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Rift valley fever surveillance in the lower Senegal river basin: update 10 years after the epidemic

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Summary After the Rift valley fever (RVF) epidemic of 1987 in the Senegal River Basin, RVF surveillance based on serosurveys has been conducted for 10 years. Serum samples were obtained from 1336 persons and from sheep and goats in selected areas, and these were tested for IgG/IgM RVF antibodies by ELISA. After a period of regular decrease in RVF prevalence in domestic animals until 1993, an epizootic was observed in all herds in 1994–95 with increases in IgM levels and abortions. During the same period, no human cases or RVF IgM were detected. The RVF IgG prevalence significantly correlated with date of birth: children born after 1987 have a low prevalence (5%) in clear contrast to the older population (25.3%) in Podor district. A retrospective analysis of rainfall and RVF prevalence in small domestic animals over the last 10 years showed that the re-emergence correlated with heavy rainfall. A general analysis of the risk of re-emergence and the efficiency of this RVF surveillance system are presented.

keywords Rift valley fever, seroprevalence, rainfall, Senegal

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Introduction

Rift Valley Fever (RVF) is an acute phleboviral disease (family: *Bunyaviridae*) affecting domestic animals with occasional human involvement. RVF virus has been isolated in mosquitoes from many West African countries (Meegan & Bailey 1988). Antibody prevalence in domestic ungulates confirmed the existence of an enzootic disease in several ecologically different areas from rainforest to Sahelian savannah (Zeller *et al.* 1995b). Infected mosquitoes represent the principal means by which RVF virus is transmitted zoonotically. Even where endemic, transmission fluctuates in time and space. RVF epizootics have been related to rainfall in East Africa (Davies *et al.* 1985).

However, in West Africa, large-scale RVF outbreaks were not reported prior to the 1987 southern Mauritanian epidemic (Jouan *et al.* 1988). The clinical picture for human disease ranges from febrile illness to fatal haemorrhagic fever, and late complications of encephalitis or ocular disease are associated with considerable human morbidity and mortality. The virus also provokes abortions in cattle and sheep and is fatal to young lambs. Since 1988, successive serological and entomological surveys conducted in Senegal have indicated an enzootic transmission in northern Senegal, with the species of the genus *Aedes aedimorphus* as the vector during the interepizootic period (Fontenille *et al.* 1995).

According to the risk for human and livestock populations in this northern Senegal area (Thiongane *et al.* 1991), a surveillance network was estabished through physicians and veterinary agents. The objective of this network is to detect RVF cases by regularly conducting serological surveys in sentinel herds and human populations.

Our aim was to describe the Senegalese RVF surveillance system based on seroprevalence in human and small ruminant populations living on the left bank of the lower Senegal River basin. We tried to correlate the re-emergence of the virus and factors increasing transmission such as climatic parameters and demonstrated the efficiency of a serosurvey based on small domestic ruminants as a sensitive tool for the detection of RVF circulation.

Materials and methods

Study area

Our investigations were conducted in the border area along the left bank of the Senegal River (around 250 km) from Podor (16°71′N, 14°94′ W) to St Louis (16°12′N, 16°62′W), as shown in Figure 1. The localities under study are situated in the Sahelian bioclimatic zone of West Africa. Rainfall averages around 250 mm annually, but may vary considerably from year to year and occurs principally from July to October during the short rainy season. Rural activities have been largely modified since the construction of dams (Diama 1985 and Manantali 1990) on the Senegal River, which permits extended irrigation.

Rainfall data were collected from the Senegalese National Meteorology Service at 5 stations along the Senegal River: Podor, Dagana, Ross-Bethio, St Louis and M'pal. The mean annual rainfall was calculated and plotted in Figure 2 with RVF prevalence. The data was recorded from Thiongane *et al*. (1994) for the period from 1986 to 1992.

Sera collections

Sera were collected from small ruminants in the villages of Niandane, Niassante, Ross-Bethio, Rao and Mpal. Five herds of about 40 sheep or goats were bled by venipuncture. The sera were centrifuged in the field and stored at 4 °C until tested for RVF IgG and IgM antibodies using an enzyme linked immunosorbent assay (ELISA) and seroneutralization test on Vero cells infected with an RVF Smithburn strain as previously described (Thiongane *et al*. 1994).

