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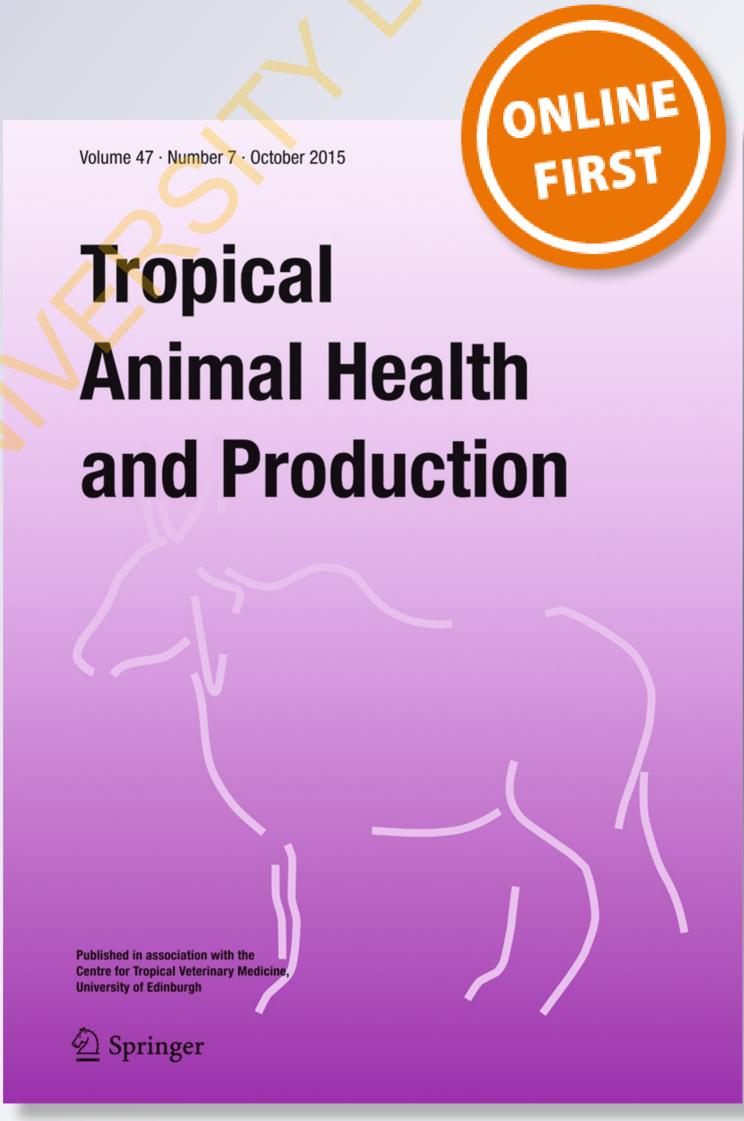

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REGULAR ARTICLES

Sero-positivity and associated risk factors for contagious bovine pleuropneumonia under two cattle production systems in North Central Nigeria

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Abstract A cross-sectional survey of 765 cattle in 125 nomadic and 375 cattle in 125 sedentary herds was conducted to investigate prevalence and risk factors for contagious bovine pleuropneumonia (CBPP) in the two production systems of Niger State in North Central Nigeria, between January and August 2013. Data on herd characteristics were collected using structured questionnaires administered on herd owners. Serological analysis was conducted using competitive enzyme linked immunosorbent assay (c-ELISA) test. Descriptive, univariate, and multivariate statistical analyses were conducted with OpenEpi version 2.3.1 software. Statistical significance was held at $P<0.05$. CBPP sero-prevalence in nomadic cattle was 16.2 % (confidence interval (CI) 13.7–19.0) and 9.6 % (CI 6.9–12.9) in sedentary cattle. The overall cattle-level sero-prevalence for two the cattle production systems was 14.0 % (CI 12.1–16.1). Age and agro-ecological zones were significantly ($P<0.001$ and $P<0.001$, respectively) associated with sero-positivity to *Mmm* in nomadic production. Agro-ecological zone C had the highest sero-prevalence (25.3 %, CI 20.2–31.0). No significant cattle factors were detected in sedentary production. Factors significantly associated with CBPP occurrence at herd-level were contacts with other herds during grazing ($P<0.001$) and at watering points ($P<0.001$). Others were introduction of new cattle into herd ($P<0.001$), outbreaks of CBPP in an area ($P<0.001$), socio-cultural factors of cattle gifts and dowry payment ($P<0.001$), herd composition of keeping cattle and small ruminants together ($P<0.001$), and long trekking during migrations ($P=0.0009$). This study had shown the burden of CBPP in the two production systems. Sero-diagnosis and risk factor identification should be institutionalized as elements of epidemio-surveillance and control strategies for CBPP, especially in resource-poor pastoralists' settlements in Nigeria.

