Overview of foot and mouth disease in southern Africa *

G.R. THOMSON **

Summary: The prevalence of foot and mouth disease (FMD) in the southern African subcontinent between 1931 and 1990 is summarised, together with the major features of the epidemiology and control of the disease. The author emphasises the role of wildlife, especially African buffalo (Syncerus caffer). A proposal is made for a more structured and co-operative approach to investigating the extent and nature of antigenic variation within the Southern African Territories (SAT) types of FMD virus.

Quantification of the economic impact of FMD on the agro-economics of the subcontinent is attempted, and the importance of the social values of rural peoples in this respect is explained.


INTRODUCTION

Foot and mouth disease (FMD) has had a profound effect on the agricultural economies of southern African countries since March 1931, when the disease mysteriously re-appeared in the region after an absence of several decades. For the purpose of this paper, southern Africa includes the following ten countries: Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe (27). With hindsight, it is clear that the disappearance of FMD at about the turn of the century was more apparent than real; a result of the great rinderpest panzootic of 1896-1905 which decimated not only the cattle population but also the major maintenance host of FMD in this region, the African buffalo (Syncerus caffer). As an illustration, early in this century the buffalo population of the Kruger National Park in South Africa numbered less than 100 animals, but thereafter grew almost exponentially until there were more than 30,000 in the 1980s (20). The recovery of the buffalo and cattle populations presumably increased the frequency of contact between these two species, and eventually resulted in the sudden and unexpected re-appearance of FMD on what was then known as Nuanetsi Ranch, in present-day Zimbabwe (24). The re-emergence of FMD in south-eastern Zimbabwe was not surprising, as that part of southern Africa has been more frequently afflicted than any other since 1931 and was, at least until recently, the focus of FMD in the subcontinent (11; S.K. Hargreaves, personal communication, 1994).

* This paper was presented at the Conference on foot and mouth disease, African horse sickness and contagious bovine pleuropneumonia, held in Gaborone (Botswana) from 20 to 23 April 1994.

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In sub-Saharan Africa FMD is unique, not only in having three virus types (Southern African Territories [SAT] 1, 2 and 3) which are almost exclusively endemic to the region, but also in the role which wildlife, particularly buffalo, plays in the epidemiology of the disease. This situation makes the eradication of FMD – which has been achieved both on the North American continent and, more recently (in 1992), in Western Europe (22) – a practical impossibility in this region, unless the mass destruction of buffalo is considered an option. Eradication is being attempted with some success in several regions of South America, which has an enormous cattle population; and it must be presumed that elimination of FMD – at least in large parts of South America – will be achieved in the foreseeable future. Together with the liberalisation of trade in livestock products which is likely to result from the agreements reached at the Uruguay Round of the General Agreement on Tariffs and Trade (GATT; now the World Trade Organisation), this is likely to result in access of South American beef to the largest beef market in the world – the United States of America (USA) – from which it has been excluded for many decades on account of the danger of re-introducing FMD (23). The effect of this development on the international meat market is potentially far-reaching, as the beef market in the USA is the international price leader (23). Eradication of FMD from other parts of the world may also be possible in the long term. Such eventualities would place sub-Saharan Africa, and southern Africa in particular, in a parlous situation. It would be particularly important for southern Africa because this geo-economic region has the most developed and export-oriented agricultural economy in sub-Saharan Africa (27) and the region would then be faced with the position of being one of the few remaining foci of enzootic FMD on earth, with incalculable economic disadvantages.

The uniqueness of the virus types present in southern Africa and their interaction with large buffalo populations form the key to understanding, controlling and, perhaps, eventually eradicating FMD from this region. Further success in limiting the importance of FMD in southern Africa will be largely dependent on progress on this issue. It is fitting here to acknowledge the contribution of two committed researchers – Drs J.B. Condy and R.S. Hedger – to the present level of understanding on the role of wildlife in the epidemiology of FMD in southern Africa. These two men dedicated themselves, often with little recognition, to laying the foundations of knowledge of this problem in Zimbabwe and Botswana.

This paper attempts to put into perspective recent events in the field of FMD in southern Africa, particularly in the context of broad epidemiological features, the role of wildlife, economic impact and disease control. An attempt is made to identify areas where research and development is required, and to make suggestions in that regard.

