Journal of Helminthology (1997) **71**, 125–132

Schistosomiasis in the Senegal River Basin: before and after the construction of the dams at Diama, Senegal and Manantali, Mali and future prospects

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Abstract

Ecological changes in the Senegal River Basin (SRB) resulting from the construction of a barrage at Diama, Senegal on the Senegal River to prevent the intrusion of sea water into the river, and a dam at Manantali, Mali on the Bafing River to control the flow of water and to generate electricity, have been responsible for changes in the epidemiology of human schistosomiasis. The introduction of *Schistosoma mansoni* into the Lower and Middle Valleys of the SRB and subsequent spread of the parasite in the human population is recorded with regard to prevalence and intensity. New foci of *S. haematobium* are described. The reduction in salinity and change from an acidic to an alkaline environment in the water are beneficial to both the fecundity and growth of freshwater snails and transmission of the parasite. The creation of new irrigation canals and expansion of the rice fields have provided new habitats for intermediate hosts to colonize. The evidence for praziquantel resistance/tolerance by populations of *S. mansoni* and the possibilities of the development, production and testing of a vaccine against human schistosomiasis are discussed. Future studies will monitor the spread of human urinary and mesenteric schistosomiasis in the SRB, will evaluate further the presence of praziquantel resistance/tolerance in *S. mansoni*, will examine the heavily infected human population for pathological symptoms and determine the most appropriate methods to control this severe outbreak of human schistosomiasis.

Introduction

A widespread form of economic progress in the developing world is the building of dams and irrigation schemes, which are usually supported by international organizations such as the World Bank. Nevertheless, sometimes negative health effects detrimental to the local community accompany such schemes. In order that the balance is in favour of agricultural, economic progress, hence the improvement of living standards, pre-development assessments are carried out to forecast adverse health and environmental consequences, so that appropriate measures can be taken to mitigate and prevent such problems emerging. Each development programme has its own idiosyncracies and it is not always easy for a favourable balance between economic development and health hygiene to be achieved: one such scheme is in operation in the Senegal River Basin (SRB), where the balance between beneficial and detrimental aspects is changing with time.

Geography

The Senegal River is the second largest river in West Africa after the Niger, forming the border between Senegal and Mauritania. The SRB may be divided into three regions; the Lower Valley, the Middle Valley and the Upper Valley. The Lower Valley is a flat delta extending from the Atlantic port city of St Louis for approximately 170 km to

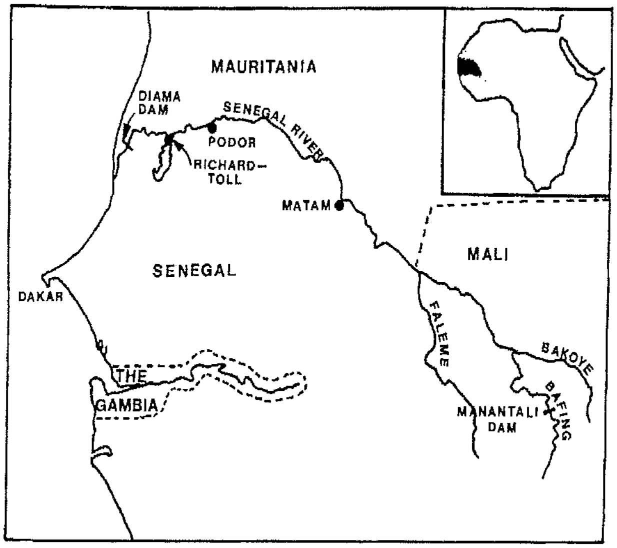

Fig. 1. A sketch map of the Senegal River Basin showing the positions of the dams at Diama and Manantali.

