HOLOCILUS BRASILIENSIS AND NECTOMYS SQUAMIPES (RODENTIA-CRICETIDAE) NATURAL HOSTS OF SCHISTOSOMA MANSONI

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After several Brazilian researchers, the author examines the capacity of two species of rodents Cricetidae, Holochilus brasiliensis and Nectomys squamipes, to maintain the biological cycle of Schistosoma mansoni in the field and to be parasite reservoir: (a) the role they are able to play in human endemiy; (b) the methods necessary to characterize the population of Schistosoma mansoni related either to man, either to rodents, either to both.

Key words: Schistosoma mansoni – Brazil – Holochilus – Nectomys Cricetidae – epidemiology – reservoir

In his talk, Rey (1992) summarized the amount of informations that have been published about wild animals infected by Schistosoma mansoni in Brazil. So I will concentrate here on a few aspects of which study might make progress in our knowledge at a time when new epidemiological situations occurring after mass treatment, reveal the role played by the rodents as potential reservoir.

FREQUENCIES OF PARASITISM OF RODENTS

Among numerous species of marsupials or rodents parasited, Holochilus brasiliensis and Nectomys squamipes* are the most frequently infected, in most of the endemic regions of Brazil (Table 1).

In the marsh around São Bento (Maranhão), the positivity rate rose to 92% of the Holochilus studied by Veiga-Borgeaud in November 1985 just before the season of multiplication of Biomphalaria glabrata (Veiga-Borgeaud, 1986, 1987). In the same municipality, in September 1991, 34 parasited Holochilus (31%) excreted on average 222 eggs for one gram a day. According to SUCAM, in 1989, the prevalence of human disease was inferior to 4%. So, since the discovery by Amorim et al (1954), epidemiologists have been raising questions in relation to the role of these rodents in the transmission of S. mansoni to man (Antunes et al., 1973; Barbosa et al., 1953, 1958; Carneiro, 1990; Carvalho, 1975; Dias, et al., 1978; Kawazoe & Pinto, 1983).

| TABLE 1 |
|-----------------|-----------|----------|
|                | % Author  | Year     |
| Didelphis      | 23 Piva   | 1966 Sergipe |
| paraguayanus   |           |          |
| Cavia apera    | 60 Barreto| 1964 Bahia     |
| Rattus norvegicus | 46 Martins | 1955 Minas Gerais |
| Rattus R.      | 59 Barbosa| 1953 Pernambuco |
| frugivorus     |           |          |
| Holochilus     | 92 Veiga  | 1986 Maranhão |
| brasiliensis   | 75 Dias   | 1978 São Paulo |
| Nectomys       | 75 Amorim| 1953 Alagoas |
| squamipes      | 57 Martins| 1955 Minas Gerais |

But if there are many papers about rates of positivity, few authors indicate in which conditions rodents have been captured: superficialy of the fields, distance from the water, estimate total population, type of environnement... It is therefore difficult to establish the reality of the prevalence, to compare the human and murine prevalences in time and space, and to know something about the ways of contamination.

Nobody has suggested that, in Brazil, the parasite of rodents should be of species differ-

*We have use here the names currently used. A revision might be necessary to avoid synonymies.
ent from human species, as Schwetz (1952) did in Africa in putting forward the idea of the existence of one variety *S. rodentium*. Several authors, using various methods, have tried to set up differences between human and murine strains: pathogenicity for white mice (Bastos et al., 1982, 1984; Silva & Andrade, 1989) compatibility for snails (Antunes et al., 1973; Dias et al., 1978; Bastos et al., 1984), sensitivity to oxamniquine (Souza et al., 1991), etc. Very recently, neither Carneiro (1990, 1991) through precipitating antigenic fractions in western-blot, nor Rodriguez (1991) through alleles forms of the G6PD have established characteristics differences between two strains of Maranhão.

Before asserting the identity of the two parasites, we have to answer three questions: (a) Is a strain allegedly of human origin but maintained for many years on white mice, still “human”? (Loverde et al., 1985); (b) Can an isolated strain from one individual (man or rodent) represent faithfully the population of parasite circulating in a focus? (C) Are the methods used in the past suitable to establish variability and intraspecific diversity which have been pointed out by Fletcher (1981), using several isoenzymatic systems and by Vieira using D.N.A. (1991).

