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ORIGINAL RESEARCH

Participatory Epidemiological Survey of Foot-And-Mouth Disease Among Some Cattle Diseases in Some Pastoral Communities of Niger, North Central, Nigeria

Wungak, Y.S.,[1*] Alhaji, N.B.,[2] Lazarus, D.D.,[1] Odetokun, I.A.,[3] Ularamu, H.G.[1]

[1]National Veterinary Research Institute, Vom Nigeria.[2]Ministry of Agriculture, Niger.[3]Department of Veterinary Public Health and Preventive Medicine, University of Ilorin.*Corresponding author email; yiltex2@gmail.com, Phone: +2348064563108

SUMMARY

Foot-and-mouth disease (FMD) is known to cause significant financial losses, making it a threat to the livelihood and food security. Disease surveillance in pastoral areas are often difficult because human populations are relatively small and highly mobile, and requires considerable flexibility and commitment. Participatory epidemiological approach was used to assess relative burden, seasonality and perceived risk factors of FMD among other important cattle diseases in cattle population of pastoral communities of North-central, Nigeria. Nine pastoral communities and three key informants from each community were purposively selected for the survey between January and December 2014. Participatory rural appraisal tools were used for participatory exercises. Kendall's Coefficient of Concordance W statistics was used for statistical analyses. Mean proportional piles (relative burden) of FMD (*Boru,Chabo*) was 17.2%, and pastoralists'agreement on the piles was strong (W=0.6855) and statistically significant (P<0.001). Key informants' perceived risk factors for FMD were: keeping healthy cattle with sick ones (17.2%), high cattle density (16.8%), grazing cattle in areas of FMD outbreaks (12.4%), long distance trekking (10.3%), giving out cattle as gift or payment for dowry (8.2%), and cattle rustling (4.9%). The key informants agreement on the risk factors was strong (W=0.8372) and statistically significant (p<0.01). FMD occurred in all seasons, but more in late rainy season (*Damina*) and less in late dry season (*Rani*). Agreement on FMD seasonal occurrence was strong (W=0.8719) and statistically significant (P<0.01). This survey revealed the relative burden and seasonal impacts of FMD in pastoral herds in North-central Nigeria. FMD surveillance, control and prevention programmes that take these factors into consideration will be beneficial to the livestock industry. The combined use of Participatory epidemiological techniques and clinical record of cases is essential for cost effective disease surveillance, reporting and control strategies in Nigeria.

Keywords: Burden, FMD, Fulani pastoralists, Participatory Epidemiology, season, Nigeria

INTRODUCTION

Foot-and-mouth disease (FMD) is a highly contagious viral disease of cloven-hoofed animals. It is caused by an *aphthovirus*, an RNA virus with a positive-sense single-stranded genome in the family *Picornaviridae*, of which there are seven immunologically distinct serotypes: O, A, C, South African Territories (SAT)1, SAT2, SAT3 and Asia1 (OIE, 2004; Maree *et al*., 2014).The disease is characterised by fever, vesicles on the buccal mucosa, feet and teats of lactating cows and sudden death in the young susceptible species (Grubman and Baxt, 2004; Molla *et al*., 2010). FMD ranks as one of the most economically important infectious and transboundary diseases of animals affecting not only international trade in livestock and animal products but also resulting in damaging consequences for the livelihoods of local farmers due to impacts upon productivity, food security, and losses of income (Mann and Sellers, 1990; Kitching, 1998).

FMD is widely distributed in the developing world, in particular Africa, Asia, Middle East and South America, where livestock farming forms the backbone of rural economies that supports approximately 70% of the world's poor (Maree *et al*., 2014). FMD outbreaks particularly affects vulnerable individuals such as women and children since approximately 75% of livestock in Africa are raised under the pastoral systems for sustainable livelihoods (Scoones *et al*., 2010; Ferguson *et al*., 2013; Miguel *et al*., 2013).The lack of veterinary infrastructure, human resources, movement controls, and appropriate vaccines render many developing countries particularly exposed to the spread of FMD (Doel, 2003; Sutmoller *et al*., 2003; Perry and Rich, 2007). In sub-Saharan Africa, two transmission cycles of FMD occur: one in which FMDV circulates between wildlife and domestic animals and the other in which the virus spreads among domestic animals. The cycle between wildlife and domestic animals occurs in southern and eastern Africa, but due to the low populations of wildlife in West Africa, the disease is maintained mainly in domestic animals (Fasina *et al*., 2013).The seroprevalence of between 50 and 78% have been reported in cattle population(Lazarus *et al*., 2012; Wungak *et al*., 2015) with serotypes A, O, SAT 1 and SAT 2 among currently circulating strains in Nigeria (Wungak *et al*., 2017;Ularamu *et al*., 2016;Vandenbussche *et al*., 2017).