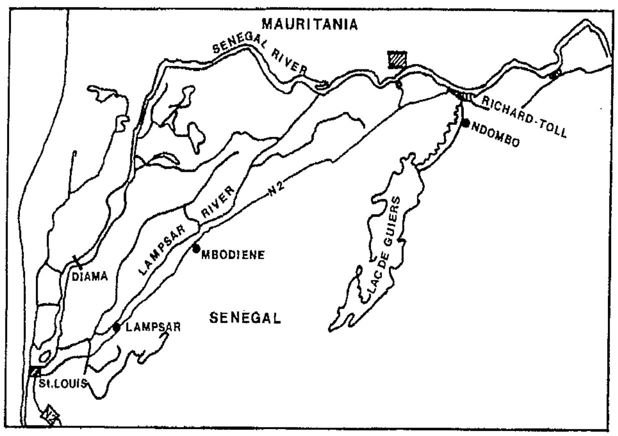

Fig. 2. A sketch map of the Lower Valley and part of the Middle Valley of the Senegal River Basin. Note the Lampsar River and the link between the Senegal River and the Lac de Guiers.

Richard-Toll. At Richard-Toll, an intake canal, the Taouey Canal, is linked to the Lac de Guiers: the lake acts as a reservoir to supply water to Dakar. The Middle Valley stretches east for a distance of about 500 km from Richard-Toll to Matam. It lies in a shallow alluvial plain 10 to 20 km wide: the region is typical sahelian with less than 300 mm of rain water per year. The Upper Valley is upstream from Matam, where the river extends southeast to south in a deep, narrow basin, most of which lies within the boundaries of Mali (fig. 1)

Villages in the river valley are categorized according to their source of water: those using wells and temporary rain-fed pools are classified as 'diéri' (rain fed agriculture) whereas those using river water are classified as 'walo' (flood water recession agriculture). The Woloff, a sedentary population, traditionally practise flood water recession agriculture; the Toucouleurs are subsistence farmers living in established villages, especially in the Middle Valley; the Peuls and Maures are nomadic groups, herdsmen and depend upon rain fed agriculture. The 'walo' stretches between the east-west main road and the river, and the 'diéri' is to the south of the east-west road (fig. 2).

Pre-dam construction

After the droughts in the early 1970s which were disastrous to the economy of the Senegal River Basin, the states of Mali, Mauritania and Senegal jointly established the Organisation pour la Mise en Valeur de Fleuve Senegal (OMVS) in order to develop and use resources of the Senegal River lying within their borders. Subsequently an integrated development scheme was designed which considered the construction of two dams, a barrage at Diama, about 40 km from the mouth of the Senegal River, to prevent the intrusion of salt water into the river at times of low water levels, and a dam on the Bafing River, Mali, a tributary of the Senegal River, to create a water reservoir–river navigation, an ocean port for Mali, agricultural irrigation, and also for the generation of hydroelectricity. The salinity levels of the river water were too high in the Lower Valley for the water to be used for irrigation for agricultural purposes

In 1976, the US Agency for International Development (USAID) and OMVS signed an agreement for a multidisciplinary assessment study to: (i) evaluate the interrelated effects of the environment caused by the development in the Senegal River Basin; (ii) optimize the long term benefits by insuring that environmental and social factors have been identified and included in the cost-benefit analysis of individual projects; and (iii) provide the OMVS riparian states with a plan of action for formulating programmes and projects that might mitigate adverse environmental effects and capitalize on those deemed beneficial.

The conclusions of the assessment study with regard to schistosomiasis were that transmission of urinary schistosomiasis (*S. haematobium*) in the delta was at a very low level, and mesenteric schistosomiasis (*S. mansoni*) did not occur (see Miller, 1982). Malek & Chaine (1989) documented the prevalence rates of urinary schistosomiasis in the SRB from 1908 onwards, and noted generally that the highest prevalences were found in the nomadic tribes who they concluded were important in disseminating the disease throughout the region. The following reasons were given in the assessment study to explain the low prevalences of *S. haematobium* and absence of *S. mansoni* in the Lower and Middle Valleys: (i) the low-density human population of the delta; (ii) little contact of the population with snail infested waters; (iii) the possibility that the 'strain' of *Bulinus guernei* syn *B. truncatus* in the delta is an inefficient intermediate host for the strain of *S. haematobium* in the Senegal River Basin; and (iv) that the waters are harmful to schistosome larvae (miracidia) because the river water is acidic with a pH 6 or below. Survey studies demonstrated that human schistosomiasis was more prevalent in the communities practising rain-fed agriculture (diéri), living some distance from the main river, which agreed with earlier observations (see Malek & Chaine, 1989). The source of

Fig. 3. The Diama dam preventing the intrusion of sea water into the Senegal River during the dry season.

