Spatial and temporal distribution of foot-and-mouth disease virus in the lake zone of Tanzania

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This study was conducted to determine the spatiotemporal distribution of foot-and-mouth disease (FMD) virus (FMDV) serotypes and evaluate the awareness of livestock keepers about FMD in Tanzania. An observational prospective study involving serological analysis, FMDV antigen detection and questionnaire survey was carried out in the lake zone of Tanzania. Seroprevalence of antibodies to the nonstructural protein 3ABC of FMDV and serotype-specific antigen detection were investigated by using SVANOVIR® FMDV 3ABC-Ab ELISA and indirect-sandwich ELISA (sELISA), respectively, whilst a structured questionnaire was used to evaluate the awareness of livestock keepers about FMD. During the period of 2010–2011, both serum and tissue (foot-and-mouth epithelia) samples were collected from cattle suspected of FMD in 13 districts of the four regions of the lake zone. A total of 107 (80.5%) out of 133 tested serum samples were seropositive to nonstructural protein 3ABC, with at least one sample being positive from all 10 districts screened. Fifteen (53.6%) out of 28 tissue epithelial samples collected from FMD cases in eight districts during the course of this study were positive to serotype O FMDV antigen. Of these eight districts, serotype O FMDV antigens were detected from seven districts and no other serotypes were recovered from animal samples screened. Questionnaire surveys in six districts indicated that livestock keepers in the lake zone were aware of the clinical manifestations (26/29 = 90.0%) and economic impact (23/29 = 79.0%) of FMD in the region. The questionnaire data showed that FMD outbreaks often occurred after rainy seasons (22/29 = 75.9%), with the highest peaks predominantly occurring just after the long rains in May and June, and at the end of the short rains in November and December of each year. The spatial distribution of the FMD cases suggested that serotype O virus exposure was the only widespread cause of the 2010–2011 outbreaks in the lake zone.

Introduction

Foot-and-mouth disease (FMD) is a highly contagious, vesicular disease of cloven-hoofed animal species (Habiela *et al.* 2010). It is caused by the foot-and-mouth disease virus (FMDV) of the genus *Aphthovirus* and the family Picornaviridae (Carrillo *et al.* 2005; OIE 2009). There are seven distinct serotypes, namely: O, A, C, South African Territories (SAT) 1, SAT 2, SAT 3, and Asia 1 (APHIS 2007; OIE 2009; Paton *et al.* 2009).

Since FMD was first reported in Tanzania in 1927 (Tanganyika Department of Veterinary Services 1927; Chibunda *et al.* 2006), efforts to eradicate this economically important disease have not been fruitful, as there are still several FMD outbreaks (long-standing endemic or periodic epidemics) being encountered. The occurrence and geographical distribution of FMDV serotypes is not clearly known and this remains to be fully explored.

This study was conducted in order to determine the current spatial and temporal distribution of the FMDV serotypes, to evaluate the awareness of livestock keepers about FMD and its socio-economic impact in the lake zone of Tanzania.

Materials and methods

Sample collection and methodology

An observational, prospective study involving serological analysis, FMDV antigen detection and questionnaire survey was carried out. Serum and epithelial tissue samples were collected from cattle suspected of FMD in 13 districts during the period of 2010–2011.

Seroprevalence of antibodies to the nonstructural protein 3ABC of FMDV were investigated by using SVANOVIR® FMDV 3ABC-Ab ELISA (Svanova Biotech AB, Sweden) and developed in collaboration with CEVAN (Centro Virologia Animal), (COREPRO Buenos Aires, Argentina). Serotype-specific antigen detection was investigated by indirect-sandwich ELISA (sELISA) supplied by the Institute for Animal Health (Pirbright Laboratory, UK); the procedure was as described by Roeder and Le Blanc Smith (1987) and Ferris and Dawson (1988).

Structured questionnaires were used to evaluate the awareness of livestock keepers about FMD and its socio-economic impact.

Data analysis

Descriptive statistics for laboratory data of both sELISA and non-structural protein 3ABC ELISA were used and frequency distributions were calculated (Thrusfield & Bertola 2005). Prevalence of positive animals was determined by dividing the number of positive serum samples by the total number of samples tested. For questionnaires, data were coded in such a way that variables (species affected, clinical signs, season and economic impacts) represented 1 and 0 for positive and negative awareness, respectively. All data were analysed with the Microsoft Excel® software (Microsoft, USA).

Results

A total of 107 (80.5%) out of 133 tested serum samples from cattle were seropositive to nonstructural protein 3ABC, with at least one sample being positive from all 10 districts screened (Table 1).

Fifteen (53.6%) out of 28 tissue epithelial samples collected from FMD cases in eight districts during the course of this study were positive to serotype O FMDV antigen. Of these eight districts, serotype O FMDV antigens were detected in seven districts and no other serotypes were recovered from animal samples screened (Table 2).

The questionnaire surveys in six districts indicated that livestock keepers in the lake zone were aware of the clinical manifestations 26/29 (90%) and economic impact 23/29 (79%) of FMD (Table 3).

TABLE 1: Overall positive sera for 3ABC-FMDV antibodies per district of lake zone.