Keywords CBPP · Nomadic · Risk factors · Sedentary · Sero-prevalence · Nigeria

Introduction

Contagious bovine pleuropneumonia (CBPP) is an economically very important infectious and contagious disease of cattle in sub-Saharan Africa, caused by *Mycoplasma mycoides* subsp. *mycoides* (*Mmm*) previously further specified as small colony (SC) type (Manso-Silván et al. 2009). It is transmitted by direct contact between infected and susceptible cattle (Tambi et al. 2006; Vilei and Frey 2010) and characterized by sero-fibrinous interlobular edema and hepatization giving a marbled appearance to the lung in acute and sub-acute cases, and capsulated lesions (sequestra) in the lungs of chronically infected cattle (Schnee et al. 2011; Tardy et al. 2011). Affected cattle developed dyspnea due to damage to the lungs, and a proportion of them died from respiratory insufficiency (Radostits et al. 2007). Once introduced into a naïve cattle herd, it causes high mortality, and those animals that survived remain chronic carriers, and at this stage, the mortality rates fall (Radostits et al. 2007; Schubert et al. 2011).

CBPP is associated with massive economic losses for cattle keepers (Windsor 2000; Tambi et al. 2006; Jiuqing et al. 2011). It impacts animal health and poverty of livestock-dependent people through decreased animal productivity,

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reduced food supply for households, and the cost of control measures (Tambi et al. 2006). With rinderpest eradicated, CBPP is the most important trans-boundary animal disease of cattle, and a barrier to trade in many African countries as it reduces the value of livestock and the income of many value chain stakeholders (Jores et al. 2013). While the disease was eradicated from the USA and it was not eradicated from Europe until the end of the twentieth century, the disease still persists in many African countries, especially in the West, Central, East, and parts of Southern Africa (Nicholas et al. 2008), and has not been reported in North Africa (Amanfu 2009).

CBPP is a major constraint to cattle production in Africa. The decline in its outbreaks and burden reports in Nigeria and other affected African countries was due to absence of science-based evidence for disease prevalence, which does not augur well for the implementation of internationally coordinated control programs as it underpins control and preventive actions (Amanfu 2009). Also, cattle managed under pastoral extensive systems are persistently at risk of contracting contagious diseases, including CBPP, due to continuous mixing of herds at grazing and watering points, and as well as socio-cultural practices of giving out cattle as dowry and gifs (FAO 2000; Mariner et al. 2006).These practices inhibit CBPP control strategies.

There is paucity of documented epidemiological based evidence on prevalence and risk factors for CBPP occurrence in extensive and semi-extensive pastoral cattle production systems under different agro-ecological conditions in Nigeria. Availability of such science-based information on burden and exposure factors would assist in the development of surveillance and control strategies for the disease in Nigeria. This study was, therefore, aimed at investigating prevalence of contagious bovine pleuropneumonia and associated potential risk factors that could predisposed to the disease in pastoral cattle herds in the three agro-ecological zones of Niger State, North Central Nigeria. The herds were under zero vaccination status because the last CBPP vaccination campaign in the state was carried out in November 2011. We hypothesized that potential risk factors cannot predispose to CBPP in pastoral cattle herds.

Materials and methods

Study area

The study was conducted in Niger State located in the North Central geopolitical zone of Nigeria, between latitude 8° 20′ N and 11° 30′ N, and longitude 3° 30′ E and 7° 20′ E. It is one of the 36 states of Nigeria and provides transit routes for pastoral nomads on seasonal migrations from the northern parts to the southern parts. It experiences two distinct seasons: rainy season that spans between April and October and dry season between November and March, with mean annual rainfall of about 1600 mm and average lowest and highest temperature of about 27 and 39 °C, respectively (MLFD 2013). The state has three agro-ecological zones, with variable climatic conditions. These are agro-ecological zone A (southern) with eight local government areas (LGAs), agro-ecological zone B (eastern) with nine LGAs, and agro-ecological zone C (northern) with eight LGAs. Also, it has an international border with the Republic of Benin at its western border, which is porous.