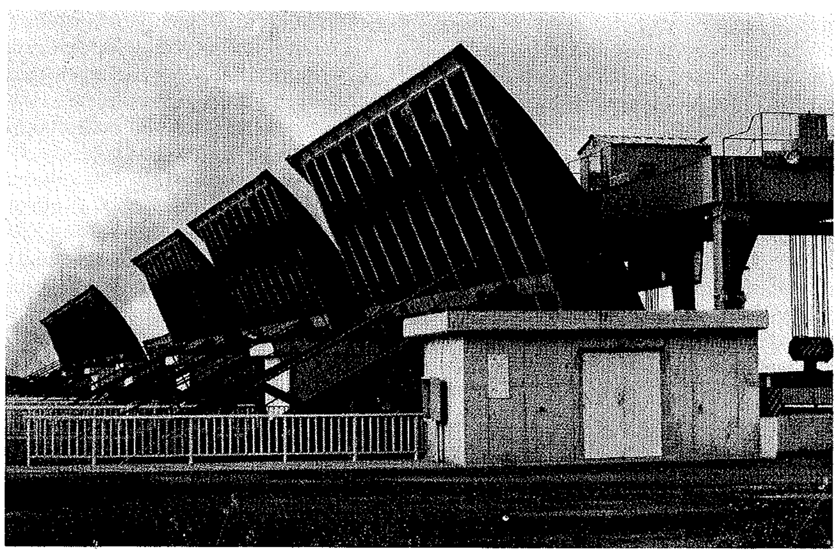

Fig. 4. The Diama dam with barriers raised to allow flood water from the river into the sea during the wet season.

infection was considered to originate from temporary laterite pools that fill during the rainy season and dry up during the dry season. Interestingly, no *Biomphalaria pfeifferi* were found during the assessment study and it was considered that mean daily temperatures of 30°C or higher prevented the establishment of viable populations of *B. pfeifferi*. Analysis of water levels in the Bafing River, near Manantali, showed an annual fluctuation of 13 m: sudden changes of water level are unfavourable to freshwater snail populations as the chances of dehydration are increased. Miller (1982) stated 'One cannot state with assurance how the planned expansion of irrigated perimeters in the Senegal River basin will affect the prevalence of human schistosomiasis. The possibility exists there will be little if any increase. Nevertheless, future surveillance for evidence of enhanced transmission is advisable.' The go ahead was given for the construction of the dams at Diama, Senegal and Manantali, Mali.

Chaine & Malek (1983) showed that all villages in the SRB and in the 'walo' had low levels of urinary schistosomiasis. Cisse *et al.* (1983) found no cases of *S. haematobium* infection in the villages in the environs of Lac de Guiers, where *B. truncatus* was abundant. *Bulinus truncatus* plays an important role in the epidemiology of *S. haematobium* in many parts of West Africa, but Southgate *et al.* (1985) reported *S. haematobium* from the Lower Valley to be incompatible with *B. truncatus.* Vercruysse *et al.* (1985) showed that the prevalences of *S. haematobium* was much higher in the 'diéri', and two 'walo' villages, Lampsar and Guédé Chantier, than in the remainder of the 'walo' villages. The comparatively high prevalences in Lampsar and Guédé Chantier were considered to be correlated with specific ecological conditions, that is, the presence of extensive irrigated rice fields which provide excellent habitats for *B. senegalensis,* an intermediate host for *S. haematobium.* However, later studies by Belot *et al.* (1993) and Picquet *et al.* (1996) failed to confirm the presence of *B. senegalensis* in the environs of Lampsar, hence the relatively high prevalence rates of *S. haematobium* pre-Diama dam may have been related to the fact that several small barrages had been constructed some 50 years earlier on the Lampsar river to prevent salt water intrusion, allowing *B. globosus* (a compatible intermediate host of *S. haematobium*) to become established. Water of the Lampsar river was used as a reservoir for St Louis and to irrigate the adjacent rice fields. Nevertheless, in the 'diéri' the primary transmission sites are the rain fed laterite pools which are often colonized by *B. senegalensis,* and this species is also found extensively in the rice fields in the environs of Podor.

