

Foot and mouth disease in Mali: the current situation and proposed control strategies

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Summary

Two main reasons prompted the authors to write this paper. First, outbreaks of foot and mouth disease (FMD) have occurred repeatedly in Mali and neighbouring countries during the last decade. Secondly, there is a pressing need for control strategies, since the first molecular epidemiological studies of FMD virus in West Africa have demonstrated that FMD transmission across national boundaries is common in this region.

The authors discuss the FMD outbreaks that occurred during the period of 1980 to 1996, which were reported to the Central Livestock Office in Mali by field veterinarians. The outbreaks in 1980 and 1982 were confined to the regions of Kayes and Gao, respectively. Between 1991 and 1992, outbreaks occurred in Segou, Sikasso and Bamako. In 1996, FMD outbreaks were reported in cattle populations throughout Mali, except in Kidal in the Sahara desert, where temperatures reach 45°C. High mortality was reported in young animals, while morbidity approached 100% in adult cattle.

Keywords

Cattle – Disease control strategy – Epidemiology – Foot and mouth disease – Mali – West Africa.

Introduction

The Republic of Mali is a landlocked country of approximately 1,204,021 km², situated between the Tropic of Cancer and the equator. The country spans three major climatic zones. A large, central band of semi-arid, sub-Saharan climate, where rain falls only from mid-June to October, is bordered in the south by tropical areas and in the north by the Sahara desert. The vegetation once described as open woodland (10) is now grassland in many parts of the country (10), due to the expansion of the desert region or 'desertification'. Rainfall is negligible in the Sahara desert.

Mali has one of the largest cattle populations in West Africa (approximately six million) (6), as well as a large number

of small ruminants. The country exports cattle to Senegal, Côte d'Ivoire, Guinea, Ghana and Nigeria (10). In addition, thousands of sheep and goats are shipped to most of the neighbouring countries each year, particularly during the festive seasons.

The cattle population consists principally of indigenous breeds, in particular the following:

- Mere cattle
- N'Dama cattle
- Zebu Peulh
- Zebu Maure
- Azawak.

Mere are short *Bos taurus* beef cattle with short horns, while Zebu are tall *Bos indicus* with long horns. Zebu are better milk producers. Zebu Peulh cattle are widely distributed across the country, with high concentrations in Segou (midwest Mali), Mopti (central Mali) and Tombouctou and Gao (north Mali). Zebu Maure are the principal breed found in Kayes and Bamako, and Nara (located in the west and northwest areas of the country, respectively). Mere comprise the herd cattle found in the southwestern region of Sikasso. Azawak cattle are confined mainly to the north of Mali, in the Gao region. However, attempting to improve livestock productivity by importing exotic breeds for cross-breeding is becoming a common practice in Mali (6).

The cattle herders of Mali practise transhumance or semi-transhumance. In summer, they seek pastures and drinking water for their animals along the river Niger, around areas of oasis and in the regions bordering Côte d'Ivoire and Burkina Faso to the south and Guinea to the west. Unfortunately, there are no physical or geographical barriers within these zones and animals from different countries mix freely. This situation, together with the free movement of livestock and livestock products among various markets in different regions and states, plays an important role in the dissemination of livestock diseases in Mali.

The economies of countries in West Africa depend principally on agriculture and livestock production (14, 19). Mali is no exception. Livestock are vital not only because they provide dietary protein for the rapidly growing human population, but also because the exporting of cattle and small ruminants to neighbouring countries provides much-needed income. Moreover, cattle play an important role in rural areas, where their manure is converted into organic nutrients and used as fertiliser on farming land, as well as for fuel in remote rural communities. It is therefore important to define strategies for controlling the infectious diseases that undermine the livestock industry.

Diseases such as foot and mouth disease (FMD) require particular attention. The long campaign to eradicate rinderpest diverted attention and effort from FMD control in West Africa (13). Furthermore, the economic impact of FMD, particularly the reduction in milk production and depreciation in the value of meat (due to weight loss in the animal and the reduction in meat quality), has been overlooked or is not well understood by livestock-owners. These factors, combined with the low mortality rate of the disease, may explain the relative lack of attention to FMD infections in Mali, in particular, and throughout the African continent as a whole (Figs 1 and 2).

