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DISTRIBUTION AND EPIDEMIOLOGICAL ROLE OF SNAILS IN THE TRANSMISSION OF HUMAN AND ANIMAL SCHISTOSOMIASIS IN SENEGAL

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ABSTRACT

Four species of schistosomes of medical and veterinary importance have been identified in Senegal, *i.e. Schistosoma haematobium*, *S. mansoni*, *S. bovis* and *S. curassoni*. Malacological surveys carried out in the different regions of Senegal and during different periods of the year make it possible to study the ecology of intermediate host snails of schistosomiasis, as well as their distribution, their abundance and their epidemiological role.

The principal snails which are potential intermediate hosts of these schistosomes are *Bulinus globosus*, *B. umbilicatus*, *B. truncatus*, *B. forskalii*, *B. senegalensis* and *Biomphalaria pfeifferi*.

Field snail surveys and laboratory experiments allow us to establish their role in the transmission of schistosomiasis: *Bulinus senegalensis*, *B. globosus* and *B. umbilicatus* transmit *S. haematobium*; *Biomphalaria pfeifferi* is the intermediate host of *S. mansoni*; *B. forskalii*, *B. truncatus* and *B. globosus* transmit *S. bovis*, and *B. umbilicatus* and *B. globosus* are intermediate hosts of *S. curassoni*.

Particular studies have been done on the ecology and population dynamics of these snails as intermediate hosts of schistosomiasis, and the results are summarized as follows: (1) A two year study in the field on temporary ponds and laboratory experiments on the ecology and behaviour of *Bulinus* species have shown that *Bulinus umbilicatus*, *B. truncatus*, *B. globosus* and *B. senegalensis* have a certain ability to resist drought which lasted six to eight months; the ecological behaviour of these snails in the natural Sahel conditions (ponds are dry six to eight months per year) is very important in the epidemiology of human and animal schistosomiasis and requires a new strategy for control (2) In a recent foci of intestinal schistosomiasis in the Senegal river basin, *Biomphalaria pfeifferi* is widespread; it colonised the total hydrographic network (river, irrigation canals, drains, and marigots) with high densities, monthly observations show seasonal fluctuations regarding snail abundance and infection rate; the transmission was taking place in all waterbodies and throughout the year.

Major changes in water management and other ecological factors have caused an increase in snail habitats. So, these optimal conditions led to the development and spread of schistosomiasis in Senegal, particularly in the Senegal river basin

INTRODUCTION

Senegal is a country in the west African savannah with a vegetation stratification changing from desert in the north to tree savannah in the southern part. Major changes in the environment occurred during the last decades, marked by drought in the mid seventies and eighties, construction of two big dams (Diama and Manantali) on the Senegal river and smaller ones in the south (regions of Kolda and Ziguinchor), and also increased rainfall in the late eighties.

The change in water management and other ecological factors caused an increase of snail habitats, with optimal conditions permitting the snails to proliferate particularly in the Senegal river basin during the period 1989- 1990 (Diaw *et al.* 1990).

The snails of the genus *Bulinus* and *Biomphalaria* are the potential intermediate hosts of human and animal schistosomes. In Senegal, with the recognition of *Schistosoma curassoni* (Albaret *et al.* 1985), four schistosome species now must be considered to be endemic, the other ones being *S. bovis*, *S. mansoni* and *S. haematobium*. *S. bovis* and *S. curassoni* are found in cattle and are widespread in the country (Diaw & Vassiliades 1987), while the two human schistosomes, *S. haematobium* and *S. mansoni* are endemic throughout Senegal and limited in some areas, respectively.

The study of the snails which are intermediate hosts of these schistosomes, their distribution, their ecology and their role in the transmission, is fundamental for the epidemiology of schistosomiasis. In this paper we present some results of our malacological research in Senegal regarding the epidemiology of human and animal schistosomiasis.

MATERIALS AND METHODS

Malacological surveys carried out in the different regions of Senegal and in different seasons and periods of the year, make it possible to study the distribution and the epidemiological role of snails intermediate hosts of human and animal schistosomiasis.

Snails were collected from irrigated canals and drains, ponds, marigots, lakes and rivers. All freshwater habitats with human and animal contacts were screened. The search for snails was done using long handled sweep nets and by examination of submerged and emerged vegetation as well as floating plants. The collected snails were placed in wide mouthed plastic buckets and taken back to the laboratory where they were washed, identified (Mandahl-Barth 1973; Brown 1980) and counted.

Following identification the snails were screened for cercariae after exposure to sunlight for 30 to 45 minutes. The cercariae were then identified with the key of Frandsen & Christensen (1984) and experimental infection was done with small animals (mice, hamster) and sometimes with sheep and goats.