Human blood samples were obtained from cohorts of inhabitants followed by the ESPOIR project in villages between January 1995 and December 1996. The ESPOIR project is a program for research and control of schistosomiasis along the Senegal River from Mali to Mauritania. The Senegalese RVF area under study is just a part of this major schistosomiasis surveillance area. The criterion for inclusion was to live in the surveillance area, independently of schistosomiasis infection. Only adults (> 15 years) were recruited in the sites of St Louis, Guidakhar (near Rosso town), and

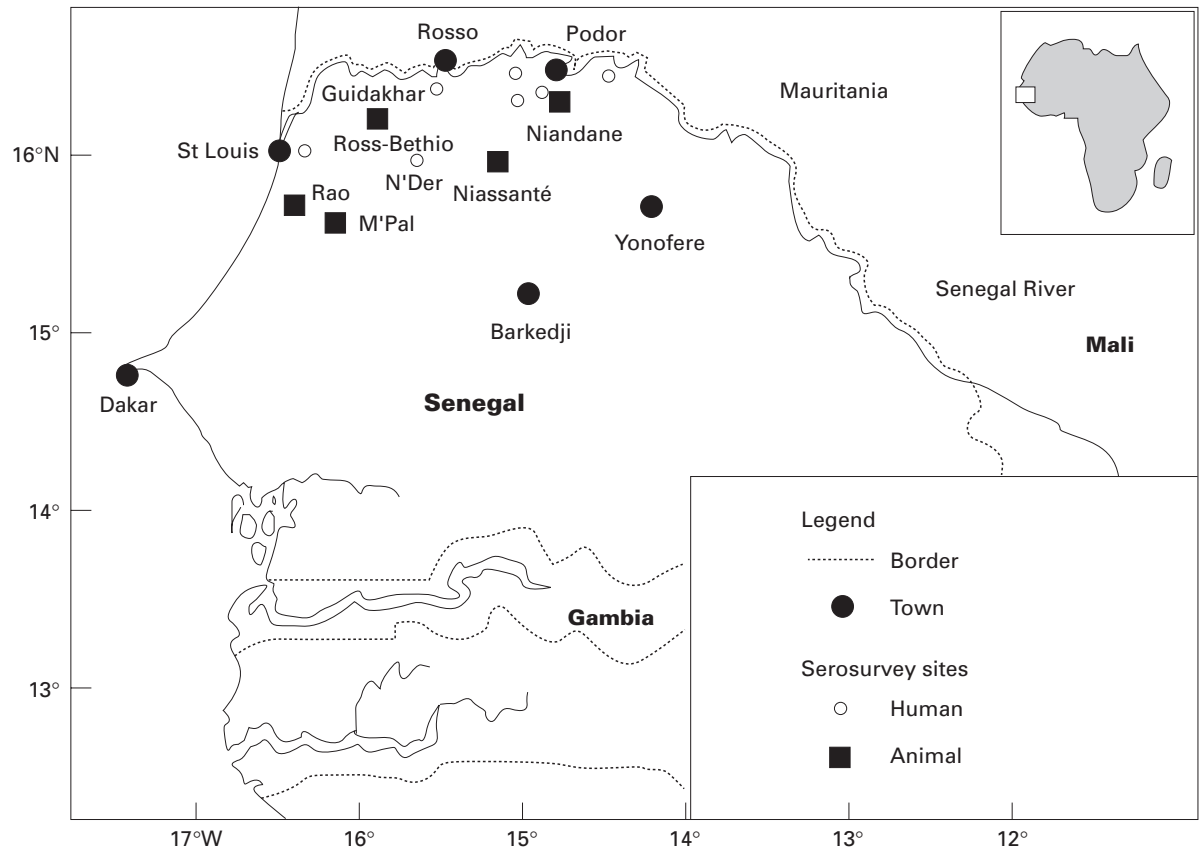

Figure 1 Map of Senegal with sites of serosurveys for humans and small domecstic animals.

