Foot and mouth disease in Zambia: 
a review of the aetiology and epidemiology and recommendations for possible control

P. Chilonda (1), J.D. Woodford (2), B. Ahmadu (1), K.L. Samui (1), M. Syakalima (1) & J.E.D. Mlangwa (1)

(1) University of Zambia, School of Veterinary Medicine, Department of Disease Control, P.O. Box 32379, Lusaka, Zambia
(2) Southern Africa Animal Disease Control Programme (Zambia), Department of Animal Production and Health, P.O. Box 50060, Lusaka, Zambia

Submitted for publication: 12 February 1999
Accepted for publication: 12 July 1999

Summary
In Zambia, foot and mouth disease (FMD) has been caused by all three of the South African Territories serotypes (SAT 1, 2 and 3) and by European types O and A. Three areas of the country which have experienced repeated occurrences of the disease are considered high-risk areas. The three areas are as follows: the southern border area between Zambia and Zimbabwe, Botswana and Namibia, the Kafue Flats and the northern border with Tanzania in the Nakonde and Mbala districts.

The transfer mechanism of the virus is poorly understood but the African buffalo (Syncerus caffer) is considered to be the natural host, acting as a reservoir of infection for the SAT types of the virus. Cattle are known to be carriers of the virus for up to two and a half years and individual semi-domesticated buffalo have been reported to act as carriers for up to five years. In wild herds of buffalo, the virus has been recorded for periods of up to twenty-five years.

Current control measures include mass vaccination of cattle in high-risk areas and restrictions on the movement of cattle from areas in which contact exists with buffalo. New protocols should be developed for the prevention and control of FMD, including the enforcement of livestock movement control, improved disease surveillance and reporting, and the monitoring of FMD virus in carrier cattle and buffalo. These measures will contribute towards building the confidence of the regulatory bodies of importing countries in the region.

Keywords

Introduction
Zambia has experienced outbreaks of foot and mouth disease (FMD) of varying magnitudes since the disease was first reported in 1933 (23, 24). The disease has been caused by all of the three South African Territories serotypes (SAT 1, 2 and 3) and the European serotypes O and A. Primary outbreaks of FMD have been shown to be spread from clinically affected and 'carrier' cattle or buffalo to susceptible cattle through contact. Cattle can remain carriers for up to two and a half years and individual semi-domesticated African buffalo (Syncerus caffer) have been reported to maintain carrier status for up to five years without showing any clinical sign of infection (17). In wild herds of buffalo, the virus has been recorded for up to 25 years and evidence suggests that the virus has persisted in some herds for over 80 years (12).
This paper reviews developments in the aetiology and epidemiology of FMD in relation to prevention and control strategies for the disease in Zambia. The increasing economic importance of FMD in Zambia is stressed since this disease denies cattle producers in Zambia access not only to the lucrative beef export markets of the United States of America, Canada, Japan, the Far East and Europe, but also to certain regional markets, in particular South Africa, which in 1994 imported in excess of 123,000 tons of beef (unpublished report, Central Statistics Office, Lusaka, 1996).

Aetiology

Five FMD virus (FMDV) serotypes, SAT 1, SAT 2, SAT 3 and types A and O, have been isolated in Zambia (15, 24). Type O has been detected on two occasions, in 1976 and 1982, following outbreaks on the northern border with Tanzania. The source of these outbreaks was attributed to a southward extension of a primary focus of infection in the Rukwa Plains in Tanzania which was a result of illegal cattle movements (7). Type A FMDV was first isolated in Zambia in 1990 in the same region and under similar circumstances (4).

