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The epidemiology of a recent focus of mixed *Schistosoma haematobium* and *Schistosoma mansoni* infections around the 'Lac de Guiers' in the Senegal River Basin, Senegal

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Summary A village with mixed *Schistosoma mansoni* and *S. haematobium* infections (probably in a early endemic phase) was identified around the Lac de Guiers in the Senegal River Basin. In documenting the epidemiology of both schistosomes, we focused on prevalence and intensity of infection, transmission patterns and the impact of treatment. *S. mansoni* prevalences (near 100%) and egg counts (overall geometric mean eggs per gram of faeces (epg) of 589 were high in all age groups, with 35% of individuals excreting > 1000 epg, and showing a slow decline in egg output only after the age of 30 years. The overall prevalence (28%) and egg counts (2% > 50 eggs/10 ml) of *S. haematobium* were low, with mean counts of 6.3 eggs/10 ml. Maximal mean *S. mansoni* egg counts were found in 5–9 year-old boys and in 15–19 year-old girls; *S. haematobium* maximal counts in 1–4 year-old boys and in girls aged 5–9. Extremely high *Biomphalaria pfeifferi* infection ratios were recorded over the whole year. Following a single treatment, re-infection was rapid with prevalences and mean egg counts of both *Schistosoma* species reaching pretreatment levels within 7 months.

keywords Senegal, schistosomiasis, *Schistosoma mansoni*, *Schistosoma haematobium*, epidemiology, treatment

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Introduction

In the lower valley of the Senegal River basin (SRB), an outbreak of intestinal schistosomiasis was reported in Richard Toll and surroundings (Talla *et al*. 1990, 1992; Stelma *et al*. 1993). The outbreak was linked with the establishment of *Biomphalaria pfeifferi* snails in the main canal in the surroundings of the city. A recent survey in the lower and middle valleys of the SRB (Picquet *et al*. 1996) showed that *S. mansoni* had spread to other villages, particularly those around the Lac de Guiers, which is linked to Richard Toll by an intake canal. All examined villages were infected, with an overall prevalence of 72%. Urinary schistosomiasis, long known to be focally endemic in the SRB (Vercruysse *et al*. 1985), has also become more widespread, e.g. in the area of Mbodiene, a village 65 km from Richard Toll (Verlé *et al*. 1994). In this region, mixed *S. haematobium* and *S. mansoni* endemicity is likely to increase further.

Picquet *et al*. (1996) found only one village (Nder) around Lac de Guiers with mixed infections. Lower observed prevalence and intensities of *S. haematobium* infections probably reflect differences in the history and intensity of transmission. Our objective was to describe the epidemiology of both *S. mansoni* and *S. haematobium* in Nder by studying the prevalence and intensity of infection, transmission patterns and the impact of treatment.

Materials and methods

Study site and population

The study was conducted in Nder, a village situated in the lower valley of the SRB 25 km south of Richard-Toll. Nder

has approximately 300 mostly Wolof inhabitants. Men are mainly involved in vegetable farming (potatoes, tomatoes), and women work both at home and in the fields. The region is typically sahelian, with a climate characterized by a short rainy season (between July and September) and a long dry season.

Epidemiological design

In November 1994, Picquet *et al*. (1996) found prevalences of 28% and 79% for *S. haematobium* and *S. mansoni*, respectively. Our study lasted from February 1996 to February 1997. Prior to the investigation, extensive information on objectives and methods was provided to the community. All villagers were invited to participate. On each sampling date, all registered participants were asked to provide one stool and one urine sample for examination. 195 individuals provided urine samples and 141 provided stool samples on all 5 sampling dates. In March 1996 and in January 1997 mass treatment with praziquantel (PZQ) at 40 mg/kg was offered to all villagers.

Parasitological techniques

Samples were always collected in the morning. Ten ml urine were filtered through Nytrel filters (WHO 1993) which were microscopically examined after adding a drop of lugol for better visualization of eggs. Faeces were processed by the Kato-Katz technique (Katz *et al*. 1972) (2 slides of 25 mg per individual). Slides were left for clearing and examined on the following day.