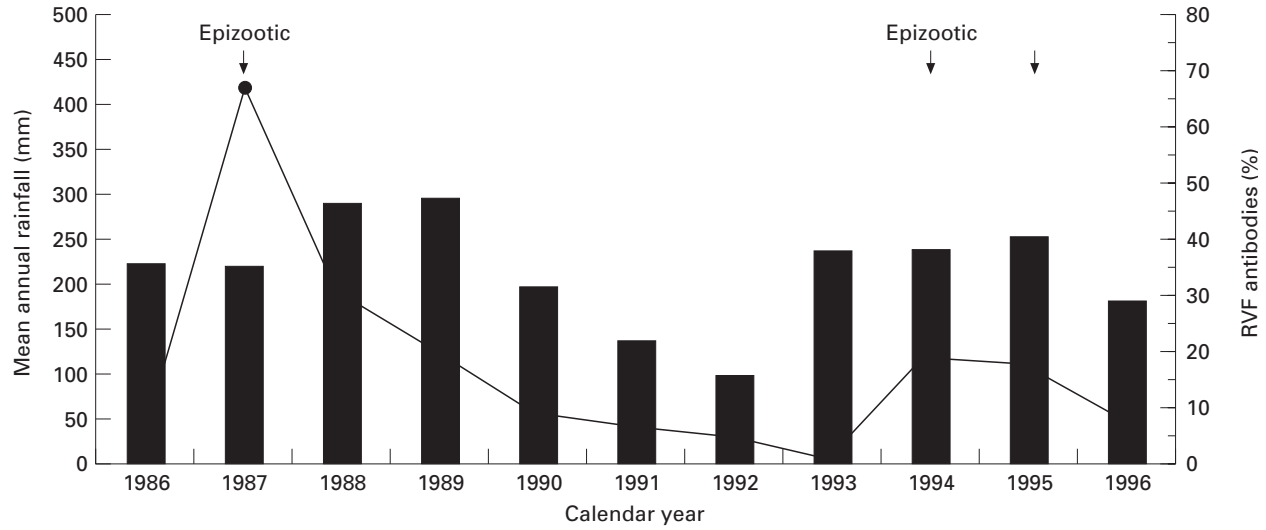

Figure 2 RVF seroprevalence curve (●) among small domestic ruminants in the lower Senegal River basin and mean annual rainfall (■) for the last 10 years.

N'Der. From 4 villages (Diatar, Donaye, Guia, Niandane) in the district of Podor, 738 individuals were randomly sampled.

Techniques

All sera were tested by ELISA for RVF IgG/IgM by a procedure adapted from Meegan *et al.* (1987). A mouse liver antigen was used. Previous tests had compared the specificity and sensitivity between seroneutralization tests (1/160) and ELISA cut-off for RVF virus (Y. Thiongane personal observation). The Chi square test was used for statistical analysis.

Results

Human RVF antibody prevalence

1346 sera were tested (Table 1). None tested positive for IgM antibodies. The overall prevalence of RVF IgG was 15.3%. The regional prevalence rate in adults ranged from 26% in the village of Guidakhar, near Rosso town (epidemic centre in 1987), to 18.9 in N'Der, and to 7.8% in St Louis. In Podor district and in Guidahar, the RVF IgG seroprevalences were similar for the two periods. In Podor district the RVF IgG seroprevalence could be correlated with age (Table 2). Two