Post-dam construction

The Diama dam was completed in 1985 (figs 3,4), and the Manantali dam in 1989. Eggs of *S. mansoni* were first noted in stool examinations in 1988 at Richard-Toll, 130 km from the dam at Diama, indicating for the first time that ecological changes caused by the dam were having an impact on the prevalence of schistosomiasis (Talla *et al.*, 1990). Intestinal schistosomiasis had never been previously reported in the delta of the Senegal River Basin, but by the end of 1989, out of 3926 stool samples examined from patients originating from Richard-Toll, 49.3% were positive. A community based prevalence study in 1990 in Richard-Toll showed that 60% of the subjects were positive (Talla *et al.*, 1992). Such data were indicative of a remarkable change, in a period of only two years, occurring in the epidemiology of intestinal schistosomiasis. Malacological field studies demonstrated that *B. pfeifferi* represented approximately 70% of all the freshwater snails collected at three different sites in the environs of Richard-Toll (Talla *et al.*, 1990), and the overall infection rate in *B. pfeifferi* collected from ten different sites in the environs of Richard-Toll was 44% (Diaw *et al.*, 1991) (fig. 5). Some of the earlier studies had demonstrated the presence of *B. pfeifferi* at different times in various habitats in the Lower and Middle Valleys of SRB, but always very sparsely distributed and with small populations (Diaw, 1980; Chaine & Malek, 1983; Schneider & Malek, 1984; Malek & Chaine, 1989). Clearly the ecological changes after construction of the dam at Diama had enabled *B. pfeifferi* to flourish and spread, a vital prerequisite for the outbreak of intestinal schistosomiasis. Diaw *et al.* (1990) pointed out a proliferation of *B. pfeifferi* in the delta of the Senegal River Basin, and later mentioned that the Taouey Canal and marigot, the canal and drains of the 'Compagnie Sucrière Sénégalaise' are the main transmission sites of *S. mansoni* in the environs of Richard-Toll. The WASH (1994) snail team found infected *B. pfeifferi* in the delta on the Mauritanian bank of the river.

The first signs of a changing distribution of *S. haematobium* infection in the delta were noted in 1989 in Mbodiene when villagers reported that some children had blood in their urine (Verlé *et al.*, 1994). Mbodiene is a small village, adjacent to the national road (N2) and a small irrigation canal, about 1 m wide: it is situated between St Louis and Richard-Toll. The canal is used by the villagers for domestic and recreational purposes. About 90% of the population of Mbodiene belong to the Woloff ethnic group and, of the 352 subjects examined, 87% were found to be infected with *S. haematobium.* Approximately one third of the infected population had more than 50 eggs/10 ml urine. In children and young adults (under 20 years of age) relatively more heavy infections (over 50 eggs/10 ml

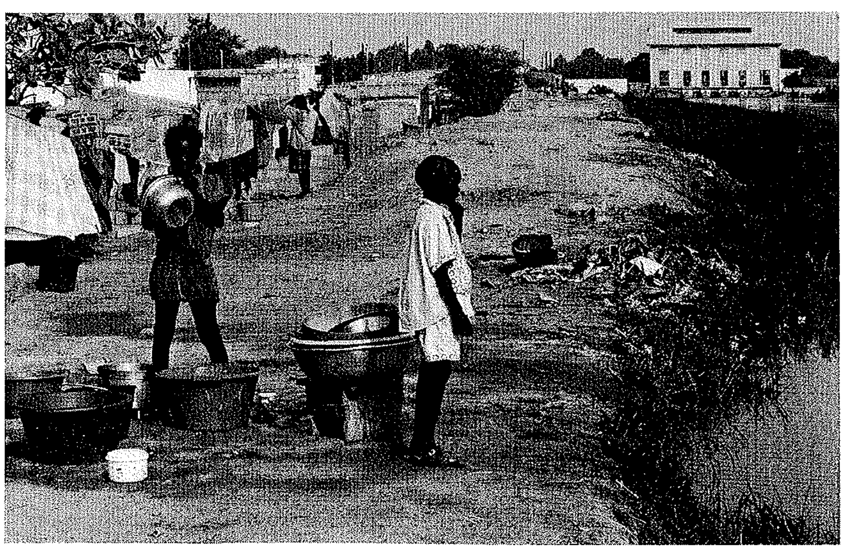

Fig. 5. A transmission site of *Schistosoma mansoni* at Richard-Toll, Senegal.

urine) were found in those people 20 years or older. According to villagers, bloody urine was unknown in the village before 1989.