Malacological surveys

One site at the small canal between Nder and the lake and one site in Lac de Guiers were selected for malacological sampling. Each month both sites were visited by 2 experienced snail collectors for 15 min. Snails were identified and screened for patent schistosome infections by exposure to light for 1 h. For *Bulinus* snails no attempt was made to discriminate *S. haematobium* from other schistosome species in the region (*S. bovis* and *S. curassoni*). Snails were not returned to the collection sites. No human water contact studies were done.

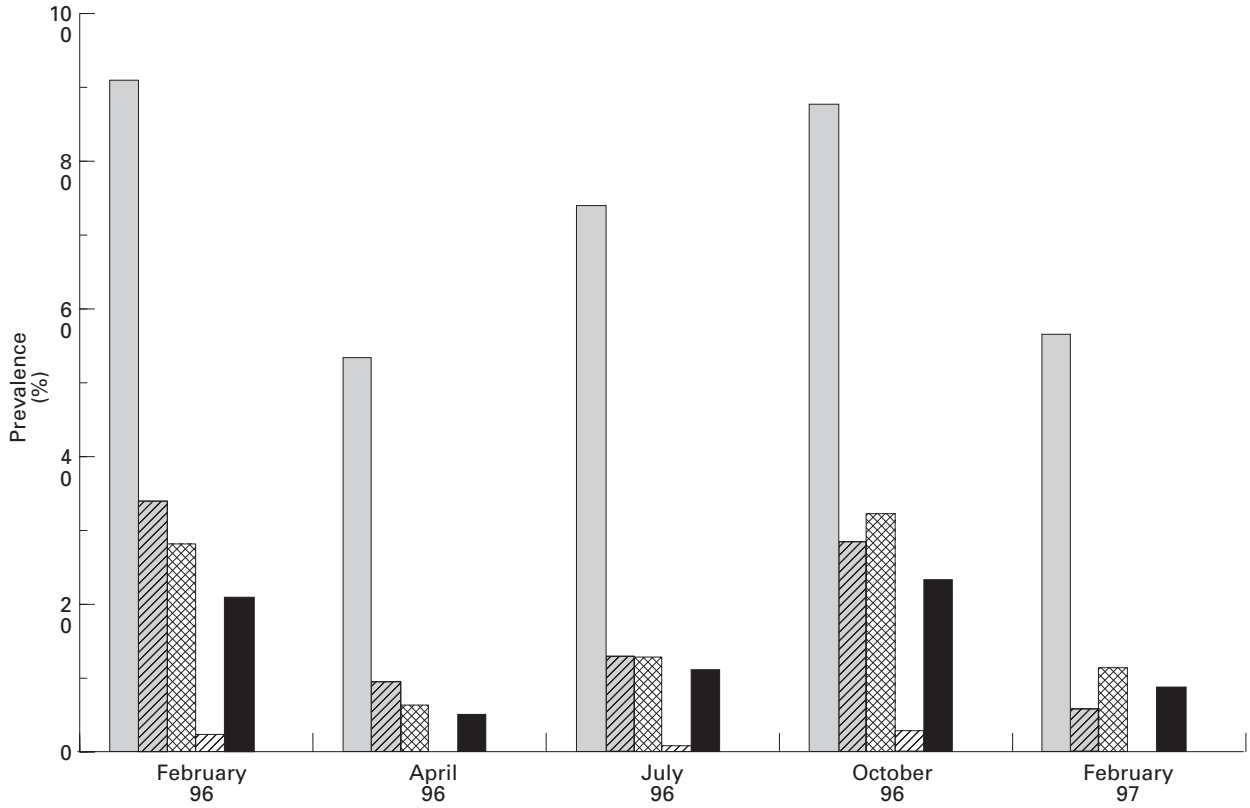

Figure 1 Overall prevalence of *Schistosoma* infections and heavy infections (>1000 epg *S. mansoni* and >50 ep 10ml *S. haematobium*). *S. mansoni* overall prevalence (▒) and heavy infections (▨); *S. haematobium* overall prevalence (▩) and heavy infections (▨). Overall prevalence mixed infections (■).

