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Prevalence, Risk Factor and Economic Impact of CBPP and Its Current Status in Ethiopia: A Review

Tsegaye Mitiku Haile
Alage TVET Collage, Department of animal health, P.O.Box 77, Alage, Ethiopia
***Corresponding author**: Tsegaye Mitiku, Alage TVET Collage, Department of Animal Health, P.O.Box 77, Alage, Ethiopia
E-mail: *tsegayemitiku52@gmail.com*

Abstract

Contagious Bovine Pleuropneumonia (CBPP) is caused by Mycoplasma mycoides subspecies mycoides small colony variant and is characterized by difficulty in breathing, loss of condition, extensive sero-fibrinous pleurisy and edema of the interlobular septae. It is one of the major constraints to cattle production in Sub-saharan and South West Africa. Transmission occurs from direct and repeats contacts between sick and healthy animals by the inhalation of infective droplets from animals active or carrier cases of the disease. The epidemiology of CBPP is characterized by the occurrence of sub-acute and symptomless infections, the persistence of chronic carriers and the spread of the disease is associated with cattle movement. In Ethiopia, CBPP is known to be endemic and is rapidly spreading to cover the whole country in a few years' time, if adequate control measures are not taken. CBPP impacts animal health and poverty of livestock-dependent people through decreased animal productivity, reduced food supply and the cost of control measures. Diagnosis of CBPP in most developing countries of Africa is based on culture and isolation of the causal agent which is fastidious and slow growing, serology and postmortem examination of lungs affected animals. Treatment is recommended only in endemic areas because the organisms may not be eliminated and carriers may develop. The possible strategies used for control in affected countries or regions are vaccinations, control the movements of cattle and slaughter of infected animals**.** The main problems to control or eradication CBPP are the absence of a field test for diagnosis, the persistence of chronic carriers after the clinical phase and the lack of extensive vaccine coverage. The major control method practiced in Ethiopia is vaccination.

Keywords: Cattle, CBPP, Economic loss, Ethiopia

Introduction

Ethiopia is heavily depending on agriculture sector which play a major role in overall economic development. Among the agricultural sectors, livestock is the one which is ranked first largest in Africa and tenth in the world (Hailu, 2014). Livestock provides a livelihood for 65% of the total population (Solomon *et al.*, 2003), and 80% of the rural population of the country and contributes 15-17% of Gross Domestic Product (GDP) and 35-49 % of agricultural GDP and 37-87% of the household incomes (Leta and Mesele, 2014). Cattle are used as source of draught power for the rural farming population, supply farm families with milk, meat, manure, and also as source of cash income, playing a significant role in the social, and cultural values of the society (Melaku, 2011; Tonamo, 2016).

Contagious bovine pleuropneumonia is an acute, subacute or chronic disease affecting cattle of the Bos genus and occasionally of water buffalo (Bubalus bubalis). It is caused by Mycoplasma species belonging to “Mycoplasma mycoides cluster” known as Mycoplasma mycoides subsp. mycoides. Acute to subacute form of this disease is characterized by a sero-fibrinous pleuropneumonia and pleural effusion. The development of pulmonary sequestra is usually seen in chronic often subclinical form, which is considered as carrier state in recovered animals (Geary and Adams, 2013).

CBPP is endemic to parts of Africa, parts of India and China; with minor outbreaks in the Middle East. Countries free of CBPP include the US, UK, and Australia. In almost all African countries CBPP is a notifiable disease with official controls on the import of cattle. This disease is a major militating factor affecting cattle production in terms of animal protein supply and economic value (Francis et al. 2018). The disease is characterized by long incubation period as long as of six months and is manifested by anorexia, fever, dyspnea, polypnea, cough, and nasal discharges. Mostly infection is limited to the respiratory tract, although arthritis occurs in young calves usually less than 6 months of age (Geary and Adams, 2013). Recovered cattle continue to be chronic carriers and usually suffer from a persistent low-grade fever and the loss of condition along with respiratory signs that are usually manifested upon exercise; these animals also become a source of infection into the uninfected herds (Amanfu, 2009).

Transmission of Mycoplasma mycoides subsp. mycoides is mainly through respiratory aerosols. The organism is also found in the urine, saliva, the fetal membranes, and in uterine discharges of the animal. For transmission of the organism close and repeated contact is necessary; however, it may spread to the distances up to 200 meters in case the climate is favorable for the transmission of the organism (Alhaji and Babalobi, 2015). The organism resides for several months to 2 years in the encapsulated lung lesions (sequestra) of the carrier animals and the cattle with subclinical infection (Tardy *et al*. 2011). The carrier animals are thought to shed the organisms, particularly in stressful conditions. Transplacental transmission of the organism is also possible (Wade *et al*. 2015).

In most continents, control strategies are based on the early detection of outbreaks, control of animal movements and stamping-out policy. However, in Africa control of the disease is only based on vaccination (T1/44 or T1SR) and antibiotic treatment (OIE, 2008; Radiostits *et al*., 2007). However, the consequences of antibiotic treatments in terms of clinical efficacy, emergence of resistant strains and persistence of chronic carriers have not been evaluated yet (Huschle *et al*., 2004). But, currently research work has shown that antibiotic treatment of cattle may greatly reduce the transmission to healthy contacts but this requires treatment of all affected cattle (CFSPH, 2015). Despite vaccination has been considered as a strategy for the control of CBPP in Ethiopia, the disease still persists in several regions of the country and its incidence increasing from year to year. This is, mainly due to lack of effective vaccine, irregular and low coverage of vaccination, lack of livestock movement control, and absence of systematic disease surveillance and reliable data (Gizaw, 2004).

The control of CBPP can be achieved by restriction of animal movement 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. However, under the current Ethiopian situation, these control strategies could not be implemented to control and eradicate the disease. Therefore, control measures through vaccination and restriction animal movement remain the most practical option in the country. 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. Hence, from the outset the epidemiological assessment of CBPP should be implemented in order to envisage a rational plan for the control and eventual eradication of CBPP from Ethiopia. Accordingly, the aims of this epidemiological survey on CBPP were to assess the distribution and prevalence of CBPP and its related risk factors.