**IMPORTANT EPIDEMIOLOGICAL FEATURES OF FOOT AND MOUTH DISEASE IN SOUTHERN AFRICA**

**Disease prevalence**

With the exception of Lesotho, FMD has been reported in all southern African countries since 1931. Most outbreaks were recorded in the decade between 1971 and 1980, when as many epizootics occurred as in the preceding two decades together (Table I). However, it is clear that most of the increase in the number of outbreaks in 1971-1980 was due mainly to a higher incidence in only two countries: Angola and, particularly, Mozambique. If these two countries are excluded from consideration in the
Table I

Prevalence of foot and mouth disease (FMD) outbreaks in livestock in southern African countries (1931-1990) *

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Angola</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>12</td>
<td>31</td>
<td>-</td>
</tr>
<tr>
<td>Botswana</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>7</td>
<td>8</td>
<td>-</td>
</tr>
<tr>
<td>Malawi</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>4</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Mozambique</td>
<td>1</td>
<td>-</td>
<td>5</td>
<td>8</td>
<td>36</td>
<td>15</td>
</tr>
<tr>
<td>Malawi</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>8</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>South Africa</td>
<td>6</td>
<td>6</td>
<td>17</td>
<td>9</td>
<td>14</td>
<td>2</td>
</tr>
<tr>
<td>Zambia</td>
<td>5</td>
<td>8</td>
<td>7</td>
<td>4</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>7</td>
<td>5</td>
<td>22</td>
<td>12</td>
<td>19</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>23</td>
<td>27</td>
<td>63</td>
<td>64</td>
<td>127</td>
<td>44</td>
</tr>
</tbody>
</table>

* Swaziland (two FMD outbreaks in 1965 and 1969) and Lesotho (FMD never diagnosed) are excluded from this list due to the low prevalence of FMD.

Sources: 6, 11, 15, 17, 28, 37, 38, 39, 41, 47, 50; Directorate of Animal Health, South Africa, 1987; Bulletin of the Office International des Epizooties.

period 1971-1980, the incidence of FMD was only slightly higher than in the previous two decades. The reason for the increased occurrence in Mozambique and Angola at that time is not certain, but it may be related to the political turmoil, social disruption and subsequent civil wars which followed the independence of these two countries from Portugal in the mid-1970s. There were two major consequences of these events in these two countries, other than the apparent initial increase in FMD prevalence: firstly, data on disease prevalence in rural areas has been difficult to obtain (resulting in inadequate reporting) and, secondly, military action in farming and wildlife areas led to considerable reductions in cattle and game populations. As an example, the cattle population of Maputo Province in Mozambique is currently estimated at only 3,000, a 97% reduction from a figure of 90,000 prior to the conflict (P. Bosman, personal communication, 1994). Hence it is likely that there is little active FMD in Angola and Mozambique at present, purely because there are so few animals.

Elsewhere, improvement in control is the most obvious reason for a decline in the occurrence of the disease after 1980; for example, Botswana last experienced active disease in 1980, while South Africa has had no outbreaks in domestic livestock since 1983, despite a number of epizootics in free-living impala (*Aepyceros melampus*) in the Kruger National Park (43). There is reason to believe that the local manufacture of good-quality vaccines since the late 1970s (Botswana Vaccine Institute) and early 1980s (Onderstepoort Institute for Exotic Diseases) has contributed significantly to this situation.

Spatial distribution

The spatial distribution of localities in southern Africa, other than in Angola and Mozambique, which have historically been associated with FMD outbreaks in domestic livestock is shown in Figure 1. Areas within Angola and Mozambique which historically have experienced FMD outbreaks are not shown in Figure 1 because good data are not available. From Figure 1, the association between areas prone to the occurrence of
Regions of southern Africa which have historically experienced regular outbreaks of foot and mouth disease in cattle, and the approximate distribution of buffalo in the subcontinent

Adapted from Lessard et al. (35)
outbreaks caused by SAT type FMD viruses and the distribution of buffalo is apparent. Conversely, outbreaks with types A and O have tended to occur in regions on the northern borders of a number of countries (Fig. 1) and are often associated with established trade routes (for example, in north-eastern Zambia and northern Malawi, which border Tanzania between Lake Tanganyika and Lake Malawi). Similarly, the northern border area of Namibia has suffered several such outbreaks, which presumably originated in Angola. Types O, A and C were frequently reported in Angola between 1958 and 1978, while type O was diagnosed in Mozambique on at least four occasions between 1974 and 1984. Botswana, South Africa and Zimbabwe have not experienced FMD caused by virus types other than SAT 1, 2 or 3.

