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## The epidemiology of human and animal schistosomiasis in the Senegal River Basin

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### Summary

The results of four field surveys in Senegal are reported. 1. A snail survey in various parts of the Senegal River Basin, including the Senegal River, temporary rain-fed pools, swamps, irrigation canals and drains, ricefields and Lac de Guier was carried out. Three species of snails were commonly found: *Bulinus guernei* was the most common, occurring in permanent habitats, *Bulinus senegalensis* occurring in laterite pools in the eastern part of the Middle Valley, and also in the ricefields of Guédé Chantier and Lampsar; *B. forskalii* was found in small numbers in Lac de Guier and Richard Toll. Three *B. guernei* were found to be naturally infected with *S. bovis*. Neither *B. jousseaumei*, *B. globosus* nor *B. umbilicatus* were found in our surveys. 2. A survey for urinary schistosomiasis was carried out in 100 villages (*walo*, near the Senegal River) and 11 villages (*diéré*, away from the river) by delivering questionnaires in schools and by direct examinations of haematuria samples. The prevalence of haematuria varied between 0 and 33%. Generally, *walos* showed low rates of haematuria with the exception of Lampsar and Guédé Chantier, and *diérés* showed higher rates of haematuria. 3. Examination of 400 cattle at the abattoir St. Louis, revealed a prevalence of 80% of schistosome infection. Two species were present, *S. bovis* and less commonly *S. curassoni*. Sometimes high worm burdens were seen, but lesions appeared to be minimal because of high ratio of male to female worms. 4. Examinations of 5722 sheep and 1752 goats in the abattoir, Dakar revealed an overall prevalence of 2.1%. Of the infected animals, 97.3% were infected with *S. curassoni* and 2.7% with *S. curassoni* and *S. bovis*. – Laboratory snail infection experiments showed that *S. curassoni* is marginally compatible with *B. senegalensis*, but incompatible with *B. guernei*.

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**Key words:** Senegal; *Schistosoma curassoni*; *S. bovis*; *S. haematobium*.

## Introduction

At least four species of schistosomes occur in Senegal: *Schistosoma haematobium*, *S. mansoni*, *S. bovis* and *S. curassoni*. Human schistosomiasis caused by *S. haematobium* and ruminant schistosomiasis caused by *S. bovis* are both prevalent in the Senegal River Basin (Marill, 1961; Chaine and Malek, 1983). Recently, *S. curassoni* has been redescribed by Vercruysse et al. (1984) from isolates obtained from sheep and goats slaughtered in the abattoir at Dakar. Little is known, however, about the distribution of *S. curassoni* or whether the parasite is also a human pathogen as believed by Grétilat (1962, 1963). Many of the infected ruminants brought to the abattoir at Dakar were believed to have been reared in the Senegal River Basin. The present study was, therefore, carried out in order to gather data on the prevalence of schistosomiasis in both humans and domestic animals and to establish the patterns of distribution of potential intermediate hosts in the Senegal River Basin.

### *Study area: the Senegal River Basin (SRB)*

The Senegal River is the second largest river in West Africa, exceeded only by the Niger. It forms the northern border between Senegal and Mauritania. Geographically, the Senegal River Basin (SRB) may be divided into three regions: the Lower Valley (Delta), Middle Valley and Upper Valley (Fig. 1). The Lower Valley is a flat delta extending East from the Atlantic port city of St. Louis for 200 km to the town of Richard-Toll. At the end of the dry season, when river flows are minimal, salt water intrudes upstream beyond Richard-Toll. An intake canal at Richard-Toll is linked to the Lac de Guier which acts as a reservoir for water supply to Dakar. The Middle Valley stretches east, then southeast for a distance of 500 km from Richard-Toll to the town of Matam near the Mali border. It lies in a shallow alluvial plain 10 to 20 km wide, surrounded by semi-desert. Upstream from Matam, the river basin extends southeast to south in a narrow deeper basin, termed the Upper Valley. The latter lies almost entirely within the boundaries of Mali, and is therefore not considered here.