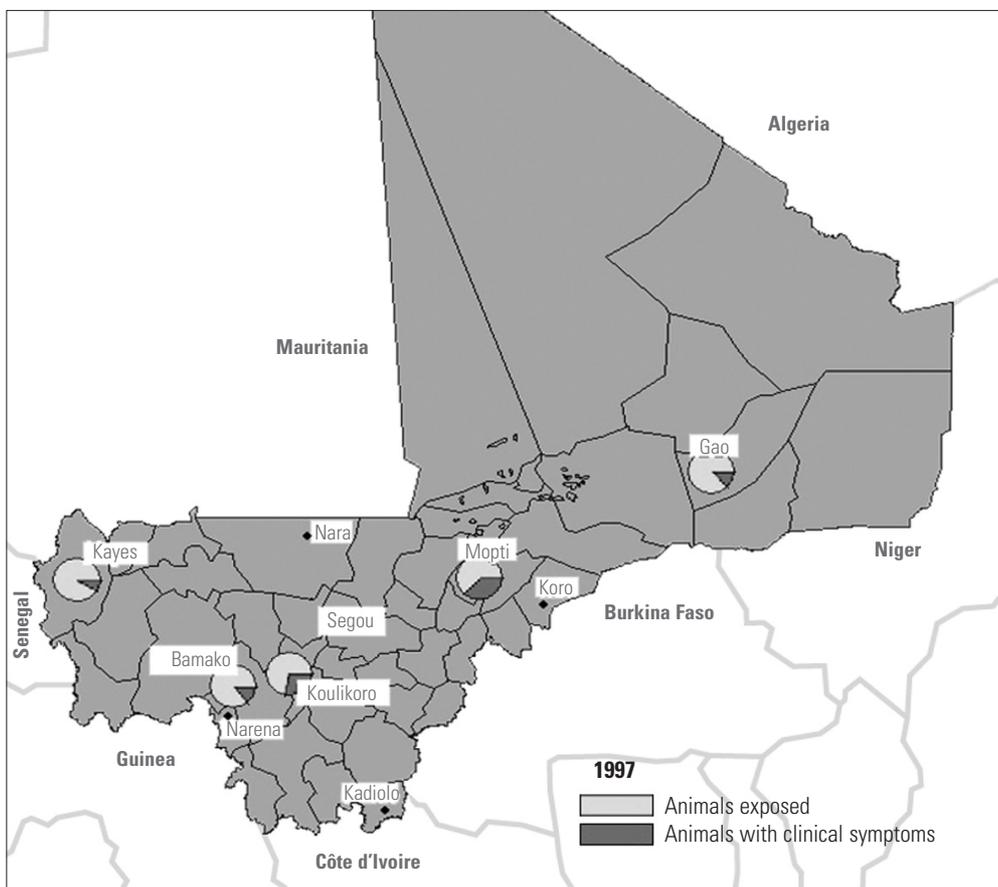


Fig. 1
The distribution of animals with clinical symptoms of foot and mouth disease and animals exposed to the foot and mouth disease virus in Mali in 1997