Study design, populations, and definitions

The study was a cross-sectional survey conducted in the three agro-ecological zones of the state between January and August 2013. It involved blood samples collection from 765 cattle in 125 nomadic herds and 375 cattle in 125 sedentary herds. Relevant individual cattle biodata and herd level information on predisposing risks for CBPP in herds were collected using interview-based structured questionnaires administered on 125 nomadic herd owners.

The target populations were the nomadic and sedentary herd owners, aged 30 years and above, and their cattle of all ages, sexes, and breeds domicile in the state during the period of survey.

For the purpose of this research, nomadic pastoral cattle herd was defined as herd in Fulani ethno-cultural group that keeps mainly cattle, has large herd size, and is on all year-round movements and on large-range grazing and watering, and with no permanent homestead. Also, sedentary pastoral (agro-pastoral) cattle herd was defined as herd that keeps more cattle and cultivates few crops, is medium in size, is semi-settled, has limited cattle movements, and is on low-range grazing near environs. It is often given supplementary feeds of crop residues, particularly during the critical period of dry season.

Sample size and sampling procedure

The sample size was determined using simple random sampling method (Thrusfield, 2009) and expected CBPP prevalence of 8.7 % (Alhaji, 2011) at 95 % confidence level. In mathematical notation, $n=Z^2 \times P_{\exp}(1-P_{\exp})/d^2$, where n is the required sample size, Z^2 is the standard deviation at 95 % confidence interval or 1.96, $P_{\exp}$ is the expected prevalence, and d is the desired absolute precision. Sample size for each herd production system and the questionnaire was obtained at 5 % desire precision, giving sample size of 125 for each. Sample sizes for the nomadic and sedentary cattle were determined at 2 and 3 % margins of error, respectively, and sample sizes of 765 and 375 were obtained for each respective production system. However, variation in desired absolute precision for the two production systems was due to the fact that nomadic cattle constituted over two thirds of the cattle populations in the state.

Sampling was performed using a multistage sampling procedure. In the first stage, the three existing agro-ecological zones—A, B, and C—in the state were considered. In the second stage, purposive sampling was used and 40 herds were selected from each production system in each of the agro-zones A and C, while 45 were selected from each production system in agro-ecological zone B. In the third stage, seven nomadic and three sedentary cattle were sampled in each of the selected nomadic and sedentary herds, respectively. Simple random sampling was used to select the 765 nomadic and 375 sedentary cattle in all selected herds through balloting.

Questionnaire design, pre-testing, and data collection

The questionnaire was designed containing mostly close-ended questions to ease data processing, minimize variation, and improve precision of responses (Thrusfield 2009). It contained questions that focused on various sub-themes like the pastoralists' demographic characteristics of gender, age, tribe, occupation, and formal education; existing knowledge on CBPP; and risk factors predisposing to the disease in herds, with specific questions on contacts with other herds at grazing and watering points, introduction of new cattle into herds, and contraction of the disease through outbreaks. Other questions were on socio-cultural factors of cattle gifts or payments for dowry, herd composition (keeping of cattle together with small ruminants in herds), and long trekking during seasonal migrations.

The questionnaire was pre-tested prior to the study on few Fulani nomadic herders on whom the actual study was conducted. It was administered by the researchers on individual nomadic herd owner whose herd was presumed to be single and independent of other herds. The pastoralist's ability to identify CBPP disease was probed further by enquiring about the clinical signs of the disease. Each pastoral herder who attested that his or her herd has had CBPP previously in the questionnaire was asked to describe its clinical signs. Those who chose cough, rapid and difficult breathing, nasal discharge, hyperthermia, and sneezing in the questionnaire were considered satisfactory. Understanding of this case definition by the respondents helped in getting good responses to predisposing herd risk to CBPP questions.

Data were collected using interviewer-administered, paper-based questionnaires on herd owners. Before commencement of each questionnaire administration, informed consent was verbally obtained from the respondents who were assured of voluntary participation, confidentiality of their responses, and the opportunity to withdraw at any time without prejudice in line with the Helsinki Declaration (WMADH 2001). Data collections were completed at the selected herd sites on a single visit.

Serum sample collection and enzyme immunoassay

Ten milliliters of whole blood was taken from jugular vein of each selected cattle, using a sterile 10-ml syringe and 18 × 1½" gauge needle for each animal. These were immediately placed into an ice bath slanted and transported to the laboratory within 7 h. The clot was allowed to form in syringe in the field before transportation. The sera were later transferred into plastic tubes and centrifuged at 3000 rpm for 20 min and then decanted into cryovials, which were identified before storage at −20 °C until analyzed.

