EDITORIAL

INFECTION AND TRANSMISSION PATTERN OF SCHISTOSOMIASIS IN IRRIGATION SCHEMES AROUND KHARTOUM STATE, SUDAN

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Abstract

Schistosomiasis (prevalence, intensity and incidence) and patterns of transmission were studied in two villages lying within the irrigated area around Khartoum State i.e. Kiryab in Seilate Scheme, East Nile Province and Baraka in Gamooeya Scheme, Omdurman Province **(1996 - 1998).** Both types of infection were recorded in Kiryab village while only the intestinal form, *S. mansoni* , was found in Baraka village.Prevalence and intensity of *S. haematobium* infection among people living in Kiryab village were 33.5% and 122.5 eggs/10 ml and those of *S. mansoni* were 17.6% and 199.6 eggs/g respectively. Prevalence and intensity of *S. mansoni* infection were 40.8% and 136.1 eggs/g in Baraka. Incidence rates among schoolchildren were 5.2% and 6.7% for *S. haematobium* and *S. mansoni* in Kiryab respectively and 10.9% for *S. mansoni* in Baraka. The overall prevalence and intensity of both types of schistosomiasis varied between the two villages of the study and in each village these indices of infection varied significantly according to age, reaching a peak in the age group 10 –19 years.Seven different species were found in snail sampling sites in the irrigation canals around the study villages. These snail species were the pulmonates: *Biomphalaria pfiefferi, Bulinus truncatus, Lymnea natalensis, Physa acuta* and *Bulinus forskalii* and the prosobranchs:_*Cleopatra builimoides* and *Melanoides tuberculata*. Pulmonates in general and the schistosome intermediate hosts (i.e. *B. pfiefferi* and *B. truncatus*) in particular were observed to vary in distribution and density according to season reaching a peak in the hot season from March to June. Transmission of infection was found to be focal and highly seasonal taking place during summer period from March to June.

EDITORIAL

Introduction

In the Sudan, schistosomiasis increased in distribution and prevalence because of expansion in water resources development projects. Thus, schistosomiasis is endemic in the Gezira-Managil, Rahad, Halfa and Kenana irrigation schemes (Fenwick *et al.*, 1982; Elias *et al.*, 1994; Hilali et al., 1995; Ahmed et al., 1996)). In Khartoum State, schistosomiasis was confined to small pump schemes in the East Nile Province, which grow vegetables and fruits for the consumption of the local market (Malek, 1962; Amin and Omer, 1972). However, with expansion in irrigation around Khartoum together with the increase in human population, schistosomiasis increased in prevalence and distribution (Hilali *et al.*, 1996). Both types of human schistosomiasis (*i.e.S. mansoni* and *S. haematobium*) were found in the three provinces of the state with a prevalence ranging from less than 1% to about 40% among schoolchildren (Hilali *et al.*, 1996). This paper provide further details about schistosomiasis in this area with an aim to provide base-line information for the control of the disease and for further studies in the future. It describes the infection and transmission pattern in two villages selected from the irrigated schemes around Khartoum State.

Material and Methods

Study area: This study was carried out in two villages, Kiryab and Baraka villages (**1996-1998)**. Kiryab village lies within the Seilate agricultural scheme which is the biggest scheme in Khartoum State covering an area of more than 30,000 feddans in East Nile province whereas Baraka village lies within the Gamooeya agricultural scheme which is covering an area of about 8,000 feddans in Omdurman Province (Figure 1). In addition to their location in two different areas, the two villages were selected for this study because they were the villages with the highest prevalence of schistosomiasis among schoolchildren in this area as reported by Hilali *et al.* (1996). A detailed census was carried out in the two villages and name, age and sex of the residents were recorded.

Diagnosis of intestinal and urinary schistosomiasis:

Stool and urine samples were taken from the residents of the two villages. The samples collected were then examined in the laboratory using the modified Kato (Teesdale and Amin, 1976) and urine filtration technique (Mott *et al.*, 1982) for the presence of *S. mansoni* and *S. haematobium* eggs respectively.

Determination of incidence:

The incidence of schistosomiasis infection was measured by examining the schoolchildren in the two villages over one year. Those found positive after the first examination were treated with praziquantel (40 mg/kg body weight) and re-examined after 45 days. Negative cases and those treated and turned negative were included in the follow up. They were examined at 6 and 12 months to determine the incidence of infection with both types of schistosomiasis.

Snail collection and examination for infection:

Identification of potential transmission sites was carried out by a preliminary survey of all types of water canals surrounding each of the two villages. Sixteen human water- contact sites were identified in this study, 10 of them were around Kiryab village and the other 6 were around Baraka village.

Snails were collected from these sites every month from August 1994 to December 1997. Snail collection was done using the scooping method described by Malek et al. (1962). Temperature was measured using a graduated glass thermometer and then 20 scoops were taken using a flat-wire mesh scoop. All snails collected were brought to the laboratory in plastic containers for the identification and counting.

Schistosome intermediate host snails i.e. Bulinus truncatus and Biomphalaria *pfeifferi*, were checked for schistosome infection by placing them in groups of 10 to 20 snails in beakers with about 100 ml of water and exposed to light. Snails in beakers in which human cercariae were seen, were put individually in small glass tubes containing water to determine the number of snails infected. Identification of schistosome cercaria was done following the identification key prepared by Frandsen and Christensen (1984).

Data analysis:

Chi-squared test was used for comparisons of proportions (Prevalence and Incidence rates). One-Way

ANOVA was used for the comparisons of means after transforming data and calculating geometric mean egg counts (Intensity of Infection). Egg counts of positive cases were only calculated.
As snails data showed abnormal distribution, non-parametric tests were used. Kurskal-Wallis oneway ANOVA was used for the comparisons of snail densities.
P-value of < 0.05 was considered as significant.

Results:

Prevalence and intensity of infection:
Both types of schistosome infections were recorded in Kiryab village while only the intestinal form (*S. mansoni)* was found in Baraka village.
Kiryab village:
Prevalence and intensity of *S. haematobium* infection among people living in this village were 33.5% and 122.5 eggs/10 ml while those of *S. mansoni* were 17.6 % and 199.6 eggs/g respectively (Table .1).
Although male individuals showed high prevalence and intensity records than females, differences in prevalence and intensity of infection with both types of schistosomes between the two sexes were not statistically significant (Table. 2). With age, both types of infection varied significantly (P < 0.05). The highest prevalence and intensity of *S. haematobium* infection were in the age group 10-19 years whereas the highest prevalence and intensity of *S. mansoni* infection were in the age groups 20-29 and 10-19 years respectively (Tables. 1). An increase in intensity of infection with both schistosomes was observed in people in the age group 50 yrs. and above.
Baraka village:
Prevalence and intensity of *S. mansoni* infection among people living in the village were 40.8 % and 136.1 eggs/g respectively. Both prevalence and intensity of *S. mansoni* infection changed significantly with age and sex (P < 0.05). There were two peaks for prevalence in the age groups 10-19 and 40-49 years and also two peaks for intensity in the age group 10-19 years and in those aged 50 years and above (Table. 3). As to sex, prevalence and intensity of infection were 48% and 182.2 eggs/g in males and 34.4 % and 101.5 eggs/g in females (Table. 4).

Table 1. Prevalence and intensity of *S.haematobium and S.mansoni* infection in Kiryab village by age.

Age groups	**No. examined**		**No. Positive**		**Prevalence**		**Intensity***	
	S. h [1]	S. m [2]	S. h [1]	S. m [2]	S. h [1]	S. m [2]	S. h [1]	S. m [2]
1-9	394	143.5	134	27	34.0	34.0	143.5	143.5
10-19	355	168.0	172	76	48.5	48.5	168.0	168.0
20-29	98	50.6	21	23	21.4	21.4	50.6	50.6
30-39	115	43.4	23	19	20.0	20.0	43.4	43.4
40-49	93	28.7	22	17	23.7	23.7	28.7	28.7
> 50	79	104.0	8	8	10.1	10.1	104.0	104.0
Total	1134	**122.5**	380	170	33.5	33.5	**122.5**	143.5

S. h = *Schistosoma haematobium* S. m = *Schistosoma mansoni*
*Total egg count per 10 ml for S. h [1] and 1 gm per for S. m[2]
Chi-square test (for both S. h [1] and S. h [1]) P < 0.001 ANOVA: P < 0.01

Table 2. Prevalence and intensity of *S. haematobium and S. mansoni* infection in Kiryab village by sex.

EDITORIAL

Sex	No. examined		No. positive		Prevalence (%)		Intensity *	
	S. h [1]	S. m	S. h [1]	S. m	S. h [1]	S. m	S. h [1]	S. m
Male	517	441	183	79	35.4	17.9	124.5	17.9
Female	617	525	197	91	31.9	17.3	120.3	17.3

*Total egg count per 10 ml for S. h [1] and 1 gm per for S. m[2] .S. h = *Schistosoma haematobium* S. m = *Schistosoma manson*Chi-square test (for both S. h [1] and S. h [1]) $P < 0.001$ ANOVA: $P < 0.01$

Table.3. Prevalence and intensity of *S. mansoni* infection in Baraka village by sex.

Sex	No. Exam	No. Pos.	Prevalence (%)	Intensity M(Eggs/10ml)
Males	277	133	48.0	182.2
Females	373	132	35.4	101.5

Chi-squared test: $P < 0.001$ ANOVA: $P < 0.01$

Table 4. Prevalence and intensity of *S. mansoni* infection in Baraka village by age.

Age groups	No. Exam	No. Pos.	Prevalence (%)	Intensity GM(Eggs/10ml)
1-9	167	45	26.9	102.5
10-19	231	119	51.5	177.1
20-29	94	42	44.7	117.3
30-49	63	22	34.9	79.0
40-49	42	21	50.0	123.8
05+	53	16	30.2	151.1
Total	650	265	40.8	136.1

Chi-square test: $P < 0.001$ ANOVA: $P < 0.01$

Incidence of infection:

No significant difference ($P > 0.05$) in incidence rates were observed by age, therefore the data were pooled for all schoolchildren and presented as one age group (6-18). For *S. haematobium*, incidence rates among schoolchildren in Kiryab at 6 months (March 1995) and 12 months (October 1995) intervals after treatment were 6.2% and 5.2% respectively (Table. 5). For *S. mansoni*, incidence rates were 1.4% and 6.7% in Kiryab and 6.2% and 10.9% in Baraka during the two periods respectively (Tables5 and 6).

Table 5. Incidence of infection with *S. haematobium and S. mansoni* among School children aged 6-18 years in Kiryab village.

Survey	**No. Examined**		**No. Positive**		**Incidence**	
	S. h	S.m	S. h	S.m	S. h	S.m
6 months (March 1995)	129	227	8	14	6.2	6.2
9 months (July 1995)	124	213	4	7	3.2	3.3
12months (October 1995)	115	211	6	23	5.2	10.9

S. h = *Schistosoma haematobium* S. m = *Schistosoma mansoni*

Table 6. Incidence of infection with *S. mansoni* among School children aged 6- 18 years in Baraka village.

Survey	No. Examined	No. Positive	Incidence
6 months (March 1995)	227	14	6.2
9 months (July 1995)	213	7	3.3
12months (October 1995)	211	23	10.9

Changes in the snail population and infection:
Seven different snail species were found in sampling sites around the two study villages, Kiryab and Baraka. These snail species were:
Pulmonates: *Bio. pfeifferi, Bul. truncatus, L. natalensis, Physa acuta* and *Bul. forskalii.*
Prosobranchs: *Cleopatra bulimoides* and *Melanoides tuberculata.*
With the exception of *L. natalensis*, which was not found in Baraka village, the remaining snail species were present in both villages.
Tables.7 and 8 summarize changes in the size of various snail species and temperature by season i.e. July-September (rainy season), October-December (post-rainy season), January-March (cold season) and April-June (hot season). Among pulmonates, the schistosome intermediate host snails scored the highest and the lowest counts during the hot and rainy seasons respectively (Table. 7). Changes in means of these snails were statistically significant ($P < 0.05$). On the other hand prosobranchs did not show significant changes by season ($P < 0.05$). Their highest records were during the rainy season.
S. haematobium infection in *B. truncatus* and *S. mansoni* infection *in B. pfiefferi* were recorded during the hot and cold seasons in the two villages. In Kiryab village, mean numbers of *S. haematobium* infected *B. truncatus* and *S. mansoni* infected *B. pfiefferi* during the cold season were 0.03 and 0.13 and during the hot season were 0.3 and 0.55 respectively whereas in Baraka village, mean number of *S. mansoni* infected *B. pfiefferi* was 0.06 and 0.5 during the cold and hot seasons respectively.
Temperature records changed significantly with season ($P < 0.05$). As shown in table 12, the highest values were recorded during April-June (hot season) and July-September (rainy season) and the lowest values were recorded during January-March (Cold season).
In both villages, intermediate host snails of schistosomes i.e. *B. pfeifferi* and *B. truncatus* increased in number with the increase in temperature from February reaching a peak in April/May every year and then declined (Figures 4, 5, 6 and 7). From June to January, snails were either absent or at low densities. Infected snails of both species were found during the period from February to June in Kiryab village (table 4 and 5). Similar pattern was observed for infected *B. pfeifferi* in Baraka village (table 6). Infected *B. pfeifferi* were not recorded during the third year in this village. Also, none of the *B. truncatus* snails collected in this village were found to be infected.
Tables 4, 5, 6 and 7 also show the changes in the size of the population of schistosome intermediate host snails over the three years of the study. More snails were found in the sites around the two villages in the second than in the first and third years.

EDITORIAL

Table7. Total and mean numbers of snails collected from all sites during the period from August 1994 to December 1997 in Kiryab and Baraka villages by. Season (Between brackets are mean numbers of snails).

Snail Species	**Jul-Sep**		**Oct-Dec**		**Jan-Mar**		**Apr-Jun**		**P*-value**	
	Kir	**Bar**	**Kir**	**Bar**	**Kir**	**Bar**	**Kir**	**Bar**	**Kir**	**Bar**
Pulmonates										
B. truncatus	158 (3.3)	162 (1.7)	342 (2.95)	170 (2.6)	449 (4.9)	285 (5.9)	285 (5.9)	1609 (38.3)	> 0.05	> 0.05
B. pfeifferi	196 (1.8)	36 (0.6)	364 (3.1)	216 (3.3)	734 (8.2)	299 (6.2)	299 (6.2)	1256 (29.9)	> 0.05	> 0.05
B. natalensis	236 (2.2)	0	264 (2.3)	0	101 (1.1)	0	1 (0.02)	0	> 0.05	0
Physa acuta	0	0	122 (1.04)	1 (0.01)	1651 (18.3)	1 (0.02)	2 (0.04)	3 (0.07)	> 0.05	> 0.05
B. forskalii	0	0	0	0	0	2 (0.04)	0	0	> 0.05	> 0.05
Inf.*B. truncatus*	0	0	0	0	3 (9.9)	0	27 (0.3)	0	> 0.05	> 0.05
Inf. *B. pjeifferi*	0		0	0	12 (0.13)	3 (0.06)	50 (0.55)	21 (0.5)	> 0.05	> 0.05
Prosobranches:										
C. builimoides	536 (33.4)	43694 (203.2)	3072 (26.3)	28242 (470.7)	892 (9.9)	4028 (61.9)	4028 (61.9)	3572 (74.4)	> 0.05	> 0.05
M. tuberculata	2694 (25.4)	2698 (44.9)	1769 (15.1)	3216 (49.5)	876 (9.7)	1303(27.1)	1303 (27.1)	1788 (42.5)	> 0.05	> 0.05

*Kruskal-Wallis One-way Analysis of variance
Kir =Kiryab village Bar = Baraka village

Table 8. Mean, Minimum and Maximum water temperature readings during the study period by season

Season	Temperature		Mean*+SE
	Minimum	Minimum	
July-September	24	32	28.95+0.12
October-December	17	29	27.49+0.19
January-March	17	30	21.80+0.32
April-June	22	34	28.86+0.20

P-value P< 0.001
* Kruskal-Wallis One-way Analysis of variance.

EDITORIAL

Discussion

This study confirms the endemicity of schistosome infections in irrigated schemes around Khartoum State which was previously reported in a study conducted in 22 schools in villages within these schemes (Hilali *et al.*, 1996). The overall prevalence and intensity of both types of schistosomiasis varied between the two villages of study and in each of the two villages these indices of infection varied significantly by age reaching a peak in the age group 10-19 years. These results are comparable to those reported from other irrigation schemes in the Sudan such as the Gezira-Managil , Rahad, White Nile and Guneid schemes (Fenwick *et al*, 1982; Ahmed, 1994; Hilali *et al*1995; Mohammed, 1998).

Both types of schistosomiasis were reported in Kiryab village while only *S. mansoni* was found in Baraka village despite the presence of intermediate host snails of both types of schistosomiasis i.e. *B. pfeifferi* and *B. truncatus* in this village. Similar observation was made in the Gezira-Managil scheme (Omer etal., 1976; Babiker etal., 1985). This may be due to the susceptibility/insusceptibility of *B. truncatus* snail or due to other unknown factors which need to be studied in the future.

In line with findings in most endemic areas, prevalence and intensity of infection with *S. mansoni* and *S. haematobium* in the two villages of study increased with age up to 20 years, followed by a decline in older age groups. This general pattern was reported from studies conducted in the Sudan and other endemic areas (Omer et al., 1976; Eltom et al.1993; Elias et al., 1994; Teklehaimont & Fletcher, 1990; ; Ndamba et al., 1994). However, there is an observed increase in intensity and/or prevalence of infection with both types of schistosomiasis in older age groups, 40-49 and above 50 in the two villages in this study. Similar observations were made in Gezira-Managil scheme (Hilali et al., 1995) and before that in Egypt (Adel-Wahab et al., 1980) where the majority of villagers over the age of 40 years were excreting large numbers of eggs. This has also been reported in Tanzania (McCullough & Magendantz, 1974) and attributed to reduced immunity in older people. However, further studies are needed to explain this observation.

Prevalence and intensity of infection with both types of schistosomiasis were higher in males than females in the two villages. However, differences by sex were only statistically significant for *S. mansoni* in Baraka village. This may be related to differences in social attitudes in the two villages. Generally, prevalence and intensity of schistosomiasis infection were reported to be higher in males than females in Sudan (Omer et al., 1976; Mohammed, 1998) and other endemic areas (King et al., 1982; Klumpp and Webbe, 1987). Differences by sex are generally attributed to differences of human water contacts performed by males and females. Males are usually involved in high-risk water contacts such as swimming and playing (Fenwick et al., 1982).

The study also showed the presence of active transmission in these schemes as illustrated by the presence of *S. mansoni* and *S. haematobium* infected snails in human water contact sites around the two study villages and by the record of new human infected cases in the two villages.

Infected snails were found in sites adjacent to human dwellings in the two villages mainly during the period from March to June over the 3-year period of the study showing that transmission is highly seasonal and focal in this area. In other irrigation schemes of the Sudan, transmission of both types of schistosomiasis was also reported to be seasonal and focal, occurring in sites near villages as in the Gezira-Managil scheme (Babiker et al., 1985; Hilali et al., 1995). Such findings should be considered in strategies of schistosomiasis control adopted in this area.

Seasonal changes in the densities of pulmonate snails in general and schistosome intermediate host snails in particular followed the general seasonal pattern observed in the Gezira-Managil scheme (Babiker, 1985; Hilali et al., 1995) and other schemes in the Sudan such as Rahad and White Nile irrigation schemes (Elias, 1992; Ahmed, 1994), and highest records were in the hot season i.e. March-June. On the other hand,

EDITORIAL

prosbranchs seemed to be less affected by the season, appearing with the highest and lowest densities during the rainy season i.e. July-September and cold season i.e. January-March respectively. This is in agreement with the findings on the prosobranch snail *C. bulimoides* in the Gezira-Managil scheme (Karoum, 1988). Similar seasonal changes of snail populations have also been reported in other endemic areas in Africa such as Lake Volta in Ghana (Klumpp and Webbe, 1987) and the highveld region of Zimbabwe (Chandiwana et al., 1987).

Seasonal changes in snail population densities as observed in this study seemed to be affected directly or indirectly by temperature. Pulmonates including the schistosome intermediate host snails i.e. *B. pfeifferi* and *B. truncatus* increased in density with the increase in temperature from February to June. Snail numbers then declined being affected by turbidity during the rainy season from July to September and remained in low densities till November when they start to build up to reach a peak in May. Prosobranchs also observed to be affected by temperature but not turbidity. The effect of temperature on distribution and growth of snail populations is well known. Low temperatures in winter reduce breeding or stop it completely while high temperatures in summer may affect the survival of snails (Dazo *et al*., 1966; Appleton, 1977; Elemam and Madsen, 1982). However, field observations have shown broad tolerance ranges from zero to 40 ^{o}C (Appleton, 1978). Water temperature records in this study ranged between 17 ^{o}C in winter and 31 ^{o}C in summer. Thus, they were all within the snails tolerance range identified by other workers in different areas.

Annual changes in snail population densities in the two villages may be related to variation in local conditions as well as variation in ecological factors from one year to another. Absence of infected *B. pfeifferi* snails in Baraka village during the third year of the study can be attributed to the schistosomiasis control programme implemented by the Ministry of Health of Khartoum state during the year 1997. This control programme included mass chemotherapy and focal and seasonal treatment of human water contact sites near villages in Gamooeya scheme with Nicloseamide (Bayluscide), and Baraka village was included in that programme.

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EDITORIAL

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