In Africa, the diversity of circulating field strains of FMDV makes the selection of sufficiently cross-protective FMD vaccines a challenge. There is a need for risk-based surveillance to determine endemic areas and factors that influence disease dissemination, to assist the design of targeted, area-wide, or ecosystem-based disease control strategies, as most African regions adopt the Food and Agriculture Organization of the United Nations (FAO)-OIE Progressive Control Pathway (PCP) for the Control of FMD (Rweyemamu *et al*., 2008). Also, the efficiency of FMD surveillance and control programmes in developing countries is often challenged by the issue of underreporting (Madin, 2011; Bellet *et al*., 2012). However, FMD is known to cause significant financial losses for small scale producers, making it a threat to the livelihood and food security of the poorest communities (Bellet *et al*., 2012).

Fulani pastoral communities in Africa live in some of the most underdeveloped environments in the world (Alhaji and Babalobi, 2016). Although these communities are reliant on their livestock as a source of socio-economic well-being, conventional veterinary services are poor and basic information on the epidemiology of important livestock diseases is limited. Epidemiological research and disease surveillance in such pastoral areas are difficult because human populations are relatively small and highly mobile, and they move their livestock across large areas with few roads and means of modern

communications (de Leeuw *et al*., 1995; Catley, 2006). In such situations, conventional approaches to veterinary research and disease surveillance require considerable flexibility and commitment. Given the resource and logistical constraints in such pastoral areas, pastoralists themselves are a valuable source of disease information (Thrusfield, 2009).This study therefore, assessed the relative burden and seasonality of FMD among other important cattle diseases as well as the perceived risk factors for the disease in pastoral cattle herds of North-central Nigeria. We hypothesized that Fulani pastoralists did not possess existing veterinary knowledge and traditional oral history about FMD and other cattle diseases and, therefore, they cannot be used for epidemiological investigation of the diseases for surveillance and research.

MATERIALS AND METHODS

Study Area

The study was conducted in Niger state, located at the southern Guinea savannah 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. Niger state provides transit routes for pastoral nomads on seasonal migrations from the northern parts to the southern parts of the country. The state 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 150 cm and duration of approximately180 days. It has average relative humidity of around 58.6% and mean lowest and highest temperature of about 22°C and 39°C, respectively. The state has an estimated cattle population of 2.4 million cattle, which are mostly in the custodies of pastoralists (MLFD, 2015).

Study Design and Social Structure of Target Populations

Participatory Epidemiology (PE) exercises were conducted using participatory approaches and methods in the Fulani pastoral communities domiciled within Niger state, to collect semi-quantitative data from the pastoralists between January and December 2014. The target populations were Fulani pastoralists, who are seasonally mobile, with scattered herds of local breeds of cattle (Bunaji, Rahaji and Bokoloji), domiciled in remote areas of the state during the study period. The average number of herds that formed a pastoral community is 28, each managed by a herd head or an owner (a man, his wives and children, or an elderly widow and her children). Average number of animals in a herd is 102 cattle of variable ages.

Definitions

In this study, Fulani pastoral herd was defined as cattle herd in Fulani ethno-cultural group that keeps mainly cattle, usually large herd of 100 cattle and above, and takes part in year-round long movements on large range for grazing and in search for water, without permanent homestead.
Participatory epidemiology is the systematic use of participatory approaches and methods to improve understanding of FMD and other cattle diseases in the Fulani pastoral communities. Relative burden is the pastoralists' perceived effects of FMD among other important cattle diseases, characterized by such indicators as fever, vesicles on the buccal mucosa, feet and teats of lactating cows and sudden death in the young of susceptible species.

Sample Size and Sampling Procedure

In this PE survey, nine Fulani pastoral communities were purposively selected across the state, in a manner that allowed for their adequate spread. These communities include: Lapai, Eyagi, Lemu, Paiko, Kuta, Bosso,Wushishi, Bobi grazing reserve and Borgu Fulani pastoral communities. Key criteria for selection of the communities included herding of cattle as main source of livelihood and remoteness of the settlements. Also, three pastoral key informants were purposively selected in each community to organize and lead other pastoralists for action-oriented participatory exercises. However for each pastoral community, the number of other

participants was not restricted. A total of 27 key informants were selected for the study.

The study protocol for the participatory survey was approved by the Niger State Ministry of Livestock and Fisheries Development, Research Ethics Committee (reference MLFD/NGS/669). Participants were provided with verbal information on the objectives of the study. Informed consents of respondents were verbally obtained before commencement of each section of participatory exercise in a community. They were assured of voluntary participation, confidentiality and the opportunity to withdraw at any time without prejudice in line with the Helsinki Declaration (WMADH, 2001). Verbal information and informed consent were deemed necessary due to the low literacy levels among the participants.

