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EPIDEMIOLOGICAL STUDY OF *SCHISTOSOMA HAEMATOBIUM* INFECTION IN THE COASTAL AREA OF KENYA

Parasitological Baseline Data in the Pilot Area, Mwachinga

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Abstract: A cross-sectional epidemiological survey on *Schistosoma haematobium* infection was carried out in a small community in the coastal area of Kenya. From the 1,206 registered inhabitants, 853 urine specimens were examined. The overall prevalence and intensity of infection were 68.2 percent and 50.0/hour respectively. Some demographical and geographical differences of infection were analyzed. The profile of age-related distribution showed sexual differences in the prevalence and intensity of infection, the prevalence of heavy infection (>1,000/hour) and the prevalence of gross hematuria. Those of females are higher than those of males especially after adolescence. This is probably due to the difference in water contact behavior. The marked higher prevalence and intensity of infection were observed among people who lived along the branch of a main river than those who lived along the main river. The difference might be due to the different degree of contamination in the rivers. There was no difference in prevalence and intensity of infection among the three main tribes.

INTRODUCTION

The coast area in Kenya has long been well known as an endemic area of *Schistosoma haematobium* infection (Highton, 1974). We started a research and control program on schistosomiasis in 1981. On the basis of a preliminary study on the distribution of the disease performed in August and September of 1981, an area called Mwachinga village was chosen as the study area (Figure 1). It is located in the Hinterland area, 20 km from Kwale town. The main reasons for the choice of this area were: 1) the village represented typical Hinterland conditions; 2) the village has a water pipeline which was inadequately used by the inhabitants for a long period of time and, therefore, could be used as a control tool in future; 3) a laboratory is conveniently located in nearby Kwale; and 4) cooperation was good among villagers and

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authorities.

The present paper is a report on the first parasitological study in our study area. The main purpose of the study was to obtain baseline data on the prevalence and the intensity of infection and to determine in detail the present status of infection of inhabitants living in the area. The results obtained here will be indispensable in beginning a cohort study on the transmission of the disease.