Recent studies conducted in different regions of the country showed that CBPP is posing a major threat to cattle production in many parts of the country, thereby causing considerable economic losses through morbidity and mortality and demanding for serious attention from the concerned body. Furthermore, CBPP has been reported from different export quarantine centers in the country which remain a threat to livestock export market and may reduce the investment in livestock production. Studies undertaken so far in Ethiopia reported seroprevalence that range from 0.4% from export from export quarantine centers (Alemayehu *et al*., 2015; Dele *et al*., 2014) to 75% from South Gondar (Tegene *et al*., 2009). Despite aforementioned situation of CBPP in the country, there is scarcity of well-documented information. Therefore, the main objective of this review was to make comprehensive document on seroprevalence and distribution of CBPP in the country. This paper systematically reviews the prevalence at herd and individual animal level and highlighted prevention options and future prospects.

Literature Review

Definition

Contagious bovine pleuropneumonia (CBPP) is acute, sub-acute or a chronic respiratory disease of cattle caused by a Mycoplasma called Mycoplasma mycoides subspecies mycoides (bovine biotype) SC (small colony). 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 (Abdo *et al*, 2000). Cattle suffering from the acute to sub-acute disease develop sero-ibrinous pleuropneumonia and severe pleural effusion (Penrith, 2014). It is also defined as an acute, sub-acute or chronic Mycoplasma disease of cattle which may cause high production losses and mortalities and characterized by fibrinous pneumonia, serofibrinous pleuritis, and oedema of the interlobular septa of the lungs (William and Amanfu, 2002).

Etiology of the Disease/CBPP

Contagious bovine pleuropneumonia is caused by Mycoplasma mycoides subspecies mycoides Small Colony (MmmSC) which belongs to the family mycoplasmataceae and genus mycoplasma. Mycoplasmas lack cell walls and are, therefore, pleomorphic and resistant to antibiotics of the beta lactamase group, such as penicillin. It is an extra-cellular pathogen that lives in close association with the host cells. Mycoplasmas are highly host specific and adapted to a main host in which they are commonly pathogenic, but may colonize other hosts (Mtui-Malamsha, 2009).

Mycoplasma mycoides subspecies mycoides Small Colony is susceptible to environmental factors and on average only survives outside the host for up to three days in tropical areas and up to two weeks in temperate zones. The agent can be inactivated within an hour at 56°C and 2 minutes at 60°C, by acid and alkaline pH and by many of the routinely used 6 disinfectants: mercuric chloride (0.01%/1 minute), phenol (1%/3 minute), and formaldehyde solution (0.5%/30 seconds). Therefore, the transmission of the agent from the infected animal to the susceptible one requires close contact. But when there is favorable condition of high humidity the agent can be moved longer distance with the aerosol (OIE, 2008)

Global Distribution of CBPP

Contagious bovine pleuropneumonia was first described in Europe in 1564 and has with the exception of South America and Madagascar, occurred throughout the world. Until the 16th century, CBPP was restricted to the alpine region of Europe, from where it spread to the west and south of the continent, as a result of cattle movements caused by wars and importations. The disease spread to the United States of America (USA) in the second half of the 19th century. CBPP spread to Australia through cattle imported from England in 1858, and from Australia the infection was taken to Asia at the beginning of the 20th century. By the end of the 19th century, CBPP had been eradicated from most of Europe, but was still present in Germany and Austria in the 1910s and 1920s (Penrith, 2014).

CBPP is widespread in Africa and is recognized to be present in some countries of Asia and Europe. In Asia, CBPP has been reported in recent times from Assam in India, Bangladesh and Myanmar. Sporadic outbreaks have been recognized in the Middle East, probably derived from importation of cattle from Africa. CBPP was eradicated from the United States of America, Zimbabwe, South Africa, Australia and China (Dupuy *et al*. 2012)..

Contagious bovine pleuropneumonia is an endemic disease in Africa where most of the outbreaks of this disease have been reported from 20 different countries in 2006, with the highest number of cases reported in Ethiopia, Cameroon, Angola, and Nigeria (Nicholas et al. 2008). In the 1990's the spread of disease was alarming and several countries previously known to be free from the disease were infected. Huge losses occurred in the cattle population due to this disease as compared to other diseases like rinderpest in Sub-Saharan African countries. The various contributing factors in the current reemergence of the disease are due to the failure in the veterinary services, the uncontrolled and increased movement of animals either because of the drought, and poor vaccine efficacy (Dupuy et al. 2012).

Epidemiological Situation of CBPP in Africa

Contagious bovine pleuropeumonia (CBPP) is widespread in Africa and, according to the OIE and to various reports in 1995, the disease is present in 24 countries of tropical Africa including Ethiopia. CBPP is now emerging as the most important animal epidemic in sub-Saharan Africa where hitherto disease-free areas are being infested and the incidence is increasing within endemic zones at an alarming rate (Litamoi, 2000). It has proved extremely difficult to make a rational estimate of the cost of CBPP in the areas where it still exists for methods of animal husbandries are geared more to survival than to profit. Nevertheless, one can estimate losses from self-subsistence farming system by evaluating the losses at farm gate market price (Maritim, 2009).

The epidemiology of CBPP in Africa is dominated by different factors. These are; cattle are the principal species affected; there is no reservoir host in wild animals; transmission is through the direct contact of susceptible animal with clinical cases or chronic carriers and cattle movements play a very important role in the maintenance and extension of the disease. CBPP has also been reported in a few countries in Southern Africa (Angola, Namibia and Zambia). the recent report revealed that based on data generated through reports submitted to AU- IBAR monthly by African union member states, CBPP is endemic in most pastoral areas of West, Central and East Africa, with at least 24 countries (45%) regularly reporting outbreaks every year for the last 10 years (Ahmed, 2016).