Picquet *et al.* (1996) carried out an extensive survey of the prevalence and intensity of mesenteric and urinary human schistosomiasis between January 1994 and March 1995, examining 7750 people from a total of 180 villages and four towns (ten districts) of the Lower and Middle Valleys of the SRB. The data showed that *S. mansoni* occurs in 18%, 72%, 96%, 100% and 79% of the villages of the Lower delta, Senegal River; Lower delta, Lampsar River; Upper delta, Senegal River; Lac de Guiers and Diéri, respectively. The mean prevalence ranged from 4.4 ± 1.0 in the villages of Lower delta–Senegal River to 71.8 ± 11.3 eggs/g in the villages of the Lac de Guiers. No *S. mansoni* was found in the Middle Valley. In contrast, *S. haematobium* was detected in 24%, 86%, 17%, 6%, 17%, 34% and 7% of the Lower delta–Senegal River; Lower delta–Lampsar River; Upper delta–Senegal River; Lac de Guiers; the 'walo' villages of the Middle Valley; and the 'diéri' villages of the Middle Valley, respectively. The mean prevalence of *S. haematobium* varied between 1.5 ± 0.5 and 51.6 ± 26.7 eggs/10ml urine in the 'diéri', and in the 'diéri' of the Middle Valley, respectively. It is remarkable that since the first observations of *S. mansoni* in 1988 in Richard-Toll that the parasite has spread so quickly through the populations of parts of the Lower Valley of the Senegal River Basin that some areas, for example, Ndombo, near Richard-Toll, is now recognized as one of the most intense foci recorded with respect to prevalence and intensity (Stelma *et al.*, 1994). More recently, Picquet *et al.* (1996) have recorded mean intensities of 1793 ± 848 eggs/g in the population around Lac de Guiers. Despite these extremely intense infections of *S. mansoni*, there is a relatively low frequency of liver and spleen enlargement according to a preliminary ultrasound study (Rouquet *et al.*, 1993). Stelma *et al.* (1994) considered that the virtual absence of serious organomegaly in people carrying heavy infections may be associated with the fact that the focus in the Senegal River Basin is comparatively young: bilharzial organomegaly is usually seen in groups between 10 and 20 years old, but the focus in Richard-Toll is only 7–8 years old, so the development of pathology is likely to become more apparent within the next 2–3 years. An ultrasonography study conducted in September–October 1993 of 190 people from Ndombo showed that the high intensities of infection were not paralleled by severe hepatosplenic morbidity. People who had been treated with praziquantel on a previous occasion had lower morbidity despite being heavily infected. Thus, antischistosomal treatment appears to reduce hepatic morbidity although it does not prevent reinfection (Kardoff *et al.*, 1996). However, the most recent study, carried out in 1994, showed that the overall prevalence of splenomegaly and hepatomegaly in a sample of the population of Ndombo had increased to 36% (Stelma *et al.*, in press), thus confirming earlier predictions.

In other transmission foci, for example, Guadeloupe and Brazil, some species of rodents have been shown to play a rôle in the epidemiology of *S. mansoni* (Rey, 1993; Imbert Establet, 1986). Duplantier & Sène (unpublished) investigated whether rodents are involved in the epidemiology of *S. mansoni* in the environs of Richard-Toll. Over 2000 individuals belonging to six different rodent species and one insectivore species were examined over a period of three years commencing July 1990 for the infection with *S. mansoni*: only two murid species, *Arvicanthis niloticus* and *Mastomys huberti*, were found to be infected, with prevalences of approximately 5%. The mean parasitic load was about 20 worms per rodent. Interestingly, Duplantier & Sène (unpublished) showed that there was a decrease in prevalence the further a trapping station was situated from areas of human habitation. If a sylvatic cycle concerning only rodents occurred, Duplantier & Sène (unpublished) argued that the prevalences should be similar in different trapping areas, as the biotopes were similar to each other apart from the varying density of the human population. Hence it was concluded that rodents do not play a significant role in the transmission of intestinal schistosomiasis in Richard-Toll. Enzyme analyses using seven enzymes showed that that worms originating from humans and murids showed that all systems were polymorphic, but no significant variation could be detected in the worms from man and rodents. Thus, the enzyme data support the view that there are not two biologically distinct life cycles, maintained in rats and humans (Sène *et al.*, in press). In addition to the establishment of new transmission foci of *S. mansoni*, there has also been a significant increase in the prevalence and intensity of *S. haematobium* in the SRB, but not as marked as that of *S. mansoni*.