Prevalence of FMD virus types and intra-typic variation within SAT type viruses

Of the 350 epizootics in southern Africa reported since 1931 (Table I), approximately 41% have been caused by SAT 2 virus, 25% by SAT 1, 7% by SAT 3, 7% by type A, 6% by type O and 1% by type C, while in 13% of outbreaks the virus involved was untyped (6, 11, 15, 17, 28, 37, 38, 39, 41, 47, 50; Directorate of Animal Health [South Africa], unpublished findings, 1987). The difference in the prevalence of outbreaks caused by the three SAT types is one of the perplexing issues in the epidemiology of FMD in southern Africa.

The development of techniques which enable genome sequencing of ribonucleic acid (RNA) viruses has been exploited in the field of FMD research in recent years to derive precise relationships between groups of viruses where the epidemiological relationships were frequently unknown. By combining field data with information on genetic relationships derived from sequencing, it is now possible to follow the spread of FMD viruses with a high degree of certainty. Thus, for example, we now know that SAT type viruses in southern Africa tend to evolve independently in different geographic locations (47, 48). It has also been shown that the SAT 2 outbreaks which occurred in cattle in Zimbabwe between 1983 and 1989 were caused by viruses which were closely related although the outbreaks were widely separated in time and place (47). Similarly, the apparently distinct outbreaks of FMD in impala in the Kruger National Park in 1988 and 1989 were shown to be caused by the same virus (47). Conversely, however, two SAT 2 outbreaks which occurred within a few weeks of each other in Zimbabwe in 1989 (at Mutorashanga on 27 March, and at Gweru on 4 May), were not directly related.

Water scarcity and FMD outbreaks

It has been suggested (17, 32, 33) and it is widely believed that outbreaks of FMD in southern Africa occur more frequently in periods of water scarcity when both domestic stock and wildlife tend to congregate at water points, i.e. during droughts or the dry winter months which are characteristic of most southern African countries. While this is logical, the facts do not entirely support the contention in regard to outbreaks in domestic livestock. Thus there is no obvious association between the occurrence of FMD in South Africa and the generally dry periods of the quasi eighteen-year oscillation cycle in rainfall described by Tyson (46). On the contrary, Table II shows that more FMD outbreaks have generally occurred in wet periods than in dry. Equally, there is no evidence for seasonal FMD occurrence in livestock in South Africa, Namibia or Zambia (41, 43, 50). In Zimbabwe, where the best records have been kept, fewer outbreaks appear to have started in the driest months of the year (July to October) than in late summer, autumn or early winter (March to June) when water supply is usually less of a problem (Fig. 2). As an exception, however, seven of the eight outbreaks which occurred in Malawi between 1957 and 1975 started in winter (16, 17).
TABLE II

Long-term association between outbreaks of foot and mouth disease (FMD) and rainfall in South Africa

(46)

<table>
<thead>
<tr>
<th>Wet/dry period</th>
<th>Years</th>
<th>No. of FMD outbreaks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet</td>
<td>1933/1934-1943/1944</td>
<td>6</td>
</tr>
<tr>
<td>Dry</td>
<td>1944/1945-1952/1953</td>
<td>8</td>
</tr>
</tbody>
</table>

Role of wildlife

Available evidence leads increasingly to the conclusion that the African buffalo is the only wildlife species which is important in the maintenance of FMD in southern Africa, despite serological data indicating that other ungulate species become infected periodically (3, 12; Onderstepoort Institute for Exotic Diseases, unpublished findings). Even in the Kruger National Park in South Africa, where epizootics of FMD regularly occur in impala, low antibody prevalence rates indicate that FMD viruses are not maintained by impala between epizootics (G.R. Thomson, R.G. Bengis, V.G. Elliott, N.T. Van der Walt, C. de W. Van Vuuren, unpublished findings, 1985-1994), and impala, unlike buffalo and cattle, do not appear to become persistently infected (i.e. carriers) (1, 30). The consensus therefore seems to be that buffalo are the usual source of infection for both wildlife and domestic livestock. Nevertheless, it is well recognised that domestic cattle are efficient maintenance hosts for FMD viruses if effective control is not maintained, and indeed there is good evidence to suggest that the FMD outbreaks caused by SAT 2 in Zimbabwe between 1983 and 1989 were all related and were probably maintained in cattle over that period (47; S.K. Hargreaves, personal communication, 1994; A. Bastos, unpublished findings, 1994).
The circumstances under which FMD virus is transmitted from buffalo to cattle and other species are not accurately understood. Within most buffalo populations, the infection rate with SAT 1, 2 and 3 viruses is high, although there are a few populations, such as those in the Addo Elephant Park and northern KwaZulu/Natal game parks in South Africa, which are free from infection with these viruses (26). In the Kruger National Park, 75% of buffalo have serological evidence of infection with all three serotypes of SAT viruses by the age of one year (N.T. Van der Walt, J.J. Esterhuysen, V.G. Elliott, D.K. Mkwanazi, R.G. Bengis and G.R. Thomson, unpublished findings, 1994). It is possible that a high proportion of young animals in breeding herds are acutely infected at certain periods, resulting in considerable virus production which would provide a potential source of infection for other animals in the vicinity (45). Surprisingly, however, although in some instances acutely-infected buffalo have been found to transmit the infection easily to cattle with which they were in close contact (19, 44), this does not always occur (29, 44, 49).