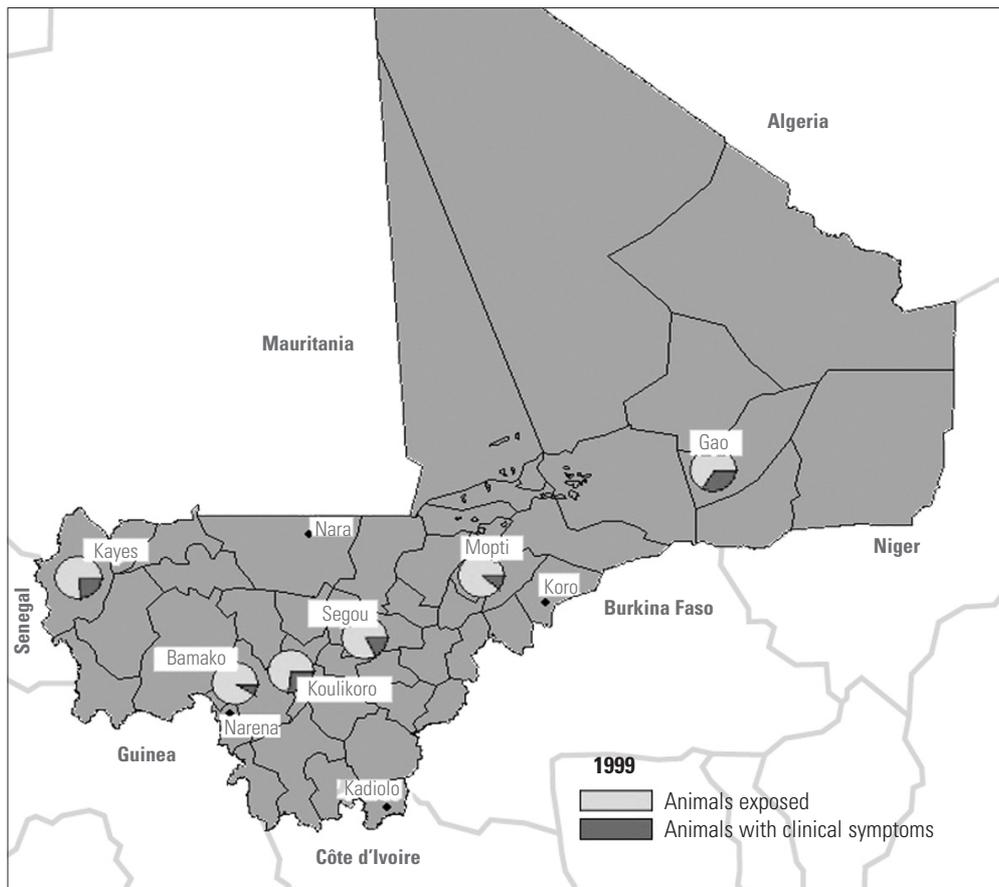


Fig. 2
The distribution of animals with clinical symptoms of foot and mouth disease and animals exposed to the foot and mouth disease virus in Mali in 1999

The disease status of foot and mouth disease in Mali

Controlling FMD is an important step in improving livestock production. Effective control of FMD depends initially on assessing the impact of the disease on livestock production in Mali, its occurrence (spatial or temporal) and its patterns of spread. There are seven FMD virus (FMDV) serotypes, as follows:

- type A
- type O
- type C
- SAT type 1 (SAT-1)
- SAT type 2 (SAT-2)
- SAT type 3 (SAT-3)
- Asia 1.

Of these, three serotypes have been identified in Mali, namely: A, O and SAT-2 (11, 24) (unpublished findings, Central Veterinary Laboratory [CVL], Mali, 1998).

The complex nature of animal movements within Mali, as well as movements across boundaries with other countries, presents a major problem in disease control. The observation that FMD viruses from West Africa can be grouped according to their year of isolation, rather than their geographical location (21, 22), tends to indicate that animal movements in this region are unrestricted.

Recent reports on FMD outbreaks in Mali show that approximately 14,000 cattle were exposed to the virus in 1997 and 30,000 in 1999 (Table I, Figs 1 and 2). The vesicles and erosions on the mucous membranes of the oral cavity, lips and interdigital spaces of affected cattle were reported from clinical examinations conducted by the field public Veterinary Services (unpublished findings, Direction Nationale de l'Appui au Monde Rural [DNAMR], 1999). However, attempts to isolate the virus failed, due to bacterial contamination of the infectious specimens. The poor condition of the samples was probably due to the lack of adequate collecting materials in the field. Nonetheless, a serological test using the antigen detection kit from Pirbright resulted in the first identification of FMDV serotype O in Mali during the 1998 outbreak (unpublished findings, CVL, Mali). In addition, the serum samples collected from some

Table I
Summary of outbreaks of foot and mouth disease in Mali in 1997 and 1999

Year	Outbreak areas	No. of outbreaks	Exposed animals	Animals with clinical symptoms	Mortality	Average morbidity
1997	Kayes	7	2,102	195	5	37.56 %
	Bamako	3	1,783	308	11	
	Koulikoro	6	9,600	3,829	10	
	Mopti	1	500	300	1	
	Gao	2	203	30	4	
	Total	19	14,188	4,662	31	
1999	Kayes	4	970	312	5	
	Koulikoro	12	10,310	3,891	35(calves)	
	Mopti	7	11,052	1,493	17(16 calves)	
	Segou	5	2,750	600	5	
	Sikasso	NA	NA	NA	NA	
	Bamako	10	2,873	284	29(calves)	
	Gao	8	1,878	971	7	
	Total	46	29,833	7,551	98	