Participatory Data Collection

Advocacy visits were made to each community a week prior to the proposed participatory exercises with the necessary permission obtained from Ardo or Dikko (Fulani community leaders). Key informants were told that the survey was only meant to investigate burden of important cattle diseases in Fulani pastoral communities, using their existing veterinary knowledge and perceptions about livestock diseases, which will be used for designing surveillance and control strategies. However, FMD was never specifically mentioned to avoid bias, especially where it is not a major challenge. The PE was conducted by an appraisal team trained on participatory methods as previously described (Catley *et al*., 2002; Catley, 2005). Participatory rural appraisal tools including semi-structured interview, checklist, key informants, proportional piling, matrix scoring, seasonal calendar and triangulation were used. Participatory rural appraisal (PRA) tools were used to collect qualitative and semi-quantitative data as previously described (Chambers, 1994; Mariner and Paskin, 2000).

Key Informants, Semi-Structured Interview and Checklist

Key informants were the traditional Fulani pastoral leaders or elders in the communities who command much respect among their members. According to the Fulani tradition, they are considered to be more knowledgeable than other pastoralists on animal health and production management. They led other pastoralists in their respective communities to the group participatory exercises. Semi-structured interview **(**SSI) began with introduction of the appraisal team and explanation of purpose of the visit to the whole participants. During each session of the SSI, which ran for about three hours, general information about cattle diseases encountered and their perceived predisposing risk factors in the communities were discussed.

In order to facilitate discussion, the appraisal team asked questions that began with more general topics on cattle husbandry system followed by areas on specific important diseases affecting their cattle. These were guided by a pre-tested checklist of open-ended questions that standardized discussions, and questions were probed depending on the key informants' responses. Diseases identified were probed and expanded descriptions of their clinical and epidemiological manifestations obtained. Also, participants were told to identify and list perceived risk factors for the various diseases and were probed to explain how they predisposed to the occurrence of the diseases. Interviews were conducted using the local languages used for communication in the study area (*Fulfulde* and *Hausa)*. Detailed descriptions of FMD and other cattle diseases in each pastoral community were collected and recorded.

Proportional Piling of Relative Burden of Foot-and-Mouth Disease and Other Cattle Diseases

In each community, pastoralists were asked to name ten most important diseases perceived to be affecting their cattle within a ten-year period preceding the interview. The pastoralists often used local disease names to identify cattle diseases. Once the participations had compiled the list of diseases, ten circles were drawn on flip

charts, each representing a mentioned disease. Pastoralists were given 100 pebbles, which they piled into the circles proportionally to the perceived impact of each disease to the community, in terms of loss in milk and weight as well as reproductive performance, to mention few. The appraisal team then counted the pebbles placed in each circle to give a proportion that determined relative burden and rank of each disease in that pastoral community.

Matrix Scoring for Clinical Manifestations of Foot-and-Mouth Disease and some Cattle Diseases

Matrix scoring of perceived clinical signs associated with FMD and other five important cattle diseases was conducted. SSI was conducted on the pastoralists to identify six most important cattle diseases among those mentioned during proportional piling technique, and were used for the matrix scoring technique (Catley, 2005;Catley, 2006). Furthermore, they were asked to identify and list fifteen (15) important clinical indicators that are associated with the six identified diseases. The clinical indicators were then placed on the *y*-axis of the drawn matrix chart on flip charts and the six diseases were placed on the *x*-axis. Ten pebbles were allocated to each clinical sign (indicators) and participants divided the pebbles relative to perceived association of each indicator to a disease in the matrix.

Proportional Piling of Risk Factors for Foot-and-Mouth Disease Occurrence

The key informants and other participants in each pastoral community were asked to name ten (10) most important perceived risk factors that predisposed to FMD (*Boru, Chabo*) occurrence in their cattle herds within the preceding ten-year period. Once the pastoralists had agreed on the listed risk factors, the appraisal team then probed them further on the epidemiological significance of each factor to the occurrence of FMD in cattle. They were then compiled and ten circles drawn on flip charts, each representing a mentioned risk factor. Pastoralists were given 100 pebbles and they piled them in the circles proportionally to the perceived influence of each factor on the occurrence of FMD in herds. The appraisal team then counted the pebbles in each circle and proportions of relative influence of each factor on FMD occurrence in the pastoral communities were obtained.

