

# A socioecological approach to the control of *Schistosoma mansoni* in St Lucia

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*Systematic observations of man/water contact in a valley endemic for S. mansoni in St Lucia were carried out prior to the introduction of a household water supply. The observations indicated that exposure of the population to cercaria-infested rivers and streams could be broken down into different types related to distinct and measurable domestic and economic activities. The number and duration of daily contacts with water played an important role in determining the relative risk of infection and correlated significantly with the number of infected persons by age in a survey conducted immediately following the observations. Consideration should be given to measuring and assessing the relative importance of different activities involving contact with water in relation to transmission and the formulation of control strategies.*

In this paper, the implications of adopting a socioecological approach to the control of *S. mansoni* are investigated. A "socioecological approach" means that the ecosystem is regarded as consisting of a number of interacting social and ecological subsystems in which the human subsystem plays a special role. Each subsystem is a cluster of variables and within each cluster there are "key" variables that have the property of restoring host-parasite populations within the ecosystem to a stable relationship whenever the wider system is disturbed, such as occurs in an epidemic. The objective of a control programme with this type of approach is to select, measure, and then influence the key sociocultural variables so that the disease can either be controlled or, more rarely, eradicated. In areas endemic for *S. mansoni*, it has been suggested that the washing of clothes by women and the widespread habit of children playing in water, which are presumed to be major causes of infection, could be assessed quantitatively in terms of the number of contacts with water (1).

A model of *S. mansoni* transmission developed by Macdonald (2) assumes that the exposure of a human population to cercaria-infected waters can be measured in this way, and that there is a threshold level of exposure below which the transmission cycle can be broken. If this is so, some aspects of behav-

our such as washing clothes in a river, playing in water, etc. can conceivably constitute key variables within the human subsystem. By either reducing or eliminating the intensity of these activities, a reduction in infection rates should occur and, in some instances, ultimately there may be a break in the transmission cycle.

In this paper, the relative importance of various types of activity involving contact with water in the *S. mansoni* transmission cycle will be explored, together with the implications these types of activity have for control strategies.

Major water contact studies have been reported from Egypt (2), Puerto Rico (4), and Southern Rhodesia (3). While interesting and important data on the daily water-contact patterns have been collected in these areas, there is no clear indication of how representative these observations are either over a period of time or for the community as a whole.

In the present study, an attempt has been made to overcome these deficiencies by supplementing quantitative water-contact observations over a 15-month period at a representative number of sites with anthropological techniques of enquiry.

The observations described form part of an assessment of a pilot scheme conducted by the St Lucian Research and Control Department (5, 6) to control transmission of *S. mansoni* by providing domestic water supplies.

Three valleys in St Lucia given over to banana production were selected for a comparison of three

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approaches to control: (a) biological, i.e., chemical control of the snail intermediate host (*Biomphalaria glabrata*); (b) medical, i.e., treatment of infected persons; and (c) socioecological, i.e., an attempt to reduce contact of the local population with contaminated water by providing a domestic water supply and health education.

The water-contact observations were made before and after the introduction of the domestic water supply in order to assess the degree of exposure to *S. mansoni* and the effect on transmission of reducing the risk of exposure. The post-control observations and the corresponding epidemiological results will be presented later.

#### PROJECT AREA

St Lucia is a mountainous tropical island with a Creole population of 100 000, approximately 50 000 of whom are exposed to *S. mansoni* infection, mostly in the rural areas.

The area in which the water-supply was installed, Riche Fond, is a fan-shaped valley lying between a central mountain range and the east coast. There was a population of approximately 6000, about 2000 of whom lived in the five villages that were to receive the household water supply. It is this section of the valley where the present water-contact observations were made (5, 6).

The penepplain is drained by a grid of ditches, between which are planted rows of banana trees. On the valley slopes, a variety of root crops, interspersed with small holdings of bananas, are grown by peasant farmers. Two main rivers meander through the valley, and most of the settlements are located on their banks or near smaller tributaries. The rivers and streams are narrow and shallow and are easily crossed by the local people when they are attending to their small garden plots.