A competitive enzyme linked immunosorbent assay (c-ELISA), developed by the OIE Collaborating Centre for the diagnosis and control of animal diseases in tropical countries (Le Goff and Thiaucourt 1998), was used. It detected antibodies in infected herds even if they persist for a longer period of time (FAO 2003; Niang et al. 2006). The test performance on CBPP has sensitivity of 99.9 % and greater specificity of more than 63.8 % (OIE 2014).

The c-ELISA was conducted using commercial *M. mycoides* subsp. *mycoides* (*Mmm*) Antibody Test Kit CBPP, ELISA version: P05410/02 (CIRAD/IDEXX Institut Pourquier Laboratories, Montpellier, France) according to manufacturers' instructions. Optical densities (ODs) were measured at 450 nm using the photometer Spectra Fluor (Tecan, Crailsheim, Germany). Only positive serum samples with percentage inhibition (INH%) cutoff value of 50 % and above were considered as positive.

Defined variables

In this study, covariates (hypothesized explanatory variables) were assessed at cattle and herd levels. At the cattle level, age, sex, breeds, and agro-ecological zones were the independent (explanatory) variables while positive and negative serological outcomes constituted the dependent (outcome) variables. Herd-level sero-prevalence was also determined, and a herd was considered sero-positive if it has at least one sero-positive cattle. Separate sero-prevalence estimates were established for each agro-ecological zone.

At the herd-level, herd characteristics of traditional cattle management practices constituted the explanatory variables, while existing knowledge responses of the pastoralists on the herd characteristics were the outcome variables. These were segregated into "satisfactory" and "'poor" "knowledge" responses. To measure the responses, the scoring system ranged between 1 and 20 points, which were converted to 100 %. The score range was further categorized into poor (≤10 points, ≤50 %) and satisfactory (≥11 points, ≥51 %) to keep them as binary variables.

Data management and analyses

Collected data were summarized and entered into Microsoft Excel 7 spreadsheet (Microsoft Corporation, Redmond, WA, USA) and stored. Open Source Epidemiologic Statistics for Public Health (OpenEpi) version 2.3.1 (Dean et al. 2009) was used for the statistical analysis. Descriptive and analytical statistics were used to describe the obtained data.

The associations between individual cattle sero-positivity and *M. mycoides* subsp. *mycoides* as well as herd-level risk factors for the disease were investigated using univariable analyses by chi-square test. All factors found to be biologically plausible and significant were subjected to multivariate analyses using likelihood stepwise backward logistic regression models to control for confounding and test for effect modification. $P<0.05$ was considered statistically significant at both analyses.

Results

Demographic information

The mean age of the pastoral respondents was 52.1±10.9 SD. Majorities (30.4 %) of the respondents were in the age group of 41–50 years. Majority (64.8 %) of them were of Fulani tribe and nomadic pastoralists. Other tribes that participated in the survey were Nupe (7.2 %), Hausa (12.8 %), and other tribes (15.2 %) and were of sedentary settlements. Nearly two thirds (69.9 %) never had formal education, while very few had primary (8.0 %), secondary (10.4 %), and tertiary (12.8 %) education.

Cattle-level sero-prevalence and associated risk factors

Of the 765 cattle sampled and sera examined for antibodies to *Mmm* antigen in nomadic production system, 16.2 % (124/764; 95 % confidence interval (CI) 13.7–19.0) were sero-positive, and 9.6 % (36/375; 95 % CI 6.8–13) were sero-positive in sedentary management system (Table 2). The overall cattle-level sero-prevalence from the two cattle production systems was 14.0 % (160/1140; 95 % CI 12.11–16.14). In the agro-ecological zones, the highest sero-prevalence of 25.3 % (95 % CI 20.2–31.0) was observed in agro-ecological zone C, while the lowest of 6.2 % (95 % CI 20.2–31.0) was observed in agro-ecological zone B in nomadic production system (Table 1). In sedentary production system, the highest sero-prevalence of 12.5 % (95 % CI 7.5–19.4) was observed also in agro-ecological zone C and the lowest of 6.7 % (95 % CI 3.3–11.9) in agro-ecological zone B (Table 2).