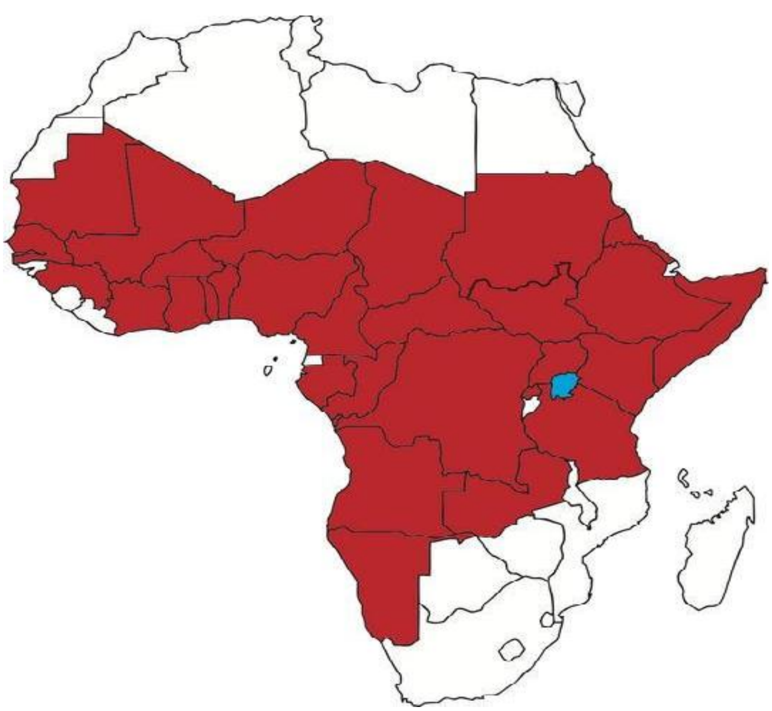

Figure 1: Geographical distribution of CBPP disease across African countries. Source: Mersha *et al*. (2015)

Study conducted at East Wollega and West Showa zones by Mersha (2017) on cattle, a total of 576 serum samples were collected who recorded overall seroprevalence of CBPP was 14.6%, which is comparably in agreement with the findings of various researchers who reported prevalence of 12% in southern zone of Tigray region of Ethiopia (Teklue *et al.*, 2015), 14% in Niger state of north central Nigeria (Alhaji and Babalobi, 2016), 14.3% in Kajiado district of Kenya (Matua-Alumira *et al.* 2006), 17.19% in Khartoum State of Sudan (Elhassan, 2012), and 17% in Turkana district of Kenya (Maritim, 2009).

On the other hand, the finding of this study was higher than the results of Gizaw (2004) in Somali regional state (10.3%), Ahmed (2004) in Borena (9.4%), Atnafie *et al.*(2015) in Bishoftu abattoir and Adama quarantine (6.85%), Alemayehu *et al.*(2015) in Borena pastoral of Oromia (0.4%), Kassaye and Molla (2013) in export quarantine of in and around Adama (4%), Geresu *et al* (2017) in Dello Mena and Sawena districts of Bale zone (6.51%), Schnier *et al*. (2006) in south western Kenya (9.7%), Mbengue *et al.* (2013) in Senegal (0.43%), Mtui-Malamsha (2009) in the Maasai ecosystem of south-western Kenya (11.21%), and Zarina *et al*. (2016) in north east states of Peninsular Malaysia Pertanika (8%).

Host Range

Under natural conditions, CBPP affects only cattle, both *Bos Taurus* (European) and *Bos indicus* (zebu) types. The domestic buffalo *(Bubalus bubalis)* is susceptible but the African wild buffalo *(Syncerus caffer)* is not. Clinical cases have also been reported in yak and captive bison. Sheep and goats can be infected, although they are not thought to be important in the epidemiology of CBPP and White-tailed deer have been infected experimentally (Matui-Malamsha, 2009).

Some serological response may occur in other animal species, such as the gnu (*Gorgon taurinus),* and a case has been described of a Willems's phenomenon in a roan antelope *(Hippotragus equinus).* It is considered that CBPP has no wild reservoir. Camels are resistant to the infection. *M. mycoides* can be isolated from cases of pneumonia in goats and very rarely in sheep. But, the role of small ruminants as a reservoir for CBPP has not been demonstrated. Very rare infections in bison *(Bison bonasus)* and yak *(Bos grunniens)* have been detected in zoos (Penrith, 2014).

Transmission

Mycoplasma mycoides sub.spp *mycoides* SC is mainly transmitted from animal to animal in respiratory aerosols. This organism also occurs in saliva, urine, fetal membranes and uterine discharges. Trans-placental transmission is also possible. Although there are a few subjective reports of transmission on fomites, mycoplasmas do not survive for more than a few days in the environment, hence indirect transmission is thought to be unimportant in the epidemiology of this disease (CFSPH, 2015).
Moreover, in other report confirmed that the disease is transmitted almost exclusively by direct contact between infected and susceptible cattle, by means of infected aerosols from exhaled air. Airborne spread up to 200 meters is thought to be possible and conditions under which cattle are herded closely together is favored the rapid spread of the disease. Carrier animals, including sub-clinically infected cattle, can retain viable organisms in encapsulated lung lesions (sequestra) for several months or more (one source indicates up to two years). These animals are thought to be capable of shedding organisms, particularly when stressed (FAO, 2002).

Morbidity and Mortality

The morbidity and mortality rates for CBPP are highly variable. In a naive herd, the outcome varies from complete recovery of all animals to the death of the majority. Morbidity increases with close confinement, due to the increase in transmission, and infection rates can be as high as 50-80% in some situations. The mortality rate ranges from 10% to 80%, although mortality greater than 50% is reported to be uncommon (FAO, 2000; CFSPH, 2015).

The severity of the illness can also be affected by the virulence of the strain, and secondary factors in the animal, such as nutrition and parasitism. As well as there may be breed-related differences in susceptibility. African and recent European isolates may differ in virulence because when they are first introduced into a naïve herd; African isolates usually cause acute disease severe, clinical signs and high mortality. Once the disease has become established, the mortality rates falls and the number of animals with chronic disease rises (Amanfu, 2009).

Risk Factors of CBPP

Contagious bovine pleuropneumonia is a multifactorial disease, where factors associated with the host, factors associated with the agent and factors associated with the environment are the determinant for the occurrence of infectious diseases (Thiaucourt, 2015).

Host Related Factors

Breeds: Among zebu, some breeds are remarkably resistant to CBPP like Somba, the breed of coastal lagoons of Benin and the small Côte d'Ivoire breed.

The Maasai breed of Tanganyika is equally resistant (80-85%) of them recover without treatment whereas the European breeds and their crosses are more receptive (Radostitis *et al.,* 2007).