Statistical analysis

Analysis covered those individuals who provided urine and stool samples on all 5 sampling dates. Mean prevalences and mean egg counts were calculated for infected individuals divided into 7 age classes (1–4, 5–9, 10–14, 15–19, 20–29, 30–39, ⩾ 40 years); geometric mean (GM) values of positive samples only were used to assess egg counts. The parasitological cure rate was calculated as the proportion of people who had been excreting eggs before treatment and were not excreting eggs 6 weeks after treatment. The reduction in intensity was calculated as 1 – (GM eggs/g after treatment/GM eggs/g before treatment) × 100.

Results

Prevalence and intensity of infection

The overall prevalence and the prevalence of severe infections from February 1996 to February 1997 are shown in Figure 1. In October 1996 (219 days after treatment) prevalences of *S. mansoni* (88% *vs*. 91% in February 1996), of *S. haematobium* (32% *vs*. 28%) and of mixed infections (23% *vs*. 21%) had returned to pretreatment levels.

The overall intensity of *S. mansoni* infections was 589 epg at day 0 with 35% of individuals excreting > 1000 epg. By 219 days after treatment, overall intensity of infection was again approaching pretreatment levels: 523 epg with 29% of individuals excreting > 1000 epg.

The overall intensity of *S. haematobium* infections remained low during the entire study period, with a maximum of 6.3 eggs/10 ml in October 96. Only 2% of all individuals (all children) excreted > 50 eggs/10 ml before treatment with little change by 219 days after treatment (3%) and 0% after treatment in January 1997.

Table 1 shows parasitological cure rates and reductions in egg counts after treatments in March 1996 and in January 1997. The overall cure rate after the first treatment of March 1996 was 41.9% for *S. mansoni* and 78% for *S. haematobium*; intensity reduction rates were 66.5% and 79%, respectively. After the second treatment similar cure and intensity reduction rates were observed for *S. mansoni*, whereas the intensity reduction rate for *S. haematobium* was lower (35%), reflecting low infection intensities.

Prevalence and intensity of infection relative to age and to gender

Figures 2 and 3 show the prevalence and egg count distribution of *S. mansoni* and of *S. haematobium* infections relative to age in February 1996 (before the first treatment) and in October 1996 (7 months after treatment). The prevalences of *S. mansoni* on both sampling dates were nearly 100% even in the youngest age group (1–4), with a slow decline only after the age of 30 years. In February 1996, mean egg counts were highest (954 epg) in the 5–9 age group with a decrease in intensity from the age of 30 years onwards. In October 1996 maximal mean egg counts (1328 epg) were again observed in the 5–9 age group; mean egg counts were decreased in individuals > 10 years.

The prevalences of *S. haematobium* relative to age at both sampling dates were very similar. The highest prevalence was observed (for both sexes) in 5–9 year-old children and decreased to < 10% from the 30–39 age group onwards.

At the start of the study, the overall prevalence of *S. mansoni* was 94% in males and 90% in females with mean egg counts of 481 and 699 epg, respectively; and for *S. haematobium* the overall prevalence was 26% in males and 29% in females, with mean egg counts of 3 and 5.9 eggs/10 ml, respectively. The peak of *S. mansoni* infection intensity was found in 5–9 year-old boys and in 15–19 year-old girls. *S. haematobium* age-intensity curves peaked at the 1–4 year-old group for males (7.4 eggs/10 ml) and the 5–9 year-old group for females (7.1 eggs/10 ml).