#### MATERIALS AND METHODS

##### *Parasitological survey*

In the two parasitological surveys carried out by the St Lucian Research and Control Department before and after the present observations, all houses in the project area were numbered and a map was prepared showing their location. The names, sex, and age of occupants were recorded and stool containers inscribed with their names were left and collected the following day.

##### *Laboratory techniques*

Stools were examined at the St Lucian Research and Control laboratory by a formalin-glycerol sedimentation method. Up to three slide preparations were examined for *S. mansoni*. Stools found positive were then examined quantitatively by the filtration staining method in which 10 ml of stool was emulsified in 90 ml of formalin-glycerol solution and 1 ml of suspension was filtered through each of two filter papers, one of which was examined and the other retained for subsequent examination.

##### *Methods of investigation*

For the purposes of the study, water contact was divided into two main types: "domestic" and "economic". Domestic contact usually took place at selected sites on the rivers and streams a short distance from the settlements where householders washed clothes, bathed, swam, and collected water. This type of contact was close to the villages and was regular in character.

Contact resulting from economic activities, on the other hand, was irregular and occurred over a much wider area and was mostly restricted to one type of activity—fording the innumerable streams throughout the area.

Domestic contact was studied: (a) by questioning members of selected households; and (b) by observing domestic water contact at river and stream sites.

Economic contact was studied: (a) by observing sites near the points to which the residents brought their bananas for sale, and (b) by interviewing householders to assess contact other than at the observed sites.

##### *Case histories of household members*

Personal case histories were collected as part of a community study focusing on the relationship between social factors and water contact. The object was to identify those variables within the sociocultural system that, when influenced, should lead to a reduction in exposure to infection by *S. mansoni*.

In one of the experimental villages (Grande Ravine) social-anthropological techniques were used to investigate carefully the relationship between role allocation and patterns of water use. In order to follow the changing roles of members in this community with respect to type, frequency, and duration of water contact, all 69 households were observed over a 3-year period.

### *Research design*

After an initial survey, it was established that the majority of the 2000 population of the study area had contact with water for domestic purposes at 15 major sites. In order to avoid a seasonal bias, water contact patterns were observed over a 15-month period before the installation of the household water supply.

Because of daily variations in water contact, each site was observed on each of the 7 days of the week. The sites were arranged into a balanced incomplete block of 7 (days)  $\times$  15 (months), i.e., 105 days of observation. In each month, observations were conducted for 7 days (i.e., one for each day of the week), and the design was balanced so that any two sites were observed during the same week of observations three times in the 15 months.

At each site, the following data were collected for each individual observed: time of arrival at and departure from the river, degree of body surface exposed to water, name, age, sex, and house location.

Over 1000 persons were observed during the 15-month period. However, in order to correlate parasitological and water-contact data on the same individuals, only the 558 persons who provided stools on two occasions (before and after the observations) were taken into account. As some of the older males were less responsive in providing stools on the two occasions, this has, to some extent, weighted the sample in favour of the younger age groups.

Persons who frequented sites other than those observed or who had medical treatment for schistosomiasis were excluded from the correlation analysis.

### *Interviews with householders*

Household interviews were made, among other things, to determine whether persons were coming into contact with water other than at the observed sites. Most persons interviewed were found to attend regularly one or, at the most, two sites for domestic purposes. Information was also obtained on the average number of days per week that villagers visited their garden plots and on the number of times they entered the many small streams on their way to work, as well as the actual amount of water contact in the gardens and plantations.

### *Observers*

During the course of the study two observers were used, one for 7 months and the other for 8 months.

As they were local persons, they were soon able to identify most of the people using the rivers and streams.

It might be thought that the presence of observers would affect the normal water contact pattern but numerous checks made on river sites while the observations were being carried out showed that very few persons were deliberately avoiding their regular sites.

