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Geo-spatial distribution of serologically detected bovine Foot and Mouth Disease (FMD) serotype outbreaks in Ilesha Baruba, Kwara State-Nigeria

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ABSTRACT

The study was aimed at assessing the prevalence and distribution of bovine Foot and Mouth Disease (FMD) serotypes in Ilesha Baruba, Kwara state-Nigeria. To identify the source of epidemics, geo-spatial analysis was done on the FMD outbreak locations (n=15) using Global Positioning Service (GPS) device (Etrex^R). Randomly sampled bovine sera (n=64) from herd representatives were subjected to FMD 3ABC enzyme-linked immunosorbent assay (FMD 3ABC ELISA) and solid-phase competitive ELISA (SP-cELISA), for the screening and serotyping of FMD virus, respectively. Through ELISA, the FMD serotypes detected in this study were- serotype O (83%; n=53/64), serotype A (7.8%; n=5/64), serotype vaccine O (1.6%; n=1/64), and serotype vaccine SAT2 (1.6%; n=1/64). Multiple serotypes were observed in two different combinations; these were O and A (4.7%; n=3/64), and O and SAT2 (1.6%; n=1/64). FMD multiple serotype infections were associated with absence of cross-immunity between serotypes and cross reactivity enhanced by clustered herds, highland study area topography, road and river interconnectivity, possible human settlements, activities and traffic. This study provides baseline information on geo-spatial distribution, and identification of prevalent FMD serotypes in Ilesha Baruba, Kwara state-Nigeria.

Keywords

ELISA, FMDV serotypes, Geo-spatial analysis, Outbreaks, Ilesha Baruba

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INTRODUCTION

Foot and Mouth Disease (FMD) is a highly infectious disease affecting several animals like cattle, sheep, pigs, and many wildlife species. FMD causes reduced productivity in animals and thus affects economy of a country (Jamal and Belsham, 2013). The phylogenetic inference revealed from molecular studies of viruses contributed significantly to the spatial and evolutionary pathways underlying the source of FMD epidemics. The increasing economic losses for FMD on the livelihood of livestock owners and trade are associated with the emergence of more virulent FMD viruses, as evidenced by genetic diversification of serotypes (Di Nardo et al., 2011). However, the epidemiology of FMD in Nigeria is inadequately understood and utilized (Olabode, 2012), despite enormous contributions of several researches with little applications of satellite imaging and bioinformatics.

Satellite techniques like geographical information system (GIS), remote sensing, and global positioning

system (GPS) are modern techniques. Although the satellite technique was started as a technological tool, it was rapidly evolved into science in the mid-eighties. Later, in 1992, the technique was first used in epidemiological studies of infectious disease, especially for providing early warning signs to trans-boundary animal diseases (Olabode et al., 2014a). These applications also aided effective visualization of spatial distribution of cattle and their movement pattern especially in relation to land-use, vegetation cover, water resources and annual seasonal changes in Nigeria (Esuruoso et al., 2005). Besides, several attempts have been made to apply the technique in management and control of some parasitic diseases in some African countries (Dozie et al., 2007). However, application of this technique in Nigeria is yet to be explored, and highly desirable for livestock diseases, as the livestock are heavily laden with numerous diseases of economic value.

Satellite applications especially GIS could be a promising breakthrough in controlling of FMD and other economic diseases of both human and livestock. Therefore, this study was aimed to assess the occurrence and distribution of FMD serotypes within the study area using ELISA tests, GIS and google earth tools.

MATERIALS AND METHODS

Study area: Ilesha Baruba is a major town and district in Baruten Local Government Area of Kwara state. The market is being used for the sales and distribution of cattle from Mali, Togo, Benin, Burkina Faso, and Senegal to other parts of Nigeria (Olabode et al., 2014b). The location of Baruten Local Government Area in Nigeria is very important as it shares boundaries to the west with Benin Republic, to south with Irepo Local Government Area of Oyo State, to north with Babana district in Borgu LGA of Niger State, and to east with Kaiama LGA of Kwara state. The road-distance from Kosubosu (LGA headquarters) in Yashikira district to Ilorin (administrative division) is about 503 km; this may facilitate human and livestock traffic. The people of this region are mainly engaged with agriculture, animal husbandry, and trading activities.