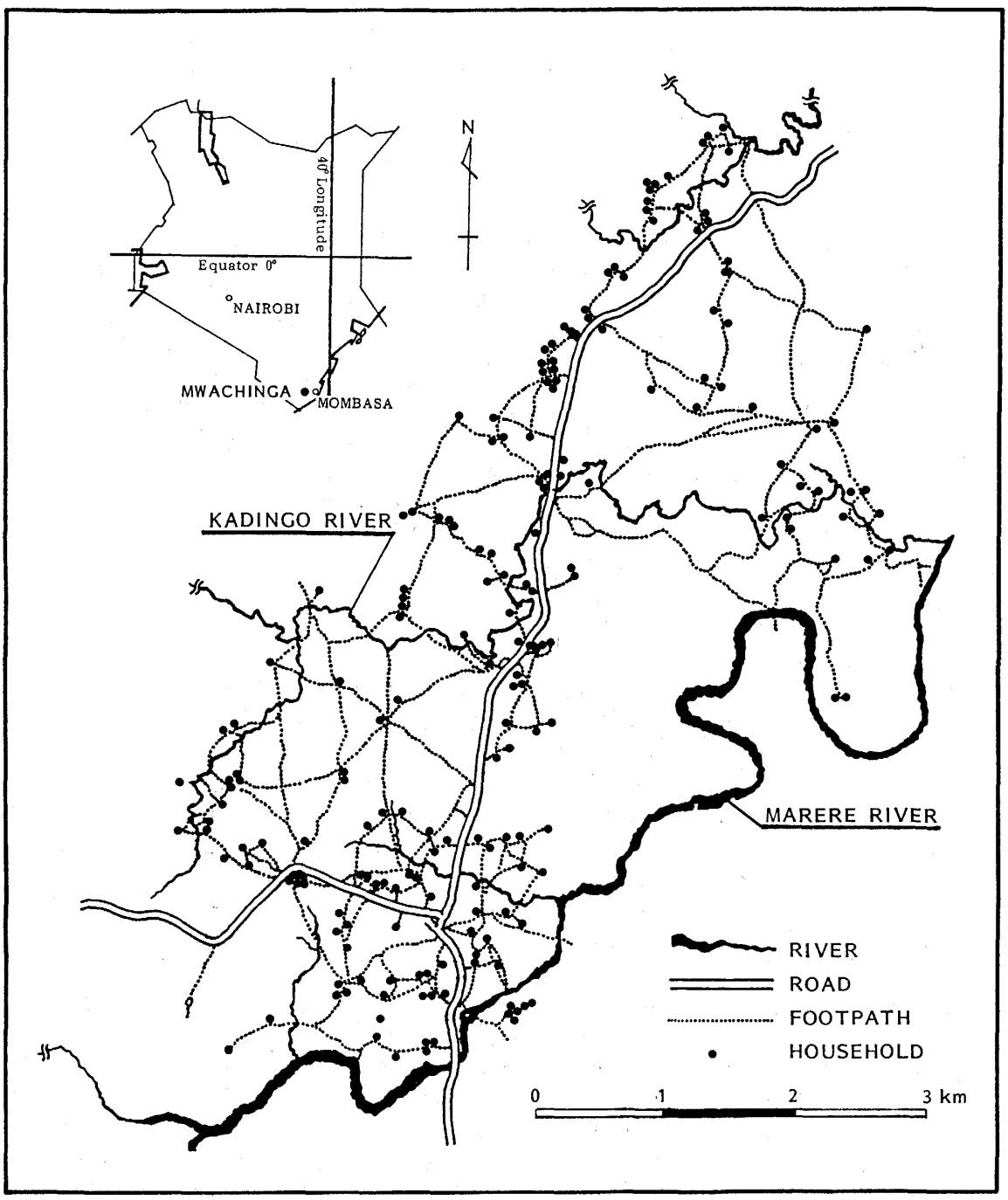

Figure 1 Map of Mwachinga.

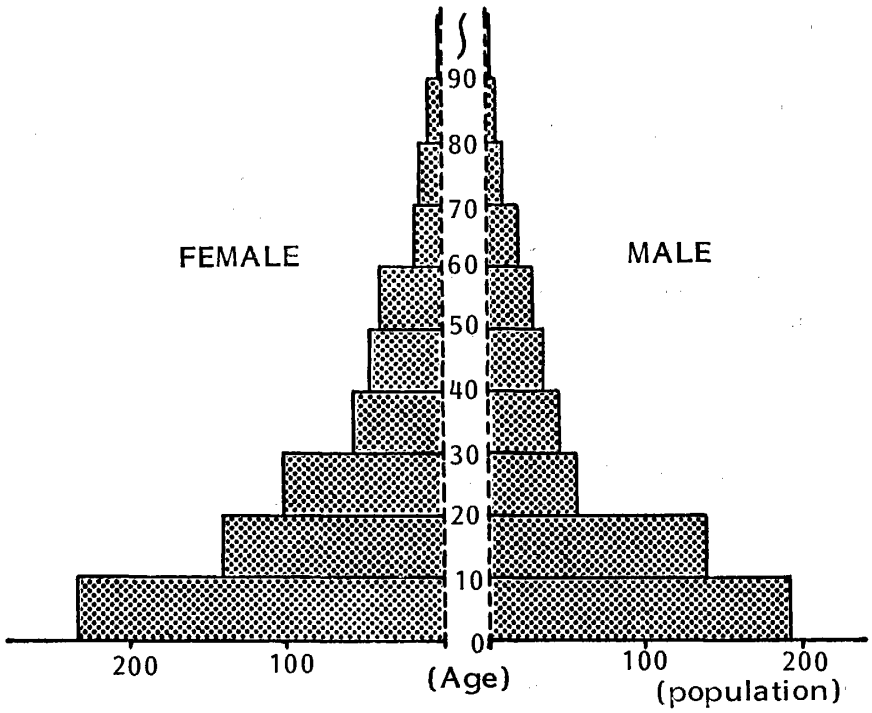

Figure 2 Population pyramid in June, 1982.