NA: not available

of these animals demonstrated high antibody titres against FMDV, when tested by enzyme-linked immunosorbent assay (ELISA). The 1998 outbreak was characterised by high morbidity in adult cattle and high mortality in young animals. Since the virus could not be isolated, one can speculate about an increase in the susceptibility of the cattle herds or the presence of a particularly virulent FMD strain in the country. Interestingly, mortality rates were higher on dairy farms stocked with exotic breeds, than on farms with hybrid cattle, indicating that introduced breeds appear to be more susceptible to the FMD viruses endemic to West Africa.

Possible reservoirs of the virus

Although wild animals have been reported as playing an important role in the epidemiology of FMDV in southern Africa (29), this is less likely to be the case in Mali because of its small wildlife population. It is likely that cattle are more significant in the maintenance of FMDV in Mali, since animals which have recovered from the illness are not often removed from the herds. Thus, subclinical infections are likely and probably constitute an important reservoir of the virus. The possible role of carrier cattle in transmitting the disease is supported by the fact that many outbreaks have been reported following the introduction of new animals into herds (unpublished findings, DNAMR). Sheep and goats are reported to carry the virus for up to six and nine months, respectively (1, 12, 25). In Mali, the population of small ruminants has been estimated at 10 million (6). Since small ruminants habitually share the

grazing areas browsed by cattle, and their living areas are often in close proximity, their role in the transmission of FMDV to cattle must be considered in future studies.

Although cattle serum samples from the rinderpest eradication campaign are available for FMD sero-surveys, large scale sero-monitoring of small ruminants has not been conducted. Sera should be collected from goats and sheep as it is important to determine the role of these animals in the epidemiology of the disease. Since animals are not vaccinated in Mali, a positive result from the liquid phase blocking ELISA, and to non-structural proteins, will indicate infection (16).

Mechanisms for the transmission of the virus from carrier animals remain obscure. However, the stress caused by moving animals to new locations is one mechanism that may trigger an outbreak (8), as it is believed to depress the immune system and precipitate the shedding of virus in carrier animals. However, experimental attempts to activate FMDV through stress have been equivocal (9, 27). Alternative mechanisms, such as sexual transmission of the virus from carriers, have also been proposed (2, 20).

Preventing and controlling FMD requires a good diagnostic laboratory, good quarantine facilities and qualified personnel. The CVL does have the serological and polymerase chain reaction (PCR) facilities needed to diagnose FMD. Moreover, the CVL routinely conducts ELISAs to detect antibodies and antigen.

However, the high-quality quarantine facilities and strict protocols used in countries which are free of FMD do not exist in Mali, since the disease is currently endemic throughout the country. Although PCRs and ELISAs are routinely performed, contamination of tissue cultures has been a major problem in virus isolation. A well-designed and well-equipped tissue culture laboratory should be a priority at the CVL, so that the virus isolation which is so essential to diagnosing FMD can be achieved.

It should be noted that a bank of sera is maintained at the CVL. These sera can be used for serological surveillance to determine the zones where FMD infection is at a high prevalence. Assessing the prevalence of the disease depends on the accuracy of the diagnosis techniques used for the study, as well as on adequate laboratory support. This is particularly important for a disease that requires special virus isolation and characterisation.

In southern Africa, African buffalo (*Syncerus caffer*) have been shown to be efficient hosts for maintaining SAT-type viruses (4, 30), capable of transmitting FMD to cloven-hoofed animals in close proximity under natural conditions (3, 5). Other wildlife species that play a role in the epidemiology of the disease in this region include impala (*Aepyceros melampus*) and kudu (*Tragelaphus*