Age: In the natural disease the susceptibility of animals related to age has three phases: young animals have low susceptibility which develops only minor lesions of tendons and joints but not the severe pulmonary form; animals greater than 1year are moderately susceptible and a final phase of full susceptibility which explains the choice of cattle over two years of age. Age of the animal is directly associated with the disease (Almaw *et al.,* 2016).

Pathogen Related Factor

Pathogen related factors: Mycoplasma mycoides subspecies mycoides Small Colony is sensitive to all environment influences; do not ordinarily survive outside the animal body for more than a few hours. But it secretes different virulence factors like, genes of encoding surface proteins, enzymes and transport proteins responsible for the production of H_2O_2 and the capsule which is thought to have toxic effect on the animal (Dupuy *et al.,* 2012)

Seasonal Dynamics

Season seems to play a role in stimulating CBPP infection, particularly the rainy season, when animals are exposed to cold weather. Sudden changes of weather have been important factors in the spread of the disease and these may be more important than stable temperature and humidity, to which the animal may adapt (Titus, 2003). These changes may affect both the potential pathogen and the host. A dry climate diminishes the risk of spread, because infective aerosols from contaminated cattle evaporate rapidly, and the pathogen is inactivated by ultraviolet rays (Titus, 2003).

Management Related Factor

The occurrence and incidence of contagious bovine pleuropneumonia is influenced by management system, disease control policies and regulation of the country, knowledge of the disease by farmers, veterinarians and livestock field officers. The diagnosis capabilities of veterinary laboratory, disease surveillance and monitoring system, adequacy of vaccination programs, government budget allocated to control programs, desires of cattle owner and traders to control the disease are critically important management factors, which influence the effectiveness of controlling disease in a country. This affects epidemiology of the disease and crucial factor since CBPP is essentially related to the movement of animals. Areas where there is no disease before will become endemic if there is no movement control between them. Compact grouping of herds during grazing, mixing with other herds at watering points, and confinement at night within small enclosures such conditions are eminently favorable for disease transmission (Radiostits *et al.,* 2007).

Pathogenesis

The result of the multiplication of *Mmm* SC in the lung is severe inflammation that causes respiratory distress and can result in the death of 30 percent or more of the affected cattle (Penrith, 2014). However, very little is known about the factors and mechanisms that affect the pathogenicity of *MmmSC*. No secreted toxins have been identified; neither receptor molecules on the bacterial surface that mediate binding to host epithelium or induce other cellular responses in the host tissues. Although, certain factors have been associated with the pathogenesis, the precise modes of action are still elusive (Mamo *et al*., 2018).

The pathogenesis has not been fully elucidated because of the high cost of experimental work in cattle and the lack of a laboratory animal model (Thiaucourt *et al.,* 2004). Actions involved in virulence include evasion of the host‟s immune system, tight adhesion to the surface of the host‟s cells, dissemination and persistence in the host, efficient importation of required nutrients and induction of cytotoxicity in the host. Mycoplasmas have the smallest genomes of all self-replicating organisms. Complete sequencing of the genome of *Mmm* SC in 2004 has revealed a lack of genes encoding primary virulence factors like toxins, cytolysins and invasins that are generally found in other bacteria, so that virulence depends on intrinsic metabolic and catabolic functions as well as surface proteins and their regulation (Thiaucourt *et al.,* 2004; Penrith, 2014)

Clinical Signs

Clinical disease may be acute, subacute, or chronic. In the initial stages of an epidemic, the disease tends to be acute, but as the epidemic progresses subacute and chronic cases predominate. In endemic areas the disease tends to be mostly subclinical and chronic. The typical clinical signs of contagious bovine pleuropneumonia are attributable to the pulmonary lesions (Abdela and Yune, 2017).

Animals with acute infection show elevated body temperature and signs of respiratory distress. They often grunts as if suffering from pain and occasional soft, moist coughs are heard which are aggravated upon exercise or by percussion of the chest. As the disease progresses, coughing increases both in frequency and in intensity, the animal is reluctant to move, and stands with its head extended, mouth open, tongue protruded, and the elbows turned out. Contraction of the muscle of the abdominal wall occurs after each inspiration, while expiration is frequently followed by a characteristic grunt or groan. There is a mucoid discharge from the nostrils and frothy saliva accumulates around the mouth. The locality of the affected areas in the lungs is revealed by the presence of dull sounds during percussion (Alhaji and Babalobi, 2016).

Figure 2: Animal stands with its head extended, mouth open, and the elbows turned out. Source: Batu *et al*. (2016)

As the disease progress, the animals may show a nasal discharge which becomes mucopurulent, subcutaneous edema of the lower parts of the chest and abdomen, and emaciation. In some affected animals, the difficulty in breathing is aggravated by the presence of large volumes of exudates in the thorax (Hamsten et al. 2010). In subacute cases, the lung lesions are more localized and less extensive and an infrequent cough is the only clinical sign. Usually the lesions resolve without the disease being noticed clinically. The only clinical signs in chronic cases are emaciation and a cough, which commonly occurs when the animal rises (Scacchia *et al*. 2007). Pulmonary lesions may or may not develop. Severely affected animals may take many months to recover. Recovered cattle may harbor sequestra in their lungs in which the infection remains latent. Relapses may be precipitated by stress factors (Alhaji and Babalobi, 2016).

Diagnosis

The causal organism can be isolated from samples taken either from live animals or at necropsy. Samples taken from live animals are nasal swabs or nasal discharges, broncho- alveolar lavage or transtracheal washing and pleural fluid collected aseptically by puncture made in the lower part of the thoracic cavity between the seventh and eighth ribs. Blood may also be cultured (FAO, 2002).

Samples taken at necropsy are lungs with lesions, pleural fluid, lymph nodes of the broncho-pulmonary tract, and synovial fluid from those animals with arthritis. The samples should be collected from lesions at the interface between diseased and normal tissue (OIE, 2008). When dispatching samples to the laboratory, it is advisable to use a transport medium that will protect the Mycoplasmas and prevent proliferation of other bacteria (heart- infusion broth without peptone and glucose, 10% yeast extract, 20% serum, 0.3% agar, 500 International Units (IU)/ml penicillin, thallium acetate 0.2 g/litre) and the samples must be kept cool at 4°C if stored for a few days or frozen at or below -20°C for a longer period. For laboratory-to-laboratory transfer, lung fragments or pleural fluid can also be freeze-dried (OIE, 2008).