Description of the Study Area (Figure 1)

The area is not geographically isolated and so permits interaction between inhabitants and people living outside the village. The land is undulating, dotted with houses on the hill area, and partially cultivated. The main crops are corn (maize) and cassava, harvested mostly for local use. There are no irrigation canals for cultivation in the area and the inhabitants farm only in the rainy season. Along the river banks, banana trees, coconut palms and sugar cane are planted, while cashew nut trees are plentiful in the hill area. Fishing has not been established as an industry but the people often fish from the river for their own consumption.

A river named Marere flows from southwest to north through the village and serves as a limiting boundary in the east. The river also has a dam with an artificial lake located upstream. Downstream, the river joins a branch called Kadingo which seasonally flows through the middle of the village. In the dry season, the Kadingo river branch almost completely dries up leaving random pools in some areas. Although there was a main water pipeline, the villagers were forced to go either to the river or to the branch to collect water because the pipeline had been constructed mainly for Mombasa, the second biggest city in Kenya. There were only three taps along it and no other safe water sources such as boreholes and wells.

Population Census

Population census and mapping were carried out for the whole village and some of the areas along the river during the period between December 1981 and February 1982. Every house and every person was given a serial number and information such as name, sex, date of birth,

date of arrival in the village and tribe was collected. The locations of the houses and footpaths were marked on the map (Figure 1).

The total population registered as residents at the first stage of the survey was 1,206 consisting of 540 males and 666 females. The population pyramid showed a typical pattern for a rural area of Kenya, namely, a relatively smaller number of males than females especially in the younger adult groups (Figure 2). The Duruma (35.8%) and Digo (51.7%) are the main tribes living in this area. The Digo people live in the northern part of the village and the Duruma live in the southern part. The third biggest tribe is the Giryama (10.7%). Population movement does not seem to be frequent except for younger male adults who tend to move to town for employment.

Materials and Methods

The urine examination of villagers was carried out in May and June, 1982. Only a single urine sample from each individual was examined.

A quantitative examination of eggs in each urine sample was carried out by following the nuclepore method (Peters *et al.*, 1976). Membranes with 12 μm porosity and 25 mm in diameter were used to reduce the chance of clogging which occurs frequently when using a smaller poresize and diameter membrane. Egg count per unit of time was applied to determine the intensity of infection, based upon the data obtained from our recent research (Shimada *et al.*, 1987).

The collection of urine was carried out between 10.30 a.m. and 1.30 p.m.. Briefly, people were requested to urinate after 10.30 a.m., to discard their first urine and wait for at least one hour before collecting the second sample. The total volume of the second urination was collected and a part of it was filtered adjusting the number of eggs on the filter to a readable count on the same day. Total egg count was calculated according to the volume of filtered urine and the period of time between the first and the second urination. For the calculation of geometric mean value of egg count, a $\log_{10}(N+1)$ transformation was applied to all egg counts.

The color of urine samples was also recorded. It was classified into yellow, brown and red. The last two urine colors were regarded as gross hematuria.

All data were coded in computers and analyzed by using our own programs or the SAS® programs (SAS Institute Inc.).

Results

— Participation —

Of the 1,206 inhabitants first registered by census, 853 provided urine specimens suitable for the examination of the ova of *S. haematobium*. The participation rates of males and females were 68.9 and 72.2%, respectively. A relatively low response to the examination was observed in females under 5 years of age and in young adult males (Table 1).

— Age and sex distribution of prevalence of infection —

The results are summarized in Figure 3. The ova of *S. haematobium* were found in 582 or 68.2% of subjects examined in this study. The overall prevalence was 70.5% in females and

Table 1 Participation rate in the examination

Age group	Male		Female	
	Population registered	No. examined (%)	Population registered	No. examined (%)
0–4	93	58 (62.4)	125	72 (57.6)
5–9	100	78 (78.0)	109	88 (80.7)
10–14	78	61 (78.2)	67	42 (62.7)
15–19	61	39 (63.9)	74	48 (64.9)
20–29	57	31 (54.4)	102	79 (77.5)
30–39	46	25 (54.3)	57	50 (87.7)
40–49	36	27 (75.0)	47	41 (87.2)
50–59	29	23 (79.3)	41	33 (80.5)
60–	40	30 (75.0)	44	28 (63.6)
Total	540	372 (68.9)	666	481 (72.2)