After two or three months, snails free of infection were kept to be used in experimental infestation for the study of compatibility of snails with the different schistosomes. Animal schistosomiasis surveys were done in slaughter-houses in the different regions.

RESULTS

Since 1978 a series of surveys in the different regions of Senegal have provided data on the identification of the different snails which are intermediate hosts of schistosomes occurring in Senegal. They have made it possible to study snail population dynamics and seasonality of infection in each region in natural as well as man-made habitats.

It has been established from snail surveys that there is a definite association between the occurrence of large populations of snail hosts of the schistosomes and aquatic vegetation. However, snails were found in some habitats without vegetation. The principal snails

incriminated in the transmission of the schistosomes in Senegal are *Bulinus senegalensis*, *B. forskalii*, *B. truncatus*, *B. globosus*, *B. umbilicatus* and *Biomphalaria pfeifferi*. They were encountered in stagnant water, in slow flowing water or in moderately flowing water.

B. truncatus, *B. forskalii* and *B. globosus* are the most widespread snails. They are encountered in all the regions of Senegal, but the abundance varies from one ecological zone to the other. *Bulinus senegalensis* is more frequent in lateritic biotopes, particularly in the Senegal river basin (in the north) and in Tambacounda and Kaolack departments (Eastern and Center). The principal habitats are the rain-fed laterite pools.

Bulinus forskalii has the widest distribution. It is encountered in all ecological zones, but it is more frequent in the South (region of Kolda) and in the North (Senegal river basin). *Bulinus truncatus* is widespread in the country, but it is more frequent and abundant in the Senegal river basin, particularly in the delta and Lac de Guiers. *Bulinus globosus* is encountered in the Southern and Eastern regions (Kolda, Tambacounda and Kedougou), and is also present in irrigation schemes, in marigots and in the river in the Senegal river basin.

Bulinus umbilicatus is more frequent in the North (High and Middle Valley of Senegal river basin) and in the East (region of Tambacounda and Kedougou). Its habitats are frequently temporary waterbodies. *Biomphalaria pfeifferi* is found in permanent waterbodies in the South (region of Kolda), in the East (Tambacounda) and Southeast (Kedougou). Unknown in northern Senegal before the 1980s, it is seen occasionally, but not firmly established in the north and central part of the country.

Since 1989/90 it has become more abundant and widespread in the Senegal river basin, particularly in the delta and Lac de Guiers and has colonized irrigation canals, drains, marigots and the Senegal river along Richard-Toll and Rosso. The areas where the snail intermediate hosts of schistosomes are more abundant and frequent are the North, the East and the South of Senegal. There is a seasonal fluctuation in the presence and abundance of snails according to the species, the habitats and ecological areas and the data obtained in all of these surveys in the different regions of Senegal has made it possible to draw up a map of the distribution of the intermediate host snails (Diaw & Vassiliades 1987).

Concerning the epidemiological role of these snails in the transmission of schistosomiasis in Senegal, the study of their natural infection has shown that *Bulinus globosus*, *B. senegalensis* and *B. umbilicatus* are the intermediate hosts of *Schistosoma haematobium*, while *Biomphalaria pfeifferi* transmits *Schistosoma mansoni*. *Bulinus forskalii*, *B. truncatus* and *B. globosus* are intermediate hosts of *Schistosoma bovis* *Bulinus umbilicatus* and *B. globosus* transmit *Schistosoma curassoni*.

The snails were collected in areas where schistosomiasis is not endemic, and generally the natural infection rate is very low (0 to 2 per 100). But, during the outbreak of intestinal schistosomiasis in Richard-Toll, *Biomphalaria* were found heavily infested with a prevalence of 40 to 100% (Diaw *et al.* 1991). In a recent foci of *S. haematobium* in the delta, *B. globosus* has a prevalence of 29% (Verle *et al.* 1994).

Experimental infestations have also been done with the different snails and schistosomes to study their susceptibility (Table 1).

TABLE 1. Epidemiological role of snails in the transmission of schistosomes in Senegal. For both natural and experimental infections the percentage of snails infected are given. For experimental infections, the number of snails exposed is given in bracket.

