Schistosomiasis in a Low Prevalence Area: Incomplete Urbanization Increasing Risk of Infection in Paracambi, RJ, Brazil

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The risk of schistosomiasis infection and heavy infection in the locality of Sabugo was evaluated in relation to housing in areas with different urbanization development and to residential supply with snail-infested water. Critical sanitary conditions were found in areas of incomplete urbanization, where healthy water supply sources were scarce, and draining of sewage, without previous treatment, was made directly to the water-bodies used for domestic and leisure activities, despite being Biomphalaria tenagophila *snail breeding-places. Stool examinations (Kato-Katz and Lutz methods) showed prevalence of 2.9%, mean intensity of 79 eggs per gram of stool and 47% of positive cases presenting intense infection. The use of snail-contaminated water for domestic purposes was considered a risk factor for infection. It is concluded that incomplete urbanization would facilitate transmission, probably enhancing the intensity of infection and that a low prevalence could hide a highly focal transmission. The relevance of these facts upon the efficiency of epidemiologic study methods and disease control planning are then discussed.*

Key words: schistosomiasis - *Schistosoma mansoni* - epidemiology - urbanization - low prevalence - risk - Brazil

In 1990, after several schistosomiasis control programs, the number of cases of schistosomiasis mansoni in the county of Paracambi has come to a level low enough to keep abreast of the situation, with only occasional transmission in some villages (data from Fundação Nacional da Saúde - FNS). On the other hand, preliminary observations in the peri-urban village of Sabugo, which is going through an urbanization process, showed contact points among streams, residential sewage and the foci of *Biomphalaria tenagophila* (Orbigny, 1835) snails, including one in a domestic water tank. This disclosed an incomplete urbanization process, creating favourable conditions for schistosomiasis transmission in some areas of the village.

This paper, the first of a series concerned with epidemiological studies on schistosomiasis in Paracambi, aims to investigate the role of urbanization in the transmission of this parasitosis in Sabugo, through the evaluation of the risk of infection and of heavy infection (in the range 100-800 eggs per gram of faeces, according to WHO 1993), in relation to two factors: (a) dwelling in areas at different urbanization stages; (b) contact at home with water from snail breeding sites.

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MATERIALS AND METHODS

Study area and population (Fig. 1) - Sabugo is located in a valley of Paracambi (2° 35"S, 43° 40"W), a county of the State of Rio de Janeiro, southeastern Brazil. Sabuguinho and Ingá streams, which are permanent and belong to the basin of Paraíba do Sul, come from rural neighbouring villages (São José and Saudoso, respectively). They run 3 km through Sabugo. The width of the Sabuguinho stream varies from 0.50m to 2.50m. It forms backwaters and cascades of up to 20m hight. The Ingá stream ranges from 1.0 to 2.0m width, with depths ranging from 0.10m to 0.50m, and forms a marsh of about 400m^2. The climate is hot and wet, with a rainy season from December (heavier rainfall) to February. The locality has been urbanized since the seventies on a site originally known as "Fazenda Sabugo" (Sabugo Farm), which produced coffee and orange crops in the past. At the beginning of this survey the population was approximately 1,600 inhabitants, living in 320 dwellings unevenly spread, making up a rural-urban environment.

Snails - In order to identify snail breeding places, all ditches, swamps, springs, water reser-