strepsiceros). These antelope are believed to act as intermediaries in virus transmission between buffalo and domestic animals (3, 28). In West Africa, and in Mali in particular, there are relatively fewer of these susceptible wildlife and they are under threat. At present, fifteen antelope species, including the giant eland (*Taurotragus derbianus*), addax (*Addax nasomaculatus*) and slender-horned gazelle (*Gazella leptoceros*), are known to occur in Mali and two of these are endangered, i.e. the scimitar-horned oryx (*Oryx dammah*) and korrigum (*Damaliscus lunatus*) (26). Where these antelope do occur, they usually roam freely and are often seen in livestock grazing areas and at shared water holes. In addition to antelope, Mali has warthogs (*Phacochoerus aethiopicus*), about 600 elephants (*Loxodonta africana*) and around 236,000 camels (*Camelus dromedarius*), with more than 60% of this camel population found in the Sahara (6). However, the role of wildlife in the epidemiology of FMD in Mali remains unknown. In light of the current endemic situation, wildlife do not appear to be an immediate threat in the epidemiology of FMD in Mali.

A strategy to control foot and mouth disease in Mali

Genetically grouping the SAT-2 viruses isolated from Mali in 1991 (24) with the viruses isolated in Ghana and Côte d'Ivoire in 1990 (Table II), as well as the type A virus found in Mali in 1997 (11) with viruses recovered from Senegal (1996 to 1997), Mauritania (1997) and Gambia (1998), confirms that virus transmission has occurred between Mali and its neighbouring countries.

Regional studies on four FMD serotypes (SAT-1, SAT-2, O and A) (11, 22, 23, 24) indicate that virus transmission across boundaries is common in West Africa (Table II). Stricter controls on animal movements are not practical because of the limited financial and human resources in Mali and the large size of the country. Identifying high-risk zones, in areas where there is a high likelihood of frequent contacts between livestock, has been advocated. It is beyond the scope of this paper to identify all the zones in Mali where illegal animal movements have occurred. Nevertheless, high-risk areas do include the following:

- Narena, which borders Guinea
- Kadiolo, which borders Côte d'Ivoire
- Koro, which borders Burkina Faso
- Nara, which borders Mauritania.

It has also been suggested that movement controls and quarantine should be imposed on all cloven-hoofed animals crossing borders. However, as transhumance is a traditional way of life for Mali herders, this would prove

Table II
Summary of foot and mouth disease epizootics in West Africa as identified by viral protein 1 gene nucleotide sequence analysis

Isolate name	Year	Country of identity	Serotype	Sequence	Reference
CIV/4/95	1995	Côte d'Ivoire	Type A	> 96%	(11)
GHA/2/96	1996	Ghana			
GHA/4/96	1996	Ghana			
MAI/2/97	1997	Mali			
MAU/3/97	1997	Mauritania			
SEN/10/96	1996	Senegal			
SEN/10/97	1997	Senegal			
SEN/34/97	1997	Senegal			
GAM/44/98	1998	Gambia			
GAM/46/98	1998	Gambia			
GAM/52/98	1998	Gambia			
BKF/1/92	1992	Burkina Faso	Type O	> 98%	(22)
BKF/2/92	1992	Burkina Faso			
BKF/3/92	1992	Burkina Faso			
GHA/9/93	1993	Ghana			
GHA/6/93	1993	Ghana			
GHA/7/93	1993	Ghana			
GHA/5/93	1993	Ghana			
NIG/24/75	1975	Nigeria	SAT-1	> 97%	(23)
NIG/25/75	1975	Nigeria			
NIG/15/75	1975	Nigeria			
NGR/1/76	1976	Niger			
NGR/2/76	1976	Niger			
NGR/4/76	1976	Niger			
NGR/5/76	1976	Niger			
LBR/1/74	1974	Liberia	SAT-2	> 96%	(23)
IVY/9/74	1974	Côte d'Ivoire			
GHA/10/74	1974	Ghana			
GHA/14/74	1974	Ghana			
NIG/35/74	1974	Nigeria			
NIG/1/74	1974	Nigeria			
SEN/1/75	1975	Senegal			
SEN/5/75	1975	Senegal			
NIG/1/75	1975	Nigeria			
NIG/2/75	1975	Nigeria			
GAM/8/79	1979	Gambia	SAT-2	> 97%	(23)
GAM/9/79	1979	Gambia			
SEN/7/79	1979	Senegal			
SEN/8/79	1979	Senegal			
SEN/3/83	1983	Senegal			
SEN/7/83	1983	Senegal			
SEN/1/83	1983	Senegal			
IVY/2/90	1990	Côte d'Ivoire	SAT-2	> 97%	(24)
IVY/7/90	1990	Côte d'Ivoire			
GHA/2/90	1990	Ghana			
GHA/8/90	1990	Ghana			
MAI/1/91	1991	Mali			
MAI/3/91	1991	Mali			
MAI/2/91	1991	Mali			
MAI/5/91	1991	Mali			
MAI/6/91	1991	Mali			

an impossible challenge. For instance, it is the custom, often seen in the Mopti region, to move hundreds of thousands of cattle within a very short period of time, sometimes a single day. It would be impractical to establish quarantine stations capable of handling such large numbers of animals.

