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SCHISTOSOMIASIS MANSONI IN AN AREA OF LOW TRANSMISSION. I. IMPACT OF CONTROL MEASURES (1)

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SUMMARY

This work was undertaken in the municipality of Pedro de Toledo (São Paulo State, Brazil) in 1987, to clarify aspects related to the transmission levels of **Schistosoma mansoni** in a human population where the snail host is **Biomphalaria tenagophila.** Since 1980 a control programme has been undertaken in this municipality. Urban and rural populations (4,719 subjects) were submitted to faecal examinations (Kato-Katz method). The overall prevalence rate was 4.8% being higher in males (6.2%) and also in the rural zone (5.8%). The geometric mean of **S. mansoni** eggs was 35.1 eggs per gramme of faeces (epg). Approximately 80.0% of the carriers presented less than 100 epg and only 20 individuals (9.0%) eliminated more than half of total eggs. The highest index of potencial contamination (IPC) was in the age group of 5 to 20 years (57.6%). Two thirds of the investigated patients (207) were autochthonous of Pedro de Toledo. The geographical distribution of the carriers showed a clear aggregation of the autochthonous cases and a close association between human contact sites and breeding places of **B. tenagophila.** This study shows that schistosomiasis subjects were not randomly aggregated, the youngsters should be the main target in the prophylaxis, and the efficacy of the control programme.

KEY WORDS: Schistosomiasis transmission; **Schistosoma mansoni; Biomphalaria tenagophila.**

INTRODUCTION

The only species of schistosome reported from Brazil is **Schistosoma mansoni.** In Brazil, three species of **Biomphalaria** act as intermediate hosts of **S. mansoni,** and **B. glabrata** is the most efficient host for this worm in several endemic regions. **B. straminea** is considered to be the most important intermediate host in the northeast. **B. tenagophila** is found in Southeastern and Southern Brazil, and is the most important vector in some areas, like São Paulo State[6, 13].

In 1970, the Superintendency for Control of Endemic Diseases (SUCEN) of the São Paulo State Health Department established a schistosomiasis mansoni control programme in São

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Paulo State. Since then, several other regions have been submitted to this control. Amongst them is the Valley of the Ribeira river where our study area, the municipality of Pedro de Toledo, is located. Improvements in the control programme in this county resulted in a sharp decrease of infection rates from 22.8% in 1980 to 6.0% in 1988[4]. Therefore, this municipality can be considered an area of low transmission because indicators like infection rates of **B. tenagophila**, prevalence rates, and intensity of infection are low, and no symptomatic patients have been found since 1980[4, 5].

Nevertheless, the results showed that, despite of the control measures that have been taken, currently there is persistent residual human prevalence rate around 5.0%. The present study will compare the 1987 data with those obtained in 1980[5], to evaluate the efficacy of the control measures. In addition, we will discuss the main factors which could explain the persistency of these levels of transmission in Pedro de Toledo.

MATERIAL AND METHODS

1. Study area

Geographical aspects of the study area were described elsewhere[5]. In 1985 the Brazilian Institute of Geography and Statistics (IBGE)[11] estimated in 5,890 the population of Pedro de Toledo. We emphazise that in this region, **B. tenagophila** is the only intermediate host of **S. mansoni.**

2. Faeces examination

Faeces examinations were performed between July and October of 1987, by Kato-Katz quantitative method[14]. One faecal sample from each individual was collected and three thick smears were prepared, to search for eggs of **S. mansoni.** The intensity of infection was expressed by the geometric mean[17] of the numbers of eggs per gramme of faeces (epg).

3. Epidemiological classification

At the moment of treatment with oxamniquine, the carriers of **S. mansoni** were inquired by SUCEN field staff. Afterwards, the questionnaires were studied and the cases were epidemiologically classified by site of infection: Autochthonous from Pedro de Toledo; Autochthonous from other municipalities of São Paulo; Imported from other Brazilian States, and undetermined.