**Carrier status in buffalo**

Carrier animals, which may make up the majority of the buffalo population (4), may remain persistently infected for periods of five years or more (14) but are rarely (possibly intermittently) able to transmit FMD to cattle. The mechanism of this transmission is unknown, despite considerable efforts to investigate the phenomenon. In a number of instances, SAT type viruses were not transmitted from carrier buffalo to susceptible cattle despite contact periods lasting many months (2, 9, 13, 29). In such circumstances, even transmission between buffalo did not always occur (9). On the other hand, in other experiments and in at least one natural situation, transmission from carrier buffalo to cattle has been proved (18, 19, 31; W. Vosloo, R.G. Bengis, J.J. Esterhuysen and G.R. Thomson, unpublished findings, 1992). The reason(s) for these discrepancies in the results obtained in apparently similar experiments remains to be established.

An important immediate objective with respect to the carrier state must be to elucidate the cells in which FMD viruses persist, and to determine their replication strategy in the pharynx and anterior oesophagus of both buffalo and cattle. The present level of understanding on this issue has recently been reviewed (40).

Since buffalo occupy a central position in the epidemiology of FMD in southern Africa it is certain that the key to improved control of FMD in the subcontinent lies, firstly, in better understanding how the infection is maintained in buffalo populations and, secondly, in devising strategies aimed at eventually ridding buffalo of this infection, which is essentially harmless to them but threatens the agricultural economy of the entire region. Such a project is confronted by serious technical and logistical problems and if any effective progress is to be made this will require the backing of a large team with considerable resources. Clearly, in view of this and the importance of the issue to all countries in the subcontinent, it would make sense for the project to be tackled on a regional basis rather than in a piecemeal manner by small individual research teams.

**ECONOMIC IMPACT**

**Influence of FMD incidence on the economy**

Experience over many years in developed countries has shown that it is impossible to farm economically in the presence of FMD (5). Therefore, countries or economic groupings with advanced agricultural economies have endeavoured either to eradicate
the disease or to limit its effect by instituting effective control such as immunisation and zoo-sanitary measures to limit the effect of the disease and confine it as far as possible to specific geographical localities. Countries or regions which have achieved eradication, as well as those historically free of the disease, implement strict measures to prevent importation or re-importation which limit the access of agricultural products derived from countries in which the disease is enzootic. This has resulted in beef produced in southern Africa being, on the one hand, excluded from the largest market in the world – that of the USA – while on the other having to fulfil a variety of demanding requirements to maintain access to markets within the European Union (EU) (10). This is undoubtedly the most serious economic consequence of the presence of this disease in southern Africa, and an illustration of its impact was the loss to Zimbabwe of Z$200 million in beef exports to the EU following the extensive SAT 2 epizootic in May 1989 (47).

In general, the immediate economic impact of FMD on livestock in southern Africa is limited for a number of reasons. Firstly, the overall incidence of the disease is low in most countries (Table I), presumably as a result of generally efficient control measures. Secondly, the FMD enzootic areas in southern Africa are mostly in regions where either small-scale commercial agriculture or extensive cattle raising are practised (Fig. 1). FMD has its major effect on intensively-farmed, high-producing livestock and so even when it occurs in those regions its direct effect on livestock is usually limited in both duration and effect, although this has not been specifically investigated. Another factor is that southern African countries with more developed agricultural economies (e.g. South Africa and Zimbabwe) are efficient in confining epizootics of FMD to specific control areas, which are generally distant from regions of these countries where intensive farming is practised. Nevertheless, FMD is a serious impediment to the healthy development of agriculture in the subcontinent for two reasons. Firstly, there is the continual threat that FMD virus may escape from control/enzootic areas to herds and flocks in the high-producing areas of the country. Secondly, the continual presence of FMD in wildlife limits access of animal products from southern Africa to international markets, as explained above.