Seasonal Calendar of Foot-and-Mouth Disease Impacts

Seasonal calendar exercise on the seasonal impacts of FMD among some important cattle diseases was conducted. A seasonal calendar of 12 months (January – December) was considered. A matrix was designed and the 12 months were further grouped into four sub-seasons identified by the Fulani pastoralists for the occurrence of cattle diseases in the state, namely: *Kaka* or early dry season (October to December), *Rani* or late dry season (January to March), *Bazara* or early rainy season (April to June), and *Damina* or late rainy season (July to September). The seasons in the matrix calendar were presented on the *x*-axis while the diseases, including the FMD were on the *y*-axis. Ten (10) pebbles were allocated to each disease (indicator) and the participants scored the pebbles proportionally to the relative burden of each disease in each season.

Triangulation

Data obtained from each participatory exercise in each community were cross-checked and further debated among the participants until a consensus view or agreement was obtained. The results of the nine pastoral communities were also triangulated (compared) at the end of the PE by the appraisal team, analysed and mean outcomes of perceived relative burden and seasonal trend of FMD and some important cattle diseases obtained. Also, names of the diseases and descriptions given by the pastoralists were validated at the zonal veterinary offices and veterinary field epidemiologists' experts' opinions. The appraisal team triangulated the results of the risk factors from the nine Fulani communities to obtain their averages, which were further cross-checked with the zonal veterinary officers and veterinary

epidemiologists' expert opinions for final validities.

Data Analysis

Data obtained were qualitative and semi-quantitative in nature; the former were probed and discussed during SSI without being subjected to formal statistical analyses, while the later, semi-quantitative (mostly from piling, scoring and ranking exercises), were entered into a Microsoft Excel® 7 database (Microsoft Corporation, Redmond WA, USA) and stored. Descriptive statistics of rates and means were used to describe the relative burden of FMD among other cattle diseases and their seasonal calendar in the pastoral communities. The Kendall's Coefficient of Concordance W statistic, a non-parametric statistics (Kendall and Smith, 1939; Siegel and Castellan, 1994; Legendre, 2010) was used.

KendallW_Pgm.php software programme (www.StasToDo.com) was used to assess agreements among the key informants and other pastoralists at 95% confidence level. The software provides a single analysis of Kendall *W*. The data were presented in a matrix, in which rows represented cattle disease conditions (subjects) and columns represented key informants groups (raters, or rankers). Columns were separated by spaces or tabs, and each row had the same number of columns. Each cell contained the value (or scores) for row subject as allocated by column ranker. A value of $P<0.05$ indicates statistical significance of the agreements.

RESULTS

Proportional Piles of Relative Burden of Foot-and-Mouth Disease

Key informants and other pastoralists demonstrated detailed existing veterinary knowledge and traditional oral history of cattle diseases during the participatory exercises in their communities, with FMD indicated as one of the most important cattle diseases. Although the list of cattle diseases mentioned varied from one pastoral community to the other, FMD was featured prominently in all the communities. Cattle diseases that were averagely ranked as great burden in the nine Fulani communities were FMD(*Boru*^{H}, *Chabo*^{F}), Trypanosomosis(*Samore*^{H,} *Shammol*^{F}), Contagious bovine pleuropneumonia (CBPP)(*Ciwonhuhu*^{H}, *Huttu*^{F}), Fasciolosis (*Ciwomhanta*^{H}, *Heri*^{F}), Bovine brucellosis (*Bakkale*, *Yande*), Rift Valley fever(*Gabi-gabi*^{F}), (*Bolla*^{F}), Dermatophilosis (*Kirchi*^{H}, *Ngunya*^{F}, *Garje*^{F}), Lumpy skin disease (*Ciwonbollo*^{H}, *Tollo*^{F}), and Ringworm (*Shanikoje*^{F}) (figure 1).

The mean proportional piles (relative burden) of FMD (*Boru, Chabo*) among other cattle diseases in Lapai, Lemu, Eyagi, Paiko, Kuta, Bosso, Wushishi, Bobi Grazing Reserve, and Borgu Fulani pastoral communities was 17.2%, which was adjudged by the pastoral key informants to be the most important cattle disease in terms of impact on cattle production and reproduction in their communities. The Fulani pastoralists called FMD (*Boru*, *Chabo*), in *Fulfulde* and *Hausa* languages, respectively. The agreement of the key informants on the relative burdens of FMD and some cattle diseases in Niger state was strong ($W = 0.6855$) and statistically significant ($p<0.05$).