4. Potencial contamination of the environment

The environmental contamination with eggs of **S. mansoni** eggs was estimated using the index of potencial contamination (IPC)[13]. The calculation of IPC is shown in Table II.

5. Geographical distribution

The geographical distribution of the carriers and other aspects correlated with the transmission of schistosomiasis were evaluated and plotted in maps of the endemic area. The localities boundaries were defined by geographical features and information given by the field staff of SUCEN.

6. Statistical analysis

The statistical analysis was done using the Statistical Analysis System (SAS)[19]. In the comparative analysis, the difference was considered not to be statistically significant (rejection of the null hypothesis of equality) if the p value was larger than 0.10. The methods used were: parametric Analysis of Variance[21], and the non-parametric tests of Wilcoxon and Kruskal-Wallis[16].

The confidence interval for the geometric mean is given as $AB \pm XY$ where AB = punctual estimate and XY = standard-deviation, instead of $AB \overset{\times}{\div} XY$ because, the first is more frequently used in biological and health sciences. We used the approximate estimation of the standard deviation given by BLISS[2].

RESULTS

A total of 4,719 subjects (aproximately 83% of the total population) was studied and the overall schistosomiasis mansoni prevalence rate was 4.8%. The distribution of these rates per sex and age revealed marked differences (Figure 1). The infection rates in males (6.2%) was double the rate of females (3.3%) (Table I). Higher pre-

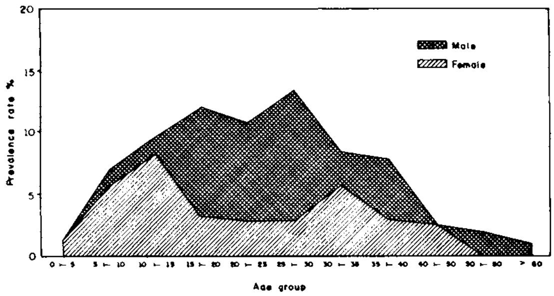

Fig. 1 — Prevalence rate of schistosomiasis mansoni by Kato-Katz method, according to age group and sex, in the municipality of Pedro de Toledo, São Paulo State, Brazil, 1987.

valence rates were found in the following age groups: 10 ⊢ 15 (9.1%), 15 ⊢ 20 (8.0%), 25 ⊢ 30 (7.7%) and 30 ⊢ 35 (7.0%) (Table II). The inhabitants of the rural zone presented a higher infection rate (5.8%) compared to those of the urban area (3.4%).

The geometric mean of number of **S. mansoni** eggs was 35.1 epg (arithmetic mean = 83.6 epg) amongst 220 investigated subjects (Table I). The intensity of infection was higher in the age group 15 to 30 reaching a maximum in the age group 20 ⊢ 25 (49.0 epg) (Figure 2). Due to the small number of subjects older than 30 years examined in this study, the geometric mean for the number of eggs was calculated for two groups, namely 30 ⊢ 40 and > 40. The comparison between the geometric mean of adults and children, showed a significant statistical difference at the 0.05 level and children (< 15 years old) had significantly less eggs in their faeces. When these individuals were separated by sex, there was some indication of difference amongst them for males but it was not significant at the 0.10 level (p = 0.12). The non-parametric Wilcoxon test[16] showed indication of differences in adult/child and in male/female at the 0.05 level. At the 0.10 level the difference was statistically significant for adult/child even after separation by sex or age groups.

The intensity of infection revealed that only 20 subjects (9.0% of the total) were responsible for more than half of the excreted eggs (Figure 3). The geometric mean of number of **S. mansoni** eggs in this group was 419.7 epg. Otherwise, 80.0% of the investigated cases presented 100 epg or less, and 52.7% of them contributed with only 9.6% of the total number.

The epidemiological investigation was done in 207 (out of 225 subjects) and 67.1% were autochthonous from Pedro de Toledo, 9.7% from other municipalities in São Paulo State 12.6% from other Brazilian States and 10.6% indetermined. We noted that all imported carriers came from hyperendemic areas of schistosomiasis in Brazil.