Study design: This purposive study was conducted among 12 cattle herds involving 15 outbreaks over a period of 4 months (December 2010 to March 2011) (Table 1). The herds were sampled based on complains from owners, and presence of clinical signs observed at the time of first examination. From each outbreak, six

(6) animals with signs of FMD without evidence of vesicles were randomly selected for collection of blood. Three sampling locations namely, Bode I, Bode II (Gberrebereru) in Bode/Babanne ward, and Bukaru-Rontuwa in Sinawu/Tumbunya wards in Ilesha district were indexed as latitude and longitude using a GPS device (Table 1).

Sample collection: Whole blood (5 mL) samples were collected using 10 mL syringe from the jugular veins of FMD-affected-cattle. The blood samples were kept into 5 mL plastic bottles (ANTEC^R) having no anticoagulant. The bottles were allowed to stand at room temperature at an angle of 45° for sera separation. The sera were collected and stored in cryovials, then packed on ice for transportation to the laboratory, and finally stored at -20°C (-70°C for longer time storage) until use.

Preparation of FMD outbreak digital maps of Ilesha Baruba district using geographic data collection method: Geo-spatial tools were used for collection of data, and outbreak mappings was recorded as described by Esuruoso et al. (2005). The GIS was used in the geo-spatial analysis and for monitoring the spread of FMD outbreaks, herd proximity and outbreak locations and topography, distribution of disease serotypes and closeness to features that can spin off the virus within the study area, as described by Maheshwaran and Craglia (2004).

Data projection and geo-referencing: The study area was extracted from the spot satellite imagery from Google Earth Pro by the conversion of data set to .kml (keyhole Markup language) file. The data frame of Arc GIS 10.1 was projected to WGS 1984 of Universal Transverse Mercator for other features to be overlaid. Features such as roads and rivers in the study area were digitalized and geo-referenced to the coordinated system to give data view mode which was transferred to layout view for map title, north arrow, scale bar and legend insertion.

Geo-spatial Analysis: Spatial analysis was conducted based on proximity analysis with buffering operation carried out from 500 m to 1 km range to determine closeness of animal herds to water sources and roads, which were potential means of disease spread. Hill shade operation was further performed using the Shuttle Radar Topography Mission (SRTM) Data of 90 m to illustrate study area topography for the determination of each cattle herd elevation in relation to water sources and directional flow. This analysis was conducted at GEO-APPs Limited, NASRDA Abuja.

Sero-assay using FMD 3ABC-ELISA: Competitive ELISA (cELISA) was used to assay the FMD antibodies as described by Clavijo et al. (2004a). The samples were considered positive if they inhibited 50% or more of the signal strength of the standard negative control.

Serotyping assay using Solid Phase Competitive blocking ELISA (SP-cELISA): SP-cELISA, described by Clavijo et al. (2004b), was conducted for serotyping of FMDV. The samples were considered positive if they inhibited 50% or more of the signal strength of the standard vesicular FMDV antigen capture assay. This assay was conducted at the FMD Laboratory, National Centre for Animal Diseases, Winnipeg, Canada.

Statistical Analysis: The positive reactors were expressed as simple descriptive statistics such as percentage, and both positive and negative FMD reactors were compared by Chi-square. The nearest neighborhood index analysis was also performed to determine the spatial distribution of cattle herds in the area which was expressed as Observed Mean Distance Ratio to the Expected Mean Distance (EMD). The EMD was the average distance between neighbors in a hypothetical random distribution. For index less than 1, the exhibited pattern was referred as clustered, and for index greater than 1, the trend was termed dispersion or competition (Krivoruchko and Krause 2012).

RESULTS AND DISCUSSION

A total of 4,248 cattle in 3 locations of Ilesha Baruba district were investigated (Figure 1 and 2). Fifteen outbreaks were recorded, in which 842 cattle were clinically affected with a morbidity rate of 19.82% (Table 1). The occurrence of FMD outbreaks found in our study was similar to the previous report of Olabode et al. (2013). In our study, the geo-spatial analysis revealed the location of towns, forests, roads and river networks, as scene features on overlay and spot imagery maps of the study areas (Figure 3), which were highlighted as possible features that enhanced viral spread leading to high disease morbidity.

