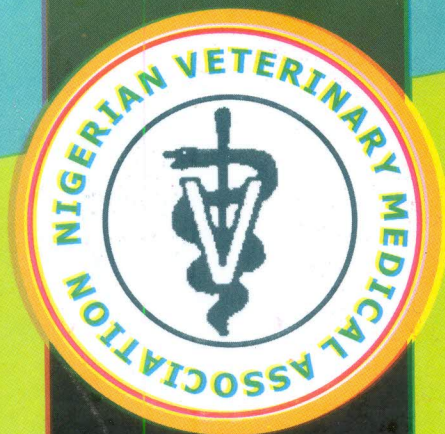




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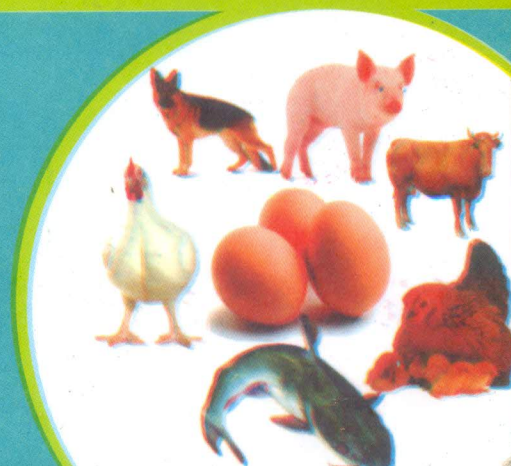
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CONTAGIOUS BOVINE PLEUROPNEUMONIA IN NIGERIA: REVIEW OF OUTBREAKS, RISK FACTORS, AND INTERVENTION APPROACHES

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Abstract

Contagious Bovine Pleuropneumonia (CBPP) burden in Nigeria reduced significantly following the eradication of Rinderpest in 1997. However, strong barriers to prompt detection of outbreaks, treatment and routine vaccination of CBPP still persist, particularly among the hard to reach populations under a 2 classical sub groups of the Nomads and sedentary Fulanis, where the incidence of CBPP can be 20 times higher than those recorded against the settled or institutional farmers in Nigeria. In this review, we explored the long standing challenges posed by CBPP in Nigeria focusing on outbreak patterns, risk factors and intervention strategies in preparation towards our collaboration efforts with the international bodies for cross-border CBPP control programme in Nigeria. In our previous review, we pointed out that the present tools for diagnosis and control are adequate for eradication and what is necessary are resources to improve vaccine coverage to levels of at least 80%, last seen in the 1970s when CBPP was restricted to very few countries of Africa. A study in Namibia supported strategic antimicrobial treatment in conjunction with routine and massive vaccination. The Italian veterinary control authorities eradicated CBPP in less than 3 years by movement control, stamped out policy through abattoir surveillance and

effective animal identification system. This is presently not feasible in Nigeria, however, Rinderpest was a much more difficult disease to eradicate than CBPP, but it was eventually successfully eradicated through vaccination control programmes with the stakeholders' concept of good will and co-operation. Collaboration initiatives with full commitment are critical factors in controlling CBPP in Nigeria. Hence, extra funds should be set aside by Nigerian government to improve vaccine coverage using the T1/44 with targeted use of antibiotics in outbreaks overseen by OIE experts.

Keywords: CBBP, Nigeria, Outbreaks, Risk factors, Interventions.

Introduction

Contagious bovine pleuropneumonia (CBPP), caused by *Mycoplasma mycoides* subsp. *mycoides* (Mmm) previously further specified as Small Colony (SC) type (Manso-Silván *et al.*, 2009), is manifested by anorexia, fever, dyspnoea, polypnoea, cough and nasal discharges (Radostits *et al.*, 2007). CBPP in Nigeria was categorized broadly into three zones with the far North being Enzootic, the Middle/Central belt States Exposed, while the Southern States were regarded as Free of the disease. Phylogenetically, Mmm is a member of the *Mycoplasma mycoides* cluster, which has six members that are pathogens of small and large ruminants (Manso-Silvan *et al.*, 2009). Identification of members of this group is associated with difficulties due to shared biochemical, immunologic, and genetic characteristics (Miles *et al.*, 2006). Although Mmm is thought to be a very homogeneous taxon, previous studies have shown Mmm strains are geographically heterogeneous which could be differentiated using molecular typing assays and grouped into two major epidemiological and clinical distinct clusters: one cluster contains isolates from different European countries and a second cluster contains Africa and Australian strains (Yaya *et al.*, 2008). CBPP is of age and the aetiology was first reported by cultivation by Nocard and Roux in 1898 (Nocard and Roux, 1990). *Mycoplasma* is a genus of bacteria without a traditional cell wall (Ryan and Ray, 2004), hence, they are unaffected by many common antibiotics such as penicillin and other β -lactam antibiotics that target cell wall synthesis. Mycoplasmas are the smallest free-living, self-replicating bacteria, having diameters of 300 to 800 nm (Fraser *et al.*, 1995). Due to their small size and flexibility, they can pass through filters that are commonly used in cell culture. *Mycoplasma* can be parasitic or saprotrophic (Fraser *et al.*, 1995). *Mycoplasma* species have one of the smallest genomes of free-living organisms (Fraser *et al.*, 1995). Because of their simple genome, *Mycoplasma* exploit host cells to provide their energy and biosynthesis requirements.

Literature Review

Methodology

Main databases that were searched were those from OIE website, Veterinary journals, Veterinary libraries, National Veterinary Research Institute's Library and other Veterinary journals at the local and international levels. The OIE Enhanced Surveillance System (ETS) database and literature were utilised to obtain epidemiological information for CBPP (Contagious Bovine Pleuropneumonia) outbreaks in Nigeria from 2005 to 2017. The review covered the OIE website; Veterinary research institutes libraries, Food and Agricultural organisation, United Nations for Food and Drug Control, using Keywords as CBPP, *Mycoplasma mycoides* subsp. *mycoides* SC, outbreaks, review, Nigeria. Studies carried out of Nigeria and outside the year under review were excluded. Review approach focused mainly on reported cases of CBPP outbreaks in Nigeria. The analyses of intervention approaches carried out in the literature was analysed manually and summarised in Table 1.