All three SAT serotypes of FMD have been isolated from carrier African buffalo in Zambia (16). However, until very recently, the SAT 3 serotypes had not been recorded in cattle in Zambia. In November 1994, following reports of an outbreak of FMD in the Caprivi Strip in Namibia, a suspected outbreak of the disease was reported in the same vicinity on the north bank of the Zambezi River. Although more than 2,500 head of cattle were examined for mouth lesions, no typical FMD lesions were detected (15). During a follow-up mission to monitor vaccination activities, a number of cattle with typical mouth and interdigital lesions were observed some distance from the primary focus. Attempts to send viable viral samples for typing failed. Since the serotype which caused the outbreak in Namibia was confirmed as SAT 3 (22), the outbreak in Zambia was suspected to be also caused by this serotype, in view of the frequent illegal movements of cattle across the border at that time of the year. In June 1995, a new outbreak of FMD was reported on the northern bank of the Zambezi river near Kazungula, Southern Province. The clinical appearance of the disease was very mild, but the outbreak spread westwards, beyond Sesheke, Western Province, before adequate control measures could be mobilised. Virus samples were submitted to the Central Veterinary Research Institute in Balmoral, and the SAT 3 FMDV serotype was detected using an antigen trapping enzyme-linked immunosorbent assay (ELISA) (25).

Epidemiology

For many years, the role of carrier cattle and carrier buffalo in the transmission of FMD to susceptible cattle has been the subject of controversy. Measures to control FMD in countries which have gained access to lucrative export markets include the following:

- the elimination of wild African buffalo from commercial cattle production areas
- fencing-off land to separate cattle from buffalo
- restriction on the movement of people and cattle in areas where buffalo exist
- vaccination of large numbers of cattle adjacent to wildlife conservation areas.

These measures have been justified on economic grounds. Greater understanding of the mechanism of transmission and the relative risk of transmission from carrier cattle and carrier buffalo would help to determine which of the above can be justified on epidemiological grounds. Furthermore, wild buffalo are a valuable component of some commercial enterprises and the total exclusion of buffalo from more easily accessible cattle production areas represents a financial loss to many game ranchers. The interests of all stakeholders should be considered in the development of a strategy for the control of FMD, to avoid unnecessary restrictions being imposed on rural communities living in areas adjacent to wildlife reserves (28).

Field evidence has shown that the transmission of the virus from adult carrier buffalo to calves occurs as the maternally-derived passive immunity wanes (10), although an attempt to reproduce this finding experimentally failed (5). Furthermore, FMDV has been shown to be maintained in isolated herds of wild African buffalo for as long as twenty-five years (11) and perhaps up to eighty years (12). This evidence indicates that the African buffalo is a natural host of the SAT types of FMDV and can act as a source of infection to cattle, under certain, as yet undefined, conditions. However, under both natural and experimental conditions, the transmission of FMD from carrier buffalo to cattle has to be regarded as a rare event.

Numerous attempts to achieve transmission of FMD from carrier buffalo to susceptible cattle under experimental conditions have been inconclusive (1, 3, 9). Hedger and Condy succeeded in achieving transmission from carrier buffalo to susceptible cattle that had previously been maintained in close contact (18). More recently, a successful experiment to demonstrate FMD transmission from buffalo to susceptible cattle was recorded in Zimbabwe (12). Interestingly, whilst the buffalo were in the acute stage of infection during the height of the dry season, no transmission to the susceptible contact cattle occurred even though a large amount of virus was being excreted at that time. Five months later, during the rainy season, when probang samples yielded only small amounts of virus, transmission did occur. The authors suggested that unknown factors affecting the susceptibility of the cattle, the virulence of the virus or the survival of the virus between the hosts could have favoured the transmission of the virus at that particular time.
Natural transmission from carrier buffalo to vaccinated cattle was observed in the Rifa River district on the eastern shore of Lake Kariba, in Zimbabwe (13). It was suggested that transmission from adult carrier buffalo to the vaccinated cattle might have occurred indirectly through contact with infected buffalo calves with waning maternal antibody titres, in the vicinity of a common watering point. However, it is difficult to explain why vaccinated cattle were affected and why cattle from two other herds in the same region which had been maintained for five years as sentinel herds for trypanosomosis control, had not succumbed to any previous outbreak of FMD. Furthermore, approximately 600,000 head of cattle which are vaccinated biannually live in areas adjacent to wildlife conservation areas where contact with buffalo occurs regularly and yet where no outbreaks of FMD have been recorded to date.