In nomadic production system, only age and agro-ecological zones were significantly associated with sero-positivity to *M. mycoides* subsp. *mycoides* infections during univariate analysis (Table 3). On subsequent logistic regressions, age groups 3–4 and ≥5 years were significantly less likely [odds ratio (OR) 0.50, 95 % CI 0.23–0.88; and OR 0.26, 95 % CI 0.14–0.50, respectively] not to be exposed to the infection. Also, agro-ecological zones A and C were significantly less likely (OR 0.29, 95 % CI 0.16–0.53; and OR 0.21, 95 % CI 0.12–0.36, respectively) not to have risk factors that will predispose to *Mmm* infection (Table 4).

However, at the cattle level in sedentary production system, all the risk factors were not significantly associated with sero-positivity to *Mmm* infection at univariate analysis and therefore logistic regression was not subsequently conducted (Table 5).

Herd-level sero-prevalence and associated risk factors

Herd-level sero-prevalence of CBPP in nomadic pastoral herds was 47.2 % (59/125; 95 % CI 38.2–56.3) (Table 1), while in the sedentary herds, the sero-prevalence was 27.2 % (34/125; 95 % CI 19.6–35.9) (Table 2). In the agro-ecological zones, the highest sero-prevalence of 72.5 % (95 % CI 56.1–83.4) was observed in agro-ecological zone C, while the lowest of 15.6 % (95 % CI 6.5–29.5) was obtained in agro-ecological zone B in nomadic production system (Table 1). In sedentary production system, agro-ecological zone C had the highest sero-prevalence of 37.5 % (95 % CI 22.7–54.2) and the lowest of 17.8 % (95 % CI 8.0–32.1) in agro-ecological zone B (Table 2).

Factors that included contacts with other herds at grazing and watering points, introduction of new cattle into herd,

Table 1 Cattle- and herd-level sero-prevalence of contagious bovine pleuropneumonia in nomadic production system in Niger State, North Central Nigeria

Agro-ecological zone	No. of cattle sampled	No. +ve	% +ve (95 % CI)	No. of herds sampled	No. +ve	% +ve (95 % CI)
A	245	45	18.4 (13.9, 23.6)	40	23	57.5(40.9, 73.0)
B	275	17	6.2 (20.2, 31.0)	45	7	15.6 (6.5, 29.5)
C	245	62	25.3 (20.2, 31.0)	40	29	72.5 (56.1, 83.4)
Overall	765	124	16.2 (13.7, 19.0)	125	59	47.2 (38.2, 56.3)

A southern agro-ecological zone, *B* eastern agro-ecological zone, *C* northern agro-ecological zone, *No. +ve* number positive, *% + ve* percentage positive, *CI* confidence interval

Table 2 Cattle- and herd-level sero-prevalence of contagious bovine pleuropneumonia in sedentary production system in Niger State, North Central Nigeria

Agro-ecological zone	No. of cattle sampled	No. +ve	% +ve (95 % CI)	No. of herds sampled	No. +ve	% +ve (95 % CI)
A	120	12	10.0 (5.5, 16.4)	40	11	27.5 (14.6, 43.9)
B	135	9	6.7 (3.3, 11.9)	45	8	17.8 (8.0, 32.1)
C	120	15	12.5 (7.5, 19.4)	40	15	37.5 (22.7, 54.2)
Overall	375	36	9.6 (6.9, 12.9)	125	34	27.2 (19.6, 35.9)

A southern agro-ecological zone, *B* eastern agro-ecological zone, *C* northern agro-ecological zone, *No. +ve* number positive, *% +ve* percentage positive, *CI* confidence interval

outbreaks of CBPP in an area, socio-cultural factors of cattle gifts and payments for dowry, herd composition of keeping cattle together with small ruminants, and long trekking during seasonal migrations were significantly associated with occurrence of CBPP in herds at univariate analysis (Table 6). On subsequent regressions, it was observed that these factors were more likely to influence occurrence of the disease in the herds. Particularly, outbreak of CBPP in an area was 25 times more likely (OR 24.8; 95 % CI 7.34–83.52) to be associated with its occurrence in a pastoral herd, while socio-cultural factors (gifts or payments for dowry) were 4 times more likely [OR 4.4; 95 % CI 1.83–10.72] to be associated with its occurrence in a herd (Table 7).

Discussion

With increasing globalization, the continued presence of contagious bovine pleuropneumonia in Nigeria constitutes a serious threat to the country's food security and international trade (Obi 2005). CBPP is one of the few relatively well-surveyed cattle diseases in Nigeria, but to our knowledge, this study was the first to cover nomadic and sedentary pastoral herds and many agro-ecological zones at a time.