**Influence of FMD on rural communities**

The agricultural economies of countries in southern Africa differ not only in size from those in industrially-developed countries, but also in a number of other respects. Perhaps the most important of these is that a high proportion (sometimes over 80%) of the economically-active population is employed in the agricultural sector, albeit largely in small-scale commercial or subsistence farming (Table III). The implication is that productivity in agriculture is lower than in other sectors of the economy, where productivity is, in any event, far below that of the developed world. As an example, the agricultural sector of the South African economy, which accounts for over 60% of the animal products of the entire subcontinent (Table III), contributed only 5.3% to gross domestic product in 1985 (7), despite employing approximately 14% of the economically-active population. The socio-economic traditions of southern African peoples further exacerbate this problem, as possession of cattle is frequently viewed as an intrinsic measure of wealth (36) and there is, therefore, a disinclination to trade cattle. Thus, for example, the ‘off-take’ of cattle from communal lands in Zimbabwe is only about 3% (25). This leads to overgrazing and degradation of the veld which reduces its carrying capacity.
**TABLE III**

Agro-economic statistics relevant to foot and mouth disease for southern African countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Population (millions)</th>
<th>Population density (b)</th>
<th>GNP (US$ per capita) (b)</th>
<th>% of population employed in agriculture (a)</th>
<th>No. of livestock (× 1,000) (a)</th>
<th>Livestock products (× 1,000 tonnes) (a)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cattle</td>
<td>Sheep and goats</td>
</tr>
<tr>
<td>Angola</td>
<td>10.02</td>
<td>8.0</td>
<td>620</td>
<td>74</td>
<td>3,100</td>
<td>1,260</td>
</tr>
<tr>
<td>Botswana</td>
<td>1.33</td>
<td>2.3</td>
<td>940</td>
<td>43</td>
<td>2,616</td>
<td>2,394</td>
</tr>
<tr>
<td>Lesotho</td>
<td>1.70</td>
<td>56.0</td>
<td>470</td>
<td>86</td>
<td>530</td>
<td>2,940</td>
</tr>
<tr>
<td>Malawi</td>
<td>8.56</td>
<td>72.2</td>
<td>180</td>
<td>82</td>
<td>1,100</td>
<td>1,220</td>
</tr>
<tr>
<td>Mozambique</td>
<td>15.66</td>
<td>19.6</td>
<td>80</td>
<td>84</td>
<td>1,340</td>
<td>507</td>
</tr>
<tr>
<td>Namibia</td>
<td>1.25</td>
<td>1.5</td>
<td>1,173</td>
<td>ND</td>
<td>2,072</td>
<td>9,288</td>
</tr>
<tr>
<td>South Africa</td>
<td>38.00 (b)</td>
<td>31.0</td>
<td>2,460</td>
<td>13.6</td>
<td>11,900</td>
<td>38,467</td>
</tr>
<tr>
<td>Swaziland</td>
<td>0.77</td>
<td>44.2</td>
<td>900</td>
<td>66</td>
<td>662</td>
<td>360</td>
</tr>
<tr>
<td>Zambia</td>
<td>8.07</td>
<td>10.4</td>
<td>390</td>
<td>73</td>
<td>2,861</td>
<td>765</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>9.37</td>
<td>24.0</td>
<td>640</td>
<td>27</td>
<td>6,711</td>
<td>3,421</td>
</tr>
</tbody>
</table>

(a) estimate for 1988-1991: ref. 7  
(b) figure for 1989: ref. 27  
(c) excluding poultry meat  
(d) total wool production: ‘clean’ and ‘greasy’

GNP: gross national product (at market prices)  
ND: no data
The impact of FMD on southern Africa cannot be measured solely in monetary terms, as cattle play a central role in the everyday life of many rural Africans (36). Furthermore, because a high proportion of the population is dependent on small-scale farming, and cattle are one of the most marketable commodities available to the population (despite the basic disinclination to sell cattle, mentioned above), an active cattle market is a necessity to ensure that cash may be raised as and when required. Any widespread disruption of the livestock industry, e.g. by extensive and persistent FMD, would severely affect large numbers of people in rural areas.