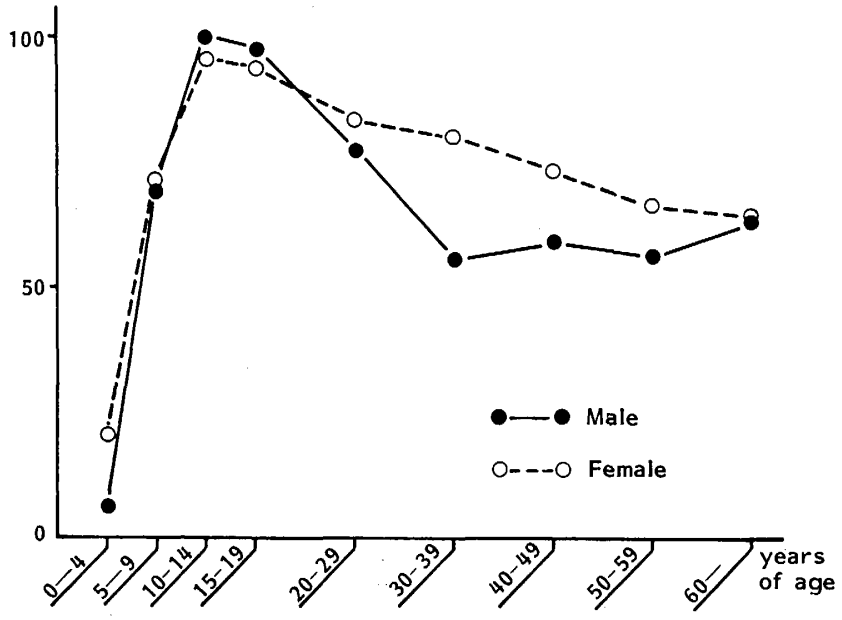

Figure 3 Prevalence of infection by age and sex.

65.3% in males. The difference was not statistically significant ($X^2=2.572$, $P=0.109$).

Since the composition of population between males and females is different, an adjustment of positive rate in each age group was applied to estimate the revised prevalences in both sexes, although the sampling was not at random. The adjusted prevalences were 64.2% in males and 70.6% in females. The difference was statistically significant at 5% confidence level ($X^2=3.899$, $P<0.05$) after the adjustment.

The profile of the prevalence curve in relation to age showed a clear difference between males and females. Although the prevalence of infection showed a clear peak of 100.0 or 95.2% at 10–15 years of age in each sex, that of females increased more rapidly with age than that of

males in the first 5 years of life. After 14 years of age, a sharp decline of prevalence was observed in males, while the prevalence in female decreased gradually. The prevalence among males was significantly lower than that among females in the age group of 0–4 and 30–39 years (X^2=5.000 and 4.762, P=0.025 and 0.029).

— Age and sex distribution of intensity of infection —

The overall geometric mean egg count was 50.00 eggs per hour, that of males being 47.07 eggs per hour and that of females 52.36 eggs per hour. No statistically significant difference was observed.

The age-intensity distribution shows almost the same curve patterns as that of age-prevalence distribution in both males and females (Figure 4). The excretions of eggs increased in number with age and reached a peak at the age of 10–14 in both sexes. In males, however, after reaching a peak of 1,429.87 eggs per hour, egg count declined rapidly and came to a stable state at less than 20 eggs per hour. In females, the intensity decreased gradually after showing a peak of 836.14 eggs per hour. The mean egg count in the 30–39 age group was significantly different between the sexes (T=3.5151, DF=73, P=0.0008).