The present study had shown that CBPP is enzootic in Niger State, with overall cattle-level sero-prevalence of 14 % using c-ELISA. This overall prevalence using the test kit indicated that there was a considerable level of cattle challenged with *Mmm* infections, without manifesting clinical signs but with evidence of detectable antibodies. The observed overall sero-prevalence was higher than the 8.7 % sero-prevalence obtained from a similar investigation in pastoral cattle camps in Niger State using similar test (Alhaji 2011) and 10.6 % in Kwara State in Nigeria (Olabode et al. 2013), but lower than 32 % sero-prevalence in a CBPP surveillance using c-ELISA in combination with abattoir survey in Nigeria (Aliyu et al. 2003). Also, Matua-Alumira et al. (2006) have reported 22.0 % overall sero-prevalence of CBPP using c-ELISA in transhumant and sedentary cattle production systems in Kajiado District, Kenya. Further, Nwankpa et al. (2004) have reported wide distribution CBPP under different pastoral settings in five states of Nigeria, with variable sero-

Table 3 Univariate analysis of factors associated with cattle-level sero-prevalence of contagious bovine pleuropneumonia in nomadic production system in Niger State, North Central Nigeria

Variables	Number tested	Number positive (%)	Number negative (%)	Chi-square	*P* value
Breeds:					
Bokoloji	134	13 (9.7)	121 (90.3)	2.77	0.09
Bunaji	631	111 (17.6)	520 (82.4)		
Sex:					
Bulls	267	41 (15.4)	226 (84.6)	0.22	0.64
Cows	498	83 (16.7)	415 (83.3)		
Age:					
1–2 years	168	12 (7.1)	156 (92.9)	22.68	<0.001
3–4 years	255	34 (13.3)	221 (86.7)		
≥5 years	342	78 (22.8)	264 (77.2)		
Agro-ecological zone:					
A	245	45 (18.4)	200 (81.6)	36.13	<0.001
B	275	17 (6.2)	258 (93.8)		
C	245	62 (25.3)	183 (74.7)		

Statistically significant at $P<0.05$

A southern agro-ecological zone, *B* eastern agro-ecological zone, *C* northern agro-ecological zone

Table 4 Multivariate logistic regression models of factors associated with cattle-level sero-prevalence of contagious bovine pleuropneumonia in nomadic production system in Niger State, North Central Nigeria

Variables	Number positive (%)	Number negative (%)	Odds ratio(95 % CI)	*P* value
Age:				
1–2 years	12 (7.1)	156 (92.9)	1.00 (ref.)	0.02
3–4 years	38 (14.7)	221 (85.3)	0.50 (0.23, 0.88)	<0.001
≥5 years	78 (22.8)	264 (77.2)	0.26 (0.14, 0.50)	
Agro-ecological zone:				
A	45 (18.4)	200 (81.6)	0.29 (0.16, 0.53)	<0.001
B	17 (6.8)	258 (93.2)	1.00 (ref.)	<0.001
C	62 (25.3)	183 (74.7)	0.21 (0.12, 0.36)	

Statistically significant at $P<0.05$

A southern agro-ecological zone, *B* eastern agro-ecological zone, *C* northern agro-ecological zone, *CI* confidence interval

prevalence using c-ELISA—Plateau State (14 %), Adamawa State (6 %), Borno State (8 %), and Lagos State (29 %).

Movements of cattle across the state, as well as the extensive nature of the pastoral herds, may have contributed to the current observed sero-prevalence, since Niger State is located at North Central Nigeria and serving as transit route for nomadic pastoralists on seasonal migrations between northern and southern parts of the country. These observations are in agreement with the reports that prevalence of CBPP tends to be higher in cattle herds on extensive management system with irregular annual vaccination coverage (Nawathe 1992; Nwanta and Umoh 1992). The variation in sero-prevalence in the two production systems is in consonants with the findings of Windsor and Wood (1998) that prevalence of CBPP varies according to the cattle production system and prevalence rates tend to be higher in extensive management system.