TABLE I

Prevalence rates and intensity of infection by **S. mansoni** (eggs counting)*, by sex, in the municipality of Pedro de Toledo, São Paulo State, Brazil, 1987.

Variables	Sex					
	male		female		TOTAL	
	(n)	%	(n)	%	(n)	%
Prevalence**	(149/2,397)	6.2	(76/2,322)	3.3	(225/4,719)	4.8
Eggs counting						
< 100	(116)	79.4	(59)	79.7	(175)	79.5
100 - 499	(27)	18.5	(13)	17.6	(40)	18.2
> 500	(3)	2.1	(2)	2.7	(5)	2.3
SUBTOTAL	(146)	100.0	(74)	100.0	(220)	100.0
Geometric mean***	(146)	38.1 ± 3.8	(74)	30.0 ± 4.4	(220)	35.1 ± 2.9

* Kato-Katz method; ** positives/examined; *** G ± sd (numbers of eggs per gramme of faeces and standard deviation).

TABLE II

Calculation index of potential contamination (IPC) in the carriers of **S. mansoni**, according to Kato-Katz method in the municipality of Pedro de Toledo, São Paulo State, Brazil, 1987.

Age group	Population structure* (n)	Population structure* %	Prevalence (%)	eggs/g of faeces**	mean of number of eggs per 100 habitants	IPC	Relative IPC (%)
		(1)	(2)	(3)	(4)	(5)	
0 ⊢ 5	(656)	14.2	1.1	40.0	44	6	1.5
5 ⊢ 10	(692)	15.0	6.2	75.9	470	70	17.6
10 ⊢ 15	(549)	12.0	9.1	64.2	584	70	17.6
15 ⊢ 20	(411)	8.9	8.0	125.3	1002	89	22.4
20 ⊢ 25	(338)	7.3	6.5	106.9	695	51	12.8
25 ⊢ 30	(310)	6.7	7.7	77.0	593	40	10.1
30 ⊢ 35	(255)	5.5	7.0	75.1	526	29	7.3
35 ⊢ 40	(268)	5.8	5.2	75.4	392	23	5.8
40 ⊢ 50	(379)	8.2	2.1	65.0	136	11	2.8
50 ⊢ 60	(389)	8.5	1.0	86.0	86	7	1.8
> 60	(365)	7.9	0.5	20.0	10	1	0.3

* studied population; ** arithmetic mean of egg output.

Obs.: The columns are indicated by numbers in parenthesis to show the calculation as follows:

(4) = (2) x (3)

(5) = (4) x (1)/100

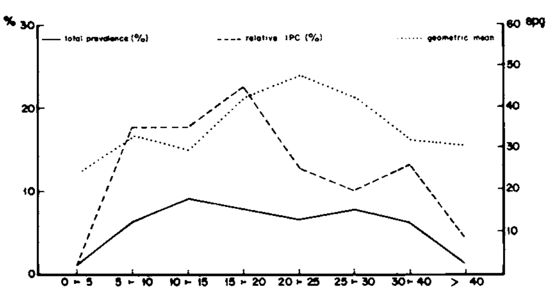

Fig. 2 — Schistosomiasis mansoni in Pedro de Toledo municipality, São Paulo State, Brazil (1987): total prevalence rate, relative index of potential contamination (IPC) and geometric mean (numbers of eggs of **S. mansoni** per gramme of faeces - epg) by Kato-Katz method.