Epidemiology

The first scientist to describe Contagious bovine pleuropneumonia (CBPP), was Gallo in 1550. CBPP spread to Africa through South Africa by importation of a Friesian bull Holland in 1854, spread the disease to its neighbouring countries: Namibia (1856), Zimbabwe (1861), Zambia (1861) and Nigeria (1924). CBPP is the most important endemic transboundary bacterial disease in Africa (OIE, 2005a, AU-IBAR, 2003a). CBPP caused by *Mycoplasma mycoides* subspecies *mycoides*, small colony (MmmSC), can occur as an acute, sub-acute or chronic respiratory disease of cattle and is characterized by serofibrinous pleuropneumonia and pulmonary sequestra. The disease caused more cattle deaths worldwide than any other bacterial disease listed by the World Organisation for Animal Health (formerly the Office International des Epizooties (OIE). CBPP causes considerable economic hardship to nomads in Nigeria who own approximately 90% of the cattle population. The persistence of CBPP in Nigeria poses a serious threat to the rest of Africa, particularly to those neighbouring countries into cattle trade with Nigeria. CBPP has been reported annually to OIE by about 30 states in Nigeria during the period 2005 to 2017. During the colonial era and for the first decades after most African countries achieved independence; CBPP was fairly well controlled, but the 1980s and 1990s saw a resurgence of the disease that is attributed to declining economies, weaker veterinary services and possibly cessation of rinderpest vaccination campaigns that incorporated vaccination for CBPP. In the last 2 decades the rate of civil unrest in the north has further spread and increased the incident and prevalent of CBPP in Nigeria and the surrounding countries (OIE, 2016 and Olorunshola et al.2017). This is an initial review of the status of CBPP in Nigeria to design a campaign programme involving the neighbouring countries of Nigeria. CBPP is a significant constraint to improved pastoral cattle productivity in sub-Saharan Africa (Fasanmi, 2013). Economically, the country suffers direct losses through infection and deaths of cattle, while indirect losses include exclusion from participation in international livestock and livestock product trade.

CBPP Outbreak

CBPP was originally more of the Northern problem until the 1970s up to the 1990s, when the socio-economic and cultural settings of the herdsmen began to change. Increased transhumance and trade cattle movement from North to the Southern States of Nigeria, which became more rapid due to adoption of vehicular transportation, there developed large-scale settlements of herdsmen within the South Western States and the South Eastern States. Some of this Fulanis settled in these regions seeking for green pasture since few Grazing Reserves set up then by the Federal Government can no longer sustain their animals. All these changes impacted tremendously on the livestock disease profile in the country, particularly CBPP. The disease therefore had a gradual spread beyond the traditional far North to the Southern States. As at today the whole country is considered as endemic. States exposed, while the Southern States were regarded as free of the disease. The North Western State was the most affected as the CBPP status records indicated in (Table 2-6 and Figures 1-4). The low vaccination figure for 1973 - 1974 was due to deployment of staff for National Census Operation. The persistence of CBPP in Nigeria poses serious threats to the Nigerian livestock economy and freed participation in the international livestock trades. Hence, the need for this study to create awareness on the common risk factors for the CBPP endemicity, barriers combating interventions and to identify and recommends the most effective intervention (s) for the complete eradication of CBPP burden in Nigeria.

CBPP OUTBREAK RECORDS IN NIGERIA (2005-2015)

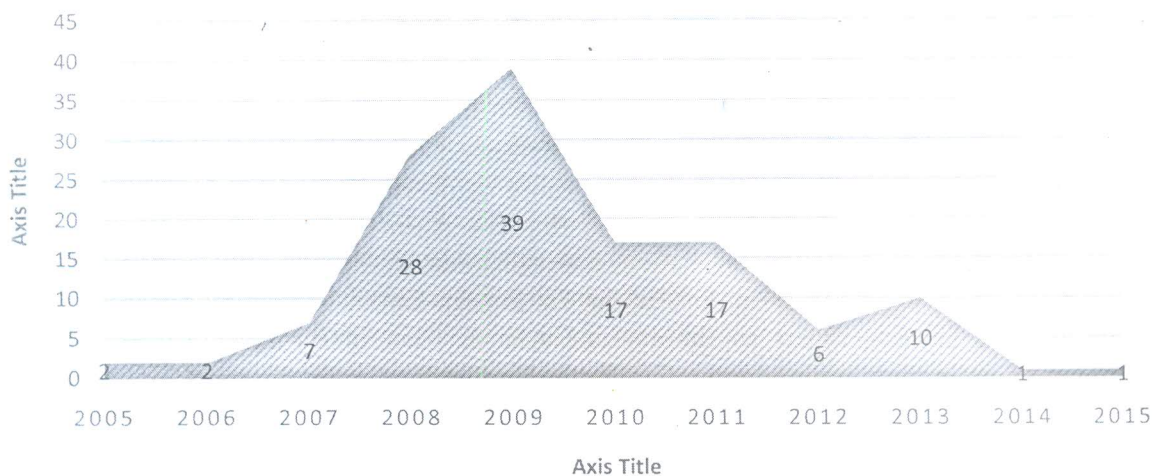


Figure 1: Showing the trends of outbreaks in Nigeria from 2005 to 2015. Adapted from OIE Annual Report (OIE, 2016)

Risk factors

One of the major risk factor associated with endemicity of CBPP in Africa was importation. CBPP disease was first reported in 1854, when an infected bull was imported into South Africa from the Netherlands (Mtui-Malamsha, 2009) and has since then been endemic in large areas of sub-Saharan Africa almost 150 years later with serious implications for cattle production and major constraints to food security in affected countries (Amanfu, 2009). Similarly, the first incidence of CBPP in Nigeria was recorded in 1924. This was the year when laboratory facilities for animal vaccine production and serological diagnosis commenced in Vom (Fasanmi, 2013).

African strains of CBPP aetiology is unique compared with the American and European strains as they are more virulent, leading to steady outbreaks with affected herds manifesting classic clinical signs and high mortality (Nicholas *et al.*, 2008). In Nigeria, on several occasions, field epidemiological inquiries failed to yield clues regarding the origin of some outbreaks encountered as a results of barriers associated with ignorance and uninformed practices on risk factors of reintroduction or resurgence of CBPP (Yaya *et al.*, 2008). Fasanmi *et al.* (2013) has advanced two risk factors to CBPP endemicity in Nigeria which includes; chronic carriers and cattle movement which had played a very important role in the maintenance and extension of the disease in Africa. Ignorance and poor information, communication and education on the outcome of vaccination characterised with tissue reactions at the site of immolation has caused the refusal of the herdsmen up taking the CBPP vaccination even though the post-vaccination tissue reactions are harmless.

OIE, 2010 opined that difficulty in CBPP diagnosis is attributable to the fact that majority of animals infected with the disease do not show clinical signs at chronic stages and this poses a major problem in surveillance and availability of different geographical lineages of Mmm (OIE, 2010). On early detection of causative organism in acute cases CBPP is usually confirmed by culture and serology, but mycoplasmas are slow growing and culture can take up to three weeks for isolation and identification (Enyaru *et al.*, 2012). In individual live cattle, confirmation of CBPP is problematic because of low specificity of the existing

serological tests, such as the complement fixations test (CFT) and competitive enzyme linked immune-sorbent assay (c-ELISA), to address issues of cross-reactions among closely related members of the *mycoides* cluster (Enyaru *et al.*, 2012). However, polymerase chain reactions (PCR) can detect Mmm strains in blood, tissues and body fluids of individual cattle, even in chronic ones (Schnee *et al.*, 2011), and differentiating strains into geographical lineages (Miles *et al.*, 2006). For control strategies since virulence widely depends on the clusters. Yahaya *et al.* (2008), reported reintroduction of animals into CBPP free herds and resurgence that results in migrating to be exposed or in contact with infected herds as sources of risk factors to the endemicity of CBPP in Nigeria (Yaya *et al.*, 2008).