Differential Diagnosis

In carrying out CBPP diagnosis it is necessary to differentiate the disease from other diseases that may present similar clinical signs or lesions are listed below (FAO, 2002; Gizaw, 2004): Rinderpest: The confusion with rinderpest results from the fever and discharges observed from the eyes, nose and mouth. However, the characteristic lesions of rinderpest, which are essentially erosions in the mouth and throughout the digestive tract, together with the profuse, often bloody diarrhea in advanced cases, should enable easy differentiation from CBPP in which these are not seen. Lung lesions are seen in more chronic cases of rinderpest, consisting of red areas of collapse together with emphysema of lung lobules and the septa separating them. At this stage, the erosive lesions of rinderpest may have healed (Gizaw, 2004).

Foot-and- mouth disease (FMD): Salivation, lameness and fever are the cause of confusion. Haemorrhagic septicaemia (HS): This is an acute disease and most affected animals die within 6 to 72 hours after the onset of clinical signs. Oedema of the throat and neck to the brisket is often very pronounced. The lung lesions seen in animals that survive the longest can appear very similar to the marbling lesion of CBPP. There may be yellow fluid in the chest cavity and the affected lung may adhere to the inside of the rib cage. Thus, in the individual case distinguishing between HS and CBPP can be difficult. Bacterial or viral broncho-pneumonia: Post mortem examination shows usually both lungs to be affected, fibrinous exudate may be present but not to the same extent as in CBPP. While dark, solid areas of lung may be seen, these are usually restricted to the anterior lobes (not the diaphragmatic lobe as in CBPP) and marbled lungs are not often seen (Nicholas *et al*., 2012).

Theileriosis (East Coast Fever): Coughing, nasal and ocular discharge and diarrhea are observed. Affected cattle show general enlargement of superficial lymph nodes and especially those of the head. The lungs contain much clear liquid, which is also present in the chest cavity. The airways in the lung may be filled with white froth. "cigarette burn-like" ulcers are seen in the abomasal folds. Tuberculosis: Tubercular nodules can superficially resemble sequestra, but they are degenerative cheese-like lesions, sometimes calcified. The lung tissue is destroyed and the same lesions are also seen in lymph nodes in the chest. The capsule of the tubercular nodules is not well defined when compared to that of sequestra. Similar lymph node lesions are always present. Actinobacillosis: The pulmonary lesions, when found, could be mistaken for sequestra. Lesions are generalized and seldom present in lungs alone. Echinococcal (hydatid) cysts: These cysts have a double wall and contain a clear liquid, often calcified when old. Foreign body reticulum pericarditis: Clinically similar to CBPP because of the dyspnoea associated with the disease (FAO, 2002; Gizaw, 2004).

Post Mortem Lesions

Gross pathological lesions in the acute stage are characterized by fibrinous deposits on the parietal surfaces of lungs and distension of the interlobular spaces with straw coloured serofibrinous exudate. In subacute cases, lesions are characterized by necrosis organized within lobules and interlobular septa and early sequestrum formation. Except for young calves, pathological lesions are generally confined to the chest cavity.

Figure 3: Coagulated yellowish thoracic fluid and fibrin deposit.   Source: Gedlu (2004)

The interlobular septa of affected lung regions are also thickened due to adsorption of the exudates and “frame” the lung lobules, which vary in colors of red, grey and yellow due to different stages of inflammatory lesions (FAO, 2002).

It gives a characteristic “marbled” appearance when dissecting the lung, pleural exudate is rarely seen in chronic cases of CBPP, but adhesions between lung lobes and to the chest wall is more common. Necrotic lesions in the lung are surrounded by capsules of fibrous connective tissue forming structures called sequestra. Sizes of sequestra can vary from 1-30 cm in diameter. A sequestrum is believed to be a source of infection if it is ruptured or drained by a bronchus, but no evidence of this has been published (Hamsten, 2009).

Diagnostic methods

Culture: *Mmm* SC needs appropriate media to grow (OIE, 2008). Many attempts to isolate fail because the organism is labile, often present in small quantities, and demanding in its growth requirements. The media should contain a basic medium (such as heart-infusion or peptone), yeast extract (preferably fresh), and horse serum (10%). Several other components can be added, such as glucose, glycerol, DNA, and fatty acids, but the effects vary with the strains. To avoid growth of other bacteria, inhibitors, such as penicillin, colistin or thallium acetate, are necessary. The media can be used as broth or solid medium with 1.0–1.2% agar (OIE, 2014).

Polymerase chain reaction (PCR) methods: The PCR is sensitive, highly specific, rapid and relatively easy to perform, primers specific for the *M. mycoides* cluster (and for *Mmm* SC (OIE, 2008) have been reported. PCR has become the method of choice for the rapid and specific identification of *Mmm* SC when the organism is isolated from a clinical sample (Nicholas *et al*., 2012).

Biochemical test : *Mycoplasma m. ssp. 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 (OIÈ, 2000).

Treatment

Antibiotic treatment is not recommended because of the possible induction of chronic carriers and the emergence of resistant Mycoplasma mycoides subsp. mycoides strains. In addition, it may suppress the progress of clinical signs and this may delay the recognition of the disease. Its effectiveness has not been adequately studied and will depend on many factors such as the type of antibiotic used, quality of the product, and proper administration of the correct dose and number of injections. Mycoplasmas are resistant to penicillin and rapidly become resistant to aminoglycoside. These antibiotics should therefore not be used for the treatment of contagious bovine pleuropneumonia (Hubschle et al. 2006).