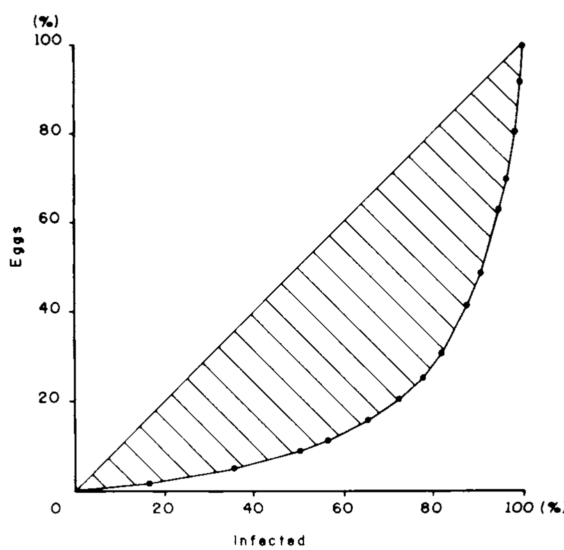

Fig. 3 — Cumulative frequency distribution of **S. mansoni** eggs and cumulative frequency distribution of infected individuals (220) in the examined population (4,719), according to the Kato-Katz method, in the municipality of Pedro de Toledo, São Paulo State, Brazil, 1987.

The age group of 15 ⊢ 20, 5 ⊢ 10, and 10 ⊢ 15 showed the highest relative IPC of 22.4%, 17.6% and 17.6% respectively (Table II and Figure 2). In age groups older than 20 ⊢ 25, this index decreased and it reached the lowest level in the age group of 61 years and over.

The mapping of endemic zones by areas of different prevalence (Figure 4), showed well defined separations amongst them. The same aspect was observed when the intensity of infection was plotted. The autochthonous subjects presented an aggregated distribution in the urban (Figure 5) as well as in the rural zone.

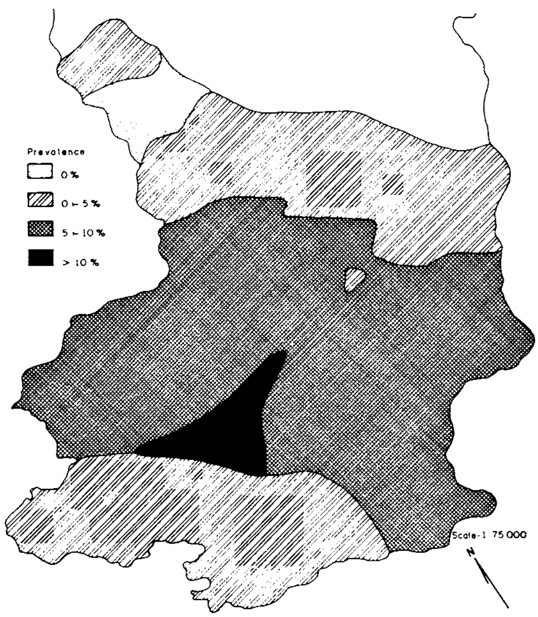

Fig. 4 — Geographical distribution of prevalence rates of schistosomiasis mansoni, in the municipality of Pedro de Toledo, São Paulo State, Brazil, 1987.

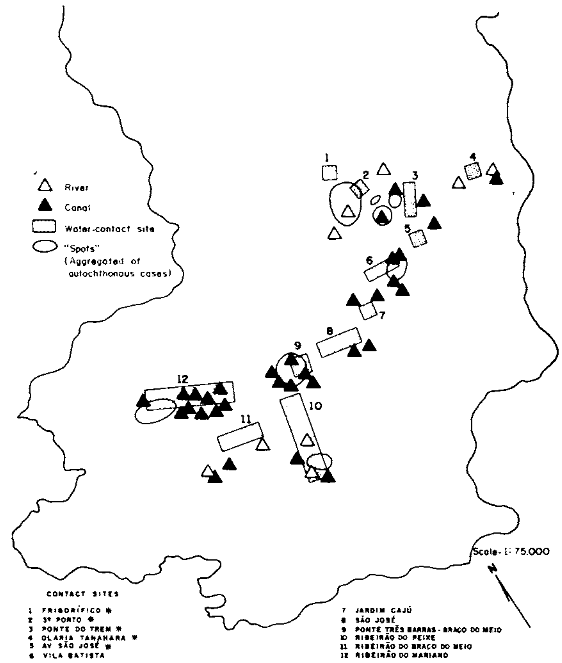

Fig. 5 — Geographical distribution of water-contact sites, **Biomphalaria tenagophila foci** and aggregations of autochthonous cases in the municipality of Pedro de Toledo, São Paulo State, Brazil, 1987.
* Contact sites located in urban zone.