In the Lower and Middle Valleys of the Senegal River Basin, there are four species of schistosome, *S. haematobium*, *S. mansoni*, *S. bovis* and *S. curassoni*; five species of *Bulinus*, *B. truncatus*, *B. forskalii*, *B. senegalensis*, *B. globosus* and *B. umbilicatus*, and one species of *Biomphalaria*, *B. pfeifferi* (fig. 6). A combination of field data and laboratory snail infection experiments indicate that *Bulinus globosus* and *B. senegalensis* are the most important intermediate hosts for *S. haematobium*; *B. umbilicatus* is also compatible but has a somewhat restricted distribution in the SRB, whereas *B. truncatus* and *B. forskalii* are incompatible with *S. haematobium*. *Schistosoma mansoni* is transmitted by *Biomphalaria pfeifferi*. *Bulinus truncatus*, *B. forskalii* and *B. senegalensis* are compatible with *S. bovis*, whereas *B. umbilicatus* is compatible with *S. curassoni* The low prevalence of *S. curassoni* in cattle in the SRB may be correlated with the sparse distribution of *B. umbilicatus* (Vercruysse *et al.*, 1994)

What are the factors which have contributed to this introduction of *S. mansoni*, and the rapid expansion of both mesenteric and urinary schistosomiasis in the SRB? There is no doubt that the physical and chemical changes to the environment resulting from the construction of the Diama and Manantali dams have favoured the spread and increase of the snail intermediate hosts of *S. mansoni* and *S. haematobium*. The Diama dam prevents the intrusion of sea water into the Senegal river: before the Diama dam there was an intrusion of sea water, at times of low water levels, up to and beyond Richard-Toll. Freshwater, planorbid snails are adversely affected by salinity, for example, at salinities of one part per thousand there is a progressive elimination of gastropod species. Hence a reduction in salinity is clearly advantageous to the growth, fecundity and colonization of new habitats, particularly for *Biomphalaria pfeifferi* and *Bulinus globosus*, both of which

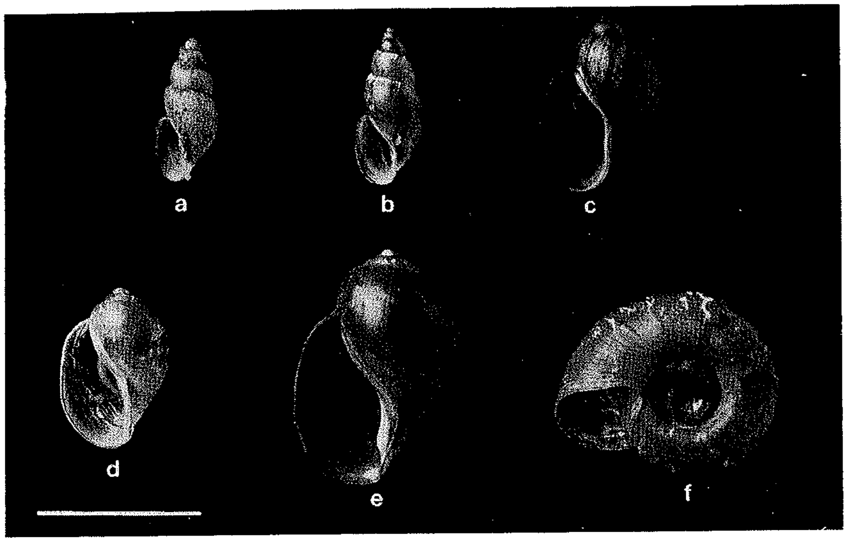

Fig. 6. Shells of the intermediate hosts of human and bovine schistosomiasis in the Senegal River Basin: a) *Bulinus forskalii;* b) *B. senegalensis;* c) *B. truncatus;* d) *B. umbilicatus;* e) *B. globosus;* f) *Biomphalaria pfeifferi.* Scale bar 5 mm