The SRB is semi-arid with average rainfall varying from a minimum of 100 mm (Podor) to a maximum of 600 mm (Matam). The rainy season usually occurs from July to September. The average temperature is 28° C, with a range from 22°–38° C. Monsoon failures are not infrequent in the Delta and Middle Valley, with serious consequences for food production. The widely publicized drought in the Sahel region in the early 1970's, and less well known more recent rain failures, were disastrous to the economy of the SRB, much of which lies in the Sahelian Zone. Such climatic factors also play an important role in the prevalence and distribution of parasite infections and arthropod vectors of disease in the river basin communities.



Fig. 1. Senegal in relation to other West African countries and the Senegal River Basin (□ area).

Two million people inhabit this region (Moulinier and Diop, 1974). Villages are categorized as to their source of water; those using river water are classified as *walo* (practizing flood water recession agriculture); those using wells and temporary rain-fed pools, are *diéré* (rain-fed agriculture).

In addition to arable farming, animal breeding is important to the region. It is estimated that there are some 500,000 cattle (zebus), 500,000 sheep and 250,000 goats (source: Veterinary services, 1977).

Finally, it is of interest to note that near St. Louis a dam is under construction (to be finished in 1985) which will block salt water intrusion during the dry season and create a reservoir for agricultural irrigation and industrial installations. The impact of the dam on public health aspects has been assessed by the U.S. Agency for International Development (Miller, 1981).

## Materials and Methods

Four field surveys were carried out: a snail survey, a village survey for human schistosomiasis, a cattle survey at St. Louis slaughterhouse and a sheep and goat survey at Dakar slaughterhouse.

### 1. Snail survey

During 1982–1983, snail surveys were carried out in various parts of the river itself, in temporary rain-fed pools, swamps, irrigation canals and drains, ricefields and the Lac de Guier. One objective was to determine the geographical distribution within the basin, of potential intermediate hosts of schistosomes, and to follow their seasonal prevalence.

Morphological examination and enzyme analyses of the snails were carried out to determine their specific identity. All samples of *Bulinus* spp. were examined weekly for natural infection with schistosomes for one month post-collection. Schistosomes were identified by infection of laboratory animals and subsequent examination of adult worms.

## 2. Village survey

A preliminary study showed the absence of *S. mansoni* and its intermediate host (*Biomphalaria* spp.), thus confirming the observations of Chaine and Malek (1983) who surveyed a total of 692 stool samples from the SRB, all of which were negative for *S. mansoni*. However, *S. haematobium* is endemic throughout the river basin and its prevalence was investigated in two ways:

- a) Questionnaire in schools for children aged between 5 and 15 years for the presence of haematuria, a recognized clinical feature of infection by *S. haematobium*, and as shown by Mott et al. (1983), a sensitive indicator. Between St. Louis and Matam, more than 100 villages classified as *walo* (near the river) and 11 villages (Forages) classified as *diéré* were visited and 30 children questioned in each village. The aim of this survey was to identify probable transmission areas of *S. haematobium*.
- b) Confirmation of the presence of *S. haematobium* by examining the haematuria samples for the presence of eggs by sedimentation. *S. haematobium* from man (Guédé Chantier) was established in the laboratory for comparative studies by exposing *Bulinus wrighti* to miracidia and then exposing hamsters to the cercariae.

## 3. Cattle schistosomiasis

A preliminary investigation showed that diagnosis of schistosomiasis based purely on clinical symptoms and egg excretion in faeces was difficult. All animals were undernourished and in poor condition and egg excretion was very low. Therefore, infections were identified (during 1981–1982) by examining for adult worms the mesenteric veins of 400 animals processed at the St. Louis slaughterhouse.

## 4. Sheep and goat schistosomiasis

Similar problems to those in cattle were encountered when diagnosing schistosomiasis in small ruminants: i.e. no obvious clinical symptoms and very low rate of egg excretion. Apart from some ( $n = 30$ ) sheep and goats actually slaughtered in the north, prevalence of schistosomiasis was based on animals examined at the Dakar slaughterhouse. It is assumed from conversations with owners that the vast majority of animals slaughtered in Dakar originated from northern Senegal.