As FMD is an endemic disease in Mali, vaccination is a crucial component of the envisaged control measures, particularly in regions which border neighbouring countries. Vaccination and disease control measures have been used successfully to establish internationally recognised FMD-free zones in South Africa, Botswana, Zimbabwe and Namibia (18). However, it is recognised that, to be effective, FMD vaccine strains should be closely related antigenically to those strains which are circulating in the field (7). The genetic distinctiveness of viruses from West Africa has already been reported (11, 22, 23, 24). As it has been demonstrated that genetic variation corresponds well with antigenic variation (7), it is unlikely that current FMD vaccines would be effective in Mali, as they contain unrelated vaccine strains.

Nevertheless, developing custom-made vaccines for specific strains circulating in particular regions is expensive. Thus, the antigenic relationship between the West African virus strains and those strains used in the vaccines which are currently available should be investigated. If there is a significant antigenic difference between the vaccines and the isolates, custom-made vaccines may then be considered to address the regional distinctiveness of the viruses found in West Africa.

Controlling FMD cannot rely solely on vaccination. Disease control measures will be of key importance in controlling FMD in Mali. It is essential that veterinarians and farm workers comply with basic disease control principles. At present, it is very common to see animal health personnel moving between farms wearing the same clothes and using the same equipment, without disinfecting these items between visits. Raising awareness among field veterinarians and farm workers about the role humans can play in the dissemination of FMDV (through their clothing, shoes, hair, etc.) is a vital step. Cleaning and disinfecting procedures are strongly recommended before leaving FMD-infected premises. Animal health and farm workers should use solutions of sodium carbonate at 4% concentration, sodium hydroxide at 2% or citric acid at 0.2%, as these are known to be effective for disinfecting contaminated surfaces (17).

Public responsibility

Since Mali is so vast in size, and the levels of animal movement are so high, it would be impossible to establish

a disease surveillance system using veterinary personnel alone. It is therefore imperative that communities report any suspicion of FMD to the local veterinarian. Disease awareness campaigns are thus essential. Vaccinating new animals before they are introduced into existing herds should also be considered.

Any large-scale awareness campaign being planned should also address a number of established practices, for example:

- discouraging the slaughtering of animals in inappropriate areas or inadequate abattoirs
- preventing sedentary herd cattle from feeding on waste dump sites.

Planning a vaccination campaign against foot and mouth disease in Mali

In FMD-endemic areas, the disease is controlled mainly through vaccination and the restriction of animal movements. However, as different conditions prevail in each country, the implementation of these control measures should be carefully evaluated to ensure that they are both effective and financially viable. Based on an individual assessment of the conditions prevailing in Mali, the authors suggest the following measures.

As FMD is most prevalent in the cold and rainy seasons, from November to February and from June until September, respectively (unpublished records of the CVL, Mali), any vaccination schedule should be designed to address these peak outbreak periods. Since FMD vaccines provide only short-lived immunity (31), a regime of two vaccinations annually is advised, the first administered from late April to May and the other from late September to October, to achieve adequate immunisation of the vaccinated animals.

A regular vaccination campaign will require the following:

- adequate human resources
- adequate equipment (transport, communication devices, cold storage facilities, etc.)
- an appropriate multivalent vaccine, incorporating those FMDV serotypes (O, A and SAT-2) that have been identified in Mali.

The cost associated with a full vaccination campaign is likely to be high. Thus, it must be determined whether such a campaign will be economically advantageous, i.e. whether the benefits derived from FMD control will

outweigh the financial costs to the country. Therefore, funding such a campaign is an issue which requires full discussion. In Mali, FMD vaccine is imported and a single dose costs approximately 1,500 CFA francs or about US \$6 per animal per year.