CAN RODENTS BE RESERVOIRS OF PARASITE?

By definition, a reservoir excrete a large number of eggs capable to infect snails. This is not the case of *Didelphis* and *Cavia aperea* (Barreto et al., 1964), which, though frequently and heavily infected, have no viable eggs in the faeces.

After Piva & Barros (1969), Dias (1978), Souza (1991) and others authors, we experimentally established that *Nectomys* and *Holochilus* excrete an average of over 1,000 eggs a day, eight months after being individually infected by 500 cercariae, without apparent trouble (Table II).

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<th>Table II</th>
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<td>Average eggs excretion at some moments of infection</td>
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<th>Fortnight positivity</th>
<th>No. 2</th>
<th>No. 6</th>
<th>No. 11</th>
<th>No. 13</th>
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</thead>
<tbody>
<tr>
<td><em>H. brasiensis</em></td>
<td>1 705</td>
<td>1 030</td>
<td>2 694</td>
<td>1 588</td>
</tr>
<tr>
<td><em>N. squamipes</em></td>
<td>3 238</td>
<td>1 840</td>
<td>2 564</td>
<td>3 589</td>
</tr>
</tbody>
</table>

Because of the low density of cercariae in many water-contact sites, we are proceeding at the moment to the same experiment with 100 cercariae.

Although the average number of eggs remains very high, it varies very much according to the sample of faeces, days and individual. This variability in the individual response to infection and the notion of aggregation of parasite should be taken into account in epidemiological surveillance.

According to various protocols (water volume, weight of stool, number of miracidium, number of eggs) we have succeeded in infecting high percentage of *B. glabrata* with eggs excreted four months after the infection of rodents (Table III).

<table>
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<th>Table III</th>
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<td>Rate of infected snails</td>
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<tr>
<th>Nectomys</th>
<th>Holochilus</th>
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<tr>
<td>3.5g of faeces in 3 of water</td>
<td>100%</td>
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<tr>
<td>300 miracidium in 100 of water</td>
<td>66%</td>
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The rate of success is scarcely smaller nine months later. This duration of excreting viable eggs can ensure the transmission when it is seasonal as it is often the case in Brazil as elsewhere.

Three experiments (Antunes et al., 1973; Carvalho, 1975; Kawazoe & Pinto, 1983) carried out in semi-natural conditions, have shown that rodents are able to ensure, on their own, the cycle of the parasite: the third paper is interesting because it prove the importance of ecological factors which favour the biological cycle; this one could not be completed in the experimental vivarium where infected and non-infected rodents had been settled, until *B. glabrata* have been introduced in the place of *B. tenagophila*; the latter, though local vectors of *S. mansoni*, did not find in the vivarium sufficient conditions to survive, to breed and to mature cercariae.

In the contrary, in October 1991, three *Nectomys*, out of nine that we found infected at São Lourenço de Mata (Pernambuco) had probably been infected in very small pond inhabited by *B. straminea* which is, wrongly considered to be poor intermediate host.
It is therefore certain that both species of rodents have the capacity to transmit *S. mansoni*, but none can tell so far in which proportion they play a role in the maintenance of human endemcy, nor how the parasites circulate between men, rodents and snails.

RESEARCH ON THE ROLE OF *RATTUS RATTUS* IN GUADELOUPE

To answer these questions, the work carried out in Guadeloupe by Combes et al. (1975), since over 20 years on the black rat, could be the starting point for fruitful research to be carried out in Brazil.

In this small island of the Antilles, the schistosomiasis has practically disappeared nowadays, due to standart of life and systemic treatment of each ill people, except for a few cases in a small focus, where the black rat is also infected. But in 1979, 4% of the 350,000 inhabitants excreted still eggs of *S. mansoni* (INSERM, 1980). Around 1975, in this small but very contrasted territory, very diverse epidemiological situations coexisted: (a) In crowdy, built-up valleys, the human prevalence was higher than murine prevalence. Nowadays, as all patients were cured, there is no infected rat: they were accidental hosts. (b) In a isolated mountain pond, with no human visitors, *Rattus* maintained alone the cycle for fifteen years until *Ampullarias* sp. accidentally introduced competed with *B. glabrata* and expelled them from the focus (Pointer et al., 1988). (c) The third type of focus is located at the back of a mangrove, on the border of a swampy forest, where a edible plants are grown. Rats and men are still found infected.