During 1981–1983, a total of 7474 animals (5722 sheep and 1752 goats) were examined. Infection was diagnosed by finding eggs in fresh scrapings of the rectal mucosa and/or the presence of adult schistosomes in the mesenteric veins (Verercuyse et al., 1984).

## 5. Laboratory studies

In order to determine the bulinid species capable of acting as intermediate hosts for *S. curassoni* in the SRB, *Bulinus guernei* and *B. senegalensis* were exposed individually to 2 to 4 miracidia for 12 h and maintained in the laboratory for at least 60 days. The snails were examined for emerging cercariae 21 days post-exposure.

# Results

## 1. Snail survey

Three bulinid species, presumed or proven to be vectors of *Schistosoma* spp. in the SRB were commonly found: *B. guernei*, *B. senegalensis* and *B. forskalii*. The distribution of the first two species is shown in Fig. 2.

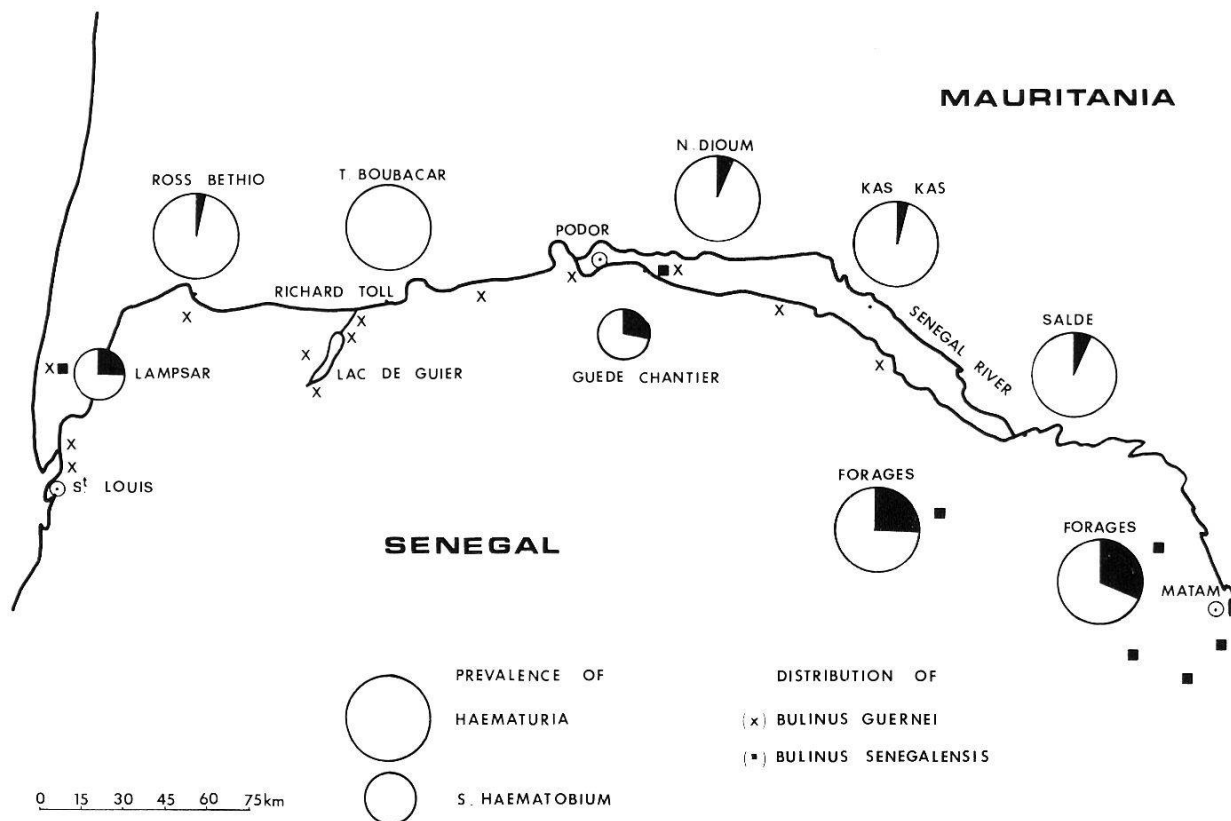


Fig. 2. Distribution of *Bulinus guernei* (X) and *Bulinus senegalensis* (■). The prevalence of haematobia and *Schistosoma haematobium* in the Senegal River Basin.