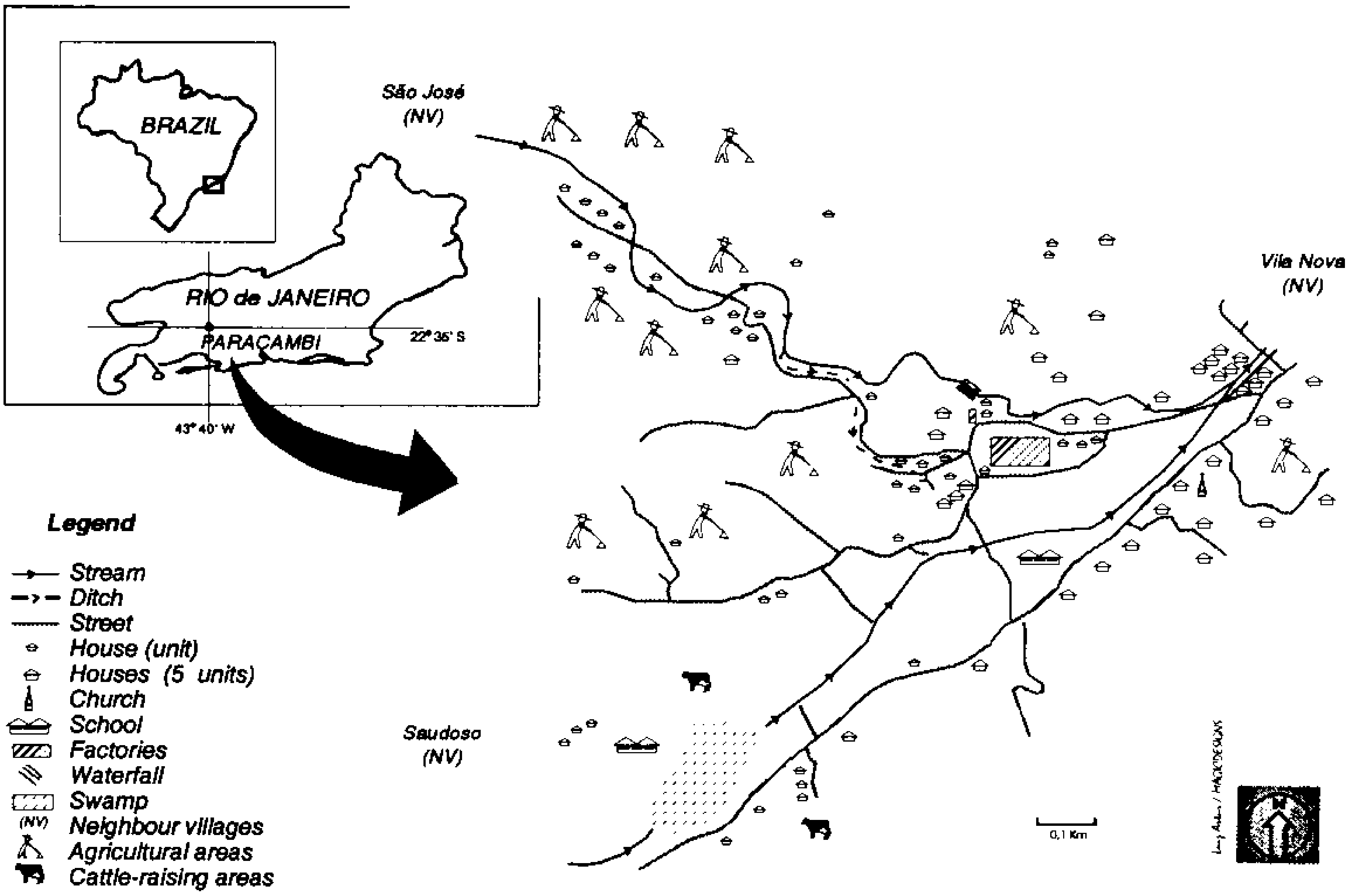

Fig. 1: schematic map of the village of Sabugo (RJ) showing the location of the county of Paracambi in Brazil.

voirs and the whole extension of streams, as well as eventual water collections in the outer residential area were surveyed, every fifteen days, from May to July. The percentage of *Schistosoma mansoni* infection at each snail breeding place was determined by repeated exposure of colected snails to artificial light, every 5 days for 60 days.

Parasitologic survey and questionaire - All houses were visited to register the residents, to give them appropriate containers for stool examination and to apply questions on personal, socio- ecologic, economic and cultural data (Loureiro 1989). Stool examinations were carried out using the Lutz (free sedimentation) (Rey 1990) and Kato-Katz (Katz et al. 1972) methods, the latter performed by FNS staff, following guidelines set up by this institution for the county of Paracambi (one slide per person).

Areas of the locality - After a thorough observation of the area, and through the enquiry performed in the houses, a sketch map was prepared registering socio-ecological factors such as kind of water source, kind of sewage disposal, proximity in relation to water bodies, to snail breeding places, to transmission sites and to rural or urban-like areas. From this map different areas of the village were defined, according to socio-ecological criteria.