Table 1 Parisitological cure rates and the intensity reduction rates after treatment with PZQ

	Schistosoma mansoni		*Schistosoma haematobium*	
	Mar 96	Jan 97	Mar 96	Jan 97
Cure rates†				
Treated	129	113	54	63
Cured	54 (41.9)	48 (42.5)	42 (78)	39 (62)
Intensity reduction rates‡				
Before treatment	484	478	5.1	6.3
After treatment	162 (66.5)	140 (70.7)	1.05 (79)	4.1 (35)

† values given as No. of subjects (%); ‡ values given as Eggs/g (%) for *Schistosoma mansoni* and Eggs/10ml (%) for *Schistosoma haematobium*.

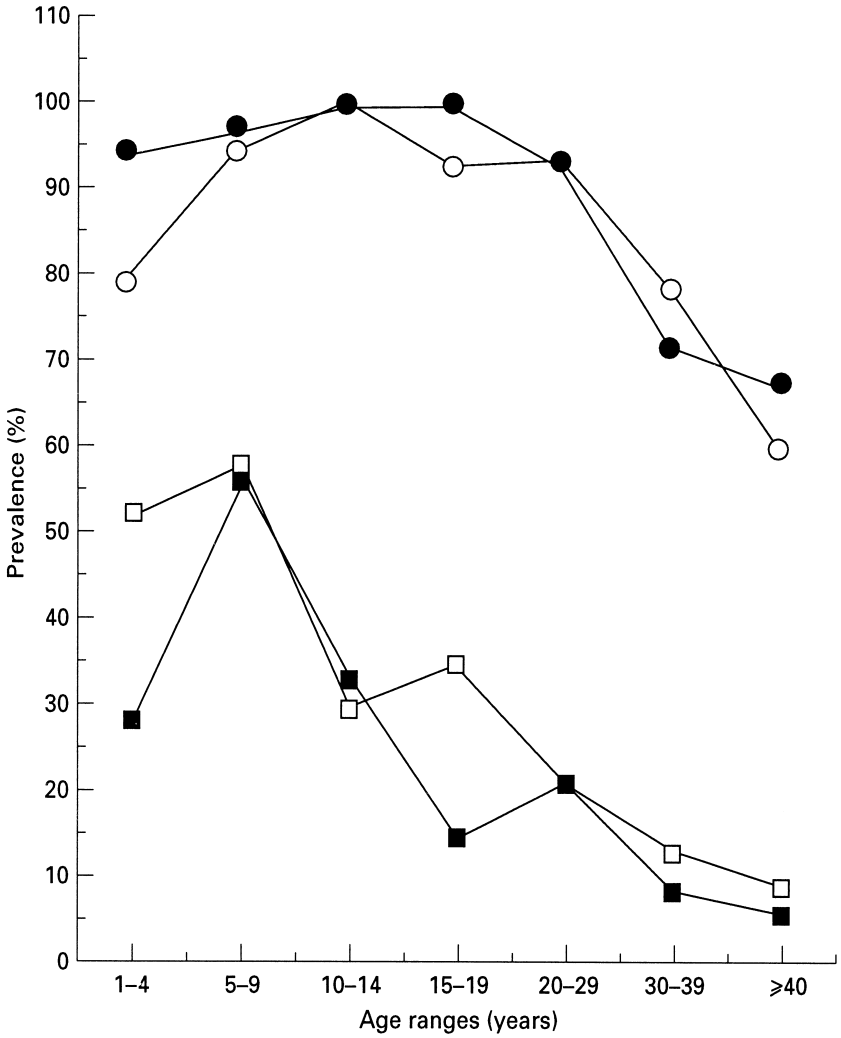

Figure 2 Age related prevalences before (open symbols) and 7 months after (closed symbols) treatment. ○,● *S. mansoni* infection; ■,□ *S. haematobium* infection.