are less tolerant of salinity than *B. truncatus* (Donnelly *et al.*, 1983; Meir-Brook *et al.*, 1987). This fact affords an explanation as to why *B. truncatus* was the most widespread bulinid snail in the Senegal River Basin before the Diama dam. Salinity also adversely effects the transmission of the parasite, for Donnelly *et al.* (1984) showed that the survival of miracidia decreased progressively above 7/10³, and Christensen *et al.* (1979) showed that the ability of the cercariae of *S. mansoni* to penetrate the skin decreased at salinity levels above 2.4/10³. Thus, a reduction in levels of salinity is both beneficial to the intermediate hosts and to the parasites, increasing the efficiency of transmission. Measurements of pH at transmission foci in the Lower and Middle Valleys indicate a change from a more acidic environment, with a pH from about 6, to a more alkaline environment with a pH of 7–8: an alkaline environment is more favourable to freshwater snails from the point of view of growth and fecundity, whereas an acid environment results in a low reproductive potential for snails (Vercruysse *et al.*, 1994; Picquet *et al.*, 1996). The reasons for the apparent change in pH of the waters of the Senegal River Basin since the construction of the dams are not clear. The irrigated area in the SRB has steadily increased, from 12,000 ha in 1985 to 67,788 ha in 1994, providing additional habitats for *B. senegalensis.* Picquet *et al.* (1996), in a survey of 18 villages around Lac de Guiers, demonstrated that all villages were infected with *S. mansoni,* and one (Nder) was infected with *S. haematobium.* Prevalences and intensities of *S. mansoni* were higher on the eastern side of the lake (81.3% with a mean egg count of 2088 eggs/g) than on the western side (50.3%, with 111 eggs/g). The prevalence of *S. haematobium* in Nder was 27.7% and the fact that it is still highly restricted in Lac de Guiers suggests a very recent introduction. The changes in ecological conditions, specifically the reduction in levels of salinity, more stable water levels, water with a neutral or slightly alkaline pH have enabled *B. globosus* to become established in new habitats.

Chemotherapy

Chemotherapy is valuable tool in any schistosomiasis control programme. Praziquantel (a heterocyclic pyrazine-isoquinoline) is currently the drug of choice for the treatment of human schistosomiasis and, as it is highly efficacious and well tolerated in a single dose at 40 mg/kg body weight, it is sometimes used for morbidity control through population 'mass' treatment (Stelma *et al.*, 1995). Eggs are the major cause of pathology, and egg counts in urine and or faeces are severely reduced post treatment. However, whilst carrying out drug treatment and reinfection studies in a random sample of the population of Ndombo, near Richard-Toll, Stelma *et al.* (1995) noted that only 18% of those treated were cured after re-examining the treated population 12 weeks later. A number of factors were proposed to explain the low cure rate: rapid re-infection after treatment in a focus of high transmission; the presence of immature worms at the time of treatment (these are less susceptible to praziquantel than adult worms); low levels of anti-schistosome immunity in the recently exposed population (immunity may be required to enhance the activity of praziquantel); the possibility of resistance or tolerance to praziquantel. Indeed, antigen detection data indicated that in most non-cured patients adult worms did persist after treatment (Stelma *et al.*, 1995). Furthermore, Fallon *et al.* (1995) showed that an isolate of *S. mansoni* from Senegal was less susceptible to treatment with praziquantel than isolates from Kenya and Puerto Rico. It is well established that the larger the biomass of parasites, the greater the chances of a drug to fail (White & Olliaro, 1996). The intensities of infection with *S. mansoni* in the Senegal River Basin are some of the heaviest recorded, thus it is perhaps not surprising that praziquantel does not achieve a 100% cure rate. It is possible that within a population of schistosomes some individuals are more tolerant or resistant than others to praziquantel, so regular drug treatment may provide the necessary selection pressure to increase the frequency of drug resistant/tolerant worms in the population. Interestingly, there have been two reports of the selection of praziquantel resistance in *S. mansoni* in the laboratory (Fallon & Doenhoff, 1994; Ismail *et al.*, 1994). The apparent failure of praziquantel to produce the expected cure rates at the recommended dosage in some areas is cause for concern, but there have been no reports as yet of multiple drug resistance/tolerance in schistosomes, so the populations which exhibit resistance/tolerance to praziquantel are fully susceptible to oxamniquine and vice versa.

