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A study of some factors influencing the epidemiology of urinary schistosomiasis at Ifakara (Kilombero District, Morogoro Region, Tanzania)

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Summary

Some factors influencing the epidemiology of urinary schistosomiasis were studied at Ifakara between 1978 and 1980. Ifakara is situated in the fertile plain of the Kilombero river in the south-eastern part of Tanzania. The overall prevalence of *Schistosoma haematobium* infection among primary school children (6–19 years) in the Ifakara agglomeration was 21% (730/3478). The highest prevalence was observed in both sexes in the age group 15–19 years. Distinct variations in prevalence were found between the individual schools examined, ranging from 5 to 71% and indicating a focal transmission of the disease. The intensity of *S. haematobium* infection in the individual schools was relatively low, ranging from 5 to 36 eggs/10 ml urine. However, the frequency of microhaematuria among infected subjects was high, reaching 100% from an egg output of 50 eggs/10 ml onwards.

Forty-nine waterbodies – most of them man-made – with *Bulinus (Ph.) globosus* and/or *B. (Ph.) nasutus* were found, 12 of them harboured *B. (Ph.) globosus* shedding cercariae of the mammalian type. These waterbodies were mainly localized in the northern and north-eastern areas of Ifakara where the primary schools with the highest prevalence of *S. haematobium* were found. Most of these waterbodies were known to be bathing places for the children. Susceptibility experiments with *B. (Ph.) globosus* and *B. (Ph.) nasutus* indicated that *B. (Ph.) globosus* is possibly the only intermediate host for *S. haematobium* in the areas examined. No *Biomphalaria*, the intermediate hosts for *S. mansoni*, were found. In addition, the knowledge and awareness of the local population about urinary schistosomiasis were assessed by a questionnaire survey.

Key words: Tanzania; *S. haematobium; B. (Ph.) globosus; B. (Ph.) nasutus;* haematuria.

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Introduction

Ifakara, the capital of Kilombero District, is a rural town which, together with the numerous surrounding villages and hamlets forms an agglomeration of some 38 000 inhabitants (Census of Tanzania, 1978). It is situated at about 8° 9′ S and 36° 40′ E, in the wide Kilombero river-plain, 6.5 km north of the Kilombero river, at an altitude of 230–260 metres. The prevailing vegetation is open grassland including swampy areas along the Kilombero river (Jätzold and Baum, 1968). There are heavy rains mainly in March and April and lighter, less regular ones in December and January (Freyvogel, 1960; Freyvogel and Kihaule, 1968; Jätzold and Baum, 1968). The people are predominantly Bantus of the seven tribes Ndamba, Mbunga, Pogoro, Bena, Ngindo, Ngoni-Ndendeule and Hehe (Jätzold and Baum, 1968) and depend mainly on farming (rice, maize and cassava).

Intestinal helminths are very common (Tanner et al., 1982) and the area is known to be holoendemic for malaria (Clyde, 1967; Freyvogel and Kihaule, 1968).

Every year a substantial number of patients of S. Francis Hospital at Ifakara are treated for schistosomiasis, mainly urinary in type (Ann. Rep. of S. Francis Hospital; average of 1978–1980: 786 patients with *Schistosoma haematobium* and 24 patients with *S. mansoni* per year).

In 1971 an examination of primary school children in Ifakara-town (Degrémont, unpublished) showed the prevalence of *S. haematobium* to be 31% (31/100), and a survey of a sample of all age-groups in Ifakara-town showed a prevalence of 5.8% (23/395). Since that time no further data about the prevalence of urinary schistosomiasis in the Ifakara-area have been collected.

Other investigations on the prevalence of urinary schistosomiasis in the Kilombero District gave the following results: Sturrock (1965) examined primary school children from the Kilombero Sugar Estate (some 65 km north-east of Ifakara) and found a prevalence of 22.5% (9/40). Matovu (1977) found a prevalence of 30% (52/168) in the primary school children (age 8–11 years) of the Kilombero and Kidatu areas (60 km north-east of Ifakara). The examination of all age groups of the Ujamaa-village Namawala (50 km west of Ifakara; Zumstein, unpublished) revealed a prevalence of 21% (87/416) and a nutrition survey done by the Tanzania Food and Nutrition Centre (1979) in the Mang'ula village (40 km north-east of Ifakara) gave the prevalence of *S. haematobium* in primary school children as 34%.

The main intermediate hosts of *S. haematobium* in Tanzania are the following (Wright, 1973): *Bulinus (Ph.) globosus*, *B. (Ph.) africanus africanus*, *B. (Ph.) africanus ovoideus*, *B. (Ph.) nasutus nasutus* and *B. (Ph.) nasutus productus*. *B. (Ph.) globosus* appears to be widely distributed. It was thought by Mozley (1939) to be the main intermediate host in the east, in Zanzibar and in Pemba. It has been recorded from various other parts of the country. Webbe (1963)

regarded it as a more efficient intermediate host than *B. (Ph.) nasutus nasutus*. *B. (Ph.) nasutus* is the principal intermediate host in the Usagara-area (Webbe, 1962) and in the Misungwi-area (McCullough et al., 1973), both south of Mwanza.

In the Kilombero District Sturrock (1965) found *B. (Ph.) nasutus* and *B. (Ph.) globosus* in irrigation canals of the Kilombero Sugar Estate, but he indicated that only *B. (Ph.) globosus* was infected. Matovu (1977) found *B. (Ph.) nasutus* in the Kilombero canals and *B. (Ph.) africanus/globosus* (?) in the Kidatu/Mkamba ponds, all snails collected being found negative. In the Ifakara area preliminary malacological surveys were undertaken by Degrémont from 1970–1974 (unpublished): Several waterbodies harbouring *B. (Ph.) globosus* or *B. (Ph.) nasutus* were found, but the sites of transmission of *S. haematobium* were not localized. Although the above mentioned data show that urinary schistosomiasis is widely distributed at Ifakara and in the Kilombero District, exact data about prevalence, sites of transmission and snail species that act as intermediate hosts are still lacking.