DISCUSSION

DIAS et al (1988)[4] showed that the intensified control programme initiated in 1981 resulted in a sharp decrease in the prevalence rate, from 22.8% in 1980 to 6.0% in 1988. This low level of prevalence was maintained through 1987 when we found 4.8% of the population infected by **S. mansoni** (Table I). In 1980, the intensity of infection in Pedro de Toledo was determined by DIAS et al (1989)[5], when a control programme had been carried out with less intensity than 1987. The intensity of infection dropped from 58.5 epg in 1980[5] to 35.1 epg in 1987 (Table I). The above data attest that the county of study became an area of low transmission and the control programme can be considered effective. The control measures were: annual faeces exams, treatment of patients (oxamniquine), health education, sanitation, and the application of molluscicides. A comparison of infection rates by sex with faeces examination in 1980[5] with the present data showed that the prevalence rate remains twice as much in males (Table I). Differences between prevalence rates by sex (6.2% for males and 3.3% for females) and for age groups were observed (Figure 1). Similar results were described in other endemic areas[3, 7, 8, 9, 10, 20]. Likewise, we believe that these differences can be attributed to the patterns of contact of the population with water.

It is well known that prevalence rates by age group follow a predictable pattern: it increases until the age group of 10 to 20 years old and then decreases. In this study the high prevalence indexes were found in the younger age groups, and also in the age groups of 25 ⊢ 30 (7.7%) and 30 ⊢ 35 (7.0%) (Table II). In 1980, DIAS et al (1989)[5], in this same area, showed that the age groups of 10 ⊢ 14, 15 ⊢ 19 and 20 ⊢ 24 had significantly higher prevalence rates than the remainder age groups. In the present work the total prevalence rate curve (Figure 2) was relatively higher in the age group 5 ⊢ 20, and later adult groups, giving a nearly bimodal distribution. DIAS et al (1988)[4] have also shown that the highest prevalence indexes were about 38.0% and

17.1% in the 10 ⊢ 14 and 25 ⊢ 29 age groups respectively. We found, in similar age groups, the following maximum prevalence rates: 9.1% in 10 ⊢ 15 and 20 ⊢ 25 (Table II). We noted a sharp decrease (4.2 times) in the group between 5 and 20 also in adults (2.2 times). The more evident decrease of infection rates among the youth could be attributed to the fact that it is easier to work in the field with children than with adults. These findings are reinforced by the shift to the right of the geometric mean. The highest intensity of infection (geometric mean = 49.0 epg) was observed in the 20 ⊢ 25 age group (Figure 2). In 1980[5] the highest intensity was found in the age group of 10 ⊢ 14, with an average of 100 epg, whereas the 20 ⊢ 24 age group had only 58 epg. The 1980 findings by DIAS et al (1989)[5] described the epidemiological situation at a time when the control measures had not yet been improved. In the study area, the highest prevalence rates in the rural zone could be attributed to poor sanitation. In most Brazilian endemic areas of schistosomiasis, it is usually found that rural and urban zones have different prevalence rates[1].

In general, the majority of the population has small numbers of **S. mansoni** eggs in the faeces, while very few carriers have high intensity of infection[13]. Similar results were found in Ethiopia and in a rural community in Bahia State, Brazil, where only 6.0% of the population excreted around 50.0% of the eggs[17, 18]. In Pedro de Toledo, we found 9.0% of the subjects to be responsible for half of the total eggs in the population (Figure 3). This great concentration of eggs in a small number of individuals with heavy infection (45 carriers excreting more than 100 epg, Table I) underscores the fact that all cases of schistosomiasis studied were asymptomatic[4].

In São Paulo State, the majority of schistosomiasis subjects are infected in other Brazilian States[22]. However, in Pedro de Toledo two thirds of the carriers are autochthonous. We must emphasize that subjects from other States found in this study came from hyperendemic Brazilian regions and showed that the geometric mean of eggs from those individuals was not statistically different from the other three epidemiological classes. Amongst other factors, this similarity in the intensities of infection could be due to the long period between the infection and the parasitological diagnosis and the effect of the treatment that could have been carried out in their native States.