Malacological surveys

The temperature in both transmission sites never fell below 20 °C (January) and never exceeded 32 °C (May). Snail counts of both sites were added up. The numbers of *B. pfeifferi* snails showed clear seasonal fluctuation with highest numbers between August (150 snails collected) and January (270 collected; Figure 4). Infected snails were found at nearly each sampling date with very high ratios of infected snails (such as 85% in June and August, 77% in November and January). Three *Bulinus* spp. were collected: *B. globosus*, *B. forskalii* and *B. truncatus*. Only the first is considered to transmit *S. haematobium* in the lower valley of the SRB. Mostly less than 10 *B. globosus* were collected, with peaks between May and July coinciding with extremely high ratios of infection (81% in June; Figure 4).

Discussion

This paper documents a mixed *S. mansoni* and *S. haematobium* focus, probably in the early endemic phase, by monitoring pre- and post-treatment egg counts during one year. The main finding is high *S. mansoni* prevalences and egg counts in all age groups; *S. haematobium* prevalence and egg counts are much lower. The emergence of both *Schistosoma* infections around Lac de Guiers can be linked to several human-made ecological changes in the past decade described in detail by Southgate (1997). Although the exact time at which *S. mansoni* and *S. haematobium* were introduced into the village cannot be determined, evidence indicates that transmission was established after 1988. During the past decades, several investigators reported the total absence of both *S. mansoni* and *S. haematobium* around Lac de Guiers (Chaine & Malek

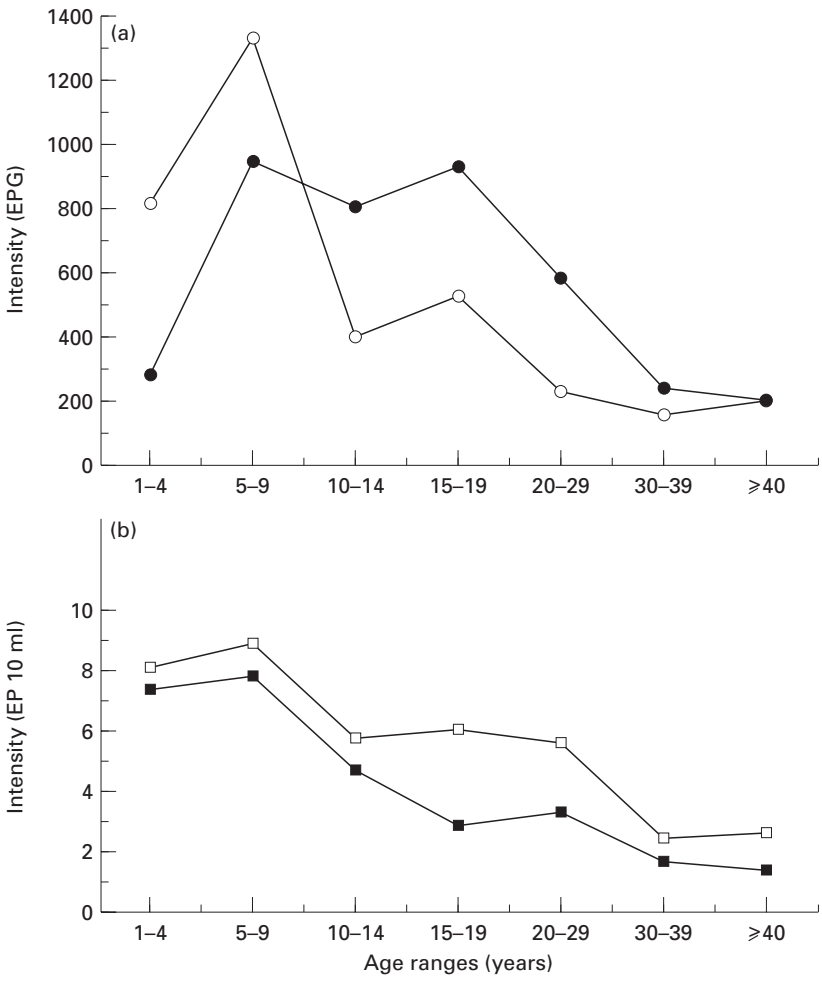

Figure 3 Egg count distibution relative to age before (open symbols) and 7 months after (closed symbols) treatment. (a) ○,● *S. mansoni* infection; (b) ■,□ *S. haematobium* infection.

1983; Cisse *et al*. 1983; Vercruysse *et al*. 1985). The first case of infection with *S. mansoni* in the SRB was only found in January 1988, and the number of cases increased very rapidly in the following years (Talla *et al*. 1990, 1992; Stelma *et al*. 1993). Picquet *et al*. (1996) found that all 18 villages surveyed around Lac de Guiers in 1995 were infected with *S. mansoni*.

Our results, dated one year later, indicate that the focus is still intensifying to such a degree that virtually everyone has become infected, often with heavy worm burdens. *S. haematobium* foci in the Lampsar area and around Podor have been reported before (Vercruysse *et al*. 1985). However, Picquet *et al*. (1996) found only one village (Nder) around Lac de Guiers to be infected. The similar prevalences and egg counts we found suggest that *S. haematobium* has not increased between surveys. In a few years, *S. mansoni* has thus become the predominant schistosome species in the area. However, *S. haematobium* infections should also be monitored, since we detected both schistosome species in a recent survey (1997) in a fishing village on the lake, 3 km north from Nder (unpublished observation).

The age-prevalence and intensity profiles of *S. mansoni* in this mixed infection village agree with the endemic profile observed in other foci in the area, e.g. Ndombo, a village 25 km north of Nder (Stelma *et al*. 1993). It has been argued that the finding of a similar age-dependent pattern in recent foci in Senegal compared to much older foci does not agree with perceptions of the role of acquired resistance but rather that factors conditional to age also have to be considered (Gryseels 1994). Data from Kenyan immigrants with short exposure to *S. mansoni* infection (14 months) also show a similar age-related pattern (Ouma *et al*. 1998). Recent data from Uganda show similar reinfection profiles after treatment in fishing and nonfishing communities, indicating a strong age-dependent resistance to (re)infection (Kabatereine *et al*. 1999). These studies add weight to the hypothesis of Gryseels

