J (2003) Policies for livestock development in the Ethiopian highlands. Environ Dev Sustain 5: 491-510.
6. Jabbar M, Negassa A, Gidyelew T (2007) Geographic distribution of cattle and shoats' populations and their market supply sheds in Ethiopia. Discussion Paper No. 2. Improving Market Opportunities. International Livestock Research Institute, https://hdl.handle.net/10568/346
7. Negassa A, Rashid S, Gebremedhin B (2011) Livestock production and marketing in Ethiopia. Ethiopian Support Strategy Program II (ESSP II) Working Paper 26. Washington, DC: IFPRI. https://hdl.handle.net/10568/10339.
8. Office International Des Epizooties (OIE), (2008). Manual of Diagnostic Tests and Vaccines for Terrestrial Animals (Mammals, birds and bees). Open Journal of Animal Sciences 12: 712-724.
9. Windsor S, Wood A (1998) Contagious Bovine Pleuropneumonia: The Costs of Control in Central/ Southern Africa. Ann NY Acad Sci 849: 299-306.
10. Abdo E, Nicolet J, Frey J (2000) Antigenic and Genetic Characterization of Lipoprotein from Mycoplasma mycoides subspecies mycoides small colony. Clinical Diagnostic Laboratory 7: 588-595.
11. March JB, Kerr K, Lema B (2003) Rapid Detection of Contagious Bovine Pleuropneumonia by a Mycoplasma mycoides subspecies mycoides small colony Capsular Polysaccharide-Specific Antigen Detection Latex Agglutination Test. Clin Diagn Lab Immunol 10: 233-240.
12. Radostits OM, Gay CC, Hinchcliff KW, Constable PD (2007) Veterinary medicine: a Text Book of the diseases of Cattle, Horses, Sheep, Pigs and Goats. Advances in Microbiology 6: 673-762.
13. Windsor RS (2000) Changing Patterns of Contagious Bovine Pleuropneumonia in Southern and Eastern Africa. In: Report of second meeting of the FAO/OIE/ consultative group on Contagious Bovine Pleuropneumonia (CBPP). Rome, Italy.
14. Desta B (1998) Se9ro-epidemiological investigation of CBPP in Ilu Ababor and Wellega, Western Ethiopia, Thesis for degree of Doctor of Veterinary Medicine, Faculty of Veterinary Medicine, University of Addis Ababa, Addis Ababa: 20-25.
15. Gashaw T (1998) Epidemiological survey of CBPP in Awi and Western Gojjam zone of Amhara Region and comparison of CFT and C-ELISA for the diagnosis of CBPP, Thesis for degree of Master of Veterinary Epidemiology, Faculty of Veterinary Medicine, Addis Ababa University and Freie Universität, Berlin. https://etd.aau.edu.et/items/8b509061-3088-4f71-9c23-4dd31c6c20d5.
16. Dejene W (1996) Contagious bovine pleuropneumonia (CBPP): Prevalence and evaluation of post-vaccination immune response in North Omo, Konso and Dirashe Regions, Ethiopia, Thesis for degree of Doctor of Veterinary Medicine, Faculty of Veterinary Medicine, Addis Ababa University, Addis Ababa, Ethiopia.
17. National Animal Health Research Centre (NAHRC)., 2000. Report on CBPP Study in Ethiopia. Serosurveillance results National Animal Health Research Centre Ethiopian Agricultural Research Organization (EARO), Sebeta, Ethiopia.
18. Afework Y (2000) Analysis of CBPP situation in Ethiopia, Past and Present. Ministry of Agriculture, Addis Ababa, Ethiopia.
19. Tambi EN, Maina OW (2004) Regional impact of CBPP in Africa. In: Regional Workshop on Validation of Strategies to Control CBPP in Participative PACE countries. Conakry, Guinea.

20. Amanfu W, Sediadie S, Masupu K, Benkirane A, Geiger Ret al. (1998) Field validation of a competitive enzyme-linked immunosorbent assay (cELISA) for the detection of Contagious Bovine Pleuropneumonia in Botswana. Rev Elev Med Vet Pays Trop 51: 189-193.
21. Vilei EM, Abdo EM, Nicolet J, Botelho A, Gonçalves R, et al. (2000) Genomic and antigenic differences between the European and African/Australian clusters of Mycoplasma mycoides subsp. mycoides SC. Microbiology 146: 477-486.
22. Monnerat M, Thiaucourt F, Poveda JB, Nicolet J, Frey J (1999) Genetic and Serological Analysisof Lipoprotein LppA in Mycoplasma mycoides subspecies mycoides large colony and Mycoplasma mycoides subspecies Capri. Clin Diagn Lab Immunol 6: 224-230.
23. Walker LR (1999) Mollicutes: In Hirsh, D. C. and Zee, Y. C. Veterinary microbiology. Blackwell Science Inc: 165-172.
24. Bessin R, Connor J (2000) Strategy for supporting the control of Contagious Bovine Pleuropneumonia (CBPP). In: Report of second meeting of the FAO/OIE consultative group on Contagious Bovine Pleuropneumonia (CBPP). Rome, Italy: 39-45.