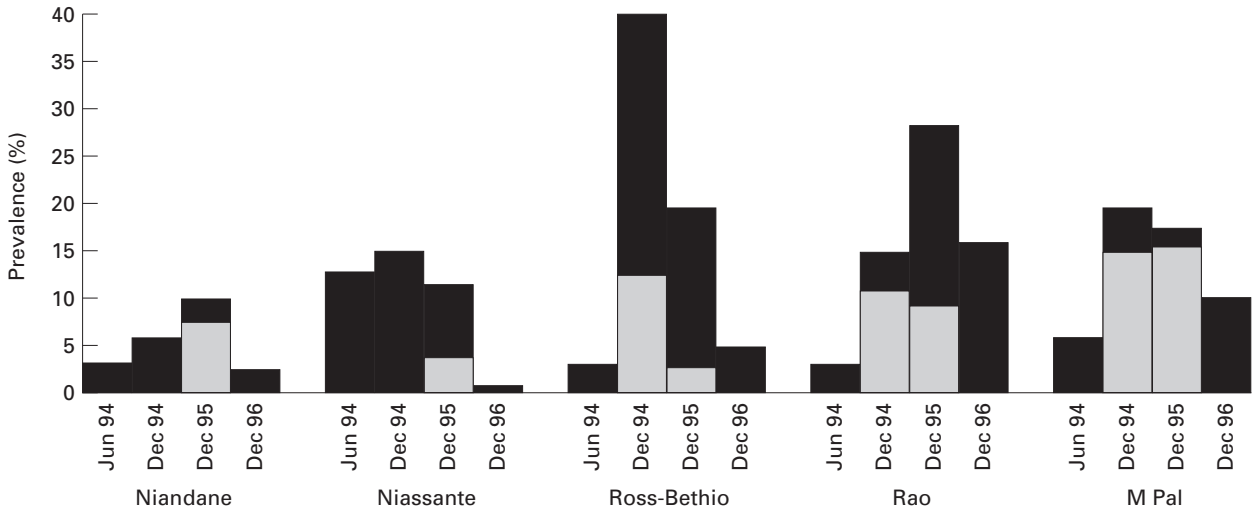

Figure 3 Prevalence of IgG (■) and IgM (■) RVF antibodies among 5 herds in the lower Senegal River basin (June 1994–December 1996).

Table 1 Prevalence of RVF antibodies (IgG-IgM) among humans in the lower Senegal River basin between April 1995 and December 1996

Sites	Date	Tested No	RVF IgG%	RVF IgM %	Age
St Louis	April 95*	270	7.8	0	Adults
N'Der	October 96	112	18.9	0	Adults
Rosso	January 95	61	21.3	0	Adults
	June 95	165	27.8	0	
Podor	Mars 96	459	13.1	0	All age
	December 96	279	16.5	0	groups
Total		1346	15.3	0	

*St Louis hospital.

Table 2 RVF IgG human antibody prevalence in Podor district according to date of birth in March and December 1996

Date	Date of birth	Tested No	RVF IgG %	RVF IgG CI 95%
March 1996	> 1987	241	4.7	2.3–8.0
	≤ 1987	218	22.5	17.1–28.6
December 1996	> 1987	157	5.7	2.6–10.6
	≤ 1987	122	30.3	22.7–38.5

Table 3 RVF IgG human antibody prevalence in Podor district by sex in March and December 1996

Date	Sex	Tested No	RVF IgG %	RVF IgG CI 95%
March 1996	Male	234	14.9	10.6–20.2
	Female	225	11.1	7.3–15.6
December 1996	Male	154	15.6	9.8–21.3
	Female	125	17.6	11.4–25.4

age ranges were established: people born after or before the epidemic of 1987. The RVF prevalence differed significantly for the two groups, respectively, 5% and 253% ($\chi^2 = 59$, degrees of freedom = 1, $P < 0.001$). However, males and females had a similar pattern for RVF antibodies (Table 3).

Animal RVF antibody prevalence

The serosurveys conducted in sheep and goats showed a significant increase of RVF IgG and IgM antibodies between June 1994 and December 1995 in all herds. Figure 3 illustrates these RVF epizootics. For example, in the flock of Ross-Bethio (40 sera tested in 1994), the RVF IgG prevalence reached a peak of 40% with 12.5% of RVF IgM. The abortion rate was about 50% in this herd, and approximately 15% in the others. Retrospective attempts at viral isolation were unsuccessful from sera as well as 3 abortion products. The epizootic first reached downstream herds (M'Pal, Rao, Ross-Bethio) during the rainy season in 1994, and secondly upstream herds (Niassante, Niandane) in 1995. A return to a low level occurred in 1996 in all herds with no evidence of seroconversion.

Retrospective data of rainfall and epizootic RVF

As shown in Figure 2, RVF seroprevalence reached a peak of around 70% after the 1987 epizootic, dropped to 30.8% in 1988 and then decreased continuously until 1993. This fall in RVF prevalence in animal population corresponded to a period of low rainfall. During a period of heavy rainfall (1993–95) RVF activity re-emerged as epizootics among herds of the lower Senegal River basin.