District	Sample positive (*n*)	Sample tested (*N*)	Positive (%)
Bariadi	13	15	86.7
Ilemela	1	4	25.0
Kwimba	12	13	92.3
Maswa	4	5	80.0
Musoma	7	7	100
Misungwi	24	27	88.9
Ngara	12	19	63.2
Rorya	11	13	84.6
Serengeti	16	17	94.1
Shinyanga	7	13	53.8
Grand Total	**107**	**133**	**80.5**

TABLE 2: Foot-and-mouth disease virus antigen detection using sELISA on 28 clinical samples.

District	Sample tested (*N*)	Sample positive (*n*)	Positive (%)	Serotype
Ngara	2	0	0	Negative
Misungwi	10	2	20	Type O
Musoma	2	2	100	Type O
Serengeti	5	3	60	Type O
Rorya	2	2	100	Type O
Misenyi	3	3	100	Type O
Muleba	2	2	100	Type O
Kahama	2	1	50	Type O
Total	**28**	**15**	**53.6**	**Type O**

The questionnaire data showed that FMD outbreaks often occurred after rainy seasons 22/29 (75.9%), with the highest peaks predominantly occurring just after the long rains (*masika*) in May and June, and at the end of the short rains (*vuli*) in November and December (Figure 1).

Discussion

The study shows that FMD is endemic and widely spread throughout all four regions of the lake zone of Tanzania (Table 1 and Figure 2). The disease is of high economic importance, especially to countries that have an intensive animal industry (Mwiine *et al.* 2010).

TABLE 3: Farmers' awareness about foot-and-mouth disease and its economic impacts.

Awareness criteria	Number of respondents (*n*)	Number of respondents (*N*)	Respondents' (%)
Foot-and-mouth disease awareness	26	29	90
Species affected	26	29	90
Clinical signs	26	29	90
Morbidity	21	29	72
Mortality	10	29	35
Economic impact	23	29	79

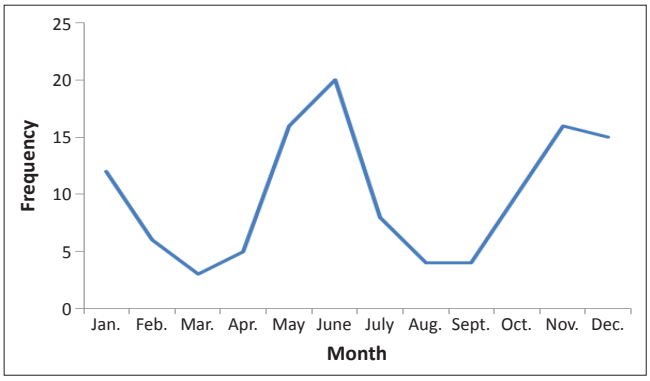

FIGURE 1: Temporal trends of foot-and-mouth disease outbreaks and its respective frequencies as scored by the respondents.

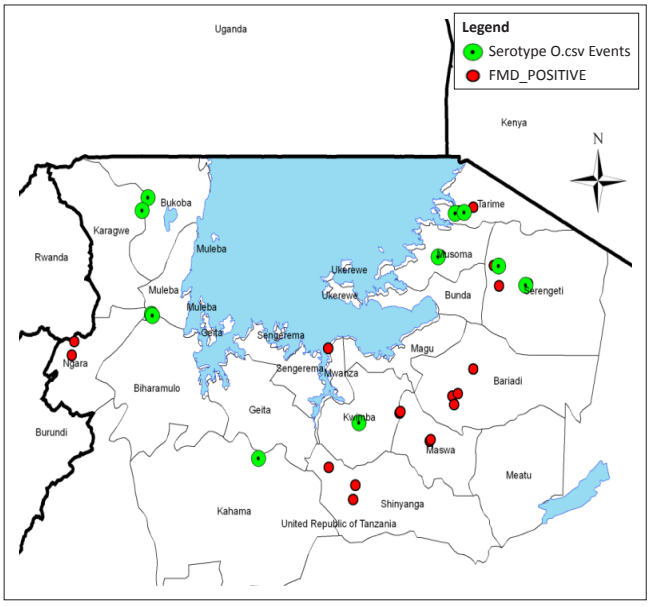

FIGURE 2: Spatial distribution of foot-and-mouth disease and its serotypes in the lake zone of Tanzania.

The questionnaire survey indicates that the group of livestock keepers was aware of the disease. They also described most of the clinical presentations of the disease very well; most of the signs listed for FMD 26/29 (90%), such as mouth and foot lesions, hypersalivation, anorexia and lameness, were consistent with what has been described by other researchers (Radostits *et al.* 1994; Jullu 2004; Tesfaye 2006; CFSPH 2007; Swai *et al.* 2009).

The findings of this study indicate a high correlation between livestock keepers' awareness of FMD and the serological diagnosis of FMDV infection by NSP 3ABC-Ab ELISA. These results also conform to the positive results obtained by sELISA test, which indicates 53.6% to be positive for FMDV serotype O in seven districts (Table 2).

This observation indicates a correlation between the laboratory results and the findings of the questionnaire survey about the awareness of livestock keepers on the clinical manifestation of FMD under the field conditions.