Prevalence, intensity and morbidity - Prevalence and intensity of infection (expressed as the geometric mean number of eggs per gram of faeces, or EPG), as well as prevalence of heavy infections in the population and percentage of positives presenting intense infections were calculated for the whole locality as well as for every area and every group of houses with or without a snail-contaminated water supply. The Spearman's coefficient (Siegel 1975) was used to test correlation between intensity and prevalence according to the area. The χ^2 and one-tailed Fisher non-parametric tests (Siegel 1975) for a significance level of 5% were used to evaluate the statistical associations between (a) prevalence of infection or prevalence of heavy infections in the population or percentage of heavy infections among positives and (b) inhabiting each area or having domestic contact with snail-contaminated water. The risks were assayed by the "Odds ratio" and confidence limits (95%) set up within the EPI-INFO software. The area of residence and the use of snail-contaminated water were tested as predictable factors for the probability of acquiring infection and the prognosis of intense infection, through an estimate of negative and positive predictive values, sensivity and specificity (Barreto 1987, 1993). Morbidity values were obtained by clinical examination.

Transmission sites and autochthonous cases - All foci of infected snails as well as the breeding places contaminated by waste materials from the houses of positive people were considered potential transmission sites. Characterization of autochthonous cases was based on an inquiry and on informal reports of contact with transmission sites and from stool screening of individuals (mainly children) born or living in the area for more than ten years.

RESULTS

Sanitation and water supplies- The 311 dwellings recorded (more than 95% of the total) had latrines. Of these, 77% had a primitive "sewage system", that carried waste materials through pipes directly to one of the streams, without any previous treatment, and often near the residential area. About 16% of the houses dumped their waste into open air ditches around the houses from which it passed, out to the streams or absorbed by the soil, after going through several houses in the neighborhood. Less than 6% of the houses had septic tanks, which were not often cleaned.

The water supply for the houses came from springs (35.8%), wells (19.5%), from Sabuguinho stream (3.6%) and from primitive water treatment stations (40.5%) where only chlorine has been added to the water. Two of the houses had neither tap nor well water, relying solely on nearby resources. Water from Sabuguinho stream was collected downstream the sewage dumping sites. Several inhabitants admitted having often used this water for drinking, bathing or filling a natural pool. At least twelve other houses used to do the same. Spring water was brought to the houses through plastic tubes, usually perforated and held on the Sabuguinho river-bed, permitting contamination. Low output of the wells led people to use other water sources, including the Sabuguinho stream. Some inhabitants with either treated or other types of water supply admitted the use of untreated water, because it was free and tasted better. Moreover, frequent interruptions in water supply forced people to use less healthy water sources.

Areas of Sabugo, snail breeding-places and transmission sites (Fig. 2) - Four peri-urban areas and one rural area, all inhabited by *B. tenagophila* snails, were identified as follows: Area 1 - The most densely populated area, with the greatest urbanization level, was crossed by the dirtiest part of the Sabuguinho stream, a transmission site with infected snails. Most of the houses received treated water and none would get water from the stream. Areas 2, 3 and 4 - These areas presented lower levels of urbanization, forming an urban-rural environment, with some agricultural areas and a garbage collecting system (although inadequate in some places). Of these, only Area 2 did not harbour infected *B. tenagophila* and had mainly treated water. Area 3 had four houses supplied by the Sabuguinho stream ditch which was a transmission site bearing infected snails; three of these had