Discussion

RVF surveillance can be accomplished by a variety of approaches including case finding, serological survey, attempts at virus isolation with animal or entomological specimens, and geographical and meteorological information systems. We chose a serological surveillance system according to local conditions, especially herd breeders' agreement, cost and effectiveness. Random selection of small ruminants was impossible. Flocks were selected so as to be representative of the areas under study, distributed along the left bank of the Senegal River. In contrast to herds, small domestic animals have a sufficient economic turnover to be sensitive to detection of RVF virus re-emergence: the nonimmune population increases with litters and with annual ritual slaughters. Many factors play a part in small ruminant mortality and abortions, independently of RVF virus activity such as parasitism and malnutrition. A specific RVF diagnosis was chosen with ELISA assay. Moreover, this diagnostic tool permits separation of IgG and IgM; and IgM are a valuable indicator of recent infections. After the 1987 epizootic, firstly a drop and then a regular decrease in RVF antibodies occurred until in 1993. In 1994 and 1995, some epizootics affected the sentinel herds, attested by both the high prevalence of IgG and IgM. Morvan *et al*. (1992) estimated the duration of IgM after a natural infection at 2–3 months. According to these authors, the detection of IgM in the sera in December corroborates infections occurring at the end of the rainy season in October-November. The animal seroprevalence curve (Figure 2) showed a decrease in RVF antibodies in herds during a relative period of drought, followed by a re-increase of

seroprevalence after excessive local rainfall. This indicates the interepizootic period ended in 1994. But the heavier rainfall began in 1993 and some evidence of RVF activities was previously notified in near sites of Barkedji and in Mauritania (Zeller *et al.* 1995a)

The human RVF prevalence was not affected by this epizootic. No IgM antibodies were detected in humans. No case was declared by sanitary agents in spite of an information campaign of this haemorrhagic fever. The Ministry of Health sent a letter to increase the awareness of sanitary and veterinary agents to haemorrhagic fever. Therefore we received abortion products for virus isolation attempts. No human cases were found. The RVF IgG prevalence is highly correlated ($P < 0.001$) with the date of birth: children born after 1987 have a low prevalence (5%) in clear contrast to the older population (25.3%) of Podor district. The RVF epizootic in 1987 was a precursor of the epidemic. Without evidence of an epizootic between 1987 and 93 in the Senegal River basin, the RVF human antibodies seem to be principally the results of the previous outbreak of 1987. Just after this outbreak, Kiazek *et al.* (1989) and Wilson *et al.* (1994), in the nearby areas of Rosso and Yonofere, respectively, showed similar IgG seroprevalences in about 30% of the overall population. This confirms the high prevalence of RVF IgG for individuals born after 1987 on the left bank of the Senegal River, extending to Podor district. Moreover, in all this area, the overall human RVF immunity decreased annually according to dynamics of population in African countries (50% in individuals under 15).

Our study could neither report a human case notified from a sanitary structure nor a recent human infection (no RVF IgM). The sheep seroprevalence increase was not related to that of humans inhabiting the same area, suggesting different mechanisms of exposure.

RVF virus transmission appeared to be clearly endemic in northern Senegal, with fluctuations according to rainfall. Zeller *et al.* (1997) recently proposed for the Ferlo region (Barkedji), 130 km south of the Senegal River, an enzootic virus maintenance cycle around temporary pools involving *Aedes vexans* and *Aedes ochraceus* as primary vectors, and epizootic amplification involving various mosquito species. At first, surplus rainfall would be necessary for intense RVF transmission allowing a higher than usual emergence of mosquito vectors. Virus amplification then occurs in domestic animals, and the role of these animals as amplifying hosts must be emphasised. This makes then a good target for RVF serosurveys. Finally, human transmission could occur through mosquito bites and also by direct transmission when assisting sick animals.

The epizootics confirmed the sensibility of this surveillance system. It is to be hoped that the serosurveys could be extended. But cooperative breeders are rare: in this Muslim region with a sheep-breeding tradition, blood sampling from both humans and animals is difficult. This is the reason for our association with the ESPOIR project.

The changing characteristics of the Senegal River basin with the water project have been social and economic impacts but also increased vector-borne disease such as schistosomiasis (Piquet *et al.* 1996) or modified malaria transmission (Faye *et al.* 1995). The irrigation of extensive areas for rice culture, the direct intervention for creating artificial overflow and future management of the Manantali dam (hydro-electric project) have modified the water flow and increased the risk of RVF transmission. Data obtained from satellite imagery will help to predict and prevent future RVF epizootics or epidemics; however, such data is expensive and will therefore be used in association with classical serosurveys based on small domestic ruminants which are sensitive, inexpensive detection tools.

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