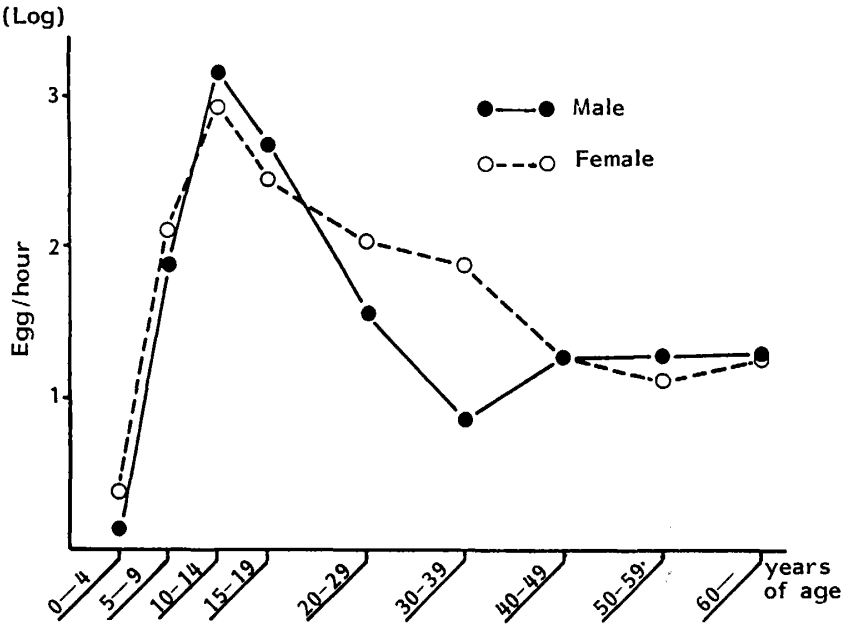

Figure 4 Intensity of infection by age and sex.

— Gross hematuria (Color of urine) —

The colors of urine were recorded on 849 out of 853 specimens. Figure 5 shows the prevalence of macroscopic hematuria in relation to age and sex.

As a whole, 61 or 7.2% were red and 273 or 32.2% were brown. There was no significant difference in overall prevalence between the sexes (X^2=0.922, P=0.337). The prevalence increased with age, reaching peaks of 66.1% for males and 66.7% for females at 10–14 years of age. The heavy hematuria or red-colored urine was restricted to persons between 7 and 19 years of age in males, although in females it was observed in adults up to 47 years of age.

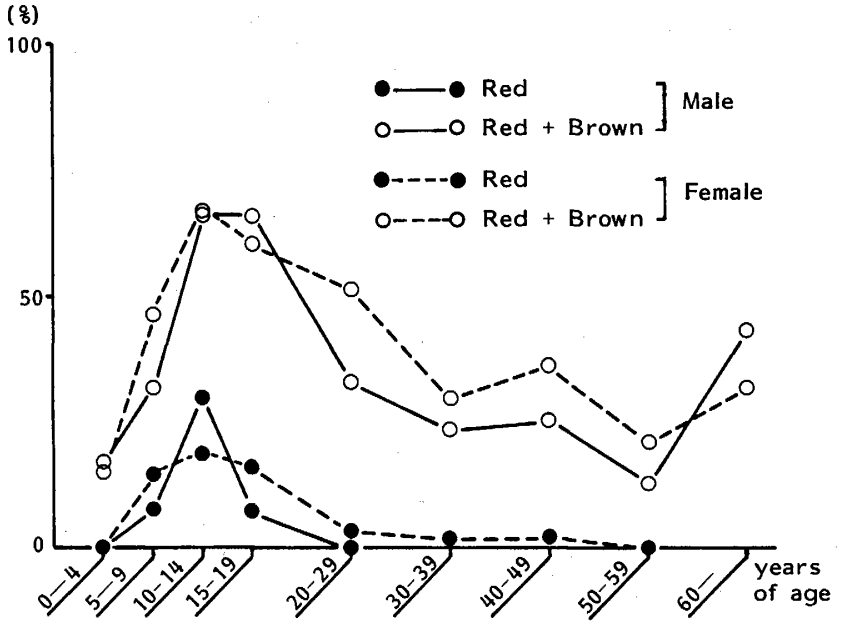

Figure 5 Prevalence of gross hematuria by age and sex.