**Influence of FMD on beef exports**

Beef exports are important to a number of southern African countries, such as Botswana, Namibia and Zimbabwe, as they generate significant amounts of foreign currency even though their overall contribution to total exports is low. In Botswana, where the contribution made by beef to total national exports is the largest, this contribution is only about 4% (27). Exports of beef from southern Africa mostly take place under the provisions of the Lomé Convention which exempts beef imports to the EU, up to a quota limit, from 90% of import duties (Table IV). Thus, this is in reality part of EU aid rendered to southern Africa since it must be remembered that the EU is the largest net exporter of beef internationally (23). There is no guarantee that the provisions of the Lomé Convention with respect to beef will be continued when the agreement comes up for re-negotiation (at the turn of the century), and some economists believe that by then South Africa will import a much higher proportion of the meat produced in southern Africa than at present (E. Jenovsky, personal communication, 1994).

In total, southern African countries have provision for exporting 44,381 tonnes of beef to the EU under the Lomé Convention (Table IV), although many do not manage to fulfil their quotas at present. The actual prices obtained are unknown, although they are considered 'good' by southern African standards (W. Wessels, personal communication, 1994) and one could estimate them to be as high as US$2,000 per tonne, giving a value of approximately US$90 million per annum (Table IV). Some countries in southern Africa, particularly Namibia and Botswana, also export beef and some mutton to South Africa: in 1992, these exports to South Africa totalled

**Table IV**

*Export of beef from southern African countries to the European Community (now European Union) under the provisions of the Lomé Convention (a)*

<table>
<thead>
<tr>
<th>Country</th>
<th>Allocation (tonnes)</th>
<th>Estimated value (US$ million) (b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Botswana</td>
<td>18,916</td>
<td>37.8</td>
</tr>
<tr>
<td>Namibia</td>
<td>13,000 (c)</td>
<td>26.0</td>
</tr>
<tr>
<td>Swaziland</td>
<td>3,365</td>
<td>6.7</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>9,100</td>
<td>18.2</td>
</tr>
<tr>
<td>Total</td>
<td>44,381</td>
<td>88.7</td>
</tr>
</tbody>
</table>

a) Fourth Africa, Caribbean, Pacific (ACP)/European Economic Community Convention signed in Lomé on 15 December 1989
b) estimate of US$2,000 per tonne (W. Wessels, personal communication, 1994)
c) Namibian quota negotiated separately (7)
48,269 tonnes of beef and 15,275 tonnes of mutton (8; E. Jenovsky, personal communication). Conversely, although South Africa is a net meat importer, small quantities of beef, mutton and pork are exported (the tendency is to export expensive cuts of meat and import cheaper cuts). In 1992, 3,386 tonnes of meat, mostly pork and beef, were exported. The total meat export trade by southern African countries is therefore in the region of 111,000 tonnes annually with an overall value of more than US$200 million (1992 South African producer prices were used to calculate the value of intra-southern African trade: 8).

If FMD were widespread in any individual country, or in the region as a whole, this would threaten the international trade in meat. The overall effect, however, would depend on the location, extent and duration of the outbreak. If South Africa were involved, the severity of the situation would be exacerbated, as meat exports from some other southern African states (e.g. Botswana) are routed through South Africa.

Influence of FMD on the dairy industry

The dairy industry is highly vulnerable to the effects of FMD primarily due to the mastitic sequelae which many high-producing cows suffer. This was re-emphasised by the experiences of some large-scale dairy farmers in Zimbabwe in 1989. However, the dairy industry in southern Africa, although relatively large in comparison with other livestock industries (Table III), is probably isolated from the effects of FMD to a significant extent, as there is little export of dairy products either from the subcontinent or between countries within the region. For example, dairy products to the value of only about R36 million (US$10.3 million) were exported from South Africa in 1993 of which over 75% was contributed by milk powder (which is unlikely to be markedly affected by FMD import restrictions). This made up less than 1% of the value of total retail sales of dairy products for that year (J. Theron, personal communication, 1994). Furthermore, the dairy industry in southern Africa, as elsewhere, is concentrated around major urban areas which are mostly far removed from enzootic FMD or control areas as well as being geographically separated from each other. Hence FMD would have to become very widespread in the subcontinent to have a really significant impact on the dairy industry.

Influence of FMD on the wool industry

The only other agricultural commodity of animal origin which is exported in significant quantities from southern Africa is wool — produced primarily in South Africa but also in Zimbabwe, Namibia and Lesotho (Table III). In 1992, South Africa exported a total of 68.5 million kg of wool in various categories, with a total value of R658.15 million (US$188 million). However, the contribution of wool to total exports in South Africa has decreased steadily by over 60% since its peak in the decade 1961-1970, when 'greasy' wool exports were 105.7 million kg per annum (J. Bornman, personal communication, 1994). Most wool is exported to the EU, but small quantities also go to Japan and the USA, i.e. FMD-free countries. Here again, should the occurrence of FMD become widespread in South Africa, exports of wool would probably be severely affected.