Nucleotide sequencing of a portion of the genome from the virus, collected during the Rifa River outbreak, revealed a 20% difference between the virus isolated from the field outbreak and the vaccine strain used to protect the sentinel cattle (13). This finding demonstrates the importance of continuous monitoring of field strains of the virus as a routine control measure in areas where vaccination is used as a means of preventing the spread of FMD from carrier buffalo to cattle which may come into close contact with the buffalo. Phylogenetic analysis of the FMDV using RNA nucleotide and deduced amino acid sequencing techniques has become a useful tool in the study of molecular epizootiology. On this basis, dendrograms have been generated which demonstrate distinct patterns of geographical clustering of FMDV strains. Differences in the patterns of geographical clustering of the three SAT serotypes of FMDV may result from the differing behaviour of these serotypes in cattle. The SAT 1 and SAT 3 types appear to be less easily transmitted from carrier buffalo to cattle as compared to SAT 2 serotypes. Furthermore, outbreaks of SAT 1 and SAT 3 types do not generally spread very extensively and perhaps do not establish long-term carrier status in cattle. In contrast, outbreaks of SAT 2 in cattle tend to spread more widely and probably initiate a longer-term carrier status in cattle (20).

The duration of the carrier status is apparently both species- and strain-dependent. Condy was able to collect virus from probang samples for up to two and a half years post infection in carrier cattle and up to five years post infection in carrier buffalo (8, 11). Anderson et al. demonstrated that only a few sheep and goats established the carrier status in an endemic area of Kenya, and then only for a period of up to nine months (2). In a review of the immunological status of FMD carrier cattle, Salt suggested that viral persistence in the carrier animal was most likely due to a failure, of as yet unidentified specific or non-specific elements of the cellular immune response, to eliminate cells infected with FMDV (27). More detailed knowledge of the cellular response in infected tissues and local lymphoid tissue is required. Cattle could maintain carrier status for periods much longer than has been previously demonstrated using virus isolation from probang samples. This could be of significance in choosing appropriate control measures. Probang samples have revealed FMDV RNA fragments when infectious virus can no longer be isolated (26). Whether this finding is an indication that infective virus is still present, is not known. Examination of the duration of the carrier status in cattle and the role of carrier animals in the epidemiology of FMD in the field is the subject of current investigations in Zimbabwe. The distribution of FMD outbreaks in Zambia is well documented (6, 23, 24). Three high risk areas have been identified where FMD has occurred repeatedly: the southern border from Livingstone westwards to a point beyond Sesheke where the border with Angola turns to the north-west; the Kafue Flats and the northern border with Tanzania between Nakonde and Mbala (Fig. 1) (21). Most of the outbreaks recorded in the Kafue Flats over the past fifty years (9 out of 13), have occurred during the dry season, when in excess of 200,000 transhumant and resident cattle populations congregate on the Flats to take advantage of an extended grazing season as the floods recede. From April to September, the herds of wild buffalo of the Kafue and Blue Lagoon National Parks also migrate in search of better grazing. The recurrent outbreaks of FMD in this region are believed to have been due either to close contact between the large concentrations of cattle and/or migratory wild buffalo. Cattle density may be an important factor in determining the risk of outbreaks occurring as a result of carrier cattle mixing with susceptible cattle (19). Since 1990, a gradual reduction has occurred in the numbers of cattle grazed on the Kafue Flats as a result of the effects of drought and outbreaks of East Coast Fever/corridor disease which were first reported in 1978. The traditional sector cattle population in Southern Province reached a peak of roughly 919,000 in 1987 and declined to approximately 662,000 by 1993 (the last year for which data was taken) (4). Thus, the decline in cattle numbers coupled with heavy poaching pressure on the edges of the Kafue National Park and the Blue Lagoon National Park may have resulted in a reduction in the frequency of contact between cattle and buffalo in the Kafue Flats. The last outbreak of FMD (SAT 2) in that area occurred in 1987/1988.