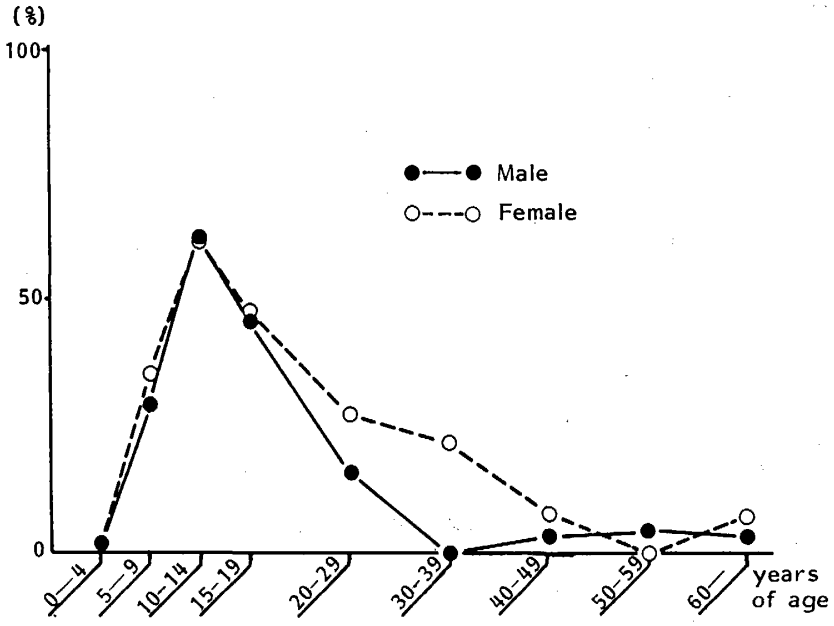

Figure 6 Prevalence of heavy infection (Egg/hour>1,000) by age and sex.

— Prevalence of heavy infection —

The prevalence of people with more than 1,000 eggs per hour is shown in Figure 6. The overall prevalence was 23.7% in males and 24.7% in females. The difference was not statistically significant.

Heavy infection was not observed before the age of 5 in either males or females. However, after the peak prevalences at the age of 10–14, which were 62.3% in males and 61.9

Table 2 Prevalence and intensity of infection in three main tribes

Tribe	Prevalence (%)		Intensity (egg/hour)	
	Male	Female	Male	Female
Digo	63.8	68.2	1.604	1.665
Duruma	69.1	73.0	1.836	1.789
Giryama	65.9	73.5	1.729	1.864

Table 3 Prevalence of *Schistosoma haematobium* infection by age and sex

Age group	Old residents				New residents			
	Male		Female		Male		Female	
	No. examined	No. infected (%)	No. examined	No. infected (%)	No. examined	No. infected (%)	No. examined	No. infected (%)
0–4	53	4 (7.6)	65	14 (21.5)	5	0 (0.0)	7	1 (14.3)
5–9	61	44 (72.1)	76	54 (71.1)	17	10 (58.8)	12	9 (75.0)
10–14	52	52 (100.0)	34	32 (94.1)	9	9 (100.0)	8	8 (100.0)
15–19	33	32 (97.0)	30	28 (93.3)	6	6 (100.0)	18	17 (94.4)
20–29	23	19 (82.6)	36	33 (91.7)	8	5 (62.5)	43	33 (76.7)
30–39	17	11 (64.7)	21	14 (66.7)	8	3 (37.5)	29	26 (89.7)
40–49	19	14 (73.7)	20	13 (65.0)	8	2 (25.0)	21	17 (81.0)
50–59	12	8 (66.7)	12	6 (50.0)	11	5 (45.5)	21	16 (76.2)
60–	9	8 (88.9)	11	7 (63.6)	21	11 (52.4)	17	11 (64.7)
Total	279	192 (68.9)	305	201 (65.9)	93	51 (54.8)	176	138 (78.4)