*B. guernei* is the most common snail found in the SRB. It is generally found in the delta and Middle Valley, throughout the year in permanent breeding places, e.g. large ponds, irrigation canals, drains, swamps and marigots and the shore lines of Lac de Guier. *B. guernei* does not occur in the main river bed. Three factors probably mitigate against colonization of the river: the high salinity of the water at certain times of the year, the strong current of the flood stage and the general absence of vegetation and debris at the edge of the river.

*B. guernei*, belonging to the *B. truncatus/tropicus* complex, occurs in the Senegal/Mali region and several authors have reported it transmitting *S. haematobium* (Grétilat, 1961; McCullough and Duke, 1954; Smithers, 1956) and *S. bovis* (Chaine and Malek, 1983). Of 220 *B. guernei* collected throughout the SRB, none was infected. Of 162 *B. guernei* collected from Guédé Chantier and sent to British Museum (London), 7 were dead on arrival, 66 were immediately preserved for malacological studies and three of the remaining 95 snails shed schistosome cercariae. Mice and hamsters were individually exposed to cercariae emanating from each of the three infected snails. Only adult male worms were recovered, but examination of acid phosphatase using isoelectric focusing demonstrated that the worms were *S. bovis* and not *S. haematobium* (Southgate et al., 1980).

*B. senegalensis*, belonging to the *B. forskalii* complex, occurs mainly in

temporary laterite pools of the eastern part of the Middle Valley and in the ricefields of Lampsar and Guédé Chantier. This species is not as uniformly distributed as *B. guernei*.

*B. senegalensis* appears to have an intrinsic requirement for aestivation (Goll, 1981; Betterton et al., 1983). Surface waters in the form of rain-fed laterite pools and ricefields are the primary transmission sites. In these laterite pools, at the beginning of the rainy season there is a rapid expansion of the snail population (July) which decreases at the beginning of the season (October-November), when the pools dry up. Under these conditions, the ability to aestivate is essential for survival. As the ricefields are irrigated, the occurrence of *B. senegalensis* does not depend solely on the rains but on the periods of rice cultivation (twice a year).

Several thousand specimens of *B. senegalensis*, mostly from Guédé Chantier, have been examined but none has been found to be naturally infected. The snail is an intermediate host for *S. haematobium* (Smithers, 1956; Chaîne and Malek, 1983; Goll and Wilkins, 1984) and has been shown to be naturally infected with *S. bovis* in the Gambia (Smithers, 1956; Wright et al., 1979).

*B. forskalii* was collected in small numbers from the shore lines of Lac de Guier and Richard-Toll. None was found infected with schistosomes. *B. forskalii* is an intermediate host for *S. intercalatum* (Wright et al., 1972) and may locally contribute to the transmission of *S. bovis* (Southgate and Knowles, 1975).

Table 1. Results of questionnaire on haematuria in villages, by district (West to East)

District	Number of villages visited	Number of children		Children with haematuria (%)
		questioned	positive for haematuria	
<i>Walo</i>				
Ross Bethio <sup>a</sup> . . . . .	22	661	13	2.0
Thille Boubacar . . . . .	26	780	0	0
N'Dioum <sup>b</sup> . . . . .	22	660	22	3.3
Kas Kas . . . . .	12	331	6	1.8
Salde . . . . .	22	662	32	4.8
Lampsar* . . . . .	1	104	26	25
Guédé Chantier* . . . . .	1	142	47	33.1
<i>Diéré</i>				
Forages . . . . .	11	327	89	27.2

\* Results on Lampsar and Guédé Chantier are based on the presence of *S. haematobium* ova in the urine samples.