At the cattle level, the survey observed age and agro-ecological zone to significantly predispose to *Mmm* sero-positivity, but only in nomadic production system. That is, the likelihood of cattle developing CBPP was dependent on their age and ecological areas of their settlements. We found the odds of *Mmm* sero-positivity to be significant in age groups 3–4 and ≥5 years. This could be due to the fact that chronic stages of the disease are more seen in adult cattle as the age progresses (Ikpa et al. 2010). However, cattle aged 3–4 years have been shown to be more prone to both acute and chronic CBPP lesions (Egwu et al. 2012). The significant association of age group ≥5 years with sero-positivity could be explained at context of the fact that increasing age is a surrogate measure of repeated exposure to subclinical disease (Boelaert et al. 2005). Similarly, age has been reported to be significantly associated with CBPP occurrence with a high sero-prevalence of 9.5 % in adult animals and low sero-prevalence of 3.0 % in young ones (Kassaye and Molla, 2012).

The high sero-prevalence observed in agro-ecological zones C and A in the two production systems cannot be unconnected

Table 5 Univariate analysis of factors associated with cattle-level sero-prevalence of contagious bovine pleuropneumonia in sedentary production system of Niger State, North Central Nigeria

Variables	Number tested	Number positive (%)	Number negative (%)	Chi-square	*P* value
Breeds:					
Bokoloji	63	5 (7.9)	58 (92.1)	0.24	0.62
Bunaji	312	31 (9.9)	281 (90.1)		
Sex:					
Bulls	85	7 (8.2)	78 (91.8)	0.24	0.63
Cows	290	29 (10.0)	261 (90.0)		
Age:					
1–2 years	71	7 (8.2)	64 (91.8)	1.34	0.51
3–4 years	114	8 (7.0)	106 (93.0)		
≥5 years	190	21 (11.1)	169 (88.9)		
Agro-ecological zone:					
A	120	12 (10.0)	108 (90.0)	2.52	0.28
B	135	9 (6.7)	126 (93.3)		
C	120	15 (12.5)	105 987.5)		

Statistically significant at $P<0.05$

A southern agro-ecological zone, *B* eastern agro-ecological zone, *C* northern agro-ecological zone

Table 6 Univariate analysis of risk factors associated with contagious bovine pleuropneumonia occurrence at the herd-level in Niger State, North Central Nigeria

Factors	Responses	Satisfactory knowledge (%)	Poor knowledge (%)	Chi-square	*P* value
Contacts with other herds during grazing	Yes	92 (88.5)	12 (11.5)	9.168	<0.001
	No	13 (61.9)	8 (38.1)		
Contacts with other herds at watering points	Yes	83 (89.2)	10 (1.8)	19.42	<0.001
	No	17 (53.1)	15 (46.9)		
Introduction of new cattle into herd	Yes	75 (85.2)	13 (14.8)	13.88	<0.001
	No	20 (54.1)	17 (45.9)		
Through outbreak of CBPP in an area	Yes	99 (94.3)	6 (5.7)	40.16	<0.001
	No	8 (40.0)	12 (60.0)		
Herd composition (herd kept with small ruminants)	Yes	34 (82.9)	7 (17.1)	27.11	<0.001
	No	28 (33.3)	56 (66.7)		
Cultural factors (gifts or payment for dowry)	Yes	51 (82.3)	11 (17.7)	20.47	<0.001
	No	22 (41.5)	31 (58.5)		
Long trekking during migrations	Yes	99 (90.8)	10 (9.2)	14.19	<0.001
	No	9 (56.3)	7 (43.7)		

Statistically significant at $P<0.05$

CBPP contagious bovine pleuropneumonia

with the fact that the two zones have high concentrations of pastoral cattle, many stock routes for cattle on seasonal movements from far north of Nigeria to the southern parts, and high close contacts of cattle at grazing and watering points due to availability of pastures especially during dry season. Further, agro-zone C particularly has common international border with the Republic of Benin, which is porous. Ecological factors that have to do with availability of water and grazing pastures have

Table 7 Multivariate legalistic regression models of risk factors associated with contagious bovine pleuropneumonia CBPP occurrence at herd level in Niger State, North Central Nigeria