Chloramphenicol should not be used in animals as it is restricted for use in humans. Antibiotics of the tetracycline family are regularly used for the treatment of contagious bovine pleuropneumonia in Africa, along with the macrolides, lincosamides and fluoroquinolones which are active against Mycoplasma Review of Literature 14 mycoides subsp. mycoides. These substances are efficient in alleviating the clinical signs in clinically affected animals, but there is some doubt as to their ability to reach organisms in all the affected organs or lesions in an animal suffering from contagious bovine pleuropneumonia, especially those

However, recent studies by Mariner *et al.* (2006) reveal that using treatment to reduce the infectious period by 50% resulted in a 64% reduction in mortality and a reduction in the prevalence of infected herds from 75.4% to 33.2%. Guidelines for the antibiotic treatment of cases of contagious bovine pleuropneumonia are therefore required before it can be recommended as a control measure in combination with the other procedures, such as vaccination and slaughter. Until these are introduced it is likely that antibiotic therapy will continue to be used to treat animals with respiratory signs; a ban on the use of such therapy is unlikely to be respected in many locations. Antibiotic therapy should, however, be used in the case of post-vaccinal reactions to control the invading edema at the site of the inoculation that develop in a small number of cases and which could jeopardize the faith of cattle owners in the efficacy of vaccination (Almaw *et al*., 2016).

Control and Prevention

In livestock disease control, there are two ways to eliminate infectious animals: removing them through slaughter or treating them. Reducing susceptibility in animals is accomplished by rendering them immune, most often by vaccination. The challenge with this approach is that the majority of the population needs to be rendered immune to interrupt transmission (overall herd immunity). Movement control and quarantine are techniques to isolate populations and prevent contact between infectious animals and susceptible animals. These groups must be kept separate until the infection fades out of the population (Mariner *et al*., 2019).

Contagious bovine pleuropneumonia has long incubation and infectious periods; control of contact rates must last months to years to be effective. Outbreaks are eradicated with quarantines, movement controls, slaughter of infected and in-contact animals, and cleaning and disinfection. So, quarantine coupled with vaccination and movement control is the most frequently used CBPP control measure (OIE, 2009).

To be effective, vaccination must target 100% of cattle within an epidemiological and geographically defined area. Vaccination must be repeated, initially at short intervals and thereafter annually over several years, i.e., not less than three to five years. Such vaccination must be maintained until evidence of CBPP eradication is demonstrated by structured surveillance. Live attenuated vaccines (T1 strain) are widely used in Africa, and only those with quality assurance certification should be used. Vaccine quality control is, therefore, an essential component of CBPP control programs. Usually there are only a small number of infected animals relative to the size of the susceptible population. Thus, elimination of infected animals is often the most effective way of reducing transmission (OIE, 2018).

Socio-Economic Importance of CBPP Disease

Animal diseases in general and CBPP in particular, impacts animal production and health through direct losses and indirect losses. Direct losses include mortality losses and morbidity losses, while indirect losses are the cost of controlling, managing the disease in herds, its effect on trade and socio-economic losses (Tambi *et al*., 2006).

Direct losses: Direct losses include losses due to morbidity and mortality due to the disease. Reductions in the production of milk, beef and draft power are considered as morbidity losses. The loss in milk could be estimated from two components: reductions due to dead cows that no longer produce milk and reductions due to diseased milk cows that do not produce the same quantity of milk as before (Radiostits et al., 2007).

Indirect costs: Indirect costs of contagious bovine pleuropneumonia include: control costs for vaccination and treatment, socio cultural costs and costs related to international trade bans. These can be associated with the subclinical or chronic nature of the disease (Tambi et al., 2006; Radostits et al., 2007). CBPP is considered as a disease of economic significance because of its ability to compromise food security through loss of protein and draft power, reduce output, increase production costs due to costs of disease control, disrupt livestock/product trade, inhibit sustained investment in livestock production and cause pain and suffering to animals (Tambi *et al*., 2006; Batu *et al.,* 2016).

Even though the economic burden of CBPP is generally difficult to compute, several studies were conducted, such as Thomson (2005) has stated that the cost of controlling CBPP using a mass vaccination programme in countries of Central, Eastern and Western Africa is quite high (300 million euros) and that even if half of this cost were to be recovered from cattle owners, many governments will still not be able to afford the rest. Tambi *et al*. (2006) estimated the cost of CBPP control by vaccination in 10 African countries during the PARC period and found unit costs to vary from 0.27 euro in Ethiopia to 0.71 euro in Côte d‟Ivoire, with an average of 0.42 euro as well as in many countries, treatment of clinical disease is at the exclusive cost of cattle owners, despite the fact that the efficacy of treatment is largely unknown as are the epidemiological consequences (Tambi *et al*., 2006).

A recent study in 12 countries in West, Central and East Africa that reported a total of 2,612 outbreaks to OIE during the period 1996 to 2002, accounting for 96% of the reports of CBPP for that period, suggested an amount of 44.8 million euros in direct losses and control costs. Based on mass vaccination for five years to attain 80% coverage and including an estimated cost of treating about the same percentage of animals, the cost-benefit ratios of controlling CBPP were favorable for the countries studied (Penrith, 2014).

According to Admassu *et al* (2015) the annual estimated losses in cattle and cattle products caused by CBPP in Ethiopia reported as Cattle death (no) 10112, Beef (metric tons) 1350, Milk (metric tons) 8500 and Drought power (working days) 1645. 2.6.2. Tambi et al., (2006) estimated the cost of control of contagious bovine pleuropneumonia to be 14.8 million euros in Africa and Ethiopia may cost on average 2.08 million euros (Tambi *et al*., 2006).

Table 1: Estimated losses in cattle and cattle products caused by CBPP

Country	Cattle death (no)	Milk (metric tones)	Beef (metric tones)	Drought power
B.Faso	1606	216	1312	365
Chad	3335	299	1927	506
Cote d'Ivior	930	83	537	141
Ethiopia	10112	1350	8500	1645
Ghana	474	64	387	108
Guinea	1395	188	1140	317
Kenya	3033	373	2316	494
Mali	2606	350	2129	593
Mauritania	556	75	476	126
Niger	785	106	672	179
Tanzania	4499	526	3527	641
Uganda	1542	180	1208	220
Total	30873	3810	24132	5335

Source: Mariner *et al*. (2006)

Current status of CBPP in Ethiopia

The Epidemiology of CBPP in Ethiopia

The origin of CBPP in Central, West and East Africa is ambiguous and it has been suggested that the infection was introduced by zebu cattle when they first migrated to the African continent. After rinderpest has been brought under control, CBPP is considered to be among the most important cattle diseases and impediments to livestock development in Ethiopia, particularly in the lowlands of the country.