Table 4 Intensity of *Schistosoma haematobium* infection by age and sex

Age group	Old residents				New residents			
	Male		Female		Male		Female	
	No. examined	Egg count per hour	No. examined	Egg count per hour	No. examined	Egg count per hour	No. examined	Egg count per hour
0–4	53	0.1627	65	0.4085	5	0.0000	7	0.0903
5–9	61	1.9220	76	2.1193	17	1.7146	12	2.0078
10–14	52	3.2549	34	2.8919	9	2.5820	8	3.0539
15–19	33	2.6927	30	2.4590	6	2.6549	18	2.4136
20–29	23	1.6892	36	2.1551	8	1.2402	43	1.9256
30–39	17	0.8944	21	1.6439	8	0.8185	29	2.0401
40–49	19	1.6655	20	0.9972	8	0.3471	21	1.5444
50–59	12	1.6484	12	1.0545	11	0.8721	21	1.1511
60–	9	1.5710	11	1.1748	21	1.1863	17	1.3108
Total	279	1.8050	305	1.6962	93	1.3126	176	1.7810

in females, the rate of decrease in prevalence was different between the sexes. At the age of 30–39 years, 22.0% of females were found to be heavily infected although none of the males over 29 excreted more than 1,000 eggs per hour.

— Other demographical distributions of infection —

The infection was also analyzed by tribe and duration of residence. Among tribes, there was no statistically significant difference in the prevalence and intensity of infection (Table 2).

No significant differences in the overall prevalence and intensity of infection were observed between people who were born in the village and those who moved in after birth (Mantel-

Table 5 Prevalence of *Schistosoma haematobium* infection by age and sex according to site of residence

Age group	People living along main river				People living along small branch			
	Male		Female		Male		Female	
	No. examined	No. infected (%)	No. examined	No. infected (%)	No. examined	No. infected (%)	No. examined	No. infected (%)
0–4	28	2 (7.1)	36	7 (19.4)	30	2 (6.7)	36	8 (22.2)
5–9	35	23 (65.7)	37	23 (62.2)	43	31 (72.1)	51	40 (78.4)
10–14	24	24 (100.0)	19	19 (100.0)	37	37 (100.0)	23	21 (91.3)
15–19	18	18 (100.0)	25	22 (88.0)	21	20 (95.2)	23	23 (100.0)
20–29	15	13 (86.7)	33	26 (78.8)	16	11 (68.8)	46	40 (87.0)
30–39	10	5 (50.0)	26	19 (73.1)	15	9 (60.0)	24	21 (87.5)
40–49	12	5 (41.7)	14	10 (71.4)	15	11 (73.3)	27	20 (74.1)
50–59	8	2 (25.0)	16	10 (62.5)	15	11 (73.3)	17	12 (70.6)
60–	15	7 (46.7)	16	10 (62.5)	15	12 (80.0)	12	8 (66.7)
Total	165	99 (60.0)	222	146 (65.8)	207	144 (69.6)	259	193 (74.5)

Table 6 Intensity of *Schistosoma haematobium* infection by age and sex according to site of residence

Age group	People living along main river				People living along small branch			
	Male		Female		Male		Female	
	No. examined	Egg count per hour	No. examined	Egg count per hour	No. examined	Egg count per hour	No. examined	Egg count per hour
0–4	28	0.1504	36	0.4159	30	0.1470	36	0.3393
5–9	35	1.6179	37	1.7622	43	2.0876	51	2.3522
10–14	24	3.1270	19	3.1847	37	3.1742	23	2.7064
15–19	18	2.7844	25	2.1248	21	2.6032	23	2.7869
20–29	15	1.7464	33	1.8770	16	1.4110	46	2.1401
30–39	10	0.6661	26	1.5868	15	1.0061	24	2.1845
40–49	12	0.9334	14	1.1955	15	1.5480	27	1.3200
50–59	8	0.5103	16	1.0648	15	1.6861	17	1.1641
60–	15	0.8041	16	1.2615	15	1.7993	12	1.2518
Total	165	1.4922	222	1.5809	207	1.8331	259	1.8527

Haenszel $X^2=0.979$, $P=0.323$; $T=1.2292$, $DF=851$, $P=0.2193$). In the new residents group, however, both the prevalence and intensity of infection were significantly lower in males than in females ($X^2=16.178$, $P=0.000$; $T=2.7695$, $DF=267$, $P=0.0060$), while there was no sexual difference in the native people (Tables 3, 4).