Factors	Satisfactory knowledge (%)	Poor knowledge (%)	Odds ratio (95 % CI)	*P* value
Contacts with other herds during grazing				
Yes	92 (88.5)	12 (11.5)	4.72	<0.001
No	13 (61.9)	8 9 (38.1)	(1.62, 13.71)	
Contacts with other herds at watering points				
Yes	83 (83.0)	10 (40.0)	7.32	<0.001
No	17 (53.1)	15 (46.9)	(2.818, 19.04)	
Introduction of new cattle into herd				
Yes	75 (85.2)	13 (14.8)	4.91	<0.001
No	20 (54.1)	17 (45.9)	(2.05, 11.76)	
Through outbreak of CBPP in an area				
Yes	99 (94.3)	6 (5.7)	24.75	<0.001
No	8 (40.0)	12 (60.0)	(7.34, 83.52)	
Herd composition (herd kept with small ruminants)				
Yes	34 (82.9)	7 (17.1)	9.714	<0.001
No	28 (33.3)	56 (66.7)	(3.83, 24.65)	
Cultural factors (gifts or payment for dowry)				
Yes	51 (82.3)	11 (17.4)	4.43	<0.001
No	22 (41.5)	31 (58.5)	(1.83, 10.72)	
Long trekking during migrations				
Yes	99 (90.8)	10 (9.8)	7.7	<0.001
No	9 (56.2)	7 (43.8)	(2.36, 25.12)	

Statistically significant at $P<0.05$

CBPP contagious bovine pleuropneumonia, *CI* confidence interval been reported to attract high density of cattle from long distances to the areas for pastures and water especially during dry season, with resultant exacerbation of the disease due to stress and close contacts (Amanfu, 2009). Similarly, Teshale et al. (2015) has reported a significant (P<0.05) association of CBPP sero-prevalence with the agro-ecology in Southern Zone of Tigray Regions in Northern Ethiopia.

The non-significant sero-positivity associated with sedentary production system could be attributed to its semi-extensive nature, with all its grazing and watering activities done with less stress and low tendency of contacts with other herds.

Among the studied risk factors at herd level, introduction of new cattle into herds and contacts with other herds during grazing and watering were observed to significantly predispose to occurrence of CBPP in herds. These findings are consistent with the reports that at the herd level, mixing of cattle at grazing and watering points, introduction of new animals into herds, and seasonal herding practices influenced CBPP occurrence and distribution patterns (Aliyu et al. 2000; Mariner et al. 2006). Also, outbreaks of CBPP in an area, cultural factors of cattle gifts or payments for dowries, and long trekking during seasonal migrations were found to be associated with occurrence of the disease in the herds. This is in consonant with the report that socio-cultural activities of pastoralists in many African countries, such as giving cattle as dowries and gifts, exacerbate CBPP occurrence and distribution and make it improbable for its elimination (FAO, 2000).

In addition, herd composition of herding and grazing cattle together with small ruminants, especially sheep, is a common practice by nomads in Nigeria. This was observed to significantly predispose to the disease in herds. Despite the fact that *Mmm* is specific for cattle, isolates of *Mmm* from small ruminants herd together with cattle have been reported (Kusiluka et al. 2000; Tardy et al. 2011). Although the role of small ruminants in the epidemiology of CBPP remains unclear, the possibility of their serving as reservoir for transmission to cattle cannot be discounted and remains a potential area for further epidemiological investigation.

A major limitation in this survey was that pastoralists less than 30 years of age were excluded, despite the fact that they constituted a large part of the populations studied and could also be cattle herd owners. Their non-inclusion was because they were not likely to possess significant existing veterinary knowledge and traditional oral history about livestock diseases, particularly on CBPP, because of less period of time they have spent with their stocks as compared to those in the higher age groups. Furthermore, the relatively small sample size of the respondents is another limitation, and these might have underestimated the effects of independent variables on the outcome variables. Also, being a cross-sectional study, the survey does not show causal relation; however, it does demonstrated the association of sero-positivity and exposure variables with the occurrence of CBPP.

Conclusion

This study has demonstrated that CBPP is prevalent and widely distributed among pastoral cattle herds in Niger State. The variations in agro-ecological zones of CBPP prevalence may be linked to geographical factors. In general, the observed results highlighted the important risk factors for the disease in cattle as well as in herds. Sero-diagnosis of CBPP and identification of risk factors for infection should be institutionalized as elements of epidemio-surveillance and control strategies, especially in resource-poor settlements. Nevertheless, to achieve effective control of this disease, strict movement control of herds and stamping out approaches should be instituted. Collaboration between state veterinary service institutions and Ardos (heads of Fulani settlements) on CBPP control strategies is not only desirable but also imperative if control measures are to be effective. Aggressive veterinary extension services to educate pastoralists on the dangers of keeping CBPP infected cattle in their herds should be pursued.

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Compliance with ethical standards

Conflict of interest None of the authors of this paper has a financial or personal relationship with other people or organizations that could inappropriately influence or bias the content of the paper.

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