Vaccine research

Vaccine research and development for schistosomiasis are major areas of activity. A number of vaccine candidates (paramyosin, IrV-5, TPI, Sm23 and Sml4) have been identified, among which are the glutathione-S-transferases (GSTs). Immunization experiments with GST have shown a decrease in parasite fecundity and egg viability, and a reduction in worm burden resulting from challenge infection (Capron *et al.*, 1992). These results show promise for the reduction in both pathology and transmission potential. However, a recent meeting in Bethesda (April 22–23, 1996) of the Steering Committee on vaccines for schistosomiasis concluded that there is some way to go before the goal, an effective vaccine for schistosomiasis, is reached. An independent assessment by two different laboratories on the vaccine candidates with most potential showed that none reached the stated goal of an induction of 40% protection or better in mice. It was suggested that possibly the instability of formulations and inadequate control of antigens and adjuvants, before and after shipping, may have contributed to the disappointing results (TDR No.50, 1996). The major challenges will be focused on the choice of the most promising molecules or mix of molecules and their mode of presentation to achieve consistent, satisfactory results in laboratory animals which will lead to limited trials (Phase 1, and Phase 2) in the human population. It is likely that Senegal will be one of the countries, endemic for schistosomiasis, where trials will be conducted.

Future prospects

There seems little doubt on the evidence of the last 8 years that we are witnessing a major outbreak of human schistosmiasis, and perhaps schistosomiasis of domestic stock although this is less well documented. It is a rapidly evolving situation, especially from the spread of the disease and the development of the infections and pathology in man. It is imperative that monitoring continues throughout the Senegal River Basin, with regard to the spread of the intermediate snail hosts and colonization of new habitats as well as the creation of new transmission foci. For example, *B. truncatus* is the most widespread bulinid snail in the Lower and Middle Valleys, but is not involved in that particular locality with the transmission of *S. haematobium,* whereas the situation is quite different in Manantali where it is a host for *S. haematobium* (De Clercq, 1996). There must be an awareness of the possible introduction from migrating, infected people of a compatible strain of *S. haematobium* into the Lower and Middle Valleys which would simply further exacerbate the situation with regard to urinary schistosomiasis. It is important that ultrasound studies continue in the population thought to be most at risk from the point of view of developing severe pathology. The Senegal situation provides an ideal opportunity of creating a further understanding of the development of immune and pathological responses to infection over the course of time. Further studies, both in the field and in the laboratory, will be required to verify the levels of tolerance and potential development of resistance in populations of *S. mansoni* to praziquantel. From a public health viewpoint it may be necessary to investigate the value of multidrug chemotherapy: emphasis in many areas of the SRB will be on disease control, which hopefully will be an integrated approach including health education, provision of more water supplies and sanitation, chemotherapy and snail control by environmental manipulation. Good lines of communication and understanding will be required and maintained between different groups working in the Senegal River Basin, especially when they have different priorities, for example research and disease control.

Acknowledgements

The study was supported by the Commission of the European Communities Research Programme 'Life Science and Technologies for Developing Countries' (TS3-CT92-0117) and is associated with the ESPOIR programme for research and control of schistosomiasis in the SRB. Thanks to Mariama Sène and Marilyn Southgate for their helpful comments on the text, and to Mike Anderson and the Photographic Division, NHM, for their help in producing the figures. Finally, I am deeply indebted to Professor Donald Lee, University of Leeds, UK who introduced me to the fascination of parasitological research in 1965 at the Molteno Institute, Cambridge and Professor Dr Jozef Vercruysse, University of Gent, Belgium who introduced me to the people of the SRB in the early 1980s.

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(Accepted 19 February 1997)