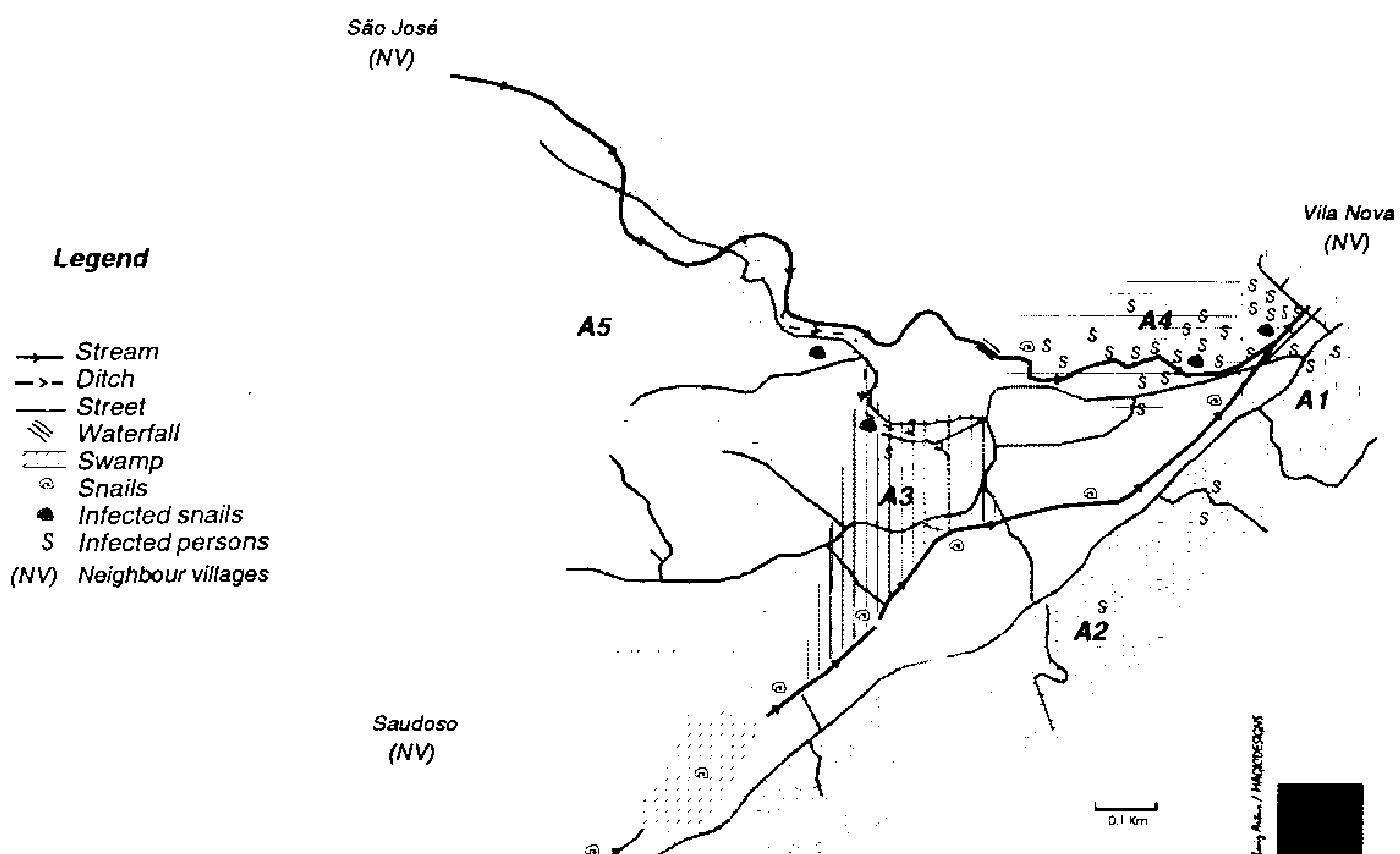

Fig. 2: areas with different stages of urbanization. Distribution of people excreting *Schistosoma mansoni* eggs, of snails and of infected snails in the village of Paracambi.

snails in their main water tank. Two houses did not receive any water. Others were supplied by wells or springs. In Area 4, many backyards were crossed by parts of the Sabuguinho stream full of infected *B. tenagophila*. In this area, domestic supply was made by spring water but they also used water from wells and from the stream (collected in the rural area above the snail breeding places). In one of the houses snails were found in the water tank, although not found in the source (spring). Area 5 was typically rural. Its houses were supplied by springs and one of them had a pool filled with water from Sabuguinho stream, which was, however, free of snails in this part of its course. Snails were found throughout Ingá stream, in a swamp and in the ditch which conducted water from Sabuguinho stream to Area 3.