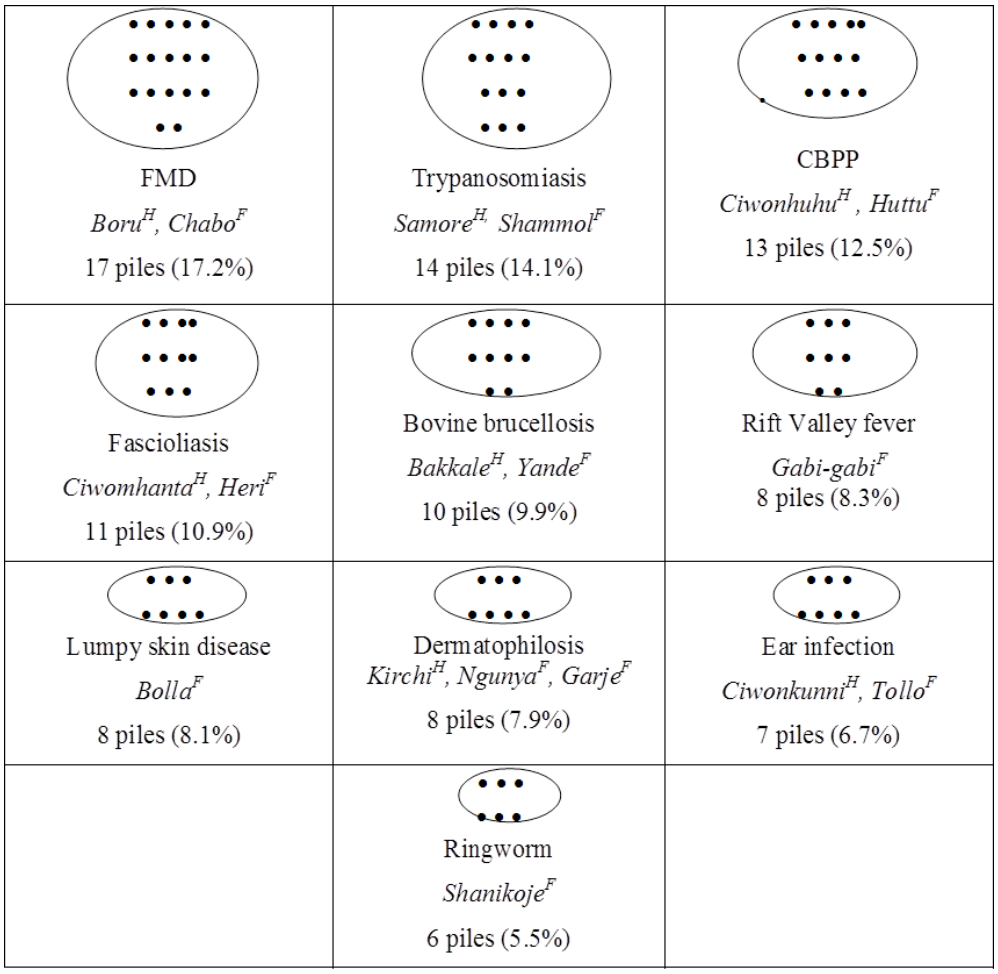

Figure 1. Mean proportional piles (rank order) of the relative burden of FMD and some cattle diseases in the nine Fulani nomadic pastoral communities of Niger State. Numbers in parenthesis are the average proportions of each disease. Superscripts *H*and *F*are the local names in *Hausa* and *Fulfulde*, respectively.

Matrix Scores of Foot-and-Mouth Disease and Some Cattle Diseases Clinical Manifestations

The six consistent important cattle diseases mentioned by pastoralists in all the nine Fulani communities were FMD (*Boru, Chabo*), Trypanosomosis (*Samore, Shammol*), CBPP (*Ciwonhuhu, Huttu*), Fasciolosis (*Ciwomhanta, Heri*), Bovine brucellosis (*Bakkale, Yande*), and Rift Valley fever (*Gabi-gabi*). The Fulani pastoralists proved to be knowledgeable at recognizing clinical signs of FMD in their cattle herds. Mean matrix scores of the fifteen clinical signs manifested by the six major diseases, including FMD, are presented in figure 2. The names *Boru* and *Chabo,* in *Fulfulde* and *Hausa* languages, respectively denote a cattle disease associated with prominent clinical manifestations of fever, salvation, vesicles on buccal mucosa, vesicles on feet of lactating cows, anorexia, emaciation, and nasal discharge. These were consistently and correctly scored for the disease with mean matrix scores of 3 piles, 2 piles, 10 piles, 10 piles, 5 piles, 5 piles, and 2 piles, respectively (figure 2). There was a significantly strong agreement among the pastoralists on clinical manifestations of FMD ($W = 0.6687$, $p<0.001$).