Control

The following factors should be considered in the development of a FMD control strategy for Zambia:

a) wild African buffalo will probably continue to act as the long-term reservoir of the SAT types of FMD viruses in sub-Saharan Africa
carrier cattle can act as a reservoir of infection for at least two and a half years, although long-term carrier status with SAT 1 and SAT 3 serotypes may be less likely.

c) to identify suitable strains and mixtures of strains for vaccines, continuous characterisation of field strains is necessary from carrier buffalo in areas where contact with cattle cannot be prevented.

d) three high-risk areas exist in Zambia, and of these, the southern border region probably presents the greatest risk.

At the current level of commercial beef production in Zambia, no economic justification exists for the establishment of a 'disease free and buffer zone' system as has been developed in Zimbabwe and Botswana. In the medium term, Zambia
should focus attention on securing an export market to South Africa, which has far less demanding import requirements than those imposed by the European Union (29).

The following recommendations can be made for the control of FMD in Zambia. These will be further discussed from an economic perspective in a separate paper.

1. Biannual vaccination of most cattle in a 'buffer zone' along the southern border with Zimbabwe, Botswana and Namibia, using trivalent SAT 1, 2 and 3 vaccine. This strategy may have prevented outbreaks in this region from 1983 to 1986 (14). Annual vaccination is advised on the northern border (choice of vaccine should be made with respect to information from Tanzania).

2. Routine pre- and post-vaccination serological surveys to monitor the efficacy of vaccination activities.

3. Evaluation workshops after each routine vaccination campaign and introduction of an incentive scheme for best performance vaccination teams.

4. Establishment of an emergency fund for vaccine procurement and mobilisation of vaccination teams for ring vaccination around confirmed outbreaks.

5. Improved surveillance and reporting of FMD outbreaks through training and extension programmes in the high-risk areas.

6. Continuous surveillance and contact with veterinary authorities in neighbouring countries to learn of FMD outbreaks before official reports become available.

7. Improved control of cross-border cattle movement through more intensive surveillance coupled with the imposition of realistic penalties for offenders.

8. Establishment of adequate border inspection and quarantine facilities at each of the border posts at Kazungula (southern border), Chirundu (eastern border) and Isoka (northern border).

9. Establishment of protocols to ensure that outbreak investigation results in collection and dispatch of viable viral material for characterisation at reference laboratories recognised by the Office International des Epizooties.

10. Regular collection and characterisation of probang samples from buffalo in the border region, Kafue National Park, Lochnivar and other areas where regular contact between cattle and buffalo occurs. Samples should be sent to the Pirbright Reference Laboratory in the United Kingdom or the Onderstepoort Veterinary Institute in South Africa, for molecular characterisation and to the Botswana Vaccine Institute or the Onderstepoort Veterinary Institute for strain comparison tests using the serum neutralisation test or ELISA for vaccine strain matching.

11. Attempts to collect serial probang samples from recovered cattle following all outbreaks of FMD in order to determine the longevity of carrier status for each of the virus types involved.

12. Improved control of livestock movement through individual identification of cattle in transit, stricter adherence to protocols for the issuance of movement permits, improved facilities for legal enforcement of livestock movement control.

13. Imposition of a total ban on the trade of cattle from within the southern border vaccination 'buffer zone' for purposes other than immediate slaughter at designated slaughterhouses. Ban to be maintained for up to two and a half years following an outbreak of FMD.