## RESULTS

### *Site use*

The observations indicated that the 15 river and stream sites varied both in type of habitat and in the emphasis given to various activities (Fig. 1). Site A was used by male workers for bathing purposes on Sundays. Sites C, D, E, and F were also washing-bathing-swimming sites located near Grande Riviere, the settlement with the greatest population density. Site G was the most popular for swimming and was also the major crossing point for workers carrying bananas for sale. Sites H, I, and K were washing-bathing-swimming sites, while site O was located on a small stream that flows into the Grande Riviere river and was regularly attended by only a few people; however, when conditions were unsuitable for activities in the main river it was relatively busy. Sites N and J were the major sites for the Grande Ravine area and were located on a stream that drains the largest banana plantation. Sites L and M were both stream sites surrounded by steep valley walls on which Debonnaire is located.

### *Cycles of human activity*

Human activities in the rivers and streams showed different degrees of regularity and it appeared useful to examine them in terms of the daily, weekly and monthly cycles as well as the broader sociocultural (e.g., domestic) cycles that influenced them.

*The daily cycle.* At sunrise (between 05 h 00 and 06 h 00) people began to move from the settlements to the rivers and streams or to their garden plots or plantations. This usually continued throughout the day until dusk when the residents began to return home. Each phase of this movement was marked by distinct and discrete domestic and occupational activities. Water carrying commenced at sunrise, when a number of children, most of whom were aged 5-9 years, collected water to take back to the house (Table 1). The children stepped into the river up to their knees and inserted their arm or arms into the river, usually up to the elbow. They stayed for

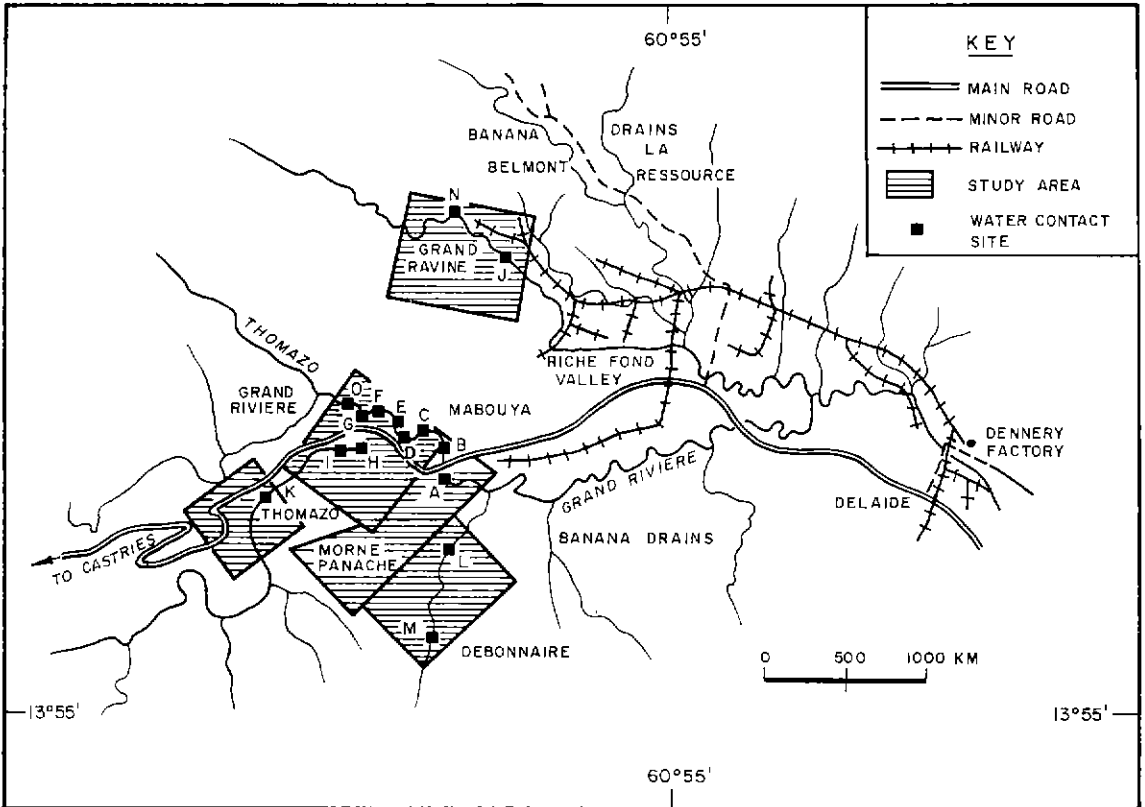


Fig. 1. Map of Riche Fond Valley showing the five settlements where observations of water contact were made.

several minutes to play in the water. The water taken back to the house was used for a variety of purposes such as washing dishes, drinking, and sponging the body.

Between 09 h 00 and 16 h 00 at a typical river site there was a small group of women washing, rinsing, and bleaching clothes. Small children accompanying them paddled in the water although seldom more than ankle deep.

Bathing was a "linked" activity in the sense that many women, when they had finished washing the clothes, then bathed. There was a high degree of body exposure, although it was of shorter duration than during clothes washing. Fewer males were observed bathing, although on Sundays some older men took the opportunity to do so at sites away from the regular washing sites.

Swimming and other play activities were popular with the smaller children. In some instances it was

difficult to separate "swimming" and "bathing". There was usually a lower degree of body exposure with swimming as the rivers and streams were extremely shallow, and at only two of the river sites could children play in water of any depth. Washing, bathing, and swimming ended at dusk.

Fording of the rivers and streams occurred for domestic and economic purposes at any time of the day. Women often crossed rivers and streams to reach washing sites and to visit other settlements, and male and female workers carried bananas from their garden plots to the market.

Other activities involving contact with water included fishing, collecting river sand and stones for road-making, washing cars, etc.

*The daily cycle and cercarial densities.* The daily cycle of human activity often coincided with biological cycles. In St Lucia, as elsewhere, cercarial densities reach their peak during the middle of the day (8)

Table 1. Frequency and duration of contact with water by 558 persons in relation to age and type of activity

Age group (years)	No. at risk		Washing clothes			Bathing			Swimming			Fording			Carrying water			Other <sup>d</sup>			Total frequency (No.)	Total duration (min)
	Male	Female	P <sup>a</sup>	C <sup>b</sup>	D <sup>c</sup>	P	C	D	P	C	D	P	C	D	P	C	D	P	C	D		
0-4	81	47	7	9	241	63	111	2809	45	92	2035	8	15	7	7	14	117	2	4	9	245	5218
5-9	76	64	26	51	1776	68	142	3534	54	85	2088	15	26	46	32	79	227	11	18	180	401	7851
10-19	48	51	28	80	3376	30	47	1045	22	40	778	14	60	62	23	41	137	10	18	358	286	5756
20-29	8	33	18	35	4115	8	14	270	3	4	76	7	25	15	7	22	27	4	6	19	126	4522
30-39	7	26	14	34	1259	6	7	482	3	3	15	7	23	16	9	16	10	1	2	19	85	1801
40-49	16	28	11	28	3522	6	9	193	-	-	-	6	25	12	2	4	100	1	2	5	68	3832
50+	30	43	8	20	1974	6	10	11	3	4	11	11	30	155	5	10	7	1	1	35	75	2293
Total	266	292	112	277	16263	187	340	8444	130	228	5003	68	204	313	85	186	625	30	51	625	1286	31273

<sup>a</sup> P - No. of persons.  
<sup>b</sup> C - No. of contacts with water.  
<sup>c</sup> D - duration of contact (min).  
<sup>d</sup> This category includes fishing, collecting river sand and stones for road making, washing cars, etc.

as did the intensity of many of the human activities, notably clothes washing (D. Sandt, personal communication, 1969). The carrying of water to the house involved a relatively lower proportion of contacts during this peak period, and it is probable that the risk of infection was much lower than for the washing-bathing-swimming that took place around midday; however, the washing that took place in the early morning and late afternoon was not particularly hazardous. The fording of rivers, on the other hand, occurred throughout the day and in a wider variety of habitats, making it an important cause of infection.

*The weekly cycle.* The frequency and duration of contact varied during the week depending on the nature of the activity. Washing of clothes and bathing reached a peak on Saturdays because many women were then free from economic activities. During the week, water contacts were fewer on Wednesdays, the day when the bananas were cut to be carried to the buying points on Thursdays and Fridays. Data on fording reflected this pattern very clearly (Fig. 2).

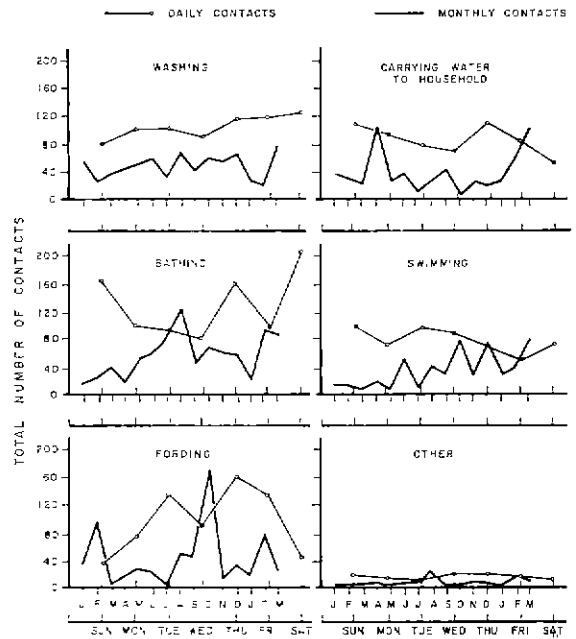


Fig. 2. Daily and monthly water contacts made by all 1348 persons observed at the 15 major sites.

*The monthly cycle.* Washing of clothes tended to be regular throughout the year and did not appear to be markedly affected by the "dry" and "wet" seasons. Water carrying reached a peak in March, at the end of the dry season, when rain water barrels, used in some households to hold drinking water, were usually empty.

Bathing and swimming were affected by the school holidays, especially in August and September. There was also an upward trend between January and June; January was the coolest month and people refrained from bathing owing to the fear of catching a "chill". Bananas were harvested throughout the year and there was therefore little monthly or seasonal pattern for fording.

*Long-term cycles.* Differential exposure to water by age and sex was also affected by long-term cycles such as the "domestic" cycle. This began when a young woman (16–20 years of age), after a number of temporary liaisons, established a household with a man, usually from another village (9, 10). Because of the strong bond with her mother, the daughter's house was often a short distance from her former home, and where a number of such unions were established there was a grouping of houses made up of those of the mother, her daughters, their spouses, and children. This constituted a cognate cluster, members of which shared land, economic and domestic work, kitchens, latrines, and river sites.

In the next decade, during which a number of small children would be born, washing activities increased. As the woman grew older (30–49 years of age), she became increasingly dependent on the children, especially girls aged 5–19 years, to assist her in domestic tasks such as carrying water and washing clothes. There was now a shifting emphasis from domestic to economic pursuits, and this was reflected in the lower level of water contact by many of the older women observed at the domestic sites.

Males played a smaller part in the daily domestic routine and mainly carried water until they reached 12–14 years of age. There was then a cessation of domestic activity and they became increasingly concerned with economic tasks, as well as searching for small fish and crustaceans in the streams.

For the older males, contact with water almost entirely resulted from economic activities except for bathing, which took place usually at weekends.

#### *Health beliefs influencing transmission*

Attitudes to health also influenced transmission. Table 1 shows a lower level of bathing by the male

population, especially those over 20 years of age. As mentioned above, in St Lucia there is a widely held belief that it is dangerous to bathe when the body is presumed to be "hot" (e.g., immediately after work) as it would lead to *fwedi* (a chill). Plantation and garden workers, therefore, seldom bathed after work, so that there was virtually no bathing during the working week.

#### *Economic contact with water*

The interviews with householders revealed that economic contact consisted mainly of crossing rivers and streams, either in walking to and from work or in carrying bananas to the market.

There was little contact with banana drainage ditches by the majority of the population. The ditches were dry for a large part of the year. Infected snails were occasionally found in these ditches but as regards transmission the ditches were less important than the streams and rivers (11).

Contact with water at the garden plots was not of great significance since, in many cases, they were on steep valley slopes and the water rapidly ran off. There were, however, some marshy plots at the base of the valley wall.

Fishing was the only other major source of "economic" contact but it was seasonal and largely confined to the younger population, especially males aged 10–19 years.

#### *Frequency and duration of domestic activities*

The frequency and duration of contact with water varied considerably for different activities. Bathing involved the highest frequency of contact and accounted for 26% of the total number of contacts in our sample of 558 persons (Table 2). Washing clothes involved a slightly smaller proportion of the total contacts (21.5%) but because of the protracted nature of this activity it accounted for 52% of the total exposure time. Swimming, which often consisted of little more than paddling in the river by children, involved fewer and shorter contacts than bathing and clothes washing.

Carrying of water was frequent only during the early and later hours of the day, and involved short exposures. Fording was not very frequent and involved short exposures, but it took place over a wide area: the fording contacts recorded at the observed sites represented only a fraction of the total number for the community.

Table 2. Frequency and duration of different types of activity among 558 individuals from the study area

Activity	Persons in contact	No. of contacts	Percentage of total contacts	Total duration (min)	Percentage of total duration	Percentage of activity carried out during peak period (11 h 00–14 h 00)
Washing clothes	112	277	22	16 263	52	44
Bathing	187	340	26			
Swimming	130	228	18			
Carrying water	85	186	14	625	2	13
Fording	68	204	16	313	1	19
Other	30	51	4	625	2	12
Total		1286		31 273		

#### RELATIONSHIP BETWEEN WATER CONTACT AND *S. MANSONI* INFECTION

The age distribution of those in contact with water and of those infected, as recorded in the post-observational parasitological survey, closely corresponded.

#### Analysis

An examination of Table 3 reveals, for each age group, a significant correlation ( $P < 0.01$ ) between the number and duration of observed contacts and the number of infections as recorded for the parasitological survey immediately following the observations.

The situation in St Lucia to some extent differs from that studied by the author at Lake Volta, Ghana, where the more concentrated nature of the water contact sites around the lake allowed more precise measurement of the degree of exposure of the population. At Lake Volta, there was an even better relationship between infection and the frequency and duration of human exposure (in that case to *S. haematobium*) (unpublished data).

#### DISCUSSION

Macdonald's idea of a "threshold" level of exposure, which has been incorporated in his epidemiological model (*I*), can be assessed in the light of the

Table 3. Relationship of water contact to *S. mansoni* infection for 558 persons

Age group (years)	No of persons observed	No. of contacts <sup>a</sup>	Percentage of total contacts	Total duration (min) <sup>b</sup>	Percentage of total duration	No of infected persons in sample following observations <sup>c</sup>	Percentage of infections	Point prevalence of post-observational survey
0–9	268	646	50	13 069	42	158	41	59 %
10–19	99	286	22	5 756	18	87	23	88 %
20–29	41	126	10	4 522	14	34	9	83 %
30–39	33	85	7	1 801	6	23	6	70 %
40–49	44	68	5	3 832	12	30	8	68 %
50 +	73	75	6	2 293	7	52	14	71 %
Total	558	1286		31 273		384		69 %

<sup>a</sup><sup>c</sup> Product-moment correlation coefficient:  $r = 0.97$  Significant at 1 % level.

<sup>b</sup><sup>c</sup> Product-moment correlation coefficient:  $r = 0.94$  Significant at 1 % level.

data reported above. As can be seen, the exposure of a human population to cercaria-infected water in St Lucia could be broken down into several different types. Human activities were complex and the nature of the exposure varied for each activity and for each age group. In the domestic sphere, the activity with the highest duration of exposure was clothes washing but bathing had a higher frequency (Table 2). "Swimming", a play activity, was usually restricted to the younger age groups. The cessation of only one of these activities would probably not, in Macdonald's terms, lead to a reduction below the threshold level.

On the other hand, it is evident that the activities were interrelated: women washing clothes had small children with them who splashed and played in the water and the women usually bathed after they had finished washing. The cessation of washing, therefore, would probably lead to an overall reduction in domestic activities. Since water carrying took place mostly when the cercariae were less active, i.e., early in the day and in the evening, this activity was probably less important epidemiologically.

The provision of a household water supply seems a logical substitute for many of these activities, which could then take place at home. On the other hand, river sites were also meeting places and had a social as well as an economic-domestic function, so that the construction of communal laundry units may be necessary to overcome this attraction to the river. Consideration of local health attitudes must also play an important role in eliciting any desired community response.

In the model of transmission developed by Macdonald, a reduction of contact frequency of, say, 80% would lead to a new, lower equilibrium level of transmission but not a complete break in the cycle (1). On the other hand, a reduction of 90% or more would probably lead to a cessation of active transmission.

In St Lucia, if frequency of contact with water were the most important parameter, then any reduction of washing-bathing-swimming would primarily benefit the younger population; the level of contact would still remain fairly high for the older age groups, since much of their contact is economic in character, and transmission would continue. On the other hand, the marked reduction in duration of contact (up to 95%) that would occur following the elimination or reduction of washing-bathing-swimming suggests that the threshold, if such exists, could be passed without any marked reduction of fording.

Attempts to reduce fording may, for economic reasons, pose problems for many control programmes. Although foot bridges have been constructed in some areas, this might prove too costly where there is a high density of small streams, as in rural St Lucia. Traditional methods of control—mollusciciding, chemotherapy, and the provision of water supplies—might in this situation initially reduce infection but long-term socioeconomic changes, for example an expansion of agriculture, could once again lead to an increase in infection rates, notwithstanding immediate reductions in water contact, snail populations, worm burdens, and correlated infection rates.

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## RÉSUMÉ

### UNE APPROCHE SOCIO-ÉCOLOGIQUE DE LA LUTTE CONTRE *SCHISTOSOMA MANSONI* À SAINTE-LUCIE

La lutte contre *Schistosoma mansoni* dans un secteur d'endémie de Sainte-Lucie est envisagée ici sous l'angle socio-écologique. On a choisi cinq collectivités où les contacts avec l'eau et la transmission par l'eau devaient être réduits grâce à la mise en place d'un système d'ap-

provisionnement en eau à domicile. Afin de voir en quoi l'approvisionnement en eau modifiait le comportement de ces collectivités, on a procédé, avant et après les mesures de lutte, à des observations sur les contacts de leurs habitants avec l'eau. L'article publié ici décrit les



observations qui ont été faites avant les mesures de lutte, et dégage les conséquences qui découlent, pour ces dernières, des résultats obtenus.

L'enquête, portant sur 558 personnes vivant dans le secteur étudié, a révélé que les contacts avec les différentes collections d'eau locales étaient liés aux activités domestiques et économiques de la population, et qu'il y avait une relation statistique significative entre la durée et la fréquence de ces contacts et l'infection à *S. mansoni*. Du point de vue de la vie domestique, la plupart des contacts étaient liés au lavage du linge, à la baignade et à la natation, tandis que dans le domaine économique, il s'agissait surtout du passage à gué des cours d'eau et de la pêche.

En 15 mois d'observation, on a pu relever des cycles d'activités quotidien, hebdomadaire et saisonnier. Des cycles sociaux de longue durée intervenaient également dans la répartition des rôles sociaux et économiques au sein de la collectivité. Les activités ménagères entraînant le contact avec l'eau augmentaient progressivement au cours de la deuxième décennie de la vie pour décliner ensuite à mesure que l'individu exerçait des responsabilités économiques plus importantes.

Ces différents schémas d'exposition présentaient une importance considérable du point de vue de la transmission. Le lavage du linge, la baignade et la natation représentaient 95% du temps d'exposition constaté aux 15 emplacements retenus comme points d'observation au bord des cours d'eau. Les autres activités, tel le passage à gué des cours d'eau, n'entraînaient pas de longues expositions mais se produisaient dans une zone géographique très étendue.

Une réduction des activités de lavage-baignade-natation devrait avoir une influence notable sur les taux d'infection parmi les groupes d'âge les plus jeunes, mais il faudrait sans doute compter avec une importante source d'infection résiduelle pour les groupes d'âge plus âgés dont les membres seraient de toute façon obligés de passer les cours d'eau à gué, activité à laquelle l'installation de l'eau courante à domicile ne changera rien. Ce fait pourrait avoir des incidences à long terme sur les résultats de tout programme de lutte. Les programmes de lutte doivent tenir compte de la nature des activités humaines entraînant un contact avec l'eau et de leurs relations avec les schémas de la transmission.

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