The survey reported here lasted from October 1978 to December 1980. Its aim was to assess the present epidemiological situation of urinary schistosomiasis in and around Ifakara. Data were collected on the prevalence and intensity of the disease in primary school children, on snail species that act as intermediate hosts, on the susceptibility of the intermediate hosts to *S. haematobium*, on potential transmission sites and on the awareness and knowledge of the local population about schistosomiasis. The data should serve as a basis for appropriate control of transmission of the disease in the Ifakara areas.

Material and Methods

a) *Areas surveyed*

The areas where primary school children were examined for *S. haematobium* infection and where waterbodies were checked for snails are shown on the maps (Figs. 1 and 2). They include Ifakara-town and the areas to the north (Machipi, Kibaoni, Nanganje), to the north-east (Katindiuka, Mbasa, Kikwawila, Kilama, Kalomo), to the south (Lipangalala, Matanila) and to the west (Lumemo, Michenga, Mahutanga).

b) *Collection and examination of urine*

Out of 20 primary schools in the agglomeration, with an official number of 6539 children, 3478 children from 15 schools, with an official number of 4631 children were examined (53% of the overall number, or 75% of the children of the 15 selected schools). The age of the children varied from 6 to 19 years (cf. Fig. 3). In the individual schools the urines of all the children present were collected between 9 and 11 a.m. (after physical exercises) because at that time most of them attended school. Name, age, sex and living-place were recorded.

In the laboratory the volume of each child's urine sample was measured and the whole sample filtered according to a modification of the technique of Bradley (1965): The urine was drawn up into a graduated 50 ml syringe and slowly filtered through a Nucleporefilter (pores 12 μm, diameter 2,5 cm; Nuclepore Corporation, Pleasanton, CA, USA). The filter was covered with a coverslip and examined under the microscope. The total number of eggs on the filter was counted and the number of eggs per 10 ml urine calculated.

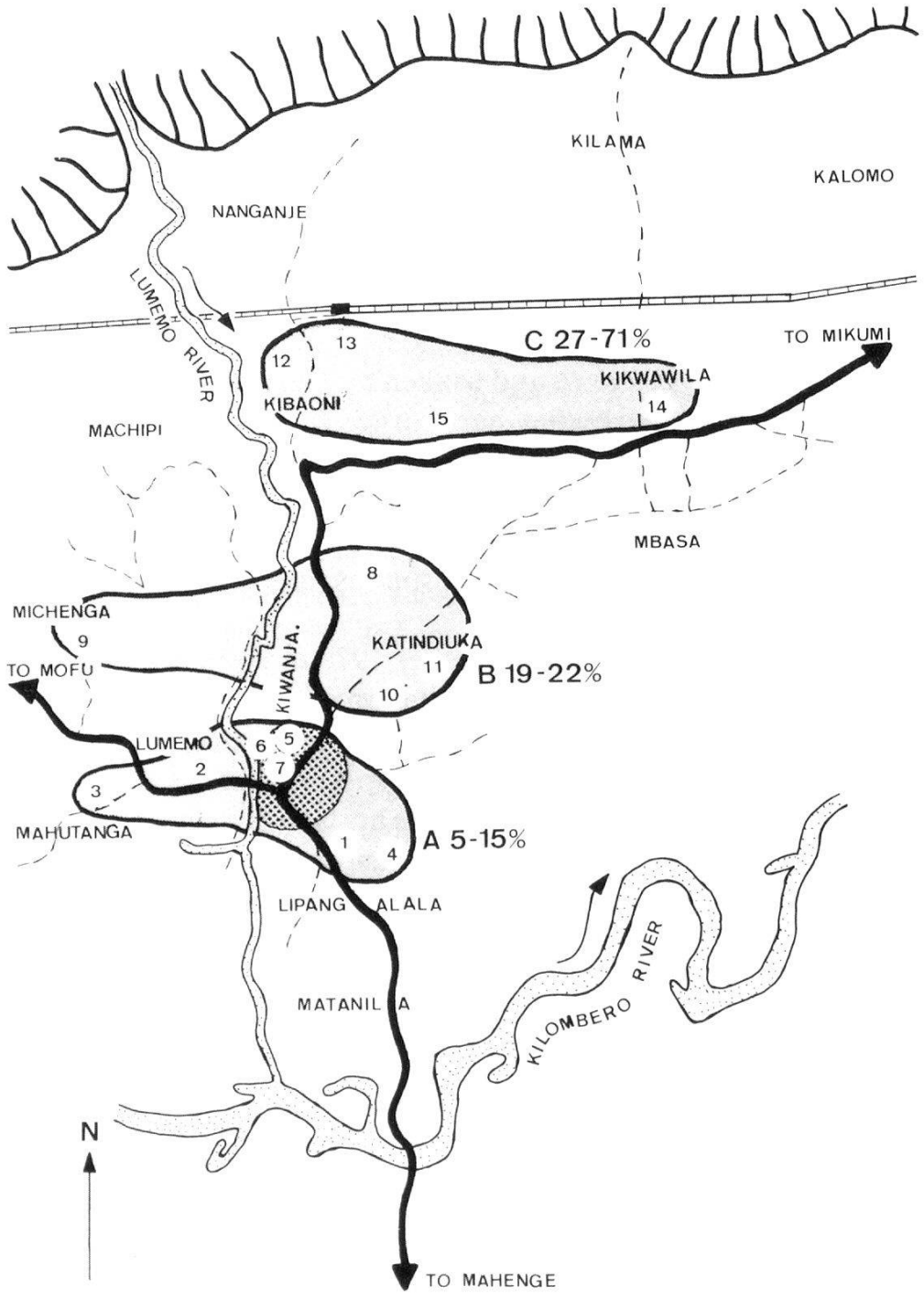

Fig. 1. Sketch map of Ifakara agglomeration: Zones with varying prevalence of *S. haematobium* infection in primary school children. Numbers = location of primary schools examined (cf. Table 1). Scale 1:150 000.

= Foothills of Iringa mountains

= Ifakara town

= Main roads

= Minor roads and tracks

= TAZARA railway

= Rivers

= Zones with primary schools of varying prevalence of *S. haematobium* infection (A–C)

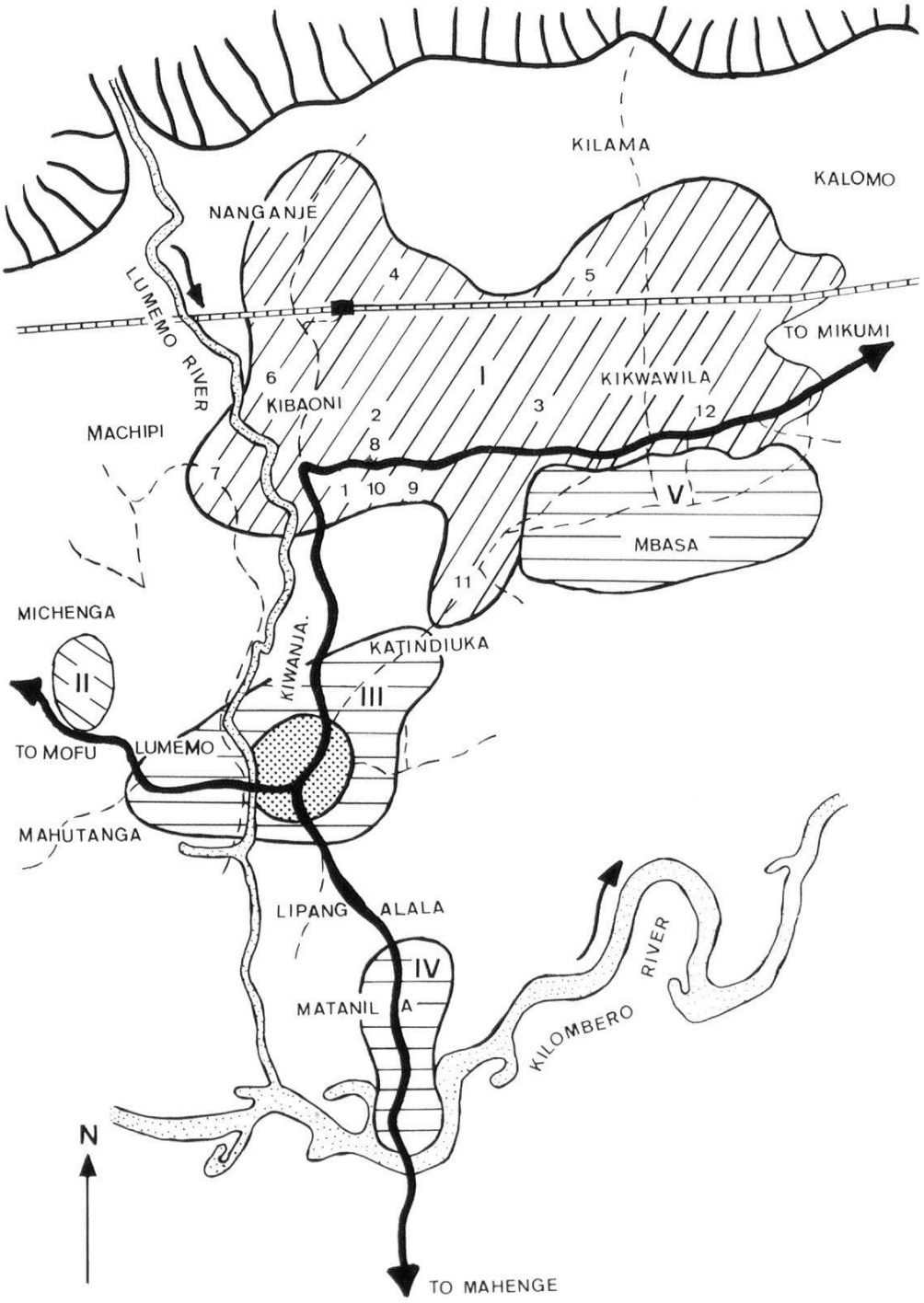

Fig. 2. Sketch map of Ifakara agglomeration: Geographical distribution of waterbodies examined for *Bulinus*. Numbers = waterbodies with *Bulinus* shedding cercariae of mammalian type (cf. Table 4). Scale 1:150 000. Further explanation see Fig. 1.

= Zone I: Waterbodies with mainly *B. (Ph.) globosus*

= Zone II: Waterbodies with mainly *B. (Ph.) nasutus*

= Zone III–V: Waterbodies without *Bulinus*

For the boys of four schools microhaematuria was measured prior to urine filtration, using dip sticks (Sangur-Test, Boehringer Mannheim GmbH, Mannheim, Germany).

c) *Collection of snails*

All waterbodies indicated by the local people were visited, mapped (Fig. 2) and, whenever possible, examined monthly for snails. *Bulinus* snails were collected, identified on the basis of the morphology of their shells (Mandahl-Barth, 1958) and checked for cercariae-shedding in the laboratory. Samples of the snails were regularly dispatched to the WHO Collaborating Centre for applied Malacology, Charlottenlund, Denmark, for confirmation. Another sample was used for laboratory studies on susceptibility to *S. haematobium;* thus the snails collected were not brought back to their original habitats.

d) *Susceptibility of snails*

Prior to laboratory infection snails from the field were kept for at least five weeks in the laboratory and checked for shedding of cercariae in order to exclude field-infection with *S. haematobium.* To test their susceptibility, *B. (Ph.) globosus* (size 5–15 mm) from 31 waterbodies in zone I (Fig. 2) and *B. (Ph.) nasutus* from two waterbodies in zone II (Fig. 2) were exposed individually to 5–10 miracidia each, obtained from *S. haematobium*-eggs from several children of different schools.

From the 21st day after exposure the snails were checked every fourth day for the shedding of cercariae. The average infection rate of the surviving snails (IR = number of snails shedding cercariae divided by the number of surviving snails) and the average prepatent period were assessed.

e) *Knowledge of the local population about urinary schistosomiasis*

In order to get information on the knowledge and awareness of the local population about urinary schistosomiasis, the children of two schools – Kapolo (Fig. 1, Nr. 15) with a high prevalence of *S. haematobium* infection and Kiyongwire (Fig. 1, Nr. 4) with a low prevalence – and their parents were interviewed by students of the Medical Assistants' Training Centre, Ifakara, using a questionnaire in Swahili[1]. The questionnaire included questions about the profession of the parents, water supply, sanitation, and the transmission and prevention of urinary schistosomiasis. The answers of the children and parents of the two schools were compared.

Results

a) *Prevalence and intensity of S. haematobium infection in primary school children*

The overall prevalence (Table 1) for all school children examined was 21% (730/3478). The overall prevalence for males was 22% (406/1829) and for females 20% (324/1649). The difference between the two sexes was not significant (χ^2-test); this also applies to each individual school except the ones of Jongo (5) and Mtoni (6) where significantly more boys were infected than girls.

The overall prevalence by age and sex is shown in Fig. 3. The highest number of children examined, of both sexes, was in the age-group 10–14 years; this applies equally to all individual schools. The highest overall prevalence of *S. haematobium* infection was found in the age-group 15–19 years. The differences in prevalence between the three age-groups of the total number of chil-

[1] Questionnaire available from the author on request.

Table 1. Prevalence and intensity of *S. haematobium* infection in primary school children at and around Ifakara

School	Prevalence		Intensity*
	Nr.	%	
1 Lipangalala	15/297	5	18
2 Lumemo	16/239	7	7
3 Mahutanga	17/190	9	5
4 Kiyongwire	17/181	9	10
5 Jongo	49/389	13	9
6 Mtoni	48/352	14	6
7 Madukani	42/289	15	8
8 Maendeleo	18/ 97	19	15
9 Michenga	42/216	19	23
10 Mholo	36/178	20	15
11 Katindiuka	40/185	22	13
12 Kibaoni	91/342	27	14
13 Milola	85/177	48	15
14 Kikwawila	115/206	56	14
15 Kapolo	99/140	71	36
Total	730/3478	21	15

* geometric mean of eggs per 10 ml urine of the infected children

dren examined are significant (χ^2-test, $p<0.05$). For boys the difference in prevalence among all three age groups was significant too. For girls the prevalence differed significantly only between age groups 6–9 years vs. 10–14 years and 15–19 years.

The prevalence in individual schools, however, varied remarkably, ranging from 5% (Lipangalala) up to 71% (Kapolo). According to their prevalence the schools can roughly be grouped into three zones (Fig. 1): A (Ifakara-town, Lipangalala, Lumemo, Mahutanga) with a prevalence of 5–15%, B (Katindiuka, Michenga) with a prevalence of 19–22%, C (Kibaoni, Kikwawila) with a prevalence of 27–71%. Kapolo, the school with the highest prevalence (71%) was examined a second time, 1½ years after the first examination. The prevalence was then 65%, which was lower but not significantly. Kikwawila too was examined a second time, 1 year after the first survey. The prevalence had increased significantly, from 56% to 71% (χ^2-test, $p<0.01$).

The intensity of the *S. haematobium* infections is shown in Table 1. It amounts overall to 15 eggs/10 ml urine. In the individual schools there were no significant differences in the intensity of infection between males and females (Wilcoxon's rank order test).

The highest egg output (36 eggs/10 ml urine) was found at Kapolo, the primary school with the highest prevalence (71%). Except Michenga all the

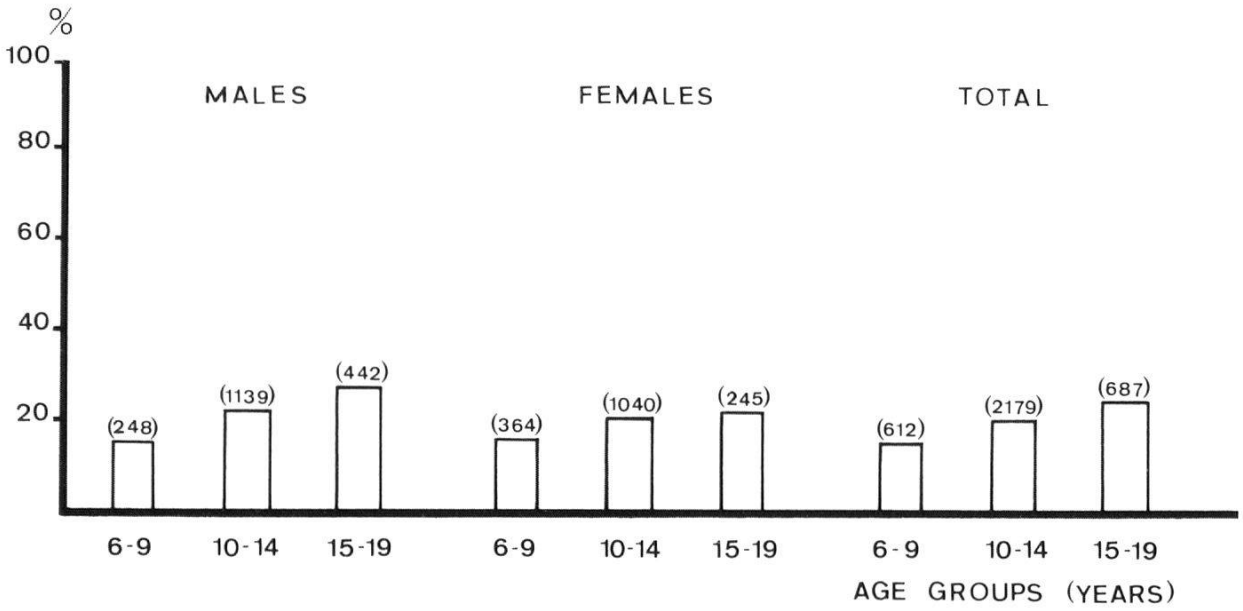

Fig. 3. Prevalence of *S. haematobium* infection in primary school children by age and sex (numbers in brackets = total number examined).

Table 2. Prevalence of *S. haematobium* infection and microhaematuria in boys of four primary schools

School	Prevalence of *S. haematobium*		Prevalence of microhaematuria			
			S. h. infected boys		apparently uninfected boys	
	Nr.	%	Nr.	%	Nr.	%
9 Michenga	16/111	14	10/16	62	3/95	3
13 Milola	55/111	50	43/55	78	5/56	9
14 Kikwawila	59/100	59	35/59	59	6/41	15
15 Kapolo	52/74	70	46/52	89	1/22	5
Total	182/396	46	134/182	74	15/214	7

other schools examined had a significantly lower egg output (Wilcoxon's rank order test, $p<0.05$). Comparing the schools examined no correlation could be established between prevalence and intensity.

b) *Microhaematuria versus prevalence and intensity of S. haematobium infection in boys*

In the four schools Michenga, Milola, Kikwawila and Kapolo, microhaematuria was checked with dip sticks in the urine samples of boys. The prevalence of *S. haematobium* and of microhaematuria is presented in Table 2. The average prevalence of *S. haematobium* in boys of the four schools was 46%; 74%

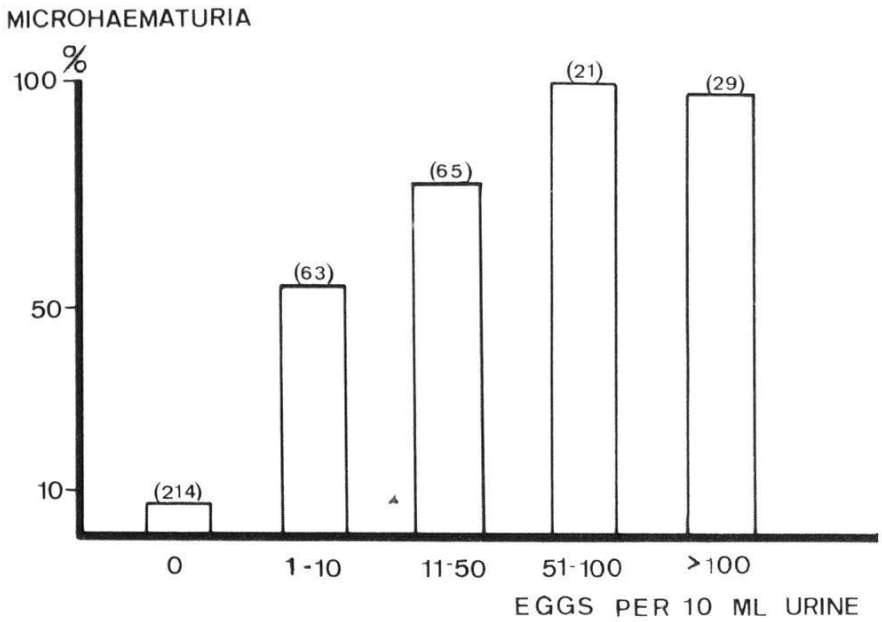

Fig. 4. Prevalence of microhaematuria in relation to *S. haematobium* egg output in boys of four primary schools (numbers in brackets = total number examined).

of the infected and 7% of the noninfected boys had microhaematuria. A correlation between *S. haematobium* infection and microhaematuria was found.

Although Kapolo, the school with the highest prevalence of *S. haematobium* (71%) had the highest prevalence of microhaematuria (89%), the frequency of microhaematuria among the infected boys of the different schools did not directly correlate with the prevalence of *S. haematobium* infection.

In Fig. 4 the prevalence of microhaematuria correlates with the egg output, reaching virtually 100% from an egg output of 50 eggs/10 ml urine onwards.

The severity of microhaematuria correlates with an increase in the intensity of infection (Table 3).

c) *Waterbodies and snails*

During the time of the investigations 87 waterbodies in and around Ifakara were identified, mapped and, whenever possible, checked monthly for infected *Bulinus* and *Biomphalaria*. Most of the waterbodies were man-made as a result of road-, track- or railway-construction or brick-manufacture.

In 49 waterbodies *Bulinus* were found. As can be seen from Fig. 2 the majority of these were situated in the northern and north-eastern areas (zone I of Fig. 2), along the main road to Mikumi and between the main road and the mountains to the north. A few snail-containing waterbodies were located in Michenga, to the west of Ifakara (zone II, Fig. 2). Of the 49 waterbodies, 40 harboured *B. (Ph.) globosus* only, 6 mainly *B. (Ph.) globosus* and, sporadically, a few *B. (Ph.) nasutus* (zone I). Two waterbodies in zone II contained mainly *B. (Ph.) nasutus* with sporadically occurring *B. (Ph.) globosus;* in one waterbody *B. (Ph.) nasutus* only was found.

Table 3. Severity of microhaematuria and intensity of *S. haematobium* infection in boys of four primary schools (cf. also Table 2; overall of all schools)

	Severity of microhaematuria (Sangur-Stick-Test)*			
	negative	+	++	+++
Nr. of *S. h.* infected boys examined	46	12	17	107
Intensity of infection**	6	8	16	34

* + = ca. 5–10 Ery./µl
++ = ca. 50 Ery./µl
+++ = ca. 250 and more Ery./µl

** geometric mean of eggs per 10 ml urine of the infected boys

The waterbodies in and around Ifakara-town (Zone III), south of Ifakara along the road to the Kilombero river (zone IV) and south of the mainroad to Mikumi, in Mbasa (zone V), were free from *Bulinus*. The same applies to the Kilombero- and Lumemo rivers.

No *Biomphalaria* were found in the areas mentioned in Fig. 2.

A total of 12 waterbodies harbouring *B. (Ph.) globosus* shedding cercariae of the mammalian type were identified in 1980. Their location can be seen in Fig. 2. Ten of these waterbodies were situated in the Kibaoni-Kikwawila-areas and were known as bathing places for the children. One was found in the Katindiuka- and one in the Machipi-area.

In Table 4, the number of snails collected monthly per man and for 10 minutes, together with the number of snails shedding cercariae of mammalian type is presented for these 12 waterbodies. In waterbodies 1–9 *Bulinus* shedding cercariae of the mammalian type were found only during one or two of the monthly surveys in the period from March to December, and each time not more than one infected snail (out of 5–78) was found.

In the waterbodies 10–12 infected snails were found during three to six monthly surveys, from February to December, and one to four infected snails (out of 8–105) per survey were found. Waterbody 10 was a man-made pond resulting from brick-manufacture. Waterbody 11 was a natural swamp with a track going through it, leading to the rice-fields. Waterbody 12 consisted of a small river passing underneath the main road to Mikumi, with severall small ponds besides the main stream. This river and its ponds were well-known bathing places for the children of the primary schools Kapolo and Kikwawila.

No *B. (Ph.) nasutus* were ever found shedding cercariae during the period of these investigations.

d) *Susceptibility of Bulinus to S. haematobium*

In 64 experiments a total number of 826 *B. (Ph.) globosus* were exposed to 5–10 miracidia from urines of several children from different schools. The

Table 4. List of waterbodies with *B. globosus* shedding cercariae of mammalian type in the Ifakara agglomeration in 1980 (cf. also Fig. 2)

Nr. of water-body	*Snails / man / 10 minutes* ★ infected snails / collected snails ★★											
	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1 ★	–	–	–	–	2,0	**2,5**	0	1,5	dry	dry	dry	dry
★★						**1/5**						
2 ★	–	–	–	–	1,0	2,5	2,4	3,0	**10,0**	0,5	0	0
★★									**1/20**			
3 ★	–	–	0,2	0,9	0	**2,0**	0,3	0,7	0	0	0	0
★★						**1/5**						
4 ★	–	–	4,4	11,0	26,6	**31,2**	20,7	3,0	1,0	2,0	0	0,7
★★						**1/78**						
5 ★	–	16,0	6,0	3,7	0,3	0	2	0,5	0	2,0	4,7	**7,3**
★★												**1/22**
6 ★	–	1,0	4,7	5,7	23,3	**25,6**	25,3	10,0	5,3	5,0	8,3	5,7
★★						**1/64**						
7 ★	–	3,5	1,0	2,0	20,4	25,2	**15,5**	127,0	dry	–	1,0	4,3
★★							**1/33**					
8 ★	0	2,7	**2,4**	**4,0**	1,7	1,0	0	0	0	0	0	0
★★			**1/11**	**1/12**								
9 ★	–	–	–	–	**6,9**	**6,5**	2,0	2,0	0,2	dry	dry	dry
★★					**1/62**	**1/59**						
10 ★	–	–	–	–	1,0	**5,7**	**3,4**	**2,2**	0	dry	dry	dry
★★						**3/17**	**1/12**	**1/13**				
11 ★	–	**4,5**	**1,3**	19,2	**15,3**	**25,0**	8,5	–	20,7	–	7,7	1,0
★★		**2/9**	**1/8**		**1/92**	**2/56**						
12 ★	0	1,3	0,2	0	**4**	0	6,5	**22,8**	**42,0**	**27,6**	**18,9**	**5,5**
★★					**1/16**			**1/57**	**1/105**	**4/69**	**3/66**	**1/22**

– no search for snails
0 no *Bulinus*

average infection rate was 32% (191/595) and the average prepatent period 45 days, with a minimum of 28 and a maximum of 78 days.

A total number of 223 *B. (Ph.) nasutus* were exposed to miracidia in the same way as *B. (Ph.) globosus*. None of these snails shed any cercariae.

Table 5. Summary of the answers of children and parents of the two primary schools Kapolo and Kiyongwire to the question «How do you get infected with schistosomiasis?»

	Kapolo		Kiyongwire	
	children (%)	parents (%)	children (%)	parents (%)
a) Respiration	2/136 (1)	0/60 (–)	2/142 (2)	0/31 (–)
b) Food	8/136 (6)	1/60 (2)	13/142 (9)	0/31 (–)
c) Mosquitoes	2/136 (1)	0/60 (–)	9/142 (6)	1/31 (3)
d) Water	115/136 (85)	37/60 (62)	109/142 (77)	22/31 (71)
1. drinking	7/115 (6)	1/37 (3)	13/109 (12)	0/22 (–)
2. bathing washing fishing	108/115 (94)	36/37 (97)	96/109 (88)	22/22 (100)
Disease transmitted by:				
2a) Fish	4/108 (4)	0/36 (–)	3/96 (3)	0/22 (–)
2b) Waterplants	7/108 (6)	0/36 (–)	9/96 (9)	0/22 (–)
2c) Watersnails	87/108 (81)	31/36 (86)	72/96 (75)	18/22 (82)
2d) do not know	10/108 (9)	5/36 (14)	12/96 (13)	4/22 (18)
e) Do not know	9/136 (7)	22/60 (36)	9/142 (6)	8/31 (26)

e) *Knowledge of the local population about urinary schistosomiasis*

The evaluation of the answers of children and parents of the two selected primary schools Kapolo and Kiyongwire to the questions relevant to transmission of schistosomiasis gave the following results: Most of the parents (97%) of the children of both schools were farmers. All of the children as well as their parents answered that they made use of their own pit-latrine. About one third of the parents and children from Kapolo said they obtained tap-water from a public-well, compared with two thirds of the parents and children of Kiyongwire.

The answers of children and parents of both schools to the question "How do you get infected with schistosomiasis?" are summarized in Table 5. Between 62 and 85% of the children and parents of both schools knew that water is responsible for the transmission of the disease.

A high percentage of children and parents (88–100%) knew that infection with schistosomiasis occurs by bathing, washing or fishing and that the disease is transmitted by aquatic snails (75–86%).

Haematuria and painful micturation, as the most obvious clinical picture of urinary schistosomiasis, was recognized by a high percentage of children and parents of both schools (81–93%).

Relatively few children and parents (32–40%) realized that the way in which an individual can protect himself from getting infected with the disease is by avoiding contact with contaminated water (playing, washing etc.).

Not urinating into water as a preventive measure to avoid the spreading of the disease was known by 42–67% of the children and parents of both schools.

Very few children and parents (6–17%) realized that the proper use of latrines would help to prevent the spreading of the disease.

The comparison of the answers of the children and parents of both schools to the questions of the questionnaire did not demonstrate any significant difference of knowledge (t-test). This means that the children and parents of Kiyongwire, the school with a low prevalence of *S. haematobium* were as aware of the disease as the children and parents of Kapolo, the school with a high prevalence.

Discussion

The previous studies mentioned in the introduction and the investigations presented in this paper confirm that urinary schistosomiasis is endemic in the Kilombero valley. The overall prevalence in primary school children in and around Ifakara in 1978–1980 was 21%, which is lower than in similar investigations at Mwanza with 65% (Forsyth and Bradley, 1966) and Tanga with 38% (Bailey and Davis, 1970). In accordance with the above-mentioned authors, the highest prevalence was found in children of both sexes at the age of 15–19 years. Except in two schools (Jongo, Mtoni) no difference in prevalence between girls and boys could be found, indicating that the water contact patterns were nearly the same for both sexes (Marti and Tanner, 1982).

The prevalence in the individual schools examined was far from being uniform; marked variations occurred between the different zones (Fig. 1, A–C). These differences in prevalence can be explained mainly by the availability of tap-water and by the distance of the living quarters from the childrens' bathing places. The primary schools of zone A (5–15%) were located in or near Ifakara-town, where most of the people are provided with tap-water from public wells. The bathing places that act as foci of transmission (Fig. 2, zone I) are too far away for the children to reach. Not all of the inhabitants of zone B (19–22%) have access to tap-water; the bathing places are nearer and more easily accessible for the children. In zone C (27–71%) even fewer people have access to public wells; their water sources consist mainly of shallow wells dug by hand, small rivers and natural ponds. This area lies within the zone where infected *Bulinus* were found.

The intensity of *S. haematobium* infection (Table 1) was surprisingly low, even in schools with a high prevalence (zone C). These results are in contrast to other investigations in Tanzania (Forsyth and Bradley, 1966; Bailey and Davis, 1970; Rugemalila et al., 1979), in Kenya (Warren et al., 1979) and in the Gambia (Wilkins et al., 1979). These reason for the low egg output may be the fact that the urines were collected between 9 and 11 a.m. and not between noon and

2 p.m., when the egg output of *S. haematobium* is at its maximum (Stimmel and Scott, 1956; Jordan, 1961; Onori, 1962) and least variable (Bradley, 1963).

On the other hand, a study on *S. haematobium* infection related morbidity among patients admitted to the S. Francis Hospital revealed a significant morbidity in adults and children with not more than 50 eggs/10 ml urine (Furrer, 1981) and a *S. haematobium* related morbidity like haematuria, proteinuria and leucocyturia was found among primary school children of the first and second standards (7–12 years) with not more than 20–50 eggs per 10 ml urine and living in the rural area of Ifakara (Tanner et al., 1982). Thus already at a relatively low egg output signs of morbidity can be found.

It is generally known that there exists a correlation between the prevalence of the disease and the intensity of infection (Goatly, 1964; Goatly and Jordan, 1965). Although in our investigations the primary school with the highest prevalence (71%) in fact showed the highest intensity of infection (36 eggs/10 ml urine) a correlation between prevalence and intensity could not be demonstrated (Table 1), probably because the sample size (number of infected children in the individual schools) was too small for differences to be statistically significant.

Despite the seemingly low intensity of *S. haematobium* infection, 74% of the infected boys suffered from microhaematuria (Table 2). This comparatively high prevalence of microhaematuria might be explained by the suboptimal time of urine collection; in reality, the egg output and the intensity of infection may be higher than was actually observed. However, other reasons for this high prevalence of microhaematuria may also exist, such as nutritional factors (Furrer, 1981; Tanner et al., 1982; Tanner et al., 1983).

Seven percent of the non-infected boys suffered from microhaematuria. As the intensity of infection was low, it was possible that the boys with light *S. haematobium* infections had no eggs in their urine on the day of the examination (Warren et al., 1979). It is further well known that there exists a considerable daily fluctuation in egg output in the urine (Stimmel and Scott, 1956; Scott, 1957; McCullough and Bradley, 1973; Wilkins, 1977; Warren et al., 1979). Probably a longitudinal examination of the urine of these boys would have resulted in the detection of *S. haematobium* eggs, at least in some of them.

Although a correlation between the prevalence of *S. haematobium* infection and the prevalence of microhaematuria was found (Table 2) the frequency of microhaematuria among *S. haematobium* infected boys of the four schools examined did not directly correlate with the prevalence of *S. haematobium* infection, probably again because the number of boys examined was too small for differences to be statistically significant. On the other hand the egg output in the four schools coincided well with the prevalence of microhaematuria (Fig. 4), which is in accordance with the investigations of Warren et al. (1979), although the intensity of infection in their investigations was much higher.

The degree of microhaematuria also correlated well with the intensity of

infection (Table 3), which is in accordance with the results of Wilkins et al. (1979) and Feldmeier et al. (1982).

The zone with primary schools of high *S. haematobium* prevalence was situated within the zone where infected *B. (Ph.) globosus* were found (Figs. 1 and 2). The schools with the highest prevalence (13, 14, 15) were localized near the waterbodies that are used as bathing places by the children, and where infected *B. (Ph.) globosus* were found. This indicates a focal transmission as it was described by Bailey and Davis (1970), McCullough et al. (1972) and McCullough and Krafft (1976).

Although in the areas examined *B. (Ph.) globosus* and to a lesser extent *B. (Ph.) nasutus* were found, only *B. (Ph.) globosus* was infected in the field and can therefore be regarded as the main intermediate host for the Ifakara agglomeration.

These observations were confirmed by the results of laboratory experiments about the susceptibility of *B. (Ph.) globosus* and *B. (Ph.) nasutus*. The latter were not susceptible to the local strain of *S. haematobium* although elsewhere *B. (Ph.) nasutus* is known to be an intermediate host for *S. haematobium* (Cridland, 1955; Mandahl-Barth, 1958; Teesdale, 1962; Webbe, 1962, 1963; Sturrock, 1965; McClelland, 1967; Danish Bilharziasis Laboratory, 1973; McCullough and Eyakuze, 1973).

During the time of our investigations the zones III–V (Fig. 2) were free of *Bulinus*. The reason remains unknown[2]. Zone V is currently being investigated by HP. Marti (in preparation).

Infected *B. (Ph.) globosus* could be found throughout the whole of 1980 (Table 4). This indicates that transmission of *S. haematobium* can be regarded as perennial (Bailey and Davis, 1970). The highest number of waterbodies with infected snails was found in June, and the peak of transmission probably occurred during this month. Waterbody 12, being a bathing place of the children of Kapolo and Kikwawila, harboured infected *Bulinus* from August to December (Table 4) and could be regarded as one of the main sites of transmission.

It should, however, be kept in mind that besides the 12 waterbodies actually found to harbour infected *Bulinus* a large number of other waterbodies with *Bulinus* populations exist. Furthermore the increasing need of bricks for the construction of houses will create additional man-made habitats for snails and possible foci of transmission (McCullough and Krafft, 1976).

In the areas investigated no *Biomphalaria* were found, therefore it can be assumed that the few people infected with *S. mansoni* acquired their infections outside the agglomeration of Ifakara.

[2] In 1981, in the area of Kiwanjasitini, about 12 small waterbodies were localized, all of them man-made, as a result of brick-manufacture. In one of these waterbodies a mixed population of *B. (Ph.) globosus* and *B. (Ph.) nasutus* was found. The snails were not shedding cercariae (Tanner, unpublished).

In our investigations nearly 100% of the children and parents answered that they made use of their own pit-latrine. This assertion of course does not correspond to reality but it does demonstrate that people are aware of the problems of sanitation. A recent census in the area of Kikwawila has shown that in fact only 57% of the households have their own pit-latrine (Tanner et al., unpublished).

Furthermore, in theory, the children and their parents were quite aware of the most obvious clinical symptoms of urinary schistosomiasis and of the mode of transmission of the disease. This indicates that the endeavours of teachers, radio, the personnel of the Hospital and the Dispensaries have been successful to a certain degree in educating people. On the other hand, both children and parents were much less conscious of ways of putting their knowledge into practice, i.e. the protection of the individual and of the community from the disease.

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