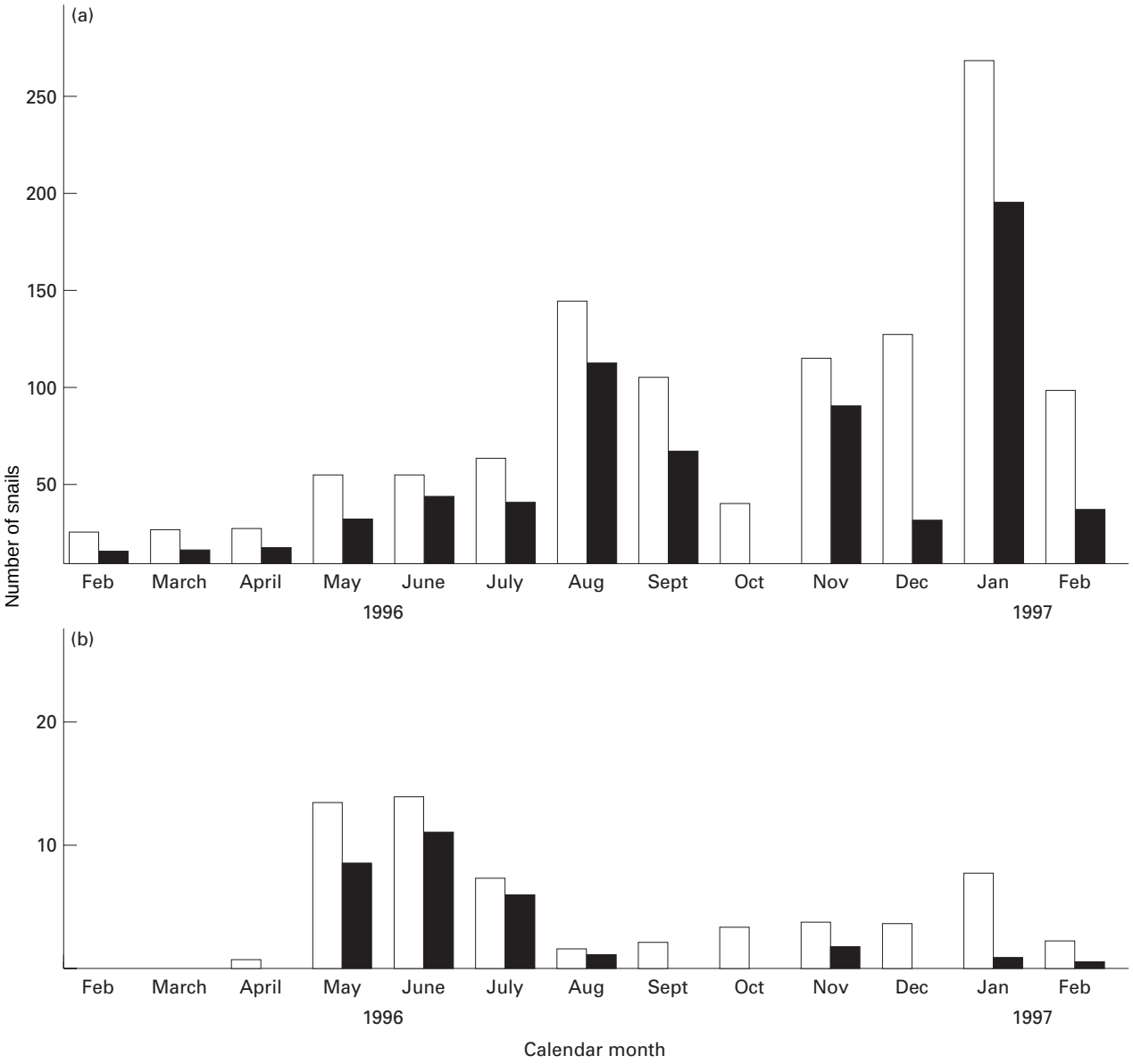

Figure 4 Seasonal fluctuations of (a) *Biomphalaria pfeifferi* and (b) *Bulinus globosus*. □ Number of snails found; ■ Number of snails infected.

(1994) that age-dependent factors rather than duration of exposure can underlie the age-intensity profile.

Both treatments with praziquantel at a dose of 40 mg/kg resulted in cure rates of approximately 42% for *S. mansoni* and 62% to 78% for *S. haematobium*; egg count reduction rates varied between 66 and 70% and 35 and 79%, respectively. Stelma *et al*. (1998) also reported relatively low cure rates in this area. However, as Picquet *et al*. (1998) have demonstrated, these can be explained by the high initial intensities of infection.

Pretreatment levels of prevalence and intensity were reached within 7 months after treatment for both *Schistosoma* species. Transmission pressure by *S. mansoni*/*S. haematobium* in this focus is intense and comparable to the situation around Richard Toll (Stelma *et al*. 1993; Ernould 1996). The intense *S. mansoni* transmission can be related to a dense snail population with a high vectorial capacity. *B. pfeifferi* snails were numerous between August and February and had extremely high infection ratios. Although seasonal fluctuations were observed, snails were found during the

whole year, indicating a continuous risk of infection. Similarly high snail infection rates were recorded in Ndombo by Diaw *et al.* (1991) and Stelma (1997). Infections in *B. globosus* snails peaked between May and August, i.e. before the main transmission period of *S. mansoni*.

In summary, our results confirm that the spread of *S. mansoni* (and at a lower level, *S. haematobium*) in the lower valley of the SRB is fast and alarming; that prevalences and intensities of *S. mansoni* infections have reached very high levels in a few years; and that rapid reinfection limits the possibilities of control through episodic treatment. Permanent health care facilities, water supply and health education are vital to mitigate the adverse effects of the hydrological and agricultural developments in this area.

Acknowledgements

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