Initially, it is the government, through its Central Livestock Office, that must raise public awareness among farmers and animal workers on the economic impact of FMD and ways of controlling the disease. The possibility of producing an FMD vaccine at the CVL should be considered, so that farmers will have access to an affordable vaccine.

When vaccination is implemented, the focus of the campaign should centre on those herds located in border areas (Kadiolo, Nara, Koro and Narena) but attempt to include all nomadic herds across the country. In 2001, Mali exported 270,000 cattle and 430,000 sheep and goats to several African countries (15). However, because of the presence of diseases such as FMD, Mali has no access to the growing international market, where prices are higher but competition more rigorous.

Conclusion

This is the first paper to address the challenge of controlling FMD in Mali, and the authors believe they have shown that such efforts must be made to reduce the threat of the disease. The control strategy proposed here will contribute to a better understanding of the epidemiology of the disease. There are important economic benefits to be

gained, both by farmers and by the country as a whole, from a more detailed knowledge of the FMD situation in Mali and its neighbouring countries in West Africa.

However, identifying high-risk FMD zones, controlling the movements of livestock in Mali and introducing facilities for quarantine are unlikely to be effective unless a regional approach to disease control and surveillance is undertaken. This is because of the frequent trans-boundary transmission of FMDV that occurs in West Africa (Table II). Finally, further studies are needed on the use of FMD vaccination. Together, such measures will help to ensure future financial benefits, such as access to international markets, to generate substantial income for this agriculturally based economy.

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La fièvre aphteuse au Mali: situation actuelle et stratégies de lutte proposées

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Résumé

Deux raisons principales ont poussé les auteurs à écrire le présent article. D'une part, des poussées de fièvre aphteuse se sont produites de façon répétée au Mali et dans les pays voisins depuis une dizaine d'années. D'autre part, il existe un besoin pressant de stratégies de lutte, car les premières études d'épidémiologie moléculaire du virus de la fièvre aphteuse en Afrique occidentale ont montré que la transmission de cette maladie à travers les frontières nationales est fréquente dans cette région.

Les auteurs examinent les poussées de fièvre aphteuse qui se sont produites durant la période allant de 1980 à 1996, telles que signalées au bureau central du bétail au Mali par les vétérinaires opérant sur le terrain. Les poussées de 1980 et de 1982 ont été confinées aux régions de Kayes et de Gao, respectivement et entre 1991 et 1992, elles se sont produites à Ségou, Sikasso et Bamako. En 1996, des foyers de la maladie ont été signalés chez des populations de bovins dans tout le Mali, sauf à Kidal, dans le désert du Sahara, où les températures atteignent 45°C. Une forte mortalité a été signalée chez les jeunes animaux, tandis que la morbidité approchait 100% chez les bovins adultes.

Mots-clés

Afrique occidentale – Bétail – Épidémiologie – Fièvre aphteuse – Mali – Stratégie de prophylaxie.



Situación actual de la fiebre aftosa en Malí y estrategias propuestas para controlarla

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Resumen

Dos son las razones básicas que indujeron a los autores a escribir el presente artículo. En primer lugar, en el pasado decenio han venido sucediéndose los brotes de fiebre aftosa en Malí y los países de alrededor. En segundo lugar, urge disponer de estrategias de control, pues los primeros estudios moleculares de la epidemiología del virus de la fiebre aftosa en el África Occidental han demostrado que su propagación transfronteriza es frecuente en la región.

Los autores describen los brotes de fiebre aftosa que tuvieron lugar entre 1980 y 1996, notificados por veterinarios locales a la oficina central de ganadería de Malí. Los brotes de 1980 y 1982 se circunscribieron a las regiones de Kayes y Gao respectivamente. Entre 1991 y 1992 hubo brotes en Segou, Sikasso y Bamako. En 1996, esos episodios afectaron a la cabaña bovina de todo el país, con la salvedad de Kidal (desierto del Sáhara), donde las temperaturas alcanzan los 45°C. En animales jóvenes se describió una mortalidad elevada, mientras que la morbilidad lindaba con el 100% en ejemplares adultos.

Palabras clave

África Occidental – Bovinos – Epidemiología – Estrategia de control zoonosanitario – Fiebre aftosa – Malí.



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