Perceived Factors Associated with Foot-and-Mouth Disease Occurrence

The mean proportional piles of the key informants' perceived risk factors identified to influence the occurrence of FMD (Fig. 3)

Diseases ⟹ / Clinical signs ⇩	Trypanosomiasis (*Samore*)	FMD (*Boru, Chabo*)	CBPP (*Ciwonhuhu*)	Fascioliasis (*Ciwon-hanta*)	Brucellosis (*Bakkale*)	Rift Valley fever (*Gabi-gabi*)
Fever	(0.0)	(2.6)	(0.7)	(0.0)	(1.1)	(4.1)
Salivation	(0.0)	(6.9)	(1.6)	(0.0)	(0.0)	(0.0)
Difficult breathing	(0.0)	(0.0)	(9.1)	(0.0)	(0.0)	(0.6)
Mouth lesions	(0.0)	(9.5)	(0.0)	(0.0)	(0.0)	(0.0)
Feet lesions	(0.0)	(9.8)	(0.0)	(0.0)	(0.2)	(0.0)
Anorexia	(1.6)	(4.9)	(0.7)	(0.5)	(0.0)	(1.1)
Emaciation	(3.8)	(5.1)	(1.9)	(3.3)	(1.1)	(0.6)
Abortion	(0.5)	(0.0)	(0.0)	(0.0)	(3.9)	(4.7)
Swollen knee joints	(0.0)	(0.0)	(3.1)	(0.0)	(6.8)	(0.0)
Cough	(3.7)	(0.0)	(5.6)	(0.2)	(0.0)	(0.0)
Nasal discharge	(0.4)	(2.1)	(0.0)	(1.7)	(0.0)	(6.3)
Rough hair coat	(2.5)	0 (0.1)	(0.0)	(6.7)	(0.0)	(0.0)
Lacrimation	(8.9)	(0.0)	(0.4)	(1.3)	(0.0)	(0.0)
Diarrhoea	(0.6)	(0.0)	(0.0)	(16.9)	(0.0)	(4.1)
Sudden death	(1.8)	(0.3)	(2.5)	(0.0)	(0.2)	(4.9)

Figure 2. Mean matrix scores of clinical signs of FMD and other important cattle diseases in Fulani pastoral communities of Niger State. Numbers in parenthesis represented the mean scores

include: keeping healthy cattle with sick ones (17 piles, 17.2%), high cattle density (17 piles, 16.8%), grazing cattle in areas of FMD outbreaks (12 piles, 12.4%), long distance trekking (10 piles, 10.3%), mixed grazing and watering with small ruminants (10 piles, 9.5%), introduction of new animal into herd (9 piles, 8.6%), giving out cattle as gift or payment for dowry (8 piles, 8.2%), culture of borrowing and loaning cattle (6 piles,6.4%), dust (aerosol) during the harmattan season (7 piles, 7.3%), and cattle rustling (5 piles, 4.9%).The key informants agreement on the risk factors was significantly strong ($W = 0.8372, p<0.01$).

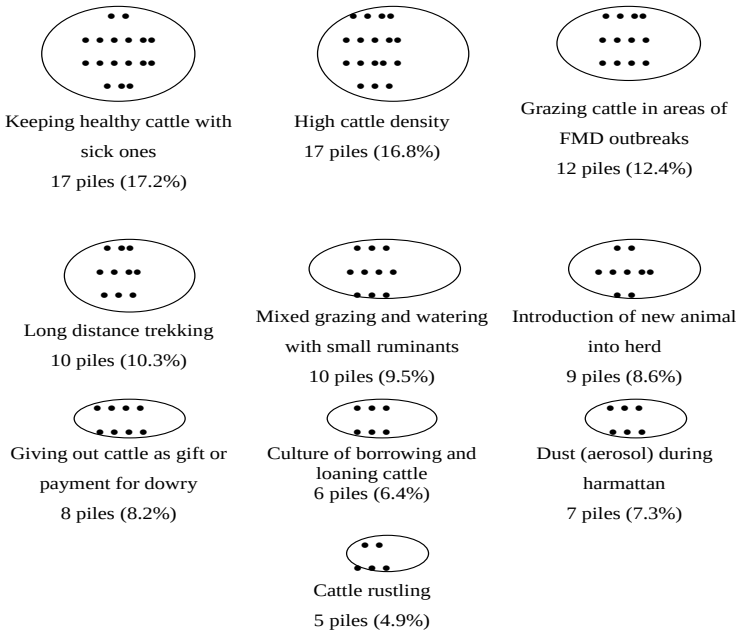

Figure 3. Mean proportional piles of the perceived risk factors for FMD occurrence in cattle in the Fulani pastoral communities of Niger State. Numbers in parenthesis are the average proportions of each risk factor.