Of course, Imbert-Establet (1980, 1982) and Jourdan & Imbert-Establet (1980) have studied the compatibility of different populations of *S. mansoni* from Guadeloupe and other places with the black rat, using various tests such as adult worms recovery rate, migration and localization of worms, faecal eggs number...

But, above all, Theron et al (1986) have discovered markers whose frequency allows to characterize populations of schistosomes related either to men, either to rats or in relation with both. These markers are: (a) The frequency of eggs of a particular shape which looks like the shape of eggs of *S. rodhaini* Rollinson et al., 1986; Theron, 1986; (b) The frequency of allelic forms of M.D.H.1 (Rollinson et al., 1986; Theron, 1986); (c) The time of maximum cercarial shedding by *B. glabrata* (Theron, 1984, 1985). This average peak of emergence occurs towards the end of the morning (i.e. 11h) where man is the main host, towards the evening (i.e. 16h) in area where rat is the main host; the intermediate patterns are observed with schistosomes originate from swamp where man and rat are involved. The adaptation character of this chronical phenomena in relation to the circadian rythm of host, is also to be found in other schistosomes in Africa (Bremont et al., 1990).

The genetic background of this intraspecific polymorphism has been proven through crossbreeding of schistosomes from the various isolates (Theron & Combes, 1988; Theron et al., 1989). Thus, in relation to different environnement a population of parasite has evolved toward different local forms that can be identified. These forms share a common genetic pool but are still exchanging genes through genetic flux of varying intensity according to the type of ecosystem. Rats related schistosome population benefit from selective pressure resulting from human treatment and changing pattern of water contacts.

SCHISTOSOMIASIS DUE AT *S. MANSONI*: A ZOONOSE?

The modalities of host-parasite relationship in Guadeloupe are in conformity to the patterns that Nelson suggested already in 1960, in his talk about the schistosomiasi zoonose in Africa (Table IV).

| TABLE IV |

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<th>ANTHROPOZONOSSES</th>
<th>AMPHIXENOSSES</th>
<th>ZOANTHROPOZONOSSES</th>
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Although the research carried out were not as thorough as in Brazil, it does not seem that, in Africa, rodents play there an important role in transmitting S. mansoni. But baboons which are accidental hosts in Kenya, were able to maintain alone the cycle in a national park of Tanzania (Fenwick, 1969; Acha & Szyfres, 1987). After comments of Nelson about anthropozooneses, we must add a new one: in Africa the animal schistosomases (S. bovis; S. matthei; S. curassoni), are able to infect man and to hybridize with S. haematobium; between this species and a fortiiori between the populations which are component of these species circulate also genic flux (Bremont et al., 1990).

In Brazil exist certainly places where schistosomiasis is a zooanthroponose: man is responsible for the contamination of rodents.

In other places, the situation is amphixenicotic. Silva & Andrade (1989) point out that in the municipality of Planalva (Bahia) the human and murine prevalence are respectively 3.26% and 47%. In the Baixada in Maranhão, Holochilus are numerous, exclusively aquatic during at least nine months, and share the same biotope as fishers and hunters; today they are more frequently infected (31%) than men (3.9%). Epidemiological conditions may perhaps already have enable the selection of a population adapted to rodents, that could be identified through modern technics.

The eventuality of occurrence of an anthropozooneose appears to be remote: genetic flux between human and murine schistosome still occurs, and the predictable increasing of human prevalence consecutive to the interrupation of treatment that have been carried out for the last ten years, are found to increase the proportion of human schistosome.

CONCLUSION

Originating from various areas of Africa, S. mansoni when appearing in Brazil, must have been doted with capacities to invest new, vacant ecological niches. It adapted itself to intermediate hosts (B. glabrata, B. straminea, B. tenagophila) but also to definitive hosts, immunologically favorable which are nowadays turning into natural reservoir of parasite.

This adaptation and consequences demands a great epidemiological attention: the control of schistosomiasis in China is progressing slowly because of animals reservoirs.

So, in my opinion, should be undertaken, in endemic focus well defined: (a) epidemiological surveys taking into account not only the parasited rodents number but also time and space variations of prevalence, intensity, dispersion of the parasite among both host populations exposed to the risk; (b) ecