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Preliminary epidemiological survey of schistosomiasis in central and southern Liberia³

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Summary

Some basic epidemiological data on schistosomiasis in central and southern Liberia were collected. A study of snail density fluctuations was carried out in waterbodies bordering the road between Harbel and Gbarnga. Samples from schoolchildren living in ten selected villages were examined for *Schistosoma* spp. and other helminths. In the coastal region no snail hosts were found, the prevalence rates in schoolchildren were low and the infections were apparently imported. Inland, the intermediate host of *Schistosoma haematobium* *Bulinus globosus* was common and the prevalence of urinary schistosomiasis was high. Further inland, around Gbarnga, both *Schistosoma mansoni* and *S. haematobium* were endemic. The seasonal patterns of patent cercarial infections in *Bulinus globosus* and *Biomphalaria pfeifferi* are described. Both snail densities and cercarial infection rates were markedly reduced by heavy rains. The results of the study may contribute to the planning of future integrated control strategy.

Key words: epidemiology; schistosomiasis; vector snails; Liberia.

Introduction

The existence of *Schistosoma haematobium* and *Schistosoma mansoni* in northern Liberia was first reported by Maas (1927; 1930) and Vogel (1932), who were the first to identify *Planorbis (Biomphalaria) pfeifferi* as the intermediate host of *S. mansoni*. Vogel also suspected *Physopsis globosa* (= *Bulinus globosus*) of being the local snail host of *S. haematobium*.

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Examining urine samples from labourers working in rubber plantations in Liberia, Miller (1957) tried to establish the distribution of *S. haematobium* in the country. He concluded that a major focus of transmission exists around Gbarnga in the Central Province (Bong County), and that the coastal region (Montserrado, Grand Bassa, Cape Mount Counties) seems to be free of transmission.

From Gbondoi in the west, to Kitoma east of Gbarnga, Vogel (1958) examined stool and urine samples in 21 communities and recorded the presence of *S. haematobium* and *S. mansoni* in Bong County; he found prevalence rates among children as high as 82% for *S. haematobium* and 68% for *S. mansoni*. In most of the villages visited Vogel found waterbodies containing *Bulinus globosus* and *Biomphalaria pfeifferi*. The first systematic snail surveys were carried out in 1968 by Sodeman (1973; 1979).

The purpose of the present study, undertaken in communities and watersites situated along the road from Harbel to Gbarnga, was to determine as precisely as possible the distribution of the potential snail hosts and to identify the main periods and sites of transmission with a view to implementing future control measures.

Description of the study area

Our investigations were carried out at settlements, situated over a distance of 170 miles, along the road from Harbel, Montserrado County, to Gbarnga in Bong County (see Fig. 1). This road being the only connection between the capital, Monrovia, and the interior of Liberia, has attracted the establishment of many villages and consequently the population has become increasingly dense. Away from the road, however, the population density remains sparse. It is estimated that about 200 000 inhabitants, or 13%, of Liberians live in Bong County.

The climate of this area is typical of the West African tropical rain-forest belt. At the coast there is only one rainy season from April to November with an annual precipitation of 3000 mm. Inland and northwards this pattern gradually changes so that at Suakoko near Gbarnga around 1500 mm of rain fall during two rainy seasons, the first from April to July, and the other during September. The average mean temperatures in Harbel show a maximum in March of 27.1° C, and a minimum in August of 24.1° C. In Suakoko the average mean temperatures are 25.8° C in May and 22.9° C in August.

Most of the research area consists of cultivated land, mainly rubber plantations, tropical subsistence farming and swamp-rice cultivation. In Suakoko the World Bank, in cooperation with the Liberian Government, started an agricultural development project in 1978 for the development of swamp-rice cultivation, cocoa and coffee in Upper Bong County.

Most of the people in the coastal region belong to the Bassa tribe. In Bong

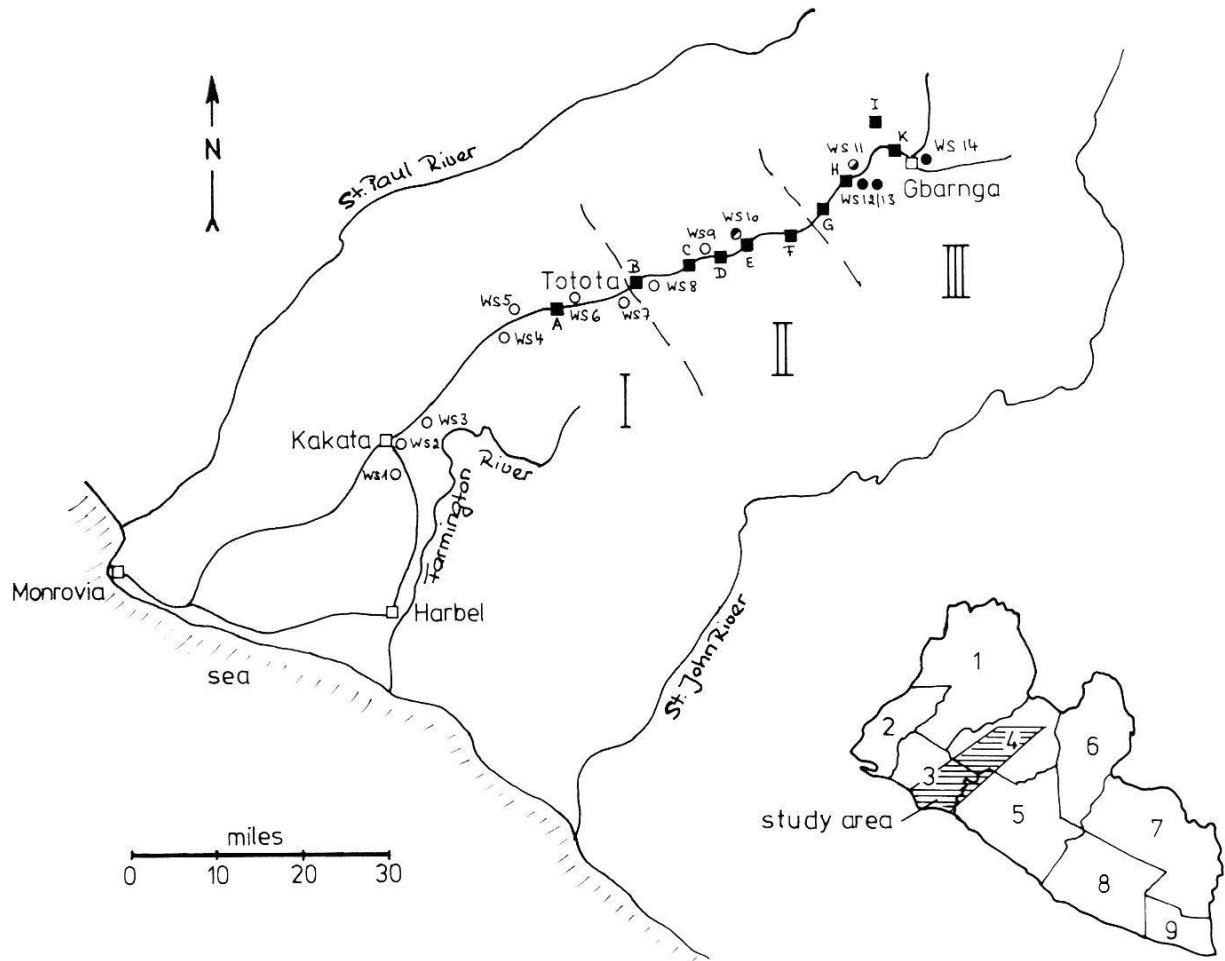


Fig. 1. Locations of the selected water-sites (ws) and the surveyed villages (A–K).

- no intermediate hosts
- ◐ *Bulinus globosus*
- ◑ *Biomphalaria pfeifferi*
- *B. globosus* and *B. pfeifferi*

| | | |
|----------------------|----------------------|----------------------|
| 1 Loffa County | 4 Bong County | 7 Grand Gedeh County |
| 2 Cape Mount County | 5 Grand Bassa County | 8 Sinoe County |
| 3 Montserrado County | 6 Nimba County | 9 Maryland County |

County about 60% are Kpelle and 30% Mandingo. Other tribes such as Gissie and Loma as well as Americo Liberians form 10% of the population.

Materials and methods

Snail population studies

The location of watersites is shown in Fig. 1. The surveys were carried out monthly from December, 1977 to December, 1978. Snails were collected manually by five men working for ten minutes, and the results were recorded as number of snails found per man per minute (s/m/m). Snail identification was made by Dr. G. Mandahl-Barth, WHO Snail Identification Centre, Danish Bilharziasis Laboratory, Charlottenlund, Denmark.

Patent trematode infections in *B. globosus*, *B. forskalii* and *B. pfeifferi* were observed by exposing the snails, in test tubes, to sunlight for at least two hours, after which they were returned to the habitats on the same day. The water in the test tubes was carefully examined, and the schistosome cercariae were identified the following day under a dissecting microscope after storage at 4° C. Conductivity of the water was measured by a WTW LF 54 field conductivity meter, temperature and oxygen by a Yellow Springs Instrument Co. Inc. Model 54 oxygen meter, and the pH by a Cole Parmer Instrument Company Digi-Sense digital pH-meter Model 5985-20. The dominant water-plants in the snail habitats were also recorded.

Stool and urine examinations

Excreta from a random sample of about 50 schoolchildren (5–15 years) from selected villages (see Fig. 1) was examined for *S. haematobium* and *S. mansoni* infection. Urine samples were collected between 10 a.m. and mid-day, then passed freshly by the method described by Olivier (1973). Microscopic examination of the eggs was carried out in the villages and the results were expressed as number of eggs per 10 ml of urine. Portions of one gramme of stool were stored in 10% Formol-saline-solution, and processed by the modified Ritchie formol-ether concentration method described by Knight et al. (1976). *S. mansoni* eggs were counted and recorded as the number per gramme of stool. The presence of other helminth eggs was also noted and the results are briefly described below.

Results

The study area can be divided (see Fig. 1) into the following three geographical sections:

- Section I: The Farmington River basin, where there is no evidence that transmission occurs.
- Section II: The western part of the St. John River basin, where *S. haematobium* only appears to be endemic, transmitted by *B. globosus*.
- Section III: The central part of the St. John River basin, where both *S. mansoni* and *S. haematobium* are endemic and transmitted by *B. pfeifferi* and *B. globosus* respectively.

The results of our snails surveys indicate that only a few specialized species can survive in Section I, where water conductivity is often quite low (see Table 1). However, high numbers of *Ferrissia eburnensis* were recorded from August to November, the months of heaviest rainfall (when as many as 63 s/m/m were collected in water-site 4). On the other hand, *Afropomus balanoides* were found only occasionally during the dry season. *B. forskalii* inhabited shallow waters where very high water-conductivity levels were recorded (water-sites 5 and 6, see Table 1). Highest snail densities occurred in October (77 s/m/m) in a natural habitat (water-site 5), while in April (8.7 s/m/m) and in August (17.0 s/m/m) largest numbers were collected in a man-made ricefield (water-site 6). None of the 400 adult *B. forskalii* was found to be shedding cercariae.

In Section II, additional snail species such as *Segmentorbis kanisaensis*, *Lymnaea natalensis* and *Bulinus globosus* were present (water-sites 9b and 10).

Table 1. Description of the water-sites and the occurrence of the different snail species

| Section | Water-site | Type of water-site | Water-current | pH min-max | Conductivity 20 min-max in μ S | Oxygen mg/l min-max | Plants | Snails |
|--|------------|--------------------|---------------|------------|------------------------------------|---------------------|----------|--------|
| I | ws 1 | creek | ± | 4.5-6.5 | 13-30 | 3.4-8.6 | 1/4/6 | A |
| | ws 2 | swamp | - | 3.4-6.5 | 15-28 | 1.4-3.9 | 1/6/7/4/ | A |
| | ws 3 | creek | ± | 4.3-7.0 | 10-20 | 1.8-5.5 | 3/6/4/1 | AB |
| | ws 4 | swamp | - | 4.3-7.0 | 11-29 | 1.6-6.2 | 4/6/3 | A |
| | ws 5 | swamp | - | 5.7-6.5 | 20-100 | 1.9-6.4 | 4 | AC |
| | ws 6 | swamp | - | 5.3-6.5 | 18-170 | 1.2-7.5 | 1/7/4/3 | AC |
| | ws 7 | stream | + | 5.4-6.5 | 18-26 | 4.2-8.1 | 4 | A |
| | ws 8 | stream | + | 5.2-6.5 | 17-24 | 4.2-8.1 | 4/3/6 | A |
| | ws 9a | swamp | - | 4.4-7.0 | 20-73 | 1.2-4.9 | 6/4 | A |
| | ws 9b | creek | ± | 4.2-5.9 | 16-58 | 2.6-4.3 | 1/4/6 | ACD |
| | ws 10 | creek | ± | 4.6-7.0 | 20-31 | 4.6-7.0 | 1/4/5/3 | ACDEF |
| | ws 11 | creek | ± | 6.0-7.0 | 23-55 | 5.3-8.4 | 6 | ACEGH |
| | ws 12 | creek | ± | 6.0-7.0 | 26-45 | 4.0-6.8 | 1/6/3 | AEFG |
| | ws 13 | swamp | - | 5.7-7.1 | 25-170 | 2.6-11.4 | 1/7 | CEFG |
| | ws 14a | creek | ± | 5.4-6.3 | 46-90 | 1.7-7.5 | 1/5/8 | CEFGH |
| | ws 14b | 6 ponds | - | 5.3-7.5 | 28-360 | 0.8-12.1 | 1/5/8 | CEFGH |
| Watercurrent: - = none; ± = slow; + = fast | | | | | | | | |

μ S = micro Siemens

Abbreviations used in Tables 1 and 2:

Plants*: No. 1 *Eichornia natans*

2 *Crinum natans*

3 *Oteilia ulvifolia*

4 *Cyrtosperma senegalensis*

5 *Commelina diffusa*

6 *Nymphaea lotus*

7 Rice

8 one aquatic plant not determined

Snails: A *Ferrissia eburnensis* (Binder)

B *Afropomus balanoidea* (Gould)

C *Bulinus forskalii* (Ehrenberg)

D *Segmentorbis kanisensis* (Preston)

E *Lympnaea natalensis* (Krauss)

F *Bulinus globosus* (Morelet)

G *Biomphalaria pfeifferi* (Krauss)

H *Pila africana* (Martens)

* The determination of the plants was made by means of the "Flora of West Tropical Africa" by J. Hutchinson and J. M. Dalziel. The Whitefriars Press Ltd, London and Tonbridge.

Table 2. Density fluctuation and infection rates of *B. globosus* (F) and *B. pfeifferi* (G)

| Water-sites | Snail species | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|-------------|---------------|--------|-------|---------|---------|---------|--------|--------|-------|-------|-------|-------|---------|
| ws 10 | F | 3.5/- | 4.3/- | 6.0/5.9 | 6.0/9.1 | 1.0/11 | 1.3/0 | 2.3/0 | 0.5/0 | 0/0 | 6.0/0 | 3.8/0 | 4.8/5.0 |
| ws 11 | G | 17.4/- | 9.7/- | - | 1.3/0 | 0.3/0 | 0.5/0 | 0/0 | 0.3/0 | 1.0/0 | 0.3/0 | 0.3/0 | 0.3/0 |
| ws 12 | F | 1.5/- | 0/0 | 0/0 | 0.3/0 | 0.4/0 | 0/0 | 1.0/0 | 0/0 | 0/0 | 0.3/0 | 0.3/0 | 0.5/0 |
| | G | 1.0/- | 3.7/0 | 8.2/1.3 | 0/0 | 2.4/7.7 | 0.3/0 | 1.3/20 | 0.3/0 | 0/0 | 0/0 | 0/0 | 0/0 |
| ws 13 | F | 0/- | 1.0/0 | 0/0 | 0.3/0 | 0.4/0 | 0/0 | dry | 0/0 | 0.5/0 | 0/0 | 0/0 | dry |
| | G | 0.8/- | 9.8/0 | 6.0/0 | 7.0/0 | 15.4/0 | 1.3/20 | dry | 0/0 | 0.3/0 | 1.0/0 | 2.0/0 | dry |

Numerator = number of snails collected per man per minute; Denominator = percentage of snails positive for schisto-cercariae

For other abbreviations used see Table 1.

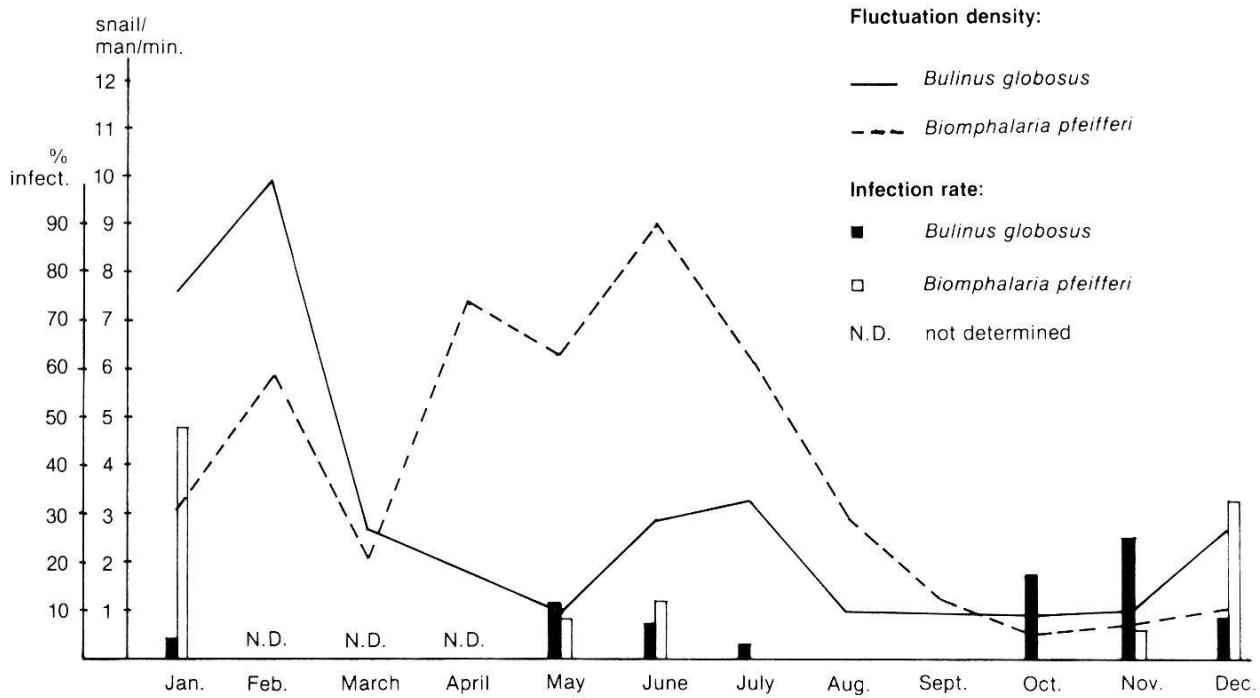


Fig. 2. Snails fluctuation density and infection rate of *Bulinus globosus* and *Biomphalaria pfeifferi* in Gbarnga (ws 14a and b).

The population density of *B. forskalii* reached a peak in May (33 s/m/m) in water-site 9b, followed by a peak of *S. kanisaensis* (July–December with a rate of 15 s/m/m), when *B. forskalii* disappeared. In water-site 10 (see Table 2) *B. globosus* was the most common species with population peaks in February and March and another in October (6 s/m/m). In this habitat snails shedding furcocercous cercariae could be found from March till May, and again in December. Water-site 10 was much used for swimming and bathing by the population of Zeansue, this providing further evidence of its major role in the transmission locally of *S. haematobium* infection.

In the water-sites examined in Section III *Biomphalaria pfeifferi* were relatively abundant. In water-sites 11, 12 and 13, which were situated close together, the population density of *B. pfeifferi* was maximum from January to May and snails shedding human schistosome-like cercariae were observed from March to June. *B. globosus*, on the other hand, were rare in these habitats and none was found with patent infections. These waterbodies were used for rice cultivation (Agricultural Experiment Station, Suakoko) and as such, were contacted by the workers. It should also be noted that the pH levels in the waterbodies of Section III were generally higher than those of the other two sections (see Table 1).

At Gbarnga water-sites 14a and 14b showed high population densities of *B. globosus*, *B. pfeifferi* and *L. natalensis*. The findings in these two habitats, which were connected for a short period only during the rainy season, are shown in Fig. 2.

No evidence of transmission was found during August and September for

Table 3. Prevalence of *S. haematobium*, *S. mansoni* and other main intestinal helminths in the study area

| Section | Location on Fig. 1 | Town | Number of children examined | <i>S. haematobium</i> in %/med. egg output per 10 ml urine | <i>S. mansoni</i> in %/med. egg output per g of stool | Ascaris in % | Trichuris in % | Hookworm in % |
|---------|-----------------------|-------------|-----------------------------------|---|--|-----------------|-------------------|------------------|
| I | A | Flehla | 49 | 8.2/32 | 4.1/29 | 38.8 | 67.6 | 71.4 |
| II | B | Totota | 47 | 41.3/8 | 4.3/33 | 53.2 | 78.7 | 53.3 |
| | C | Gbonkonima | 48 | 47.9/35 | 2.1/508 | 31.3 | 81.3 | 85.4 |
| | D | Kolila | 50 | 74.0/63 | 4.0/3 | 20.0 | 52.0 | 86.0 |
| | E | Zeansue | 44 | 67.4/105 | 4.6/2 | 56.8 | 47.7 | 59.1 |
| | F | Gbatala | 40 | 27.5/19 | 5.1/1 | 40.0 | 72.5 | 25.0 |
| III | G | Gbondoi | 46 | 36.2/16 | 37.8/6 | 33.3 | 57.8 | 68.9 |
| | H | Suakoko/SKT | 41 | 57.5/16 | 75.6/23 | 22.0 | 61.0 | 75.6 |
| | I | Synea | 48 | 50.0/26 | 68.0/47 | 38.3 | 57.5 | 68.1 |
| | K | Melekie | 24 | 50.0/11 | 79.2/80 | 12.5 | 25.0 | 29.2 |

S. haematobium, and from July to October for *S. mansoni* (Table 2). Water-sites 14a and 14b are frequently used by people living in a section of Gbarnga.

The results of the parasitological surveys in ten schools (see Fig. 1, A–K) are given in Table 3. It will be seen that in Section I prevalence rates of both schistosome species are low. The few positive children recorded had visited relatives in the Gbarnga region.

In Section II high prevalence and egg output rates of *S. haematobium* only were recorded.

In Section III, prevalence and egg output rates of both *S. haematobium* and *S. mansoni* were relatively high (see Table 3).

The frequency of the other intestinal helminths recorded in the study area varied from one village to another, with hookworm being the most common parasite observed (see Table 3).

Discussion

Our results support the early findings of Miller (1957), that no transmission of schistosomiasis occurs in the coastal region of Liberia due to the absence of the intermediate snail hosts (see Fig. 1). In this region water-conductivity is relatively low, due to heavy rainfall, and this may well be the reason for the absence of the snail host species as was earlier postulated by McClelland and Jordan (1962) when they were accounting for the absence of snail hosts in certain water-bodies in East Africa.

In Liberia, as in the neighbouring countries of Sierra Leone (Blacklock, 1924; Gordon, 1932) and Guinea (Maas, 1930) *B. globosus* is the sole host of *S. haematobium*, as is *B. pfeifferi* for *S. mansoni*. There is no evidence that *Bulinus forskalii* transmits either *S. haematobium* or *S. intercalatum* in Liberia.

During the heaviest rains (in Suakoko, September/October), snail density is low in Gbarnga (see Fig. 2) and interruption of transmission is relatively short – August/September for *S. haematobium* and July/October for *S. mansoni*. This corresponds with the findings of a snail density study carried out by Sodeman (1973; 1979) in the Gbarnga area. There are similarities between these findings and those in Lake Volta (Ghana), where *B. truncatus rohlfsi*, intermediate host of *S. haematobium* is abundant between December and July, the main growth period of *Ceratophyllum* (Chu, 1978). In the habitats in Liberia no relationship was found between the density of any species of aquatic plants and that of the snail population.

The results of the malacological surveys, together with those of the urine and stool examinations of schoolchildren clearly demonstrated the different levels of endemicity of the human schistosomes with neither being endemic in Section I; with high rates for *S. haematobium* only in Section II, and high prevalence of both *S. haematobium* and *S. mansoni* in Section III.

Prior to the present study, malacological observations (Sodeman, 1973;

1979) and parasitological surveys (Vogel, 1958) have been made in Section III only.

The infection rates of other helminths (Ascaris, Trichuris and Hookworm) are similar to those found during a survey made in a rubber plantation in southern Liberia (Stürchler et al., 1980).

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