During the past years the level of the disease is reduced in the high land due to unfavorable environment conditions for development of the organism. The irregularity and low rate of vaccination since 1992/93 and vaccination with combined Rinderpest and CBPP contribute to increased incidence of the disease and its further spread. But with the adoption of a strategy towards Rinderpest eradication, the vaccinations in the highlands have ceased since 1992/93 (MOA, 2003). Generally, the irregularity and low rate of vaccinations since 1993 seem to contribute to the The usual blanket coverage was around 50% and never reached the desired 80-100% level (MOA, 2003).

According to Gedlu (2004) study, total of 793 serum samples were tested in Somali region. Out of the 793 sera tested 82 (10.3%) were found sero-positive by c-ELISA. Sero-prevalence based on agro-ecology showed that it was highly significant in lowland than in medium altitude at 39.0% and 6.7%, respectively.

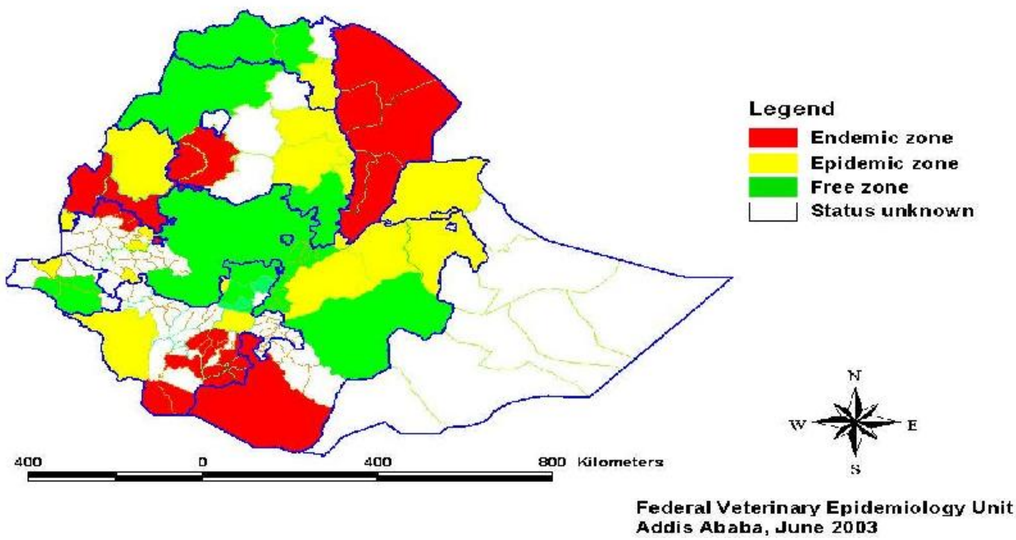

Figure 4: Map showing the different CBPP zones in Ethiopia Source: Ebisa *et al*. (2017)

CBPP out Breaks in Ethiopia

According to eleven years (1992-2002) disease outbreak reports by Federal Ministry of Agriculture, several CBPP epidemics have been recorded from the south, south-west, west, north-west and north-east regions of the country (MOA, 2002).

Different 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 (Batu *et al.*, 2016). Gizaw (2004) reported in Somale region.

Table 2: CBPP outbreak reports between1992 to 2002 years

Year	No. of Outbreaks	Cases	Death	Slaughter	PAR[a]	Morbidity Rate (%)	Mortality Rate (%)	CFR[b] (%)
1992	1	4	1	0	1500	0.27	0.07	25.00
1993	3	484	127	8	72,655	0.67	0.17	26.24
1994	0	115	46	0	20800	0.55	0.22	40.00
1995	48	429	160	7	161645	0.27	0.10	37.30
1996	96	505	183	5	83484	0.60	0.22	36.24
1997	43	753	131	16	93895	0.80	0.14	17.40
1998	187	5652	1071	77	844833	0.67	0.13	18.95
1999	94	4025	596	740	534938	0.75	0.11	14.81
2000	56	1918	274	600	210,375	0.91	0.13	14.29
2001	27	1595	252	20	312,516	0.51	0.08	15.72
2002	32	1326	421	34	267,381	0.5	0.16	31.75
Total	**587**	**16806**	**3262**	**1507**	**2,604,022**	**0.6**	**0.13**	**19.4**

Source: MOA (2002).

The cattle population at risk of CBPP and livestock production systems in CBPP endemic and epidemic zones of Ethiopia is estimated to be a total of 13,325,700 heads of cattle. All of them are considered to be at risk of CBPP, of which 5,510,700 are in endemic zones and 7,815,000 are in epidemic zones. General based on the available information, the epidemiological situation of CBPP is found in various parts of Ethiopia (Afework, 2000).

Sero-Prevalence of CBPP in Different Study Areas of Ethiopia

Recent studies conducted in different regions of the country showed that CBPP is posing a major threat to cattle production in many parts of the country, thereby causing considerable economic losses through morbidity and mortality and demanding for serious attention from the concerned body.

The study conducted by Lelisa *et al*. (2017) at Derashe district, atotal of 545 samples were collected from cattle which showed an overall prevalence of was 55.05%, this result was in agreement with Dejene (1996) in which he documented a CBPP seroprevalence of 56% in North Omo zone. However, this finding was much higher than most of the previous reports in Ethiopia; including the reports of Gedlu (2004), Ebisa *et al*.(2015), Regassa (2005) and Issa (2004) in which seroprevalence of 39, 31.8, 28 and 5.1% were recorded, respectively. Such a wide variation in the prevalence of CBPP reported from different parts of Ethiopia could be due to difference in agro ecology, management system, population density and the types of tests employed to evaluate the prevalence (Ebisa *et al*., 2015).

Table 3: Sero-prevalence distribution of CBPP in different areas of Ethiopia.