25. Andrews H, Blowey W, Boyd H, Eddy RG (2004) Bovine Medicine Diseases and Husbandry of Cattle. 2nd ed. Australia: Blackwell publishing: 868-874.
26. Radostits OM, Blood DC, Gay CC (1994) Veterinary Medicine: A textbook of the diseases of cattle, sheep, pigs, goats and horses. 8th ed. Baillière Tindall: P. 910-913.
27. Seifert HSH (1996) Tropical animal health. 2nd ed. The Netherlands: Kluwer Academic Publishers: 332-339.
28. Thrusfield M (2005) Veterinary Epidemiology. 2nd ed. Blackwell Science Ltd. Oxford: 117-198.
29. Office International Des Epizootics (OIE) (2014) Terrestrial manual, 2014. Contagious Bovine Pleuropneumonia.
30. McGavin MD, Zachaery JF (2007) Pathological Bases of Veterinary Medicine 4th ed. China: Mosby Elsevier: 509- 513.
31. Quin PJ, Markey BK, Maguire D (2003) Concise Review of Veterinary Microbiology.1st ed. USA: Black well publishing Ltd: 64-65
32. Whitford HW, Rosenbusch FR and Lauerman HL (1995) Mycoplasmosis in Animals, Laboratory Diagnosis of Mycoplasmosis in Food Animals. 1st ed. Iowa State University press/Ames: 39-49.
33. Masiga W, Domenech J (1995) Overview and Epidemiology of Contagious Bovine Pleuropneumonia in Africa. Rev sci tech Off Int Epiz 14: 611-620.
34. Newton L, Norris R (2000) Clearing a Continent. The eradication of bovine pleuropneumonia from Australia. Collingwood, Australia: CSIRO publishing.
35. Smith BP (2009) Large Animal Medicine. 4th ed. United States: Mosby Elsevier: 338.
36. Hirsh DC, Zee YC (1999) Veterinary Microbiology. 1st ed. USA: Blackwell publishing Ltd: 165.
37. Gyles CL, Prescot JF, Songer JG, Thoen CO (2004) Pathogenesis of bacterial infections in Animals. 3rd ed. USA: Blackwell publishing: 397-408
38. Hirsh DC, Maclachlan NJ, Walker RL (2004) Veterinary microbiology. 2nd ed. Blackwell science: 240-243.
39. Food and Agricultural Organization (FAO) Empres Unit (1997) Recognising CBPP, A Field Manual for Recognition. EMPRES FAO Animal Health Service, Animal Production and Health Division, Rome, Italy.
40. Office International Des Épizooties (OIE) (2000) Consultative group on Contagious Bovine Pleuropneumonia (CBPP). Report of second meeting. Reviving progressive control of CBPP in Africa, Rome, Italy.
41. Amanfu W, Sediadie S, Masupu K, Raborokgwe M, Benkirane A, et al. (2000) Comparison between c-ELISA and CFT in Detecting Antibodies to Mycoplasma mycoides mycoides Biotype SC in Cattle Affected by CBPP in Botswana. Ann NY Acad Sci 916: 365-369.
42. Office International Des Epizooties (OIE) (2002) Manual of Standards for Diagnostic Tests and Vaccines.
43. Kahn CM (2005) Merck Veterinary manual. 9th ed. USA: A Merck and Aventis national publishing Inc: 189.
44. Yigezu LM, Roger F (1997) CBPP European Union Project component 2: Improvement of diagnostic methods competitive ELISA Kit assessment Report of the second semester year 2. National Veterinary Institute, Ethiopia.
45. Msami M, Ponela Mlelwa T, Mtei J, Kapaga M (2001) Contagious Bovine Pleuropneumonia in Tanzania: Current status. Tropical Animal Health and Production 33: 21-28.
46. Thomson GR (2005) Contagious Bovine Pleuropneumonia and Poverty: A Strategy for Addressing the Effects of the Disease in sub-Saharan Africa. Research Report (DFID Animal Health.
47. MoA (1997) Livestock Development project. Ministry of Agriculture, The Federal Democratic Republic of Ethiopia. Addis Ababa, Ethiopia.
48. Masiga WN, Domenech J, Windsor R (1996) Manifestation and epidemiology of Contagious Bovine Pleuropneumonia in Africa. Rev Sci Tech off int Epiz 15: 1241-1262.
49. Guangua Woreda Agricultural and Rular Development Office (MWARDO) (2014) Report on livestock number, 2013/2014, Guangua, Chagni.
50. Javietenan Woreda Agricultural and Rular Development Office (JWARDO) (2015) Annual report on general agricultural activities, Javie Tenan, Finote Selam.
51. LeGoff C, Thiaucourt A (1998) Competitive ELISA for the specific diagnosis of contagious bovine pleuropneumonia (CBPP). Veterinary Microbiology 60: 179-191.
52. Teshale T, Temesgen T, Tsigabu N, Birhanu H, Solomon W, et al. 2015. Epidemiologica Status of Contagious Bovine Pleuropneumonia inl Southern Zone of Tigray Regions, Northern Ethiopia., Animal and Veterinary Sciences 3: 32-36.
53. Daniel G, Abdurahaman M, Tuli G, Deresa B (2016) Contagious bovine pleuropneumonia: Seroprevalence and risk factors in Western Oromia, Ethiopia. Onderstepoort Journal of Veterinary Research 83: 1-5.
54. Matua- Alumira W, Ng'ang'a Z, Kiara H, Matere C, Mbithi F, et al. (2006) The prevalence of contagious bovine pleuropneumonia (CBPP) in cattle under different production systems in Kajiado district, Kenya, Proceedings of the 11thInternational Symposium on Veterinary Epidemiology and Economics, August 06–11, 2006, Cairns, Australia.
55. Gedlu MG (2004) Serological, clinical and participatory epidemiological survey of CBPP in Somali Region', Thesis for degree of Master of Veterinary Epidemiology, Faculty of Veterinary Medicine, University of Addis Ababa, Addis Ababa.
56. Suleiman A, Bello M, Dizkwi A, Talba M, Ahmed Y (2015) Serological prevalence of Contagious Bovine Pleuropneumonia in agro pastoral areas of Nigeria. Tropical animal health and production 47: 1033-1042.
57. Ahmed I (2004) Epidemiological study of contagious bovine pleuropneumonia in Borana pastoral areas using complement fixation test and competitive enzyme-linked immunosorbent assay, Thesis for degree of Master of Veterinary Epidemiology, Faculty of Veterinary Medicine, University of Addis Ababa,

Addis Ababa.

58. Kassaye D, Molla W (2013) Seroprevalence of contagious bovine pleuropneumonia at export quarantine centers in and around Adama, Ethiopia. Tropical Animal Health and Production 45: 275-279.
59. Olabode K, Mailafia S, Adah J, Nafarnda D, Ikpa T, et al. (2013) Serological evidence of Contagious Bovine Pleuropnemonia antibodies in trade cattle (Bos Indicus) sold in Kwara state-Nigeria). International journal of microbiology Research: 14-19.
60. Mbengue B, Sarr J, Massal F (2013) Sero epidemiological studies on contagious bovinepleuropneumonia (CBPP) in Senegal. American Journal of Research Communication 1: 190-199.
61. Aliyu M, Obi U, Egwu O (2000) Prevalence of Contagious Bovine Pleuropneumonia in Northern Nigeria. Preventive veterinary medicine 47: 263-269.
62. Schnier C, MtuiMalamsha J, Cleaveland S, Kiara H, Grace D, et al. (2006) CBPP seroprevalence and associated risk factors in the Maasai ecosystem of south-western Kenya. Proceedings of the 11th International Symposium on Veterinary Epidemiology and Economics, August: 6–11.
63. Muuka G, Hang'ombe M, Nalubamba S, Kabilika S, Mwambazi L, et al. (2011) Comparison of complement fixation test, competitive ELISA and LppQ ELISA with post-mortem findings in the diagnosis of contagious bovine pleuropneumonia (CBPP). Tropical Animal Health and Production 43: 1057-1062.
64. Schubert E, Sachse K, Jores J, Heller M (2011) Serological testing of cattle experimentally infected with Mycoplasmamycoides subsp. mycoides small colony using four different tests reveals a variety of seroconversion patterns. BMC Veterinary Research 7: 72.
65. Swai E, Mwezimpya I, Ulicky E, Mbise A, Moshy W (2013) An abattoir survey of contagious bovine pleuropneumonia lesions in slaughtered cattle in selected districts in Northern Tanzania', Asian Pacific Journal of Tropical Biomedicine 3: 303-306.
66. Biruhtesfa A, Henok G, Hundera S, Surafael K (2015) Sero-Prevalence of Contagious Bovine Pleuropneumonia in Abattoirs at Bishoftu and Export Oriented Feedlots around Adama. Global Veterinaria 15: 321-324.
67. Central Statistical Authority (CSA) (1998) Agricultural Sample Survey 1997/98, volume II. Statistical bulletin Number 193, CSA, Addis Ababa, Ethiopia.
68. Ethiopia Animal Health Yearbook (2010) Ethiopia Animal Health Yearbook 2009/2010. Addis Ababa, Ethiopia.
69. Federal Veterinary Epidemiology Unit (2003) National policy and strategy for the control of CBPP. Addis Ababa, Ethiopia.
70. Fogera woreda agricultural and rular office report (2015) Report on livestock population of Fogera woreda 2014/2015, Fogera, Woreta.
71. Mecha Woreda Agricultural and Rural Development Office (MWARDO) (2014) Annual report on general agricultural activities, Mecha, Merawi.
72. Programme Centre for Tropical Veterinary Medicine, University of Edinburgh, UK.