The IPC is an important epidemiological tool to evaluate the transmission and to identify the age group of the population responsible for the maintenance of the disease[8, 12]. In spite of the relevance of this epidemiological measure, the IPC is used here for the first time in an endemic area of Brazil. We showed that 57.6% of infection was produced by individuals in the age group of 6 to 20 years (Table II and Figure 2). This result is expected in low transmission areas[13].

The geographical distribution of the subjects in Pedro de Toledo showed that areas with low infection rates were in places characterized by high altitudes, low demographic densities, small number of **B. tenagophila** breedings sites and better sanitation. The only exception to this pattern was the presence of the urban zone amongst the areas with high intensity of infection. This finding can be explained by some peculiar conditions such as: strong local population movement in this area and the aggregated distribution of autochthonous individuals. This aggregation was closely associated with water resources for human use and breeding sites of **B. tenagophila** (Figure 5). As aggregation can produce important changes in the infection index by **Schistosoma** within in the same locality[15], it will be interesting to investigate this problem in Pedro de Toledo, in order to improve the control programme.

Despite of the control programme efficacy there is a residual prevalence rate of 5.0%. The relative IPCs showed that subjects less than 21 years old had an IPC of 59.1% and, in individuals in the age group 21 to 40 years, this index was 36.0% (Table II and Figure 2). Therefore, the control measures must pay special attention to the young adults. Amongst several other factors, the young adults could be responsible for a considerable part of the residual prevalence. However, we cannot forget that re-infection, therapeutic failure, different tolerance of the local **S. mansoni** strain to the usual oxamniquine dosage, (15 mg/kg to adult and 20 to 25 mg/kg to child), the role of non-human definitive host, etc, could play a major role in the maintenance this prevalence. A detailed study of these factors will be published elsewhere.

The main conclusions are:

1. The low level of schistosomiasis transmission found in Pedro de Toledo municipality in 1987 showed the efficacy of the control programme.

2. A non-random distribution of the schistosomiasis subjects was observed. Important differences between prevalence and intensity of infection, both in relation to sex, age and settlement zone were observed.

3. Inferring from the IPC values, the subjects of the age group 6 to 20 years represent the main transmission group that justifies the decision to target control programmes toward the youth. Perhaps this age group is one of the most important in maintaining the residual prevalence.

RESUMO

Esquistossomose mansoni **em área de baixa transmissão. I. Impacto das medidas de controle.**

Este trabalho foi realizado no município de Pedro de Toledo, no Estado de São Paulo, Brasil, em 1987 para esclarecer aspectos sobre níveis de transmissão ao homem de **Schistosoma mansoni,** quando o hospedeiro intermediário é **Biomphalaria tenagophila.** Desde 1980 vem sendo desenvolvido um programa de controle neste município. Foram submetidos a exames de fezes (método de Kato-Katz) 4.719 indivíduos das zonas rural e urbana. A taxa de prevalência foi de 4,8%, sendo maior nos homens (6,2%) e também na zona rural (5,8%). Foi de 35,1% a média de ovos de **S. mansoni** por grama de fezes (epg). Cerca de 80,0% dos portadores apresentavam menos de 100 epg e somente 20 indivíduos (9,0%) eliminavam mais do que metade do total de ovos. Os mais altos índices de potencial de contaminação (IPC) ocorreram nos grupos etários de 5 a 20 anos (57,6%). Dois terços dos pacientes investigados (207) eram autóctones de Pedro de Toledo. A distribuição geográfica dos portadores demonstrou evidente agregação dos casos autóctones, assim como uma íntima associação entre locais de contato da população com os criadouros de **B. tenagophila.** Este estudo demonstra que os portadores de **S. mansoni** não estão agregados ao acaso, que os jovens devem ser o principal objetivo na profilaxia, e que o programa de controle foi eficaz.

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