Study area	Diagnostic test used	Sample size	Seroprevalence (%)	References
Oromia (Borena)	CFT and c-ELISA		5.1	Issa, 2004
Quarantine center in and around Adama	c- ELISA	3111	4	Kassaye and Molla, 2013
	CFT	3777	0.4	
Adama-Modjolivestock export industry (bulls come from Borena)	3ABC ELISA	4321	8%	Birhanu, 2014
Borena		857	61(10.4%)	
Bale		1432	128 (8.9%)	
Arsi		2019	7.7%	
Feedlot at east Shoa zone (animas originated from Borena zone)	c- ELISA	38,187	0.4%	Alemayehu *et al*., 2015
SNNP (Amaro district)	c-ELISA	400	31.8	Ebisa *et al*., 2015
Tigray (southern Zone)	CFT	384	11.9	Teklu *et al*., 2015
Bishoftu	c-ELISA	384	7.8	Atnafie *et al*., 2015
Adama		1086	5.9	
Western showa	c- ELISA	100	19	Daniel *et al*., 2016
HorroGuduruWellega		70	5.7	
Eastern Wellega		216	40.3	
Jijiga Zone	C-ELISA	140	4.3	Gedlu, 2004
Shinille Zone		653	11.6	
Sidama	c-ELISA		25.3	Malicha *et al*., 2017
East Wollega and West Shoa	c-ELISA		14.6	Mersha, 2017
Bale zone	c-ELISA		1.39	Lemu and Worku, 2017
Sawena district	c-ELISA		6.51	Geresu *et al*., 2017
Derashe	c-ELISA		55.05	Abde *et al*., 2017
Gimbo district, southern Ethiopia	c-ELISA		8.1	Mamo *et al*., 2018

Study conducted at Eastern Wollegga Zones and Horro Guduru Wollegga Zone by Mersha (2016) from cattle population, a total of 386 serum samples was collected. The result showed an overall seroprevalence of 28.5 %. The highest CBPP seroprevalence (40.3%) was observed in Gobbu Sayyo district of Eastern Wollegga Zones while the lowest seroprevalence (5.7%) was recorded in Horro district of Horro Guduru Wollegga Zone. The overall sero-prevalence similar to the work of Fayisa Ragassa (2001) which reported seroprevalence of 28%, in Bodji district of Western Wollegga and it was lower than the findings of Gedlu Mokonnen (2004) who reported seroprevalnce of 39% in Somali Regional state. The report was higher than that of Ahmed Ibrahim (2004), Schnier *et al*. (2006), Matua Alumira *et al*. (2006) and Dawit Kassaye *et al*. (2013) who reported seroprevalence of 9.4 % in Borena, 9.7 % in south western Kenya, 9.1 % in Northwest Ethiopia, 16 % in Kajiado District Kenya and 4 % in and around Adama, respectively.

Table 4: Seroprevalence of CBPP disease in different risk factors.

Variables	No. of animal Tested	Positive	% of positive
Sex	768	110	14.3%
Female	450	50	11.1%
Male	318	60	18.9%
Age	768	110	14.3%
Young	351	38	10.8%
Adult	417	72	17.3%
BCS	768	110	14.3%
Poor	302	61	20.2%
Medium	211	30	14.2%
Good	255	19	7.5%

Source: Hirpa (2020)

According to the report of Hirpa (2020) the Seroprevalence of CBPP was highest in cattle with poor body condition (20.2%), medium conditions (14.2%), and followed by good condition (7.5%). The Present result is agreed with the Finding of Ebisa *et al*. (2015), poor (40%), medium (32.3%), and good (20.6%), Suleiman *et al*. (2015) and Matui-Malamsha (2009). This could be due to be related to the weak protective immune response in poor body conditioned cattle compared to good ones. Loss of body condition is one of the indications for the presence of the infection in the animal. Mostly CBPP chronic carrier animals became emaciated because of the clinical characteristics of the disease. Besides, animals with good body condition have relatively good immunological response to the infectious agent than animals with medium and poor body condition scores (Radostitis et al., 2007).

Control and Prevention of CBPP in Ethiopia

There are four essential tools in CBPP control and eradication. These are movement control, stamping out, vaccination, and treatment. Each control measure acts by reducing the effective reproductive number of the agent in the population. However, not every country uses all of these control measures including Ethiopia. However, in Ethiopia continue to carry out annual CBPP vaccinations using the T1/44 and T1/SR vaccines (MOA, 2002). These vaccines are not 100% efficacious and confer immunity for a relatively short period of time. Mariner et al. (2006) tested the impact of mass immunisation on the persistence of infection (herd level prevalence) and found that vaccination reduced the percentage of herds persistently infected by 53% to 81%.

Some form of management of the movement of cattle from infected areas to areas that are free would favour better control than vaccination and treatment alone. Due to lack of data on movement control, this estimation of the economic impact of CBPP only took into account CBPP control by vaccination and treatment. So that CBPP prevention in Ethiopia is mainly depending upon annual vaccination since another methods are difficult to apply in our context (Gedlu, 2004).

Conclusion and Recommendations

Contagious bovine pleuropneumonia is highly contagious disease of cattle caused by Mycoplasma myciodes subspecies mycoides SC type. The disease is found in different parts of the world; especially it is the problem of developing countries; Ethiopia due to lack of enough diagnostic tools, well trained personnel, economy, strategic epidemiological surveillance for the eradication of the diseases. The main control strategy in Ethiopia is done through vaccination; and sometimes control is done by restricting the movement of cattle. At the country level, sero-prevalence studies have been conducted in different localities of the country both at production area and the quarantine stations. However, there is a great variation of reports from different areas that range from 0.4 to 75%. Thus, it requires great attention both at production area and the quarantine stations as its occurrence may cause restriction on the trade of animals and animal products internationally, affecting the export earnings of the country, thereby threatening the livelihood of pastoralists and national economy. Moreover, effective vaccination policy needs to be considered as it is the only realistic method of choice for control of CBPP in the country with movement control if possible. Therefore, based on the above conclusions, the following recommendations are forwarded.

- Adequate funding should be available to control CBPP in Ethiopia, and other countries.
- Research in the improvements of vaccine should continue and include the possibility of differentiation between vaccinated and non-vaccinated animals.
- Strategic control of CBPP should be progressive and based on impact assessment and cost benefit analysis done.
- The farmers should be made aware of about CBPP disease on economic importance, transmissions methods, and controlling techniques of the disease through veterinary extension education and possible means like media.

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