<sup>a</sup> not including Lampsar

<sup>b</sup> not including Guédé Chantier



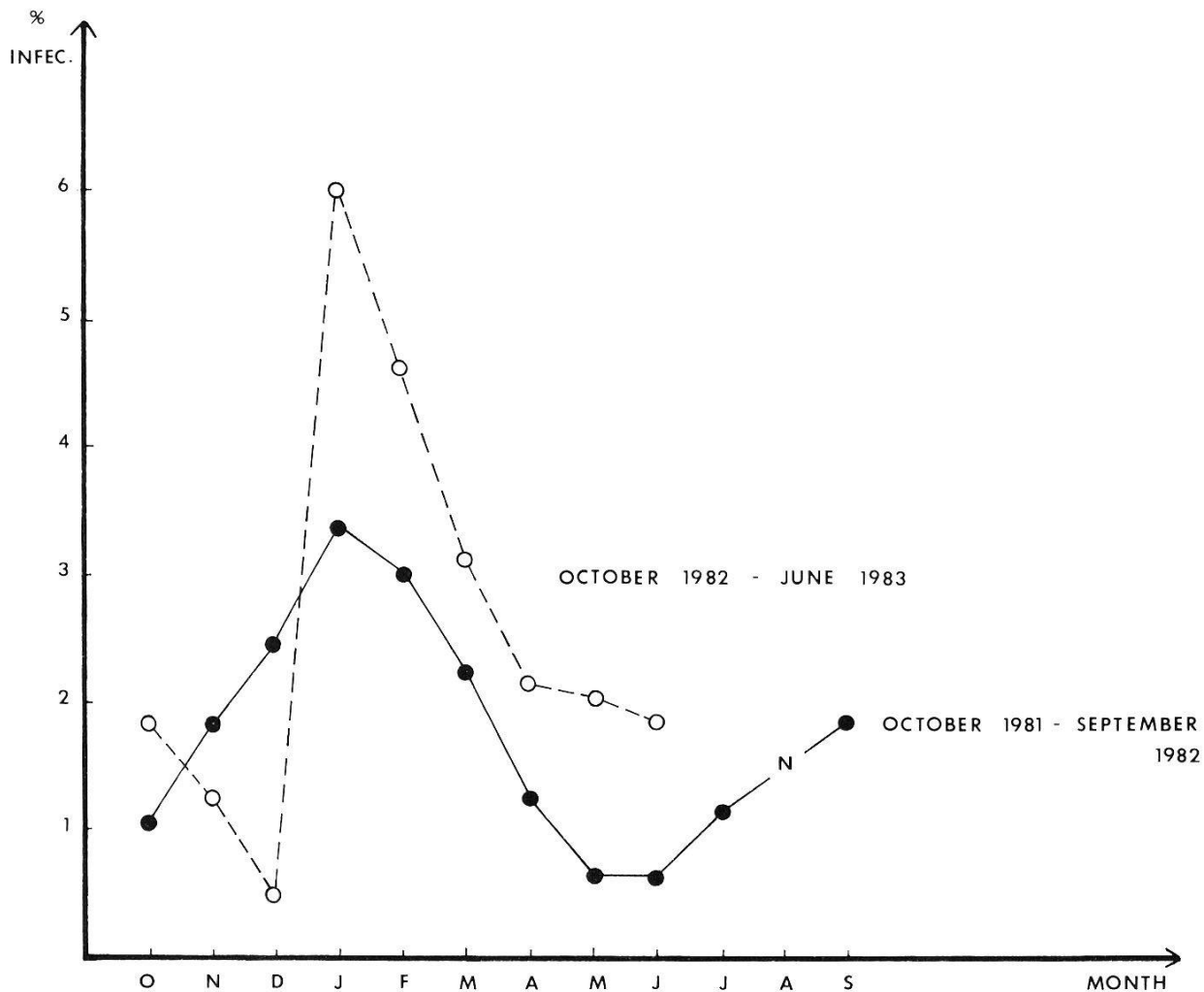


Fig. 3. Prevalence of *Schistosoma* in sheep at the Dakar abattoir, October 1981 to September 1982: 1821 sheep; October 1982 to June 1983: 3901 sheep.