— Geographical distribution of infection —

The people were divided into 2 groups according to their sites of residence, one living along the main river and the other along the small branch. The prevalence and intensity of infection are shown in Tables 5 and 6. The prevalence and intensity of infection were higher in people living along the small branch than those living along the main river (Mantel-Haenszel $X^2=7.801$, $P=0.005$; $T=3.0804$, $DF=851$, $P=0.0021$).

Discussion

It has generally been accepted that the peak prevalence and intensity of *S. haematobium* infection in an endemic area usually occur in the age group of 10–14 years and that the peaks are followed by a decline in both prevalence and intensity of infection by age 30 or earlier (Mott, 1982a; Warren, 1973). Our epidemiological data obtained from the coastal area in Kenya essentially showed the same pattern. These findings indicate that people had been constantly using contaminated river water in their daily life. The importance of the disease as a health problem in the area was also reconfirmed by a high prevalence of gross hematuria.

Our results were analyzed demographically and geographically. An unexpected result was the difference in the profile of age-related pattern of infection between sexes. The prevalence of infection, the intensity of infection, the prevalence of heavy infection and the prevalence of hematuria were higher in females than in males especially at 30–39 years of age. After 14 years of age, the prevalence and intensity of infection in female decreased gradually while sharp declines were observed in males.

A rapid decline of prevalence and intensity of infection after a peak at 10–20 years of age has been considered a characteristic of *S. haematobium* infection and has been interpreted as a result of immunity or resistance, or a decrease in water contact with age (Clarke, 1966; Dalton and Pole, 1978; Mott, 1982b; Warren, 1973).

The sexual difference observed in our study might reflect a different sexual ability to produce immunity against *S. haematobium*. Females may have weaker immunity than males. However, the sexual difference was not apparent in the people who were born and had been living in this area. It was only significantly different between the sexes in people who moved into the area after birth. Therefore, the observed sexual difference in the prevalence and intensity of infection does not seem to be due to biological differences such as immunity between the sexes.

A water contact study has been conducted in our study area. The results showed a difference of degree of water contact between the sexes (in preparation). Therefore, it is possible that the sexual difference is due to the difference of water contact behavior between males and females in the study area. Sexual differences in the magnitude of overall prevalence or intensity of infection have been reported from many endemic areas (Farooq *et al.*, 1966; King *et al.*, 1982; Lyons, 1974; Mansour *et al.*, 1981; Pugh and Gilles, 1978; Scott *et al.*, 1982; Wilkins and El-Sawy, 1977; Wilkins *et al.*, 1984). Most of these reports stated that males were

more infected than females, although the age distributions of infection did not differ between males and females. Thus, the sexual difference was usually interpreted as a result of different water contact behavior.

Differences were also observed in prevalence and intensity of infection between people living along the main river and those living along a small branch. This is probably due to the difference of degree of contamination between the two water habitats. Our snail survey revealed that many more snails lived in the small branch than in the main river, and the infection rate was also higher in the small river than in the large river (Noda *et al.*, 1987).

Therefore, these demographical and geographical differences in distribution of infection observed in the study area readily suggest that the acquisition of *S. haematobium* infection depends mainly upon the level of water contact and the degree of contamination of water with schistosome. A safe water supply may be a promising control measure in this area.

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ケニアの海岸地方における住血吸虫症の疫学的研究

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ビルハルツ住血吸虫症の横断的疫学調査をケニアの海岸地方のある村で行った。登録された1,206名の住民の内853名の尿を検査した結果，全体としての虫卵陽性率は68.2%，平均虫卵排泄数は50.0/hour であった。人口動態的，地理的にその内容を分析すると，次のような結果を得た。年齢別に，男女を比較すると，虫卵陽性率，平均虫卵排泄数，重症感染者率，血尿陽性率共に特に若年成人で女性が男性よりも高い値を示した。これは水との接触行動の違いによるものと推量される。本流と支流に沿って住む者の間では，支流の者の虫卵陽性率，平均虫卵排泄数が高かった。これは川の汚染の程度が水系によって異なるためであろう。三主要部族間に虫卵陽性率，平均虫卵排泄数の差は認められなかった。

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