Influence of FMD on game farming and wildlife usage

Commercial game farming as well as the integration of eco-tourism and wildlife utilisation are increasingly practised in southern Africa and have the potential to become important industries since they fulfill the twin objectives of earning foreign currency and conserving the environment. Much of this activity takes place in FMD enzootic areas and FMD is therefore likely to increasingly influence these commercial
activities (i.e. in terms of what control legislation permits). The value of land and animals, both wild and domestic, is affected by whether control regulations are applicable to a given farm, i.e. whether or not animals and their products can be moved freely to urban markets. In South Africa, the few buffalo (so-called 'disease-free' buffalo) which are not carriers of either FMD viruses or *Theileria parva lawrencii*, have 10-15 times the commercial value of animals from enzootic areas. This has had the inevitable consequence that buffalo have been smuggled between control areas and areas outside the so-called 'red line'. Not only are such movements difficult to detect, but their consequences may become evident only several months or years later. The illegal movement of buffalo and other wildlife presents the greatest threat to effective FMD control in South Africa for the foreseeable future.

**CONTROL**

**Movement control**

Fencing, for controlling the movement of wild and domestic animals, has been the historic linchpin of FMD control in southern Africa but has engendered much acrimonious debate with regard to its efficacy and the deleterious effects it has on wildlife (42). The principal arguments have been that FMD is unlikely to be effectively controlled by a single fence-line, as the infection has been shown to spread on air currents. At the same time the positioning of fences, particularly in Botswana and Zimbabwe, has in the past severely affected wildlife in that their migration routes have sometimes been blocked while, in times of drought, many hundreds of animals have died of thirst because their access to water has been barred.

Air-borne spread of FMD has certainly been an important feature of the spread of FMD in western Europe in the past (21), but in southern Africa air-borne dissemination has not been seriously suspected and has certainly never been demonstrated. Furthermore, there are good reasons why the experiences of western European and southern African countries have been different. The principal reasons are as follows:

- *a*) pigs, which excrete at least 1,000-fold more virus than cattle, and which have been the usual source of air-borne infection in Europe, are rare in most enzootic areas in southern Africa;

- *b*) climatic factors, in particular generally low relative humidity, do not favour FMD virus survival in aerosols in southern Africa;

- *c*) stocking rates of cattle in southern Africa are low, thus reducing the chances of infection even when infectious aerosols are present.

Although it is impossible to prove, there is a firm belief on the part of veterinary authorities in southern Africa that fences have helped considerably in controlling FMD; most authorities therefore continue to rely on fencing to control animal movement and thereby the disease.

**Immunisation**

The precise proportion of the livestock population in southern Africa which is immunised against FMD is difficult to determine. Probably no more than 10 million doses of vaccine are administered each year, and as most immunised animals receive two or three inoculations per year, it is unlikely that more than 15% of the total cattle population (approximately 33 million head) is immunised on a regular basis. In South Africa, only about 2% of cattle and even fewer sheep and goats are immunised annually.
The tendency over the last few years has been for the proportion of livestock immunised against FMD in southern Africa to decrease in order to comply with EU regulations, which stipulate that animal products for export to the EU must not be derived from immunised livestock (10). For this and other reasons, there is excess capacity for FMD vaccine production in the subcontinent. Nevertheless, the decline in incidence of FMD outbreaks, particularly in Botswana and South Africa, coincided with the use of locally-manufactured vaccine, and there is a general perception that locally-produced vaccine is of good quality.

**Vaccine composition and identification**

One technical problem remains: as most FMD outbreaks in southern Africa are derived from buffalo, there is a need to continually monitor the antigenic profiles of FMD viruses circulating in buffalo populations and match these with viruses incorporated into vaccines. Furthermore, as sequencing studies (47, 48) have shown that SAT type viruses tend to mutate independently in different geographical locations, it is important that the viruses incorporated into vaccines be appropriate for each locality in which each vaccine is used. This is something which has so far not been attempted on any structured basis, and many countries in the region suffer from the disadvantage that they do not know what the antigenic relationships are between local virus isolates circulating in buffalo and vaccine strains. They also have limited means of finding out since only two countries in the subcontinent have their own FMD laboratories and are therefore in a position to conduct such studies.