Problems about CBPP in Nigeria according to the OIE (2015) are illegal cattle movement, ineffective vaccination campaigns, and the lack of contingency plans as the immediate challenges to effective CBPP control. There are two vaccines in use in the field this includes T₁ 44 and a saponised virulent field strain. However, T₁ 44 reverts to virulence and Wilhelm's reactions at the site of inoculation. These reactions are not caused by subsequent vaccinations with T₁ 44 vaccines. Can be cured with antibiotic In a field trial T₁ 44 did not cause any local reactions, but field strains and T₁ B caused large local reactions and fever. T₁ B behaved like the local field strain, hence rejections often experience by some nomads and hence increasing the risks of CBPP outbreaks.

According to Jamilua *et al.* (2015), the level of awareness of farmers is very poor about CBPP, they concluded that most of the pastoralists in their region of study can only recognize signs such as coughing and laboured breathing which is only evident during acute and not in the chronic stage of the disease. Therefore, subclinical or chronic CBPP forms may likely have been passed unnoticed and thus unreported. Tambuwal *et al.* (2011) reported that 65% of herdsmen were aware of the existence of CBPP outbreaks in the studied area as opposed to the 35% that are not aware. It is therefore likely that the higher the level of CBPP awareness by the pastoralists and herdsmen, the more they accept and implement CBPP control options such as vaccinations uptake and early detection to reduce the number of seropositive animals and spread (Mariner *et al.*, 2005).

Jamilua *et al.* (2015) advanced some other barriers on the pathway of the pastoralists' poor access to herd health services, routine veterinary surgeon's coverage, deprivations from routine vaccinations and campaigns, and poor surveillance and reporting of outbreaks. Insecurity, insurgencies, cattle rustlers and livestock stealing as well as difficult terrains have been identified as the major barriers to veterinary services and accessibility to some settlements in Nigeria where Fulanis are residing with their cattle.

During the 70s, serious problems were encountered with the mass vaccination programme due largely to the refusal of producers to allow vaccination of their animals due to post-vaccination reactions experienced then. Subsequently, emphasis was placed on outbreaks notification, slaughter and compensation for infected animals as well as vaccination of in-contact herds. Unfortunately, the results recorded were not as encouraging as envisaged (Fasanmi, 2013).

Africans generally have porous border and uncontrolled cattle movement compounded by lack of data on the endemicity of CBPP in many parts of Africa which in turn made the accurate zoning of CBPP distribution difficult (OIE, 2013). Several studies have attributed the persistence of CBPP to animal movement within and between countries, absence of adequate diagnostic tests, the lack of use of diagnostic tests because of diminished financial support and a downturn in the use and quality of CBPP vaccine (OIE, 2010; Fasanmi, 2013). Part of the barriers to CBPP control in Nigeria are for the fact that there is no proper regulation of the

use of antibiotics in the country hence, the indiscriminate and wrong use of the antibiotics by the farmers and the quacks (OIE, 2010; Fasanmi, 2013).

Adverse effects on cattle when vaccinated against CBPP may occur if it is on naïve could be due to or Immunosuppressed cattle infected with trypanosomiasis (Ilemobade et al, 1982) or those in poor nutritional conditions and stress can lead to cattle coming down with subclinical CBPP or outbreaks with fatal acute CBPP manifestations.

A live attenuated T1/44 vaccine, confers short duration of immunity, low efficacy (Thiaucourt et al., 2000) and causes adverse post-vaccinal reactions at the site of inoculation leading to poor acceptance by farmers (Kusiluka and Sudi, 2003; Sori, 2005). Finally, the vaccine has poor stability (short shelf life), hence, the requirement for a cold chain during delivery (Rweyemamu et al., 1995) and there is the possibility of reversion to virulence (Mbulu et al., 2004).

Interventions

Tambuwal *et al.* (2011) in their survey showed that 96% of the respondents agree that CBPP is preventable and 47% responded that the disease can be prevented by vaccination, using a live attenuated vaccine (T1/44), that has played a significant role in reducing the disease prevalence. In the same study, 65% of the herdsmen were aware of the existence of CBPP outbreaks in the studied area (Tambuwal *et al.* 2011). It is therefore likely that the higher the level of CBPP awareness by the pastoralists and herdsmen, the more they accept and implement CBPP control options such as vaccinations which have been shown to effectively reduce the number of seropositive animals (Mariner *et al.*, 2005). Jamilua *et al.* 2015 opined the combination of routine vaccinations and national campaigns, and strong surveillance and reporting of outbreaks as strategies for control and eradication interventions.

Stamping out policy was the intervention strategy employed by the Americans and Europeans to eradicate CBPP from their continents in the early 20th century, prior to this time some of these developed countries have experienced sporadic outbreaks with affected herds manifesting little distinctive clinical signs and lower mortality than those found in Africa (Nicholas *et al.*, 2008). In those countries there are excellent field epidemiological surveillance outbreaks, reintroduction or resurgence of any diseases are traceable unlike in Africa where all these are still barriers to control and eradication (Yaya *et al.*, 2008).

According to Fasanmi (2013), Nigeria has made several interventions in the past on CBPP control, namely, the Joint Project (JP 28) of 1960s and the 3-Year National CBPP Programme in the early 90s. Under the JP 28, control of CBPP was attempted through a policy of compulsory mass vaccination in the enzootic areas of the country. This was followed by testing, quarantine and slaughter of affected animals. However, the mass vaccination programme was interrupted due largely to the refusal of producers to allow vaccination of their animals due to post-vaccination reactions experienced then. Subsequently, emphasis was placed on outbreaks notification, slaughter and compensation for infected animals as well as vaccination of in-contact herds. Unfortunately, the results recorded were not as promising as envisaged with mass vaccination without any sort of resistance (Fasanmi, 2013).

The most recent strategy was the 5 years CBPP mass vaccination that started 2010, which is now having a positive impact on getting vaccination up to 70% coverage. This will reduce the incidence of CBPP if sustained (Fasanmi, 2013). Fasanmi, (2013), opined that in any strategy to control disease in livestock, early diagnosis is cardinal. The reporting and documentation of outbreaks is also paramount and that emphasis should be placed on outbreaks notification, slaughter and compensation for infected animals as well as vaccination of in-contact herds.