Prevalence, intensity, morbidity and risk - 32 cases were recorded (total prevalence of 2.9%), 14 of them of heavy infection (1.3% of the population and 47.8% of the positive people). The geometric mean number of eggs per gram of stools was 79, ranging from 24 to 576.

Prevalence of the infection, prevalence of heavy infections in the five areas, proportion of positives presenting heavy infections, as well as the Odds

TABLE I

Prevalence and intensity of infection by *Schistosoma mansoni*, and prevalence of heavy infections in the population (in the range 100-800 eggs per gram of faeces) and proportion of heavy infections among positives in Sabugo/Paracambi, Brazil in 1990-1991, according to the dwelling area. Presentation of Odds-Ratio (OR) values and the significance for a level of 5% (Chi-square of Maentel-Haenzel and Fisher non-parametric tests)

Area		Prevalence of infection in the population		Intensity of infection	Prevalence of heavy infections in the population		Heavy infection among positives	
	n	%	OR		%	OR	np	%
1	376	2.9 $\chi^2 = 0.00$ $p > 0.05$	1.01 (0.45 - 2.23)[a]	77 (35-172)	1.06 $\chi^2 = 0.19$ $p > 0.05$	0.77 (0.18 - 2.70)[b]	11	36.36
2	320	0.6 $\chi^2 = 8.28$ $p < 0.05$	0,16 (0.02 - 0.63)[b]	101 (8-1283)	0,31 Fisher $p > 0.05$	0.19 (0.00 - 1.25)[b]	2	50.00
3	117	2.6 Fisher $p > 0.05$	0.87 (0.17 - 2.87)[b]	48 (11-9914)	0.85 $\chi^2 = 0.18$ $p > 0.05$	0.65 (0.02 - 4.37)[b]	3	33.30
4	196	8.2 $\chi^2 = 23.41$ $p < 0.05$	4,95 (2.30 - 10.64)[b]	87 (41-185)	4,08 Fisher $p < 0.05$	6,39 (1.91 - 22.56)[b]	16	80.00
5	94	0	-	-	-	-	-	-
Total		2.9	-	79 (39-161)	1.27	-		43.75

n - number of subjects; np - number of positive subjects; Fisher- Fisher test; χ^2- Chi-square of Maentel-Haenzel test; OR - Odds-Ratio; Intensity is expressed as geometric mean number of eggs per gram of faeces; ( )- 95% confidence limits; [a]- Cornfield 95% confidence limits for OR; [b]- Exact 95% confidence limits for OR.
Values in the boxes show statistical association and OR indicating risk.
Degrees of freedom = 1

TABLE II

Prevalence and intensity of schistosomiasis mansoni infection and prevalence of heavy infections in the population (in the range 100-800 eggs per gram of faeces) in Sabugo (Paracambi, RJ, Brazil), according to sources of residential water supply

Source	Number of subjects	Prevalence of infection (%)	Number of positive subjects	Intensity	Prevalence of heavy infections in the population (%)
Treated	486	1.65	8	72 (31-171)	0.2
Spring [a]	425	5.16	16	72 (34-154)	0.7
Well	233	2.67	5	63 (23-175)	0.2
Stream	52	4.08	3	295 (69-1270)	0.2

Intensity is expressed as geometric mean number of eggs per gram of faeces
( )- 95% confidence limits
[a]- three persons in a house with snails in the water reservoir

Ratio (OR) values and results of the statistical assays are shown on Table I. The χ^2 test showed a statistical association between living in Area 4 and *S. mansoni* infection or heavy infection. The reverse was true for inhabiting Area 2, with statistical association between living there and not being infected.The OR values suggest risk of infection and of heavy infection for the inhabitants of Area 4, and living there can be considered as a factor predicting the probability of acquiring infection because, although low, the positive predictive value (0.08) was almost three times the expected frequency value (0.03), for a sensitivity of 0.50 and a specificity of 0.83. It was not true for intense infection (positive predictive value=0.04, sensitivity=0.57 and specificity=0.83).

In Area 4, two subjects with intense infection had the hepatic-intestinal form of the disease. The one with the greater egg count had already been treated three times in the past.