14. In the long term, an integrated approach to land use planning which gives consideration to the interests of traditional farmers, commercial beef producers and wildlife resource management institutions should be adopted.
Étiologie et épidémiologie de la fièvre aphteuse en Zambie, et recommandations pour son contrôle éventuel

P. Chilonda, J.D. Woodford, B. Ahmadu, K.L. Samui, M. Syakalima & J.E.D. Mlangwa

Résumé
En Zambie, la fièvre aphteuse a été imputée aux trois sérotypes South African Territories (SAT 1, 2 et 3) ainsi qu’aux types européens O et A du virus. La maladie s’est déclarée à plusieurs reprises dans trois régions, considérées comme des zones à haut risque : la région située près de la frontière sud avec le Zimbabwe, le Botswana et la Namibie, les plaines de la Kafue et les districts de Nakonde et de Mbala à la frontière nord avec la Tanzanie.

Le mécanisme de propagation du virus est encore mal connu mais on considère que le buffle africain (Syncerus caffer) est l’hôte naturel et qu’il agit comme un réservoir d’infection pour les types SAT du virus. On sait que les bovins sont porteurs du virus pendant une période qui peut aller jusqu’à deux ans et demi tandis que certains buffles à demi domestiqués sont porteurs pendant près de cinq ans ; dans des troupeaux de buffles sauvages, le virus est présent sur des périodes pouvant aller jusqu’à vingt-cinq ans.

Les mesures de prophylaxie actuelles comprennent la vaccination de masse des bovins dans les zones à haut risque et la restriction des déplacements de bovins provenant des régions où ils peuvent avoir été en contact avec des buffles. De nouveaux protocoles devraient être mis en place pour la prévention et le contrôle de la fièvre aphteuse, dont la mise en œuvre de contrôles pour les déplacements d’animaux, l’amélioration des systèmes de surveillance et de déclaration de la maladie ainsi que le suivi du virus de la fièvre aphteuse chez les bovins et les buffles porteurs. De telles mesures sont de nature à renforcer la confiance des autorités responsables des pays importateurs de la région.

Mots-clés

Fiebre aftosa en Zambia: resumen de su etiología y epidemiología y recomendaciones para su control

P. Chilonda, J.D. Woodford, B. Ahmadu, K.L. Samui, M. Syakalima & J.E.D. Mlangwa

Resumen
Los distintos brotes de fiebre aftosa registrados en Zambia han sido provocados por los tres serotipos South African Territories (SAT 1, 2 y 3) así como por los dos tipos europeos O y A del virus. Tres zonas del país han sufrido apariciones reiteradas de la enfermedad y han sido catalogadas por ello como zonas de alto riesgo: la zona fronteriza meridional entre Zambia y Zimbabwe, Botsuana y Namibia; la zona de Kafue Flats; y los distritos de Nakonde y Mbala en la zona fronteriza septentrional con Tanzania.

Aunque no se conoce bien el mecanismo de transmisión del virus, se piensa que su huésped natural es el búfalo africano (Syncerus caffer), que ejerce de reservorio de la infección para los tipos SAT del virus. Se sabe que el ganado
vacuno puede ser portador del virus durante un período de hasta dos años y medio. En búfalos semidomésticos este periodo puede alargarse hasta cinco años, y en rebaños de búfalos salvajes los animales llegan a ser portadores del virus durante unos veinticinco años.

Entre las medidas actuales de lucha contra la enfermedad figuran la vacunación en masa del ganado vacuno en zonas de alto riesgo y la restricción de los desplazamientos de animales procedentes de zonas donde puedan estar en contacto con búfalos. Pero es necesario elaborar nuevos protocolos de prevención y lucha contra la fiebre aftosa, con las medidas oportunas para imponer y hacer cumplir el control de movimientos del ganado, mejorar los mecanismos de vigilancia y notificación de la enfermedad y controlar la posible presencia del virus en ganado y búfalos portadores. Este conjunto de medidas servirá además para inspirar confianza a las autoridades encargadas de la reglamentación en los países importadores de la región.

**Palabras clave**


---

**References**