Several studies have recommended interventions strategies on expanding on diagnostic capacity, regional approaches on epidemiological surveys, the provision of training, and veterinary surveillance for CBPP at the borders. This include suggestions on contiguous surveillance, quarantine and serological screening for CBPP free zones, ring vaccination and proper branding of vaccinated cattle in places of sporadic outbreaks or newly affected areas. The use of harmonised mass vaccination and antibiotic treatment for 5 years were also proposed for enzootic zones. All efforts should be made to minimize the likelihood of the reintroduction of CBPP into free areas by the establishment of buffer and surveillance zones (OIE, 2010; Fasanmi, 2013).

For CBPP surveillance, Regalla et al. (1996), employed abattoir screening in tracing the disease back to herd's source in Italy during the early 1990s CBPP outbreaks. Mariner (2009) opined that T1/44 vaccine is sufficient enough for CBPP eradication in addition to efficiently functioning veterinary services and annual vaccine coverage of approximately 80%. CBPP eradication was attained in Botswana by slaughter of all cattle in the infected region (Nicholas et al., 2000), although this stamp out policy had huge economic and political implications for the country in the short term. CBPP in Europe centred on slaughter of affected herds because vaccine antibody would adversely affect serological disease surveillance (Nicholas et al., 2000). In Asia, CBPP eradication was based on campaign involving mass vaccination using a novel live vaccine, prepared initially in rabbits, with reported high immunogenicity and protection, followed by quarantine and slaughter (Xin et al., 2011). Mathematical modelling has shown that even a mass vaccination campaign over a 5-year period is unlikely to achieve eradication unless other strategies are used (Mariner & Catley 2003).

The first official use of antimicrobial treatment to control an outbreak of CBPP was reported in the Caprivi region of Namibia by Hubschle et al., (2004). It had previously been shown experimentally that treatment of all CBPP-affected cattle with the antimicrobial danofloxacin (Advocin; Pfizer Animal Health) could significantly reduce transmission of the Mycoplasma to other cattle (Hubschle et al., 2004). In vitro antibiotic susceptibility testing of 41 isolates of the Mycoplasma pathogen has shown that at least 10 antimicrobials were still effective against CBPP (Ayling et al., 2005) and, despite their widespread use in Africa, antimicrobial resistance was not yet evident. Nicholas et al. (2006) emphasised the rewards of using antibiotics according to the manufacturer's recommendations in handling an outbreak where all clinically affected or seropositive herds were treated in the Caprivi region of Namibia with the antimicrobial agents. Evidence had also been advanced that the effect of antimicrobial treatment is to accelerate the healing process by promoting fibrosis in the lung, further inhibiting Mycoplasma transmission (Nicholas et al., 2008). The results of the Caprivi region of Namibia study supported the concept that strategic and targeted antimicrobial treatment can play a critical role in the control of CBPP alongside regular and comprehensive vaccination. Mariner (2009) has been an advocate of metaphylactic approach and recommended for adoption in civil society leading to the development of an evidence base for an institutional shift in policy. Additionally, Peter Lees in his personal communication, reported that metaphylactic approach of antibiotic treatment is also the most effective way of preventing the development of antibiotic resistance.

Table 1. Summary on Published Interventions on CBPP Control Approaches Worldwide

Location	Design	Intervention	References
Asia	Observational	Vaccine With Back-Up Cold Chain System	Rweyemamu et al., 1995
Europe	Epidemiological	CBPP Awareness Campaign And Vaccinations	Mariner <i>et al.</i> , 2005
Africa	Epidemiological	Vaccination With Live Attenuated T1/44	Tambuwal <i>et al.</i> 2011
Africa	Epidemiological and Campaign	Routine Vaccinations, National Campaigns, And Strong Surveillance	Jamilua <i>et al.</i> 2015
Europe and America	Action	Stamping Out Policy	Nicholas <i>et al.</i> , 2008
Nigeria	Epidemiological	Field Epidemiological Surveillance	Yaya <i>et al.</i> , 2008
Nigeria	Campaign	Joint Project (JP 28) And 3-Year National Vaccination Programme	Fasanmi 2013
Nigeria	Campaign	CBPP Mass Vaccination	Fasanmi 2013
India	Epidemiological	Abattoir Surveillance	Regalla et al.(1996)
Botswana	Action	Stamp Out Policy	(Nicholas et al.,2000),
India	Field trial	Campaign Involving Mass Vaccination	Xin et al., (2011).
Namibia	Field trial	80% T1/44 Vaccine Coverage And Effective Veterinary Service	Nicholas et al.(2000),
Namibia	Field trial	Antimicrobial Treatment	Hubschle et al., (2004).
Europe	Laboratory	10 Antimicrobials Found Still Effective	Ayling et al.(2005)
Namibia	Field trial	Proper Use Of Antibiotics	Nicholas et al.(2006)
Namibia	Field trial	Antimicrobial Treatment	Nicholas et al. (2008).
Europe	Field trial	Mathematical ModellingOf Mass Vaccination And Other Strategies	(Mariner & Catley 2003).
Europe	Field trial	Metaphylactic Approach	Mariner (2009)
Europe	Field trial	Metaphylactic Approach With Antibiotic	Peter Lees

Future research on interventions

It has been speculated that the movement of cattle 'immunised' with some attenuated African strain of vaccine may be responsible for some CBPP incidences, but no evidence exists to support this speculations (Nicholas 2009). An experimental infection in cattle in Switzerland, which compared a single new European strain with an African strain, provided some evidence in support of transgenic strains that were less virulent than African ones (Abdo et al., 1998). But some doubts remained in those who saw the lesions in the unexpected outbreaks in Italy in the early 1990s and those in Portugal 1983–1999 because of the severity of the lesions, particularly early in the epidemic (Nicholas et al., 2008). Regarding pathogenicity mechanisms such as the cyclical nature of CBPP outbreaks was well known to researchers in Africa 40–50 years ago in that as the epidemic progressed, the disease became milder (Egwu et al., 1996) hence, there is still much unknown. Previously, it was believed that *Mycoplasma* infections did not respond well to antimicrobial treatment and indeed, their use was discouraged or prohibited because of the fear of creating carrier animals that could spread infection (Provost et al., 1987). However, it is common knowledge that in the absence of an effective vaccine or sufficient coverage, farmers and field veterinarians will use antibiotics as the only available control option. Further work is necessary to check the current field situation and to identify and evaluate suitable, cost-effective antimicrobials, focusing on correct dosing regimens. Regular monitoring of antimicrobial resistance of field strains is, of course, another essential requirement (Ayling et al., 2005).