The prevalence and mean intensity of infection, as well as prevalence of heavy infections by water sources are shown in Table II.

Houses supplied by water containing intermediate hosts presented 6 cases among 57 subjects (10.53%), 2 of these with heavy infection. There was a statistical association between this water supply and the occurrence of infection ($pF_{Fisher}<0.05$), with confirmed risk of infection (OR= 4.62; Cornfield 95% Confidence Limits: 1.48-12.12), but not of heavy infections (3.51% of the subjects; $pF_{Fisher}>0.05$; OR= 1.23; Cornfield 95% Confidence Limits: 0.14-5.07).

Conclusions about whether receiving water with intermediate hosts at home was a factor predicting the probability of acquiring infection was not possible due to a low sensitivity value (0.19).

Autochthonous cases - At least 18 autochthonous cases were identified. Individuals had been in contact with the river-beds (bare-footed walking or fishing), either in the rural area or in the peri-urban one. The questionaire confirmed these as the main routes of transmission. Three patients had also a domestic source of contact and only two subjects stated never having had any contact with known or potential transmission sites of the locality.

Besides these leisure activities, soccer was played in three fields of the village. Two of them were located near the snail breeding-places, where the players would often "cool off". Another one, and its locker-room, used by people from neighboring localities, were supplied with water from the Sabuguinho stream ditch, a focus of infected snails.

DISCUSSION

The present paper gives an example of how an incomplete urbanization process, due to poverty, lack of appropriate information, and mainly to the destitution of an urban community may favour conditions for *S. mansoni* transmission, in some cases more harmful than the maintenance of rural characteristics. The results obtained herein also show that an extremely low prevalence may hide relatively high focal transmission. The relevance of these observations to the efficacy and application of epidemiological study and control methods will be discussed later.

Incomplete urbanization and transmission of schistosomiasis due to S. mansoni - Schistosomiasis due to *S. mansoni* is strongly related to bad socio-economic condictions (Kloetzel 1989, Loureiro 1989). The growing number of cases in urban areas (Mott et al. 1990) arise with the settlement of peripheral areas without appropriate provision of services and basic structure. The city of Paracambi, an "isolated focus" of schistosomiasis (unpublished data, FNS), is not an exception to the rule: most of its urban area is inhabited by low-income persons and the occupation of peripheral areas is caused by unemployment, housing problems, etc. which have created or worsened sanitation problems, among others.

This work shows that in Sabugo, streams became the obvious solution for disposal of waste materials. Moreover, absence of treated water in two of the poorest and most densely populated, typical peri-urban areas of the locality has induced the domestic use of water coming from natural and untreated sources.

Consequences of this urbanization process in Sabugo have been striking. First, streams reach the peri-urban zone polluted by stools from the rural area, and become even more polluted due to the greater concentration of houses. Secondly, since Sabuguinho stream goes through the backyards of many houses and holds small fish and crustacea, human contact with the water is predictable and almost unavoidable, despite its unpleasant smell and appearance, and the presence of *B. tenagophila*. The finding that dwelling in Area 4 may be an important risk factor for acquiring infection and heavy infection comes from these two factors. Thirdly, in contrast to the rural area, where there are several springs and few houses, the peri-urban Areas 1 and 4 have relatively high populations competing for few and distant springs. So, people have no other choice than to use water from the Sabuguinho stream, spreading the snail colonies and setting up potential transmission sites among the dwellings, as shown by the increased risk of infection for those receiving snail-infected water.

Low prevalence with high focal transmission - The most unusual result in this paper was the extremely low total prevalence followed by a proportionally high percentage of individuals with heavy infection and a high geometric mean of EPG in the population, disagreeing with previous studies in low prevalence areas where transmission was due to *B.tenagophila* (Dias et al. 1989, Marçal Jr et al. 1991). The absence of correlations between intensity and prevalence in relation to certain areas confirms these observations. However, this conclusion must be considered with caution because only four of the five areas studied yielded cases of *S. mansoni*.

In order to explain this apparently inconsistent conclusion, at least three hypotheses may be considered: (1) underestimation of the prevalence, (2) recent infection and (3) frequent reinfections of a small group of persons.