Two other species, *B. jousseaumei* and *B. globosus*, although recorded in small numbers by Chaîne and Malek (1983) were not found. It is known that another species belonging to the *africanus* complex, namely *B. umbilicatus* (Diaw, 1984), also occurs in Senegal. Although *B. umbilicatus* is more commonly found in the South-Eastern part (Tambacounda area), it has been found in the SRB Ourossogui-Matam route (Diaw, 1984).

## 2. Human schistosomiasis

There was wide variation of haematuria between villages, ranging between 0 and 33% (Fig. 2, Table 1). Children from villages close to the river (*walo*) showed low rates of haematuria with the exception of two communities, Lamp-sar and Guédé Chantier. These two villages are characterized by the presence of extensive ricefields originally established in 1940 by the Chinese. In villages situated further from the river, practicing rain-fed agriculture (*diéré*), children showed higher rates of haematuria. Thus, by correlation of haematuria with vesicular schistosomiasis, it is deduced that with the exception of Lamp-sar and



Guédé Chantier there was a lower prevalence of schistosomiasis in the communities of villages close to the river (*walo*) than in those situated further away from the river (*diéré*).

### 3. Cattle schistosomiasis

Cattle slaughtered at St. Louis mostly originate from the environs of Lac de Guier. Of the 400 cattle examined, 80% were infected, some individuals with very high worm burdens. Two species were present, *S. bovis* and *S. curassoni*, the latter less commonly occurring in 7.5% of the animals examined. Despite the occasional very high worm burden, lesions were minimal. This could possibly be explained in part by the fact that in animals with a heavy infection of *S. bovis*, there was commonly an abundance of male worms with very few females. *S. bovis* was identified either by examining the shape and size of the intrauterine eggs in paired female worms or by examining the acid phosphatase isoenzymes using isoelectric focusing (Southgate et al., 1980; Southgate et al., in press).

### 4. Sheep and goat schistosomiasis

The results on sheep and goat schistosomiasis are based on slaughterhouse animals at the Dakar abattoir. A total of 7474 animals (5722 sheep and 1752 goats) was examined; the overall prevalence was 2.1% (145 sheep and 12 goats). The size and shape of the eggs were noted in 112 animals (103 sheep and 9 goats). Nine goats and 100 sheep were infected with *S. curassoni* (97.3%) and three sheep were infected with *S. curassoni* and *S. bovis* (2.7%) (Vercruysse et al., 1984). The prevalence of *S. curassoni* infection in the animals examined in the abattoir varied from 6% in January to 1% in May (Fig. 3).

### 5. Laboratory snail infection experiments

A total of 300 uninfected *B. guernei* and 375 *B. senegalensis* were exposed in Senegal to *S. curassoni*. None of the *B. guernei* snails became infected, but two *B. senegalensis* shed cercariae 26 days p.i. Mortality of *B. senegalensis* in the laboratory was high, with only 30% of those exposed to miracidia surviving 30 days.

## Discussion

This study on the epidemiology of human and animal schistosomiasis in the SRB revealed several interesting points. The study showed that villages in the Delta and in the *walo* of the Middle Valley were almost free of schistosomiasis. It is believed that the few cases found in the *walo* of the Middle Valley were acquired elsewhere. Cisse et al. (1983) showed that the villages around Lac de Guier were free of *S. haematobium*. This corroborates the observations of Chaîne and Malek (1983). In all of these places, *B. guernei* was abundant. This, coupled with the fact that it was not possible to produce patent infections of

*S. haematobium* in *B. guernei* in the laboratory (Southgate et al., in press) suggests that *S. haematobium* from the SRB is incompatible with *B. guernei*, thus supporting the assumptions of Chaine and Malek (1983). On the other hand, Smithers (1956) isolated two snails from the Kumbija bolon (Upper River Division, The Gambia) infected with *S. haematobium* and Grétilat (1961) found infection rates of *B. guernei* varying between 2 and 8% from seven different transmission foci in Senegal. However, Grétilat's (1961) observations are open to criticism because he based his identification only on sporocysts and cercariae. Interestingly, Southgate et al. (in press) reported *S. haematobium* to be compatible with *B. umbilicatus*, a species found in Senegal but not so far in our survey area of the SRB.