Screening of FMD done by FMD 3ABC ELISA showed that 37.5% males (bulls; n=24/64) and 62.5% females (cows; n=40/64) were positive to FMD (Table 2). Serotyping study by SP-cELISA revealed that 83% (n=53/64) and 7.8% (n=5/64) viruses were of serotype O, and A, respectively. On the other hand, 4.7% (n=3/64) were combined O-A, 1.6% (n=1/64) for combined O-SAT2, 1.6% (n=1/64) for Vaccine O, and 1.6% (n=1/64) for Vaccine SAT2, respectively (Table 1).

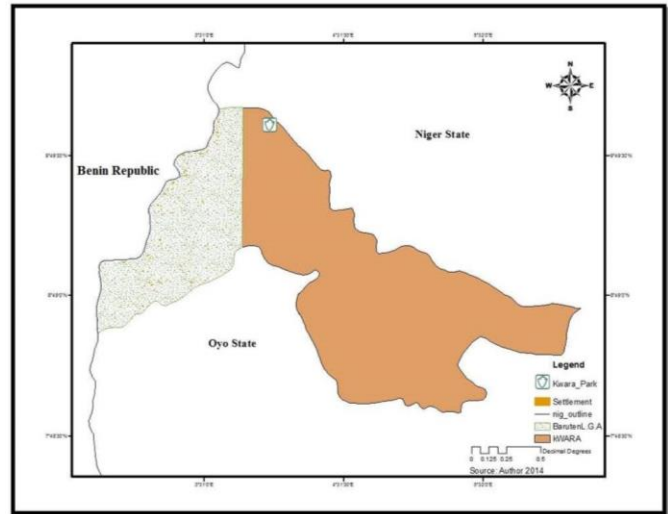


Figure 1: Showing the map of the study area.

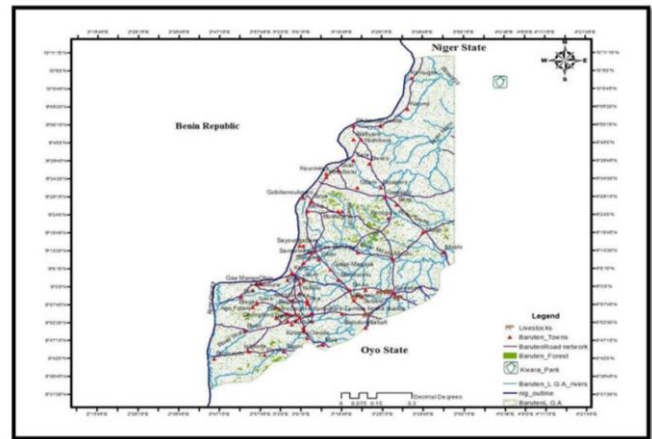


Figure 2: Showing roads, rivers and towns inter-connectivity in the study area.

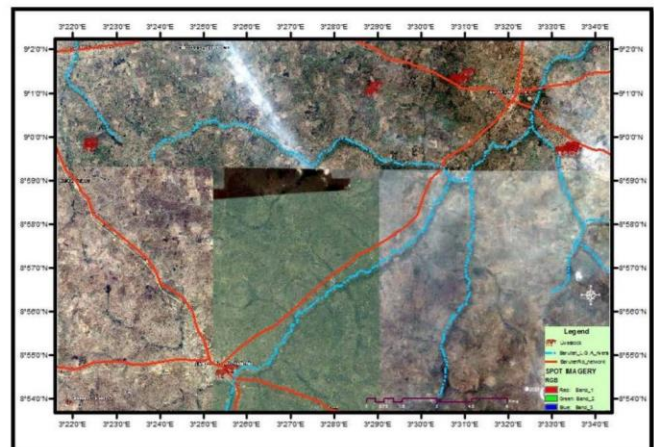


Figure 3: Spot imagery map showing scene features of the study area.

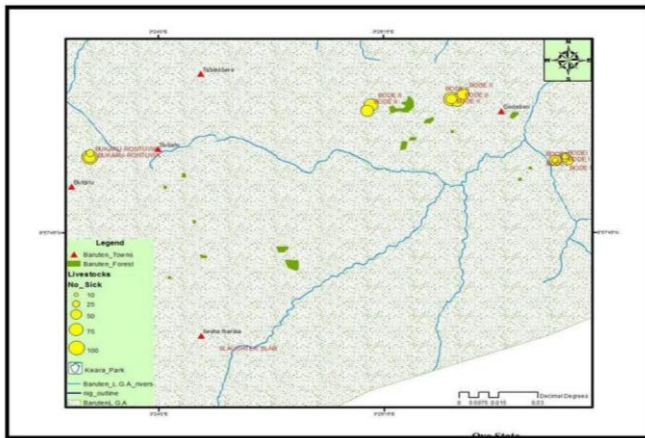


Figure 4: Showing graded quantity of FMD infected cattle in the study area.