Discussion

Cattle population in Nigeria is estimated at 16 million and over 90% of these are kept under Nomadic production systems, while about 10% are raised under intensive production systems. The nomadic culture of Nigerian herdsmen coupled with the practice of transhumance has significantly contributed to the spread of diseases in Nigeria (Fasanmi, 2013). The incidence of CBPP in Nigeria continue to rise, particularly in states close to the Nigerian borders as well as the Northern States of Nigeria and as a result of the recurrent insurgencies in and out of seasons in the Northern and now in the southern parts with increasing clashes between the Farmers and Fulanis. Hence, the choice of a review on CBPP burden and outbreaks, to inform the relevant stakeholders to provide an improved, equitable and responsive facility for CBPP control in Nigeria. According to the Office International des Epizooties OIE (2016) and various reports, CBPP is widespread in Nigeria covering 17 States (Figure 1). There used to be no CBPP in some parts of the country in the past but with the current insurgences led to people's emergency migration to the southern parts of the country in addition to the seasonal movement of the nomads. Hence, CBPP is not only enzootic or sporadic but the incidence is increasing across the nation. According to OIE 2016 reports, CBPP has become a major issue in Nigeria, placing the southern Nigeria under direct and indirect threats.

FAO (1996) and FDL (2010) estimated that CBPP in cattle have background morbidity rates of up to 50%, and 25% mortality for CBPP. They opined that past efforts have also revealed that control of CBPP has yielded poor returns due to ineffective or absent control programmes, insufficient inputs (such as vaccines), poor vaccination coverage due to limited vaccine supplies and constraints in field logistics and support funds, illiteracy of farmers and poor management systems (FAO 1996; FDL 2010). Hence, abattoir, field and laboratory surveillance approach to CBPP control strategies in Nigeria is indispensable. Data on epidemiological cost assessments are needed before policy-makers decide on supporting programmes of this nature. This is an area which needs to be addressed nationally, with an immediate launching of new campaigns and targeting states having borders or indirect

contacts with other endemic countries of Africa (Figure 2). From this review, it is certain that CBPP is still endemic in Nigeria. Majority of cattle are exposed annually with high mortalities and morbidities. More cattle are slaughtered than being destroyed. Outbreaks and incidences increase and reaches its peak by 2009 and descending as from 2010 and by 2013 it is rising again this might be the true picture of the trends but it might also be associated with the irregular surveillance, poor records and missed cases that could lead to a miss-leading data (Table 2). In 2005 one outbreak occurred in July in Nigeria but the state was not specified. In 2006 only 2 outbreaks occurred and both were reported in September and October from Adamawa State. In 2007, Bauchi and Gombe had a concurrent outbreak in September. In 2008, eight States namely; Adamawa, Bauchi, Kano, Niger, Plateau, Sokoto, Taraba and Gombe reported outbreaks. Bauchi recorded the highest outbreaks of six consecutive months from January to June as well as in September and November making up to eight months of outbreaks pulled together. This was followed by Gombe State who recorded five months of consecutive outbreaks each spanning from January till May and one more outbreak in July. Adamawa recorded five months of consecutive outbreaks spanning from January till May. The remaining States only reported only one month of outbreak each (Table 3).

In 2009, CBPP outbreaks occurred in ten States namely; Adamawa, Bauchi, Kaduna, Kano, Kebbi, Niger, Plateau, Taraba, Gombe, and Zamfara of Nigeria being the highest number of states involved under the ten years under review. Of this, Bauchi reported six months of consecutive outbreaks extending from January to June and from August to September covering a total of eight months of outbreaks like the previous year 2008. Adamawa reported four months of consecutive outbreaks i.e. in February to June 2009. Gombe had four outbreaks but not consecutively covering April with May and separately occurring in July and September. The remaining States had two (Kano, Kebbi and Zamfara) or one (Kaduna and Niger) outbreak each in year 2009 (Table 3). Unlike the immediate past two years the outbreaks in 2010 was relatively mild involving only seven States involving Borno for the very first time after five years with three months of outbreaks, first in January and then later in October and November. Similarly Plateau had three months of outbreaks but conversely with that of Borno as it occurred in the month of February and March and later in September. In 2011-8 States were involved in outbreaks of CBPP in Nigeria, with Gombe having the highest number of outbreaks for three consecutive months of May, June and July. Adamawa, Kaduna, Bauchi and Plateau had two months of outbreaks each while the rest had one including Cross-rivers and Kwara State for the first time after six years of the years under review. In 2012, only one outbreak occurred in each of these five States (Adamawa, Kwara, Oyo, Plateau, and Gombe) and Oyo is newly involved. Similarly in 2013, five States (Adamawa, Osun, Plateau, Yobe, Gombe) being only one outbreak each with Osun newly involved. In year 2014 only 2 states (Gombe, Plateau) of Nigeria experienced one outbreak each. In 2015 there was an outbreak in Nigeria but neither the number nor the State involved were specified (Table 3).

States with five years of continuous outbreaks and more includes; Bauchi (five years continuously), Plateau (seven years continuously), and Gombe (eight years continuously), while Adamawa total outbreaks of six years but discontinuously in the blocks of 1, 2 and 3 years respectively. Niger and Taraba had a continuous outbreaks of three years. Yobe had three years of outbreaks but it was in blocks of 2 and 1 year respectively. Kano and Kwara had two years of outbreaks within the years under review. Kaduna had two years but not continuously as there was a space of 2 years in between the 2 outbreaks. The remaining States (Borno, Cross-River, Kebbi, Osun, Oyo and Zamfara) had only one outbreak each throughout the years under review. Based on the reports of 2005 and 2015 it means it is

possible for an outbreak not to be reported or documented especially among the nomads who wander from state to state of Nigeria. Infact, in Kwara State precisely, there was an outbreak of this disease in November and December, 2015 affecting herds of cattle along the migrating routes of the nomads to the Benin Republic and their stop over at Kaiama LGA, where about 50 cattle died within 48 hours out of 500 and about 100 was showing the respiratory distress until the intervention of our field team (Table 4).

CBPP control by the current vaccine alone is ineffective because of its short-term immunity and poor coverage. There is no proper regulation of the use of antibiotics in the country hence, the indiscriminate and wrong use of the antibiotics by the farmers and the quacks. The persistence of CBPP in Nigeria poses a serious threat to the rest of the Africa and beyond particularly those that import live cattle from these regions.

This study will improve on the control of CBPP through the use of antibiotic chemotherapy and data emanating from the studies would help in further epidemiological surveillance work in other parts of Africa where the disease is still endemic. Cattle industry take about 50%-80% of the income realizable annually from agriculture in developing world and CBPP is one of the major deadly diseases combating this target, therefore with the development of antibiotic for the control of CBPP, this would drastically improve the economy of the developing world through cattle industry.