Perhaps the time has arrived for this problem to be addressed on a regional basis. As a first step it may be advisable to appoint a working group consisting of representatives of the two FMD laboratories in the region and the World Reference Laboratory for FMD at Pirbright (United Kingdom) to develop and implement a strategy with the following objectives:

a) to define the extent of intra-typic antigenic variation within the three SAT types in southern Africa

b) to develop a standardised methodology, whereby 'new' viruses can be rapidly and accurately compared with vaccine strains available to southern African countries and this information made available to Chief Veterinary Officers.

There are a number of possibilities in this connection, e.g. the use of monoclonal antibody panels and more rapid enzyme-linked immunosorbent assay systems such as that in use at the World Reference Laboratory (34). However, there will need to be careful assessments made on the SAT virus types to show that in vitro results reflect what happens in vivo, i.e. that protection can be determined efficiently by laboratory testing.

**Vaccination frequency**

The requirement for livestock to receive two or three doses of vaccine per year to ensure effective immunisation against FMD is financially and logistically taxing. For this reason, developmental work aimed at overcoming this requirement (e.g. by employing improved adjuvants) is desirable. This entire aspect is related not only to the duration of vaccinal immunity but also to the population dynamics of susceptible species in enzootic areas. For example, the cost-effectiveness of vaccinating sheep and goats in control areas needs to be examined. In South Africa, small stock were historically vaccinated only once a year, while recently this has been increased to twice a year. By contrast, Zimbabwe does not vaccinate these animals at all (S.K. Hargreaves,
personal communication, 1994). This whole aspect seems to warrant the application of mathematical modelling in order to better understand the interplay between population dynamics and the duration of vaccinal immunity in different species. Only then could one be sure that control strategies being implemented are appropriate.

CONCLUSIONS

FMD is and will remain a serious economic problem in southern Africa as, unlike the situation in most other parts of the world, FMD cannot be eradicated in this region at present. The major obstacle to eradication is the presence of large numbers of the principal maintenance host, the African buffalo, in border areas between southern African countries. Unfortunately, the circumstances under which transmission of FMD viruses occurs between buffalo and cattle are poorly understood.

The economic effects of FMD are to some extent measurable but the position of cattle in the socio-economics of many rural African peoples makes its potential impact, should control not be efficient, incalculable.

Reaching a better understanding of the epidemiology of FMD in southern Africa, and matching vaccine viruses with those currently circulating and constantly evolving in different buffalo populations, present major difficulties. It is proposed that a regional approach be adopted to achieve progress on these issues.

ACKNOWLEDGEMENTS

The author wishes to express his thanks to the following for kindly supplying data on agricultural production: E. Jenovsky (South African Meat Board), J. Bornman (South African Wool Board) and J. Theron (South African Dairy Foundation). In addition, J.A.W. Coetzer, E. Jenovsky and W. Löwe provided helpful comments on the manuscript.


Résumé : L'auteur fait brièvement le point sur la prévalence de la fièvre aphteuse en Afrique australe de 1931 à 1990 et retrace l'épidémiologie et la prophylaxie de la maladie dans leurs grandes lignes. Il met l'accent sur le rôle des animaux sauvages et du buffle africain (Syncerus caffer) en particulier. Il faudrait, selon lui, une coopération mieux structurée pour étudier l'importance et la nature des variations antigéniques propres aux types SAT (Southern African Territories) du virus de la fièvre aphteuse.

L'auteur s'efforce enfin d'évaluer l'impact de la fièvre aphteuse sur l'économie rurale du sous-continent en expliquant l'importance des valeurs sociales dans ce domaine.

**Resumen:** El autor hace una síntesis de la prevalencia de la fiebre aftosa en el subcontinente del África austral entre 1931 y 1990, y resume asimismo los rasgos principales de la epidemiología y control de la enfermedad. Hace hincapié en el papel de la fauna salvaje, especialmente el del búfalo africano (Syncerus caffer). También formula una propuesta para la adopción de un enfoque más estructurado y cooperativo en la investigación del grado y naturaleza de la variación antigénica entre los tipos SAT (Southern African Territories) del virus de la fiebre aftosa.

Se intenta cuantificar el impacto económico de la fiebre aftosa en la economía agrícola del subcontinente, y se expone asimismo la importancia a este respecto del sistema de valores sociales de los pueblos rurales.

**PALABRAS CLAVE:** Control de enfermedades – Convención de Lomé – Epidemiología – Fiebre aftosa – Impacto económico – Variación antigénica – Virus.

**REFERENCES**