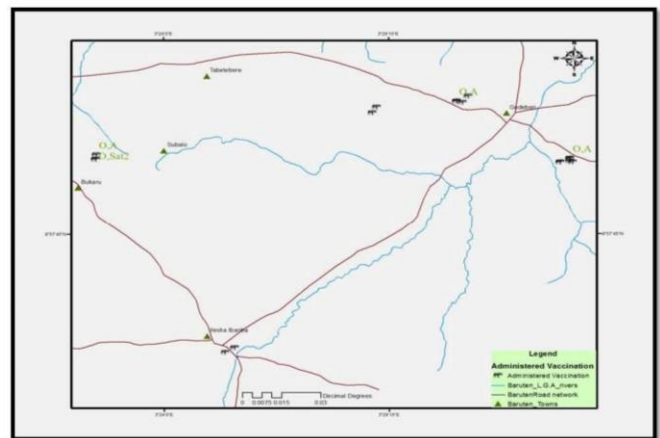


Figure 5: Showing FMD serotype outbreaks distribution in the study area.

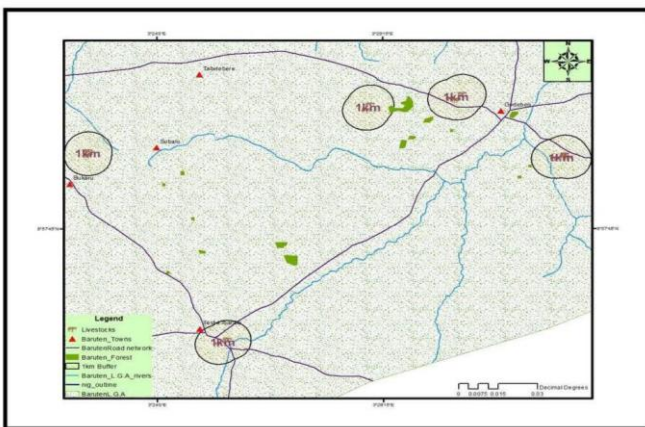


Figure 6: Showing geographic features in 1 km buffer zone with the outbreak locations.

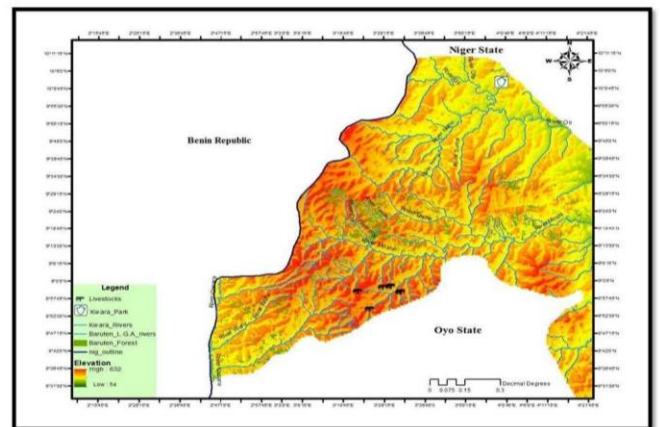


Figure 7: Showing hill shade elevation of FMD outbreak locations in the study area.

Distribution of infected cattle in each outbreak showed that O and A serotypes were mostly prevalent in Bode and Gbedeberru wards (**Figure 4**), which might be due to high viral contamination of neighboring water bodies, as the cattle grazed on river Moshi bordered by Baruten forest. On the other hand, O, A, and SAT2 were detected in Bukaru-rontuwa ward (**Table 1** and **Figure 5**). The occurrence of SAT2 could be associated with un-controlled introduction of new cattle into the herd by cross movements between herds and markets (Olabode et al., 2014b).

Outbreaks in vaccinated herds could be associated with divergently evolution of the serotypes causing antigenic variation and high variability of FMD viral genome (Longjam and Tayo, 2011). However, correlation between FMD serotypes and severity of infection was not studied.