The North Western State was the most affected as the CBPP status records indicated in Table I. As at today, CBPP is still endemic in Nigeria (Fasanmi, 2013). Unfortunately the disease reporting system, which was efficient in the 1960s and 1970s, witnessed a setback during the 1990s. The further fragmentation of the country into many more autonomous States coupled with the lack of efficient communication system and the general downturn in the economy overstretched the efficiency of the Federal Department of Livestock and Pest Control Services as well as the State Veterinary Departments. This is evident from the gross under-reporting of outbreaks of CBPP as shown in Table 3. (Fasanmi, 2013). There were few studies which estimated the awareness and prevalence of CBPP among the Fulani populations in Nigeria and most of such reports were exclusively based on abattoir surveys with focus on mostly the north eastern part of the country (Bello and Ibrahim, 2010; Tambuwal *et al.*, 2011).

CBPP is now the main disease of cattle dreaded by breeders in West and Central Africa and indeed a major source of concern for the Nigerians cattle industry (Nwankpa *et al.*, 2004). An outbreak of CBPP requires the destruction of the entire herd thereby eliminating the tendency for further spread. However, in a large country like Nigeria where the disease is endemic, stamping out is now not physically or economically feasible due to lack of a good framework for disease reporting, slaughter and compensation of farmers for affected animals (Lombin *et al.*, 2004), thus resulting in situation where farmers conceal disease outbreaks and treat quietly with antibiotics. Since there is little information on the effect of treatment on the generation of carriers and the roles of carriers on the spread of the disease there is a strong perceptions that the use of antibiotics at least predisposes infected animals or may cause infected animals to become carriers of CBPP (Electronic conference, 2003). But if the Veterinarians do not use antibiotics, the farmers get it and use it is the reality on the field (Lombin *et al.*, 2004). The increasing importance of the disease emphasizes the needs for studies to determine the actual efficacy of some of these antibiotics against CBPP notorious aetiology *Mycoplasma mycoides* subsp *mycoides* Small Colony type.

Data from the OIE show that up to 2015, at least 25 countries were affected by CBPP, although more are probably affected as some do not carry out regular or comprehensive surveillance. Countries reporting the most outbreaks in the decade up to 2015 include:

Ethiopia (624), Ghana (585), Tanzania (173), Angola (168), Cameroon (144), Zambia (127), Nigeria (123), Togo (123), Cote D'Ivoire (113), Burkina Faso (105), Benin (85), Congo (68), Chad (55), Uganda (51) and Kenya (51). It is interesting to note that the disease prevalence has hardly changed over the last 20 years showing that attempts at control have been mostly unsuccessful. The disease in sub-Saharan Africa is mostly characterized by a chronic endemicity with occasionally severe outbreaks when naïve herds are exposed to infected animals moved, often illegally, across borders. CBPP can persist indefinitely in small populations (Mariner, 2009). Evidence has shown that the causative agent of contagious bovine pleuropneumonia (CBPP) (*Mycoplasma mycoides* subsp. *mycoides*), may have emerged from a closely related goat pathogen as recently as 300 years ago, which corresponds to the first description of CBPP in Europe. Despite being eradicated from European and American countries, and upon all the robust diagnostic technology and improved epidemiological tools over the last 20 years, CBPP continues to plague sub-Saharan Africa affecting at least 25 countries, in particular Ethiopia, Ghana, Tanzania, Cameroon, Angola, Nigeria and Zambia (Olorunshola et al., 2017). Whereas the current tools in Africa if well utilised are sufficient for CBPP eradication, however, continued investment on new vaccines and diagnostic tests development at the expense of increasing production and coverage with T1/44 vaccine has been a major drawback to CBPP eradication in the continent (Olorunshola et al., 2017). Agreed that T1/44 vaccine is not perfect but it reduced the incidences of CBPP significantly when used before and alongside with rinderpest campaigns in the 1970s in many parts of Africa; particularly those countries with effective veterinary services and 80% annual vaccine coverage (Olorunshola et al. 2017). For more comprehensive reviews, readers should refer to Egwu et al. (1996). Nicholas et al. (2000) and Nicholas et al (2008).

Recommendations

Aliyu et al 2015 advanced the following recommendations based on their findings that: 1) Public health sensitization campaigns should be intensified as poor information dissemination is likely to enhance the spread of CBPP and other livestock diseases. 2) More grazing and watering facilities for livestock production should be made available to cattle herdsman particularly in dry season when such points are few. This will reduce the frequency and duration of contacts between herds of different disease conditions. 3) The directorate of veterinary services in the country should conduct refresher training for its technical staff on adequate data documentation and management. 4) Provision of adequate Data tools to all veterinary clinics in the country by the state directorate of veterinary service. 5) Close supervision and monitoring by senior National officers during campaigns and routinely should be employed in order to checkmate issues of data falsification and fabrication. 6) The Federal government should improve on CBPP immunization accessibility since there is high utilization of the vaccine by the pastoralists. 7) Interventions by way of support from local and international Non-Governmental Organization (NGOs) are needed to strength livestock vaccination in the state.

To eradicate CBPP would involve losses through stamping out and movement restrictions. The only realistic option for Africa is vaccination and the two options are to develop new vaccines or to use existing ones. The development of new vaccines would be costly and may require many years of research efforts. Efficacy, production and political issues would have to be resolved before meaningful progress could be made. The biggest issue however, is that of funding. Who would fund vaccine development/research? Therefore, the way forward is to improve existing vaccines by increasing their thermal stability; viability and immunogenicity. This is certainly possible because vaccines used in Australia were stable at 37°C. Improvements may be made by i) increasing the buffering capacity of media used in vaccine

production by the inclusion of HEPES, ii) discontinuing the use of Magnesium Sulphate ($MgSO_4$) in the reconstitution buffer because it causes a pH change leading to decrease in viability of Mycoplasma organisms and iii) use phosphate buffered saline as diluents. Inclusion of a pH indicator could help monitor shift in pH after vaccine reconstitution. These simple technical changes with proper funding for production and quality control, could improve the efficacy of current vaccines significantly. There are possible opportunities to improve vaccine products and these may be made by simple modifications in the formulation including the reconstitution buffer, attenuation of strains by genetic modification and minimization of adverse reactions.

Although the use of antibiotics are strictly under control against CBPP in the field. For instance Tetracycline or tylosin can reduce inflammation at the inoculation site post-vaccination but did not prevent infection. Either of them can reduce the severity of lung lesions but can't prevent lesion formation, and the pathogen would be able to persist in the host. Quality and dosage of the antibiotic may not be optimal, hence prone to resistance, may not prevent infection but may provide time for the animal to develop immunity. Hence some scholars advocated for the combination of vaccination and the use of antibiotics for CBPP control and eradication in Africa.

In terms of diagnostic tests, the results of an FAO/IAEA Co-ordinated Research Project (CRP) on the "Monitoring of contagious bovine pleuropneumonia (CBPP) in Africa using enzyme immunoassays" showed that the complement fixation test (CFT) and a competitive ELISA for the detection of antibodies to *MmmSC* were adequate tools for the monitoring and surveillance of CBPP.