The first hypothesis is possible, since there are limitations concerning the Kato-Katz method among other coproscopic methods for schistosomiasis diagnosis (Kloetzel 1962, Barreto et al. 1980, 1990, Loureiro & Galvão 1983, Brinckman et al. 1988, WHO 1993), and limitations are agravated when prevalence is low (Dias et al. 1989, Hoshino-Shimizu et al. 1992). This would underestimate the number of cases or, according to the examiner's experience, overestimate the number of eggs (Chieffi et al. 1981). In the present investigation, taking into account the considerable experience of the technicians, it is more likely that intensity was underestimated than overestimated.

The second hypothesis requires only recent contact of the people with the transmission sites in Sabugo, but this idea was refuted by the replies in the questionaire.

The third hypothesis, perfectly acceptable, suggests the idea that the occurrence of "clusters" may interfere with infection levels, as has been verified in Pedro de Toledo (São Paulo, Brazil), another area of low prevalence where the intermediate snail host is *B. tenagophila* (Marçal Jr et al. 1991). In Sabugo, most of the infected individuals lived near the infection focus, especially in Area 4, repolluting it with *S. mansoni* eggs, due to primitive sanitary conditions, forming a site of intense miracidia contamination. This situation favoured contact of these larvae with the intermediate hosts, which were also grouped on the same site, probably due to the large concentration of organic wastes from the sewage. Release of cercariae would happen in the same place, which was always visited by the same individuals. In this way, although cases would be limited to a few people visiting that focus, intensity of infection would be enhanced by the association of clusters of hosts (vertebrate and invertebrate) and the parasite larval forms, agravated by incomplete urbanization, cultural factors and the use of Sabuguinho stream as a source of leisure and livelihood by a community with few choices. This hypothesis is confirmed by the statistical association detected between heavy infection and dwelling in Area 4, as well as the observation of groups of positive individuals' houses in the neighborhood of a transmission site located between Areas 1 and 4, which agrees with the observations made by Kloetzel (1989) concerning the coincidence of location of a transmission site and a cluster of patients.

Contamination of this group of people would be further favoured by a gentle water flow (in part due to the slowing of the stream by garbage and wastes), favouring the clustering of helminth eggs and larvae and of intermediate hosts.

Relevance of the observations for epidemiological methodology - Diagnosis - The low prevalence of schistosomiasis in the locality and the possible underestimation of the number of cases indicate the need for more efficient diagnostic methods. Hoshino-Shimizu et al. (1992) and Noya et al. (1992) recommend serologic methods, while Barreto et al. (1990) and Rabello (1992) show the efficiency of the Kato-Katz method can be improved with a greater number of samples.

The need for a microstatistical analysis - Macrostatistical analysis of data from this work would have underestimated the importance of schistosomiasis transmission in Sabugo as a public health problem. A detailed analysis on a reduced scale (smaller areas or groups of individuals with similar characteristics) revealed the existence of high risk groups and foci with substantial transmission potential, similar to foci in more highly endemic areas. Therefore it is clear that, in order to set up a control program suitable to the locality, epidemiologic research is necessary to find peculiarities related to the intensity of infection, morbidity and transmission, as well as to identify the transmission foci and clusters of infected people, and the risk factors against which control efforts must be directed. Considering the present case, Area 4 and the houses served by mollusc-infected water deserve special attention.

Relevance of the observations for carried out on the control methods - For short and long-term control of schistosomiasis in Sabugo, modifications of the socio-ecologic, socio-cultural and bioecologic levels of transmission are needed, besides chemotherapy synchronized with snail control. Such developments require substantial government investments, mainly in sanitation, which agrees with the World Health Organization recommendations (WHO 1993). Individual initiatives would be restrained mainly by the following factors related to the low socio-economic level of the community: (1) the cost of conducting water of good quality would be high, since either treated water or the few sources of good quality untreated water are very far away; (2) fishing and bathing in the streams, as well as soccer playing (which causes frequent contact with the transmission sites), are free leisure activities, easily available in the locality; (3) the costs and the techniques (usually unknown) deter the community from building and maintaining septic tanks.

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