Seasonal incidence of FMD was found to be high at the end of the long rainy season (May and June) and also at the end of short rainy season (*vuli*) (November and December), as shown in Figure 1. The lowest incidence of FMD outbreak was reported during the long rainy season (*masika*) (March and April) and during August and September (Figure 1). The reasons for this observation could be ascribed to movement of animals searching for pastures and water. Many herds of cattle meet at such places, thereby hastening the spread of infection from one herd to another.

The FMD study on NSP 3ABC antibody detection revealed evidence of infection, and that spatial distribution of the disease in the lake zone was 80.5% (Table 1).

The study using sELISA revealed that the spatial distributions of FMD outbreaks in the year 2010–2011 in the lake zone were caused mainly by serotype O virus (Figure 2). These findings are in agreement with Rweyemamu *et al.* (2008), who reported that serotype O was the most widely prevalent serotype in most parts of the world, including Tanzania.

In this study, the detection of serotype O virus antigens in all four regions of the lake zone, which was reported to be negative by Swai *et al.* (2009) and Jullu (2004) in this zone, depicts the possibility of re-introduction of serotype O. This may be the cause of the acute epidemic (sporadic) outbreaks of FMD in almost all the districts of the lake zone. The reintroduction of type O virus could be due to loose and free border movement of animals (livestock and wildlife) to and from neighbouring countries, such as Kenya and Uganda in Eastern Africa. Furthermore, the spread of serotype O virus within the districts of the lake zone could be associated with movement of animals from one district or region to another during trade and marketing. It could also be associated with the long-distance grazing movements practiced by agro-pastoralists with large herds of cattle searching of pastures and water.

This study provides evidence that the presence of FMD is an endemic situation in almost all the districts and regions of the lake zone. Serotype O has been detected as the most, and probably the only, prevailing serotype in the lake zone of Tanzania during the 2010–2011 outbreaks.

Serotype O virus has not been detected in the lake zone for years; the research conducted by Jullu (2004), by using both sELISA and real time polymerase chain reaction (RT-PCR), reported only serotype SAT 1 in Musoma urban and SAT2 in Musoma Urban and Tarime from samples collected in 1999. Samples collected in 2003 in Ukerewe and Mwanza city detected serotypes SAT 2. Jullu (2004) used the same protocol and kit for sELISA as was used in the current study. However, serotype O was detected in the Northern Zone (Arusha), Eastern zone (Dar es Salaam) and Southern Highland (Iringa and Mbeya) from samples collected for the period 1997–2003 (Jullu 2004).

Swai *et al.* (2009) detected only serotypes SAT 1 and SAT 2 in the lake zone from samples collected between 1997 and 2004. Recently, findings by Kasanga *et al.* (2011) could not detect the presence of serotype O in the lake zone from the samples collected from 1967–2009.

The detection of only serotype O virus in samples collected in the lake zone during 2010 and 2011, which was not detected by other researchers (Jullu 2004; Swai *et al.* 2009; Kasanga *et al.* 2011), provides a great challenge to the routine disease surveillance.

The recent occurrence of epidemic (sporadic) outbreaks with the classical clinical signs signifies the naive immunity status of the animals. This situation can be probably due to introduction of either the new strain of serotype O virus or reintroduction of serotype O virus with variant pathogenicity, which was not present some years back. With regard to the location of the lake zone and the widespread finding of the FMDV serotype O in all four regions, the probability of the infection is either from the vaccines or from the neighbouring countries. This is because some farmers, especially from the Kagera region, do vaccinate their animals by using FMD polyvalent vaccine from Kenya; the rest of the zone has no recent history of FMD vaccination.

The current study highlights the FMDV serotype (serotype O) prevalence in the lake zone and also the extent of spatial distribution of FMD in this zone. This is an important step, as the information detailed in this study is useful in vaccine matching and selection of vaccine candidate strains for the region. This will help in the recommendation for an appropriate approach and proper control programme of FMD in Tanzania.

Conclusion

The spatial distribution of the FMD cases suggests that serotype O virus exposure was the only widespread cause

of the 2010–2011 outbreaks in the lake zone of Tanzania. The temporal occurrence of FMD has been noted after rainy seasons, with the highest peaks predominantly encountered just after long rains and at the end of the short rains.

The observed agreement between the livestock keepers in the current study and previous veterinary literature regarding most of the exhibited signs of important cattle diseases has proven that in the lake zone, livestock keepers have great knowledge about FMD. This is especially regarding disease outbreak, period of occurrence, diagnosis of the disease and its economic impacts.

The research indicates that the disease is endemic in the lake zone. It suggests that extensive and regular sero-surveillance, virus isolation and characterisations of the field FMDV isolates need to be conducted for the possible development of a relevant vaccine from the local circulating field serotype or strains.

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Competing interests

The authors declare that they have no financial or personal relationship(s) that may have inappropriately influenced them in writing this article.

Authors' contributions

J.M.G. (Tanzania Veterinary Laboratory Agency –Mwanza) was the research project leader. C.J.K. (Sokoine University of Agriculture) was the research project supervisor.

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