The prevalence of haematuria and therefore schistosomiasis in two *walo* villages (Lampsar and Guédé Chantier) and the *diéré* was much higher than in the other *walo* villages examined. Distribution of the infection in these places could be correlated with specific ecological conditions. Lampsar and Guédé Chantier are both characterized by the presence of extensive irrigated ricefields which supported large populations of *B. senegalensis*, thus agreeing with Goll's (1981) observations that this species is not only confined to laterite pools, but that irrigated rice cultivation is likely to provide new habits for *B. senegalensis* to become established. The presence of *B. senegalensis* in the rice fields is of great interest with regard to the impact of the dam under construction near St. Louis, on transmission patterns of urinary schistosomiasis. A feasibility study carried out by U.S. AID and OMVS (Organisation pour la mise en valeur du Fleuve Sénégal) (Miller, 1981) quoted: "... one cannot state which assurance how the planned expansion of irrigated perimeters in the Senegal River Basin will affect the prevalence of human schistosomiasis but the possibility exists there will be little or no increase. This bodes well for the proposed further development of 24,000 ha for rice crop on completion of this barrage." On the contrary, our results show that the possibility exists for *B. senegalensis* to become established in the ricefields with a concomitant increase in urinary schistosomiasis. Regular surveillance for new foci of *S. haematobium* in the ricefields, once created, is strongly advised.

For the *diéré* villages, the primary transmission sites are the rain-fed laterite pools which are also colonised by *B. senegalensis*.

The high prevalence of schistosomiasis in cattle must be correlated with intensive transmission foci. The cattle slaughtered at the St. Louis' abattoir originate primary from the Lac de Guier region. *B. guernei*, and, to a lesser extent, *B. forskalii* are present in the region. Both species have been cited as intermediate hosts of *S. bovis* (Chaine and Malek, 1983). The fact that naturally infected *B. guernei* have been found, and are compatible with *S. bovis* in the laboratory, strongly suggests that *B. guernei* is the primary intermediate host of *S. bovis* in the SRB (Southgate et al., in press).

The results presented here on the prevalence of *S. bovis* are in accordance

with those of Marill (1961) who also found a prevalence rate of 80% of *S. bovis* in cattle examined at St. Louis. However, the rate varied between 2 and 100% in cattle from other villages along the SRB which might reflect the distribution of the snail fauna.

Surveys on the prevalence of *Schistosoma* spp. in sheep and goats in Senegal are scarce. Marill (1961) found 46 out of 151 (30.4%) sheep examined positive for *S. bovis* in northern Senegal. Prevalence varied between 20 and 100% in different villages. Grétilat (1963) described *S. curassoni* from sheep and goats in Senegal, but failed to provide any information on prevalence.

The low prevalence and low intensity of *S. curassoni* infections in sheep and goats could be explained by the fact that the goats and sheep slaughtered at the Dakar abattoir may not have necessarily originated from areas where transmission of *S. curassoni* is occurring. The excellent compatibility between *S. curassoni* and *B. umblicatus* in the laboratory is a strong indication that this snail may be important in the epidemiology of the disease (Southgate et al., in press). If *B. senegalensis* is also involved, then transmission would be limited to the periods of the rains unless transmission is occurring in cultivated ricefields. Clearly, future field studies should be directed towards mapping the distribution of *B. umblicatus* and examining snails for natural schistosome infections. It is conceivable that *S. curassoni* is much more widely distributed throughout Africa than hitherto realized.

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