	Natural infection			Experimental infection		
Bulinus species	*S. haema-tobium*	*S. bovis*	*S. curas-soni*	*S. haema-tobium*	*S. bovis*	*S. curassoni*
B. truncatus	0	0.5-0.8	0	7.6 (145)	63.6 (100)	0 (30)
B. umbilicatus	1 - 2	0	0.8-1.3	27.6 (756)	13.3 (100)	70 (50)
B. globosus	0.5-1	1.5-2	0.6-1	41.0 (145)		13 (24)
B. senegalensis	0.3-0.8	0	0	0.0 (145)	0.0 (100)	0 (80)
B. forskalii	0	0.3-1	0	0.0 (145)	48.9 (228)	0 (24)

The results of two years study in the field (three temporary ponds) in a North-Soudanian area of Senegal (region of Tambacounda) on the ecology of *Bulinus* species confirm resistance to the drought, particularly *B. umbilicatus* and *B. senegalensis*. Monthly observations have shown that the relative abundance of *B. umbilicatus* is higher than that of *B. senegalensis*. These ponds are dry for six to eight months a year, but the populations of snails regenerate regularly, a fact which presupposes a certain ability to resist drought. Some come through this period successfully and 70 to 80% of these snails are the middle sized ones. Immediately after the first rains they resume their activity and lay egg masses intensively in order to reconstitute the population. In this area only *B. umbilicatus* intervenes in the transmission of the schistosomes *S. haematobium* and *S. curassoni* which occurs between September and November (Diaw *et al.* 1989).

In the natural Sahel conditions the epidemiological cycle is short and everything happens within four to six months regarding the regeneration and the growth of the population of molluscs, the infection and the transmission of schistosomiasis.

This ecological behaviour of these *Bulinus* species in the North-Soudanian region is very important in the epidemiology of human and animal trematodosis and requires a new strategy for control.

Distribution and prevalence of Biomphalaria pfeifferi *in Richard-Toll*

An outbreak of intestinal schistosomiasis (1989) has been reported in Richard-Toll (Delta of Senegal river) with a overall prevalence of 43% (Talla *et al.* 1990). A malacological survey has been carried out in this area to study the density of *Biomphalaria pfeifferi*, their distribution in the different waterbodies and their rate of infection.

Four epidemiological aquatic systems were identified, comprising an irrigated system with irrigation canals and drains of the C.S.S. (Senegal Sugar Company), the system of Taouey Canal, the system of Taouey Marigot and the Senegal River. All have permanent water. The irrigated system accounted for 73% of snails collected, the Taouey Marigot 16%, the Taouey Canal 8% and the Senegal River 3%. The density of *Biomphalaria* is very high and varies from 0 to 200 per sample. Seasonal fluctuations are observed regarding snail abundance and infection rate.

The transmission is taking place in all aquatic systems and throughout the year, the overall rate of infection of *Biomphalaria* being 44%, but it varies from site to site according to the waterbody and from month to month (0 to 100% and 2 to 52%) (Diaw *et al.* 1991).

Monthly observations have shown that the peaks in the abundance of *Biomphalaria* are localised in the warmer periods (June to October), but the highest rates of infection are observed during the coldest periods (November to May). The study is ongoing.

DISCUSSION

Surveys are necessary to study the population dynamics of snails in natural and in man-made habitats, and their distribution and seasonal infection with schistosomes and other trematodes. In Senegal we have seen that snails are concentrated in the North, the South and in the East where ecological conditions are better for their development. They are in areas with a high hydrographic network density (river, lakes, marigots, irrigation canals, drains, ponds, waterbodies) and a relatively heavy rainfall.

These areas are those where trematode caused diseases in general and particularly human and animal
schistosomiasis are very developed. Major factors which influence disease epidemiology include environmental changes (natural and/or man-made) and human behaviour. The typical example we have in Senegal is the outbreak of intestinal schistosomiasis in Richard-Toll in the Senegal river basin which occurred three years after the Diama dam was built (Talla *et al.* 1990). This outbreak is the combination of several things, including the fact that the dam and the irrigation schemes created more favourable habitats for snails, particularly making it easy for *Biomphalaria pfeifferi*, which before was unknown in the North, to proliferate in the delta and Lac de Guiers. The outbreak was also related to the relative heavy rainfall in 1989/1990, and also to the presence in Richard-Toll of migrant labourers from different regions, especially the South bringing *Schistosoma mansoni* with them.

In the Senegal river basin, the opening of Diama and Manantali dams, the increase of irrigated systems and the rainfall led to the development and spread of human and animal trematode caused diseases (high prevalences of human schistosomiasis and animal fascioliasis and paramphistomiasis were observed during the period 1992/1994).

Concerning the epidemiological role of snails, we need to elucidate the role of *B. truncatus* particularly in the Senegal river basin, in the epidemiology of *S. haematobium* and we need to update our knowledge about the epidemiology of these diseases, considering that it is a dynamic interaction between the environment, host, intermediate host and parasite. Repeated malacological surveys are necessary in studying the epidemiological role of snails whose distribution and abundance are not static. Malacological data are also fundamental for epidemiological studies of trematode caused diseases, particularly schistosomiasis and the control of these diseases.

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