Seasons ⇒ / Diseases/conditions ⇓	Early rainy season (*Bazara*)	Late rainy season (*Damina*)	Early dry season (*Kaka*)	Late dry season (*Rani*)
Trypanosomiasis (*Samore*^{H}, *Shammol*^{F})	••••• (5.1)	•••• (4.1)	•••• (4.0)	•••••• (6.6)
Fascioliasis (*Ciwon-hanta*^{H}, *Heri*^{F})	•••• (3.9)	•••• ••••• (8.5)	•••• (3.6)	•• (1.9)
Brucellosis (*Bakkale*^{H}, *Yande*^{F})	••• (2.9)	•• (2.1)	•••• (3.7)	••••• (4.9)
FMD (*Boru*^{H}, *Chabo*^{F})	•••• (3.5)	••••• •••• (9.1)	••••• (5.2)	••• (2.5)
CBPP (*Ciwon-huhu*^{H}, *Huttu*^{F})$^{+}$	•••• (4.2)	••• (2.6)	•••• •••• (7.8)	••••• (5.5)
Rift valley fever (*Gabi-gabi*^{F})	••••• (4.5)	•••• ••••• (9.3)	••• (3.3)	•• (2.1)

Figure 4.Mean seasonal burden of FMD and other important cattle diseases in the Fulani pastoral communities of Niger State. Numbers in parenthesis are the average scores

Seasonal Impacts of Foot-And-Mouth Disease and Some Cattle Diseases

Although FMD occurred in all seasons as indicated in the seasonal scores, the disease was however more prevalent with more impact in one sub-season than another. The key informants and other pastoralists scored FMD to occur in all seasons, but the occurrence was more in late rainy season (*Damina*), followed by early dry season (*Kaka*) and less in late dry season (*Rani*) (Figs. 4 and 5). Pastoralists' agreement on the seasonal occurrence of FMD among some cattle diseases was strong (W = 0.8719) and statistically significant (P<0.01).

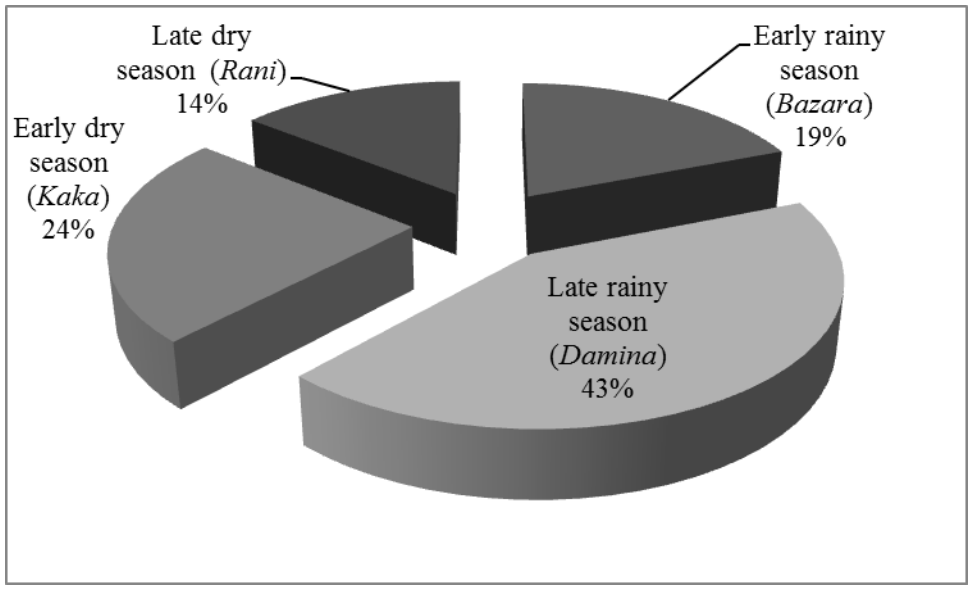

Figure 5.Proportional seasonal scores of FMD impacts in Fulani pastoral communities of Niger State. Words in parenthesis were local names for the seasons

DISCUSSION

We found that Fulani pastoralists possess significant existing veterinary knowledge and rich traditional oral history about FMD and other important cattle diseases enzootic in their herds, although most of them do not possess formal education. To our knowledge, this study was the first to cover Fulani pastoral communities and their herds in Niger state using PE techniques to assess and validate burden of FMD at a time. PE is an emerging field that is based on the use of participatory techniques for systemic harvesting of epidemiological intelligence information contained within community observations, existing veterinary knowledge (clinical and epidemiological disease information) and traditional oral history to improve the understanding of diseases and options for animal disease control (Catley, 2005;Catley, 2006;Thrusfield, 2009; Catley *et al*., 2012). Although FMD was not the only important disease that affects cattle herded by the Fulani pastoralists in Nigeria, it proved to be one of the important diseases that had the greatest impacts on the livelihoods of these pastoralists.

This survey found FMD (*Boru, Chabo*) to be the most important cattle health problem and an enzootic disease in the study area. The relatively high burden of FMD among other cattle diseases was partly due to absence of effective surveillance as well as prevention and control strategies in the marginalized rural communities. The clinical indicators described by the pastoralists indicated that they were aware of most clinical presentations of the disease. Indeed most of the signs listed for FMD were consistent with those reported in different PE studies (Catley *et al*., 2001;Catley *et al*.,2004).Similarly, pastoralists in the Borena Plateau of Ethiopia recognized FMD as cattle disease locally called *Hoyalee* with the clinical signs and indicators of kissing sound, salivation, lameness/footsore, mouth lesions and contagiousness (Jibat *et al*., 2013). FMD is known to be characterized by fever, profuse salivation, vesicles in the mouth and on the feet and a drastic reduction in milk production, with sudden death in

young stock (Radostits *et al*., 2006).The identified clinical manifestations of FMD in the study areas were judged to be sufficiently specific to contribute to the design of the disease surveillance system. Proportional piling results showed that pastoralists were aware of the risk factors, especially the socio-cultural ones, which influence occurrence of FMD in cattle herds. The key informants provided detailed and accurate clinical descriptions of FMD and had greater appreciation of the risk factors associated with the disease. This suggests that PE could be used to detect FMD incidence earlier by taking advantage of the livestock owner's observations through the integration of active syndromic surveillance geared to the level of outbreak probability (Mariner and Paskin, 2000; Grace *et al*., 2008).Using participatory disease surveillance (PDS), FMD was identified to be the most important disease of livestock, especially buffalo, in Dakahlia Governorate, Egypt (Abou El-Amaiem, 2015).

The seasonal calendar created by the pastoralists described variations in disease occurrence associated with rainfall pattern over four seasons of the year. This could be because pastoralists recognize the seasons from the amount of rainfall, rather than the calendar date. The pastoralists scored FMD to occur in all seasons, but occurrence was more in late rainy season (*Damina*).These findings are similar to the reports of previous studies conducted on FMD in Nigeria, in which occurrence and impacts of FMD occurred more during the late rainy season (Waziri and Yunusa, 2014; Olabode *et al*., 2014; Elelu *et al*.,2016).Similarly in Ethiopia, the seasonal calendar exercise demonstrated variations in the amount of rainfall and cases of FMD over four distinct seasons identified, namely *Bonahagayaa*, the long dry season (December to February); *Ganna*, the long rainy season (March to May); *Adollessa*, the short dry season (June to August); and *Hagayya*, the short rainy season (September to November) (Jibat*et al*., 2013).The Food and Agriculture Organization of United Nations has previously noted that the classification of climatic events into seasons varies considerably even within ethnic groups (FAO, 1990). From previous studies conducted in Nigeria and Ethiopia, it was reported that animal diseases occur in both dry and wet season but attributed increased stress and high cattle movement during dry season to increase the prevalence (Abdulkadir, 1989; Rufael *et al*., 2008).

There is extensive ethno-veterinary knowledge that pastoralists have been known to possess and on which they rely to diagnose or treat many livestock diseases (Rufael *et al*., 2008). Fulani pastoralists are the most affected with FMD, because of non-availability of vaccine and lack of awareness about importance of FMD vaccination programme. It is possible that the proper collection and analysis of data for FMD are often under reported by conventional veterinary services. Hence, data collection in pastoral areas can better be managed through PE approach.

Geographical bias in PE survey was reduced by making specific efforts to cover settlements that are distant or difficult to access. Seasonal bias was reduced by conducting exercises across a whole year. The possibility of a subject bias was minimized by giving no special attention to FMD. Professional team bias was decreased through proper training of the appraisal team. 'Dominant-speaker' bias was reduced by allowing as many participants as possible to give their views on a certain issue and by also prompting rather silent participants during SSI.

This study has shown that Fulani pastoralists possessed rich existing veterinary knowledge and traditional oral history about FMD, and have identified it to be one of the most important cattle diseases in Nigeria. The highest burden of FMD was reported during the late rainy season and lowest during the late dry season. The surveillance system and control programme that takes these variables into consideration will be beneficial to the livestock industry. The combined use of PE techniques and clinical records of cases Including

seromonitoring and causative agent detection are essential for effective disease surveillance, reporting and control strategies in Nigeria.

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