Cattle locations in 500 m buffer zones (**Figure 6**) in and around the Ilesha market, slaughter slab as well as Bode I and II in Gbedeberru wards showed closer proximity to the access road coming from Bukaru to Ilesha and that which linked Tabetebere to Gbedeberru. The cattle camp in Bukaru-rontuwa ward was over 1 km to the main road from Kosubosu (LGA headquarters) in Yashikira district through Gidan Magajjia to Ilesha baruba which ultimately linked to Ilorin. This network of roads could easily facilitate spreading of FMD outbreaks. Furthermore, 1 km buffer zones confirmed river networks as potential facilitators of viral spread in addition to the clustered (NNI Ratio=0.095054) nature of the herds and outbreaks as illustrated by Nearest Neighborhood Index Ratio.

Table 1: Bovine FMD sero-positive reactors diagnosed and serotyped in Ilesha Baruba outbreaks using Solid-Phase (SP)-cELISA

Outbreak ID	Location/Ward	Herd size	No. affected	Positive (n/6)**	Serotype O	Serotype A	Vaccine O	Vaccine SAT	Combined serotype
2*	Bode I	380	60	5	5	-	-	-	-
3		78	22	5	5	-	-	-	-
8		200	40	5	5	-	-	-	-
13		200	20	4	2	-	-	1	1 (O, A) ^a
14*		380	20	6	2	3	1	-	-
15		280	50	5	4	1	-	-	-
1*	Bode II	300	50	4	3	-	-	-	1 (O, A) ^a
4		220	80	4	4	-	-	-	-
5*		300	100	3	3	-	-	-	-
6		260	60	4	4	-	-	-	-
9		250	70	3	3	-	-	-	-
10		350	80	3	3	-	-	-	-
7*	Bukaru-rontuwa	450	100	4	3	1	-	-	-
11		150	30	4	3	-	-	-	1 (O, A) ^a
12*		450	60	5	4	-	-	-	1 (O, SAT2) ^b
Total		4,248	842	64/90	53/64	5/64	1/64	1/64	3+1/64
%					83%	7.8%	1.6%	1.6%	^a4.7% + ^b1.6%

*Repeated outbreaks; ^aCombined outbreak of O and A; ^bCombined outbreak of O and SAT2.

**Six (6) samples were randomly collected from each FMD suspected herd.

Table 2: Sex-based bovine sero-positive reactors diagnosed in FMD outbreaks in Ilesha Baruba using SP-cELISA and 3ABC-ELISA

Sex	No. Positive	No. Negative	Total	%
Male	24 (37.5%)	13	37	64.9
Female	40 (62.5%)	13	53	75.5
Total	64 (100%)	26	90	71.11

X²= 53.0 df=1 (*p*<0.05)

The use of common animal health personnel, who moved between farms by wearing same clothes and used same equipment without disinfection, could be associated with observed disease spread (Olabode et al., 2014b). The terrain height of cattle herd in relation to water bodies and Kwara National Park using elevation data of the area from Shuttle Radar Topographic Mission Satellite (SRTM) of 90 m (Figure 7) showed that the outbreaks occurred on higher lands might be due to cattle concentration, availability of water and pasture. However, this could facilitate spreading and transportation of disease virus from infected herds through contaminated flowing rivers to lower elevations downstream, which increased susceptibility of livestock and wild animals in and around the National Park.

The wind could also play a role in the spread of viral aerosol produced by infected cattle within and between the highlands to lowlands, as previously reported by Lubroth (2002), indicating the capacity of wind to carry FMD aerosol droplets over a distance of 60 km. Cattle are easily infected by aerosol virus generated by other

animals. The cattle could be infected with as little as 20 TCID₅₀ (tissues culture infective dose) of virus (Kitching, 2002).

The weak disease reporting system particularly by the clients, livestock superintendents, veterinarians, lack of biosecurity, self-medication by the owners, and unapproved ethno-veterinary practice were subjecting the cattle at FMD risk (Olabode et al., 2014b). Also, absence of continuous database monitoring system could facilitate the spread of FMD among the cattle in this region.

CONCLUSIONS

This study provides a preliminary report on the use of GIS in elucidation of FMD occurrence and distribution. National sero-surveillance program aided by GIS could be conducted to facilitate further understanding of FMD occurrence and distribution in Nigeria. Biosecurity awareness campaign among herd owners and relevant stakeholders on the role of FMD virus dissemination, and control methods are also suggested.

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