There are many gaps in the scientific knowledge on CBPP. Virulence factors and the genes responsible have not been identified; these genes and those that lead to a protective response must also be identified. The genes that may confer virulence or protection are not the same as those responsible for attenuation of an organism. Research towards better vaccines is important. It is also important that diagnostic research continues to distinguish between vaccinated and non-vaccinated and infected animals. The serological tests CFT and the successfully validated cELISA may perform differently in different countries, but are adequate for surveillance purposes.

For a new vaccine to replace T1/44, it should, ideally, be stable, given in a single dose, provide a longer duration of immunity and higher levels of protection and not cause adverse reactions. Few vaccines to date have met these criteria. It would seem that only live vaccines could achieve the majority of these targets such as the Ben-1 vaccine used in China, where protection rates with lyophilised product were reported to be 100% even after 2 years (Xin et al., 2011).

Trials to test this vaccine in the African environment are currently underway, though the unusual production method of generating enough pleural fluid in experimentally infected animals may provide a challenge. A succession of inactivated vaccines has been tried and tested over the last two decades.

Two new approaches to vaccination against CBPP were reported by Nicholas et al. (2005). The first consisted of a whole cell Mycoplasma vaccine inactivated with saponin (an approach, which had previously been found to be protective for bovine mycoplasmosis, contagious agalactia and CCPP) and the second comprised a recombinant subunit vaccine prepared from the highly immunogenic lipoprotein LppQ 1 (Abdo et al., 1998). In spite of two vaccinations at six weekly intervals and high antibody responses, there was no evidence in the small number of animals used of any protection afforded by either preparation; rather, there appeared to be elaborated exacerbation pathological lesions in the vaccinated animals

Table 6: Seasonal Variations of outbreaks of CBPP in Nigeria-2005-2015

State		Months and seasonal variations													Total
Year		Dry season			Raining season				Dry season Dec				Dry	Rain	
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov			
2005	Nigeria													/	1
	Adamawa												/	/	2
	Bauchi													/	1
	Gombe													/	1
2008	Adamawa													//	5
	Bauchi													////	8
	Kano													/	1
	Niger													/	1
	Plateau													/	2
	Sokoto													/	1
	Taraba														2
	Gombe													///	6
2009	Adamawa													//	4
	Bauchi													////	8
	Kaduna													/	1
	Kano													//	2

[illegible]

	Oyo																	/				1
	Plateau																	/				1
	Gombe																	/				1
2013	Adamawa																	/				1
	Osun																	/				1
	Plateau																		//			2
	Yobe																	/				1
	Gombe																		/			1
2014	Gombe																	/				1
	Plateau																		/			1
2015	Nigeria																					
	Total																	51	48			99

Collated from OIE Annual Report (OIE, 2016)

Table 7: State against annual outbreaks of CBPP for the period under review=2005-2015

State	Year										
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Adamawa											
Bauchi											
Borno											
Cross-River											
Kaduna											
Kano											
Kebbi											
Kwara											
Niger											
Osun											
Oyo											
Plateau											
Taraba											
Gombe											
Yobe											
Zamfara											

Collated from OIE Annual Report (OIE, 2016)

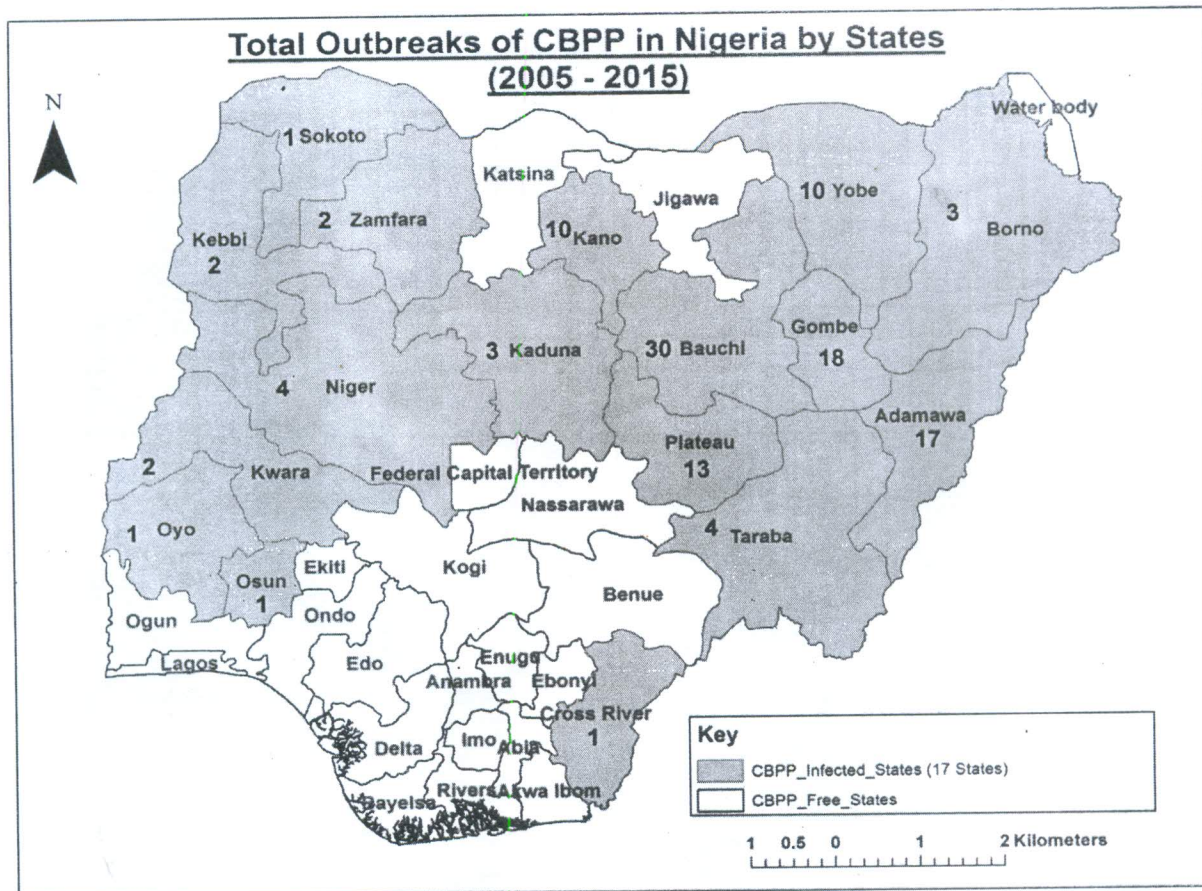


Figure II. Adapted from OIE Annual Report (OIE, 2016)

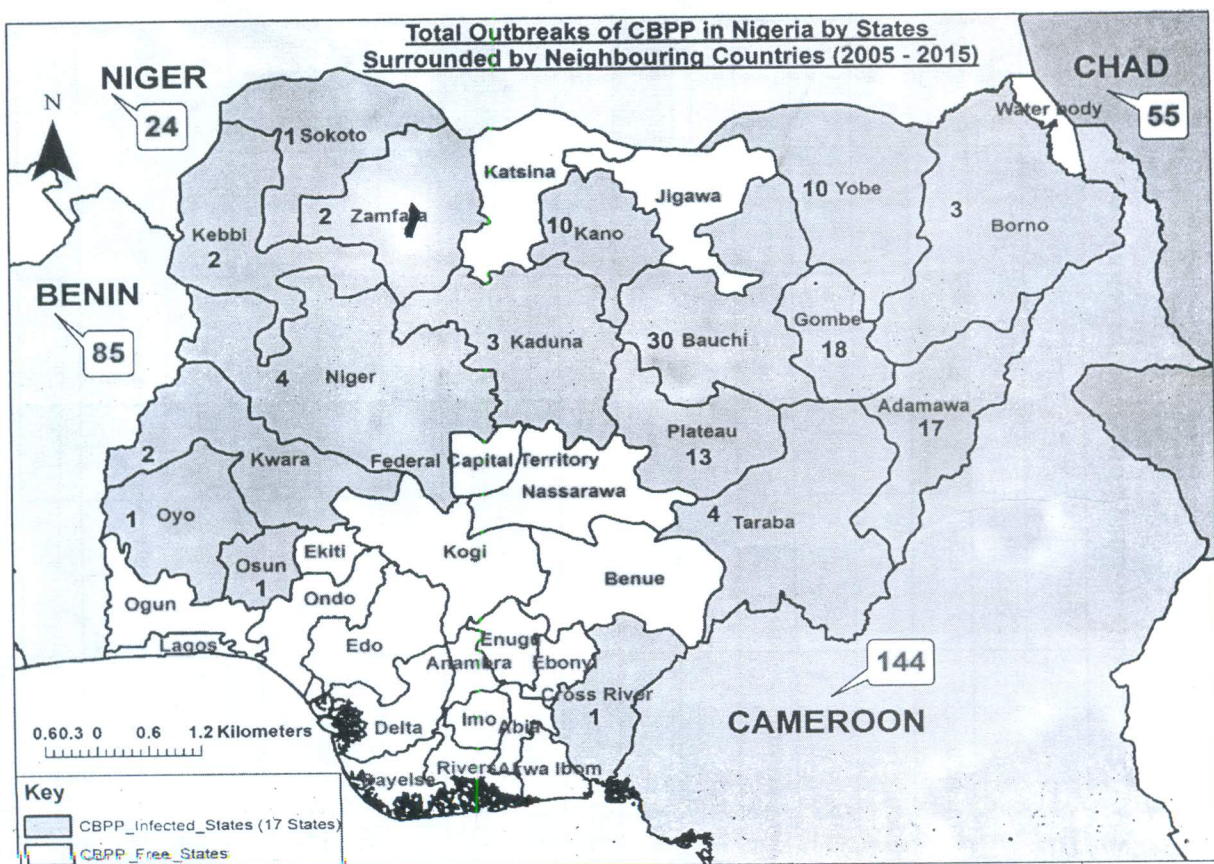
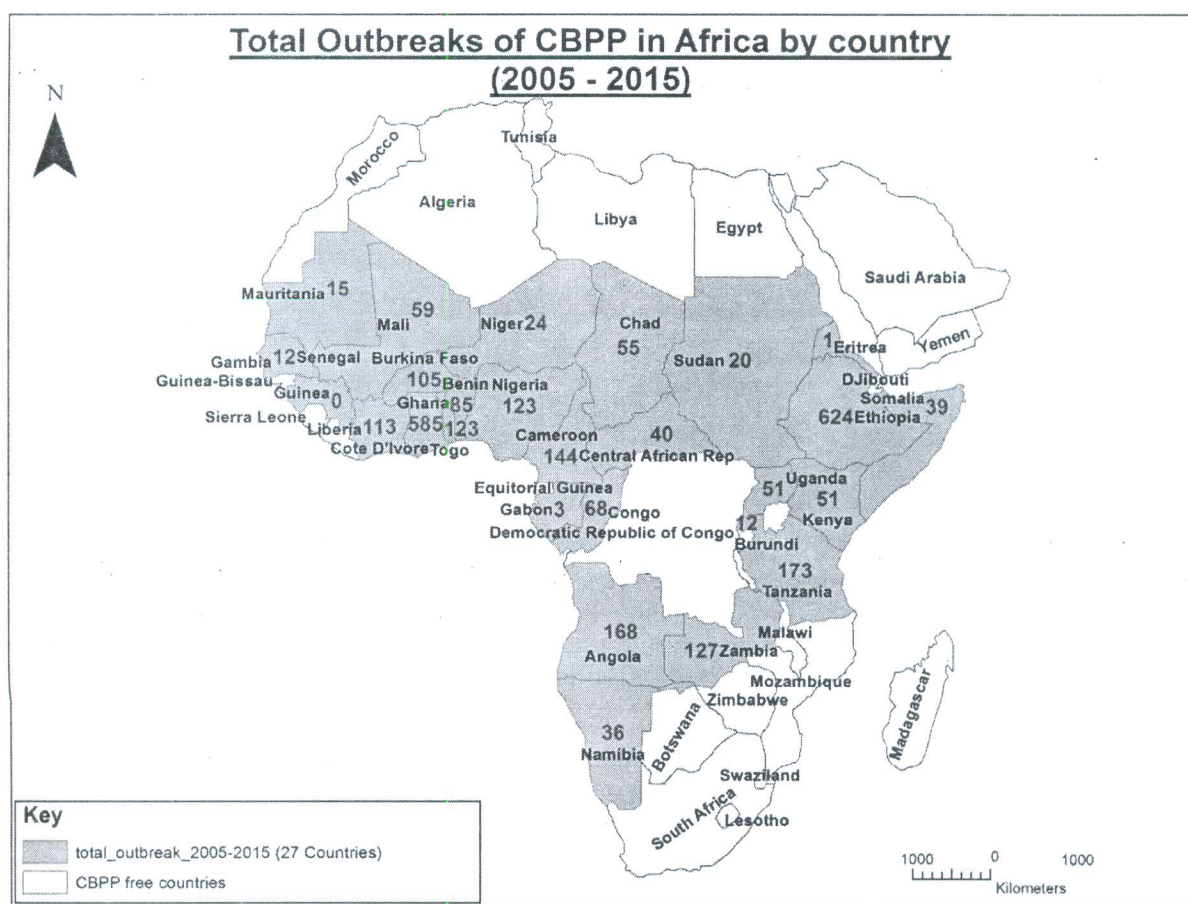


Figure III. Adapted from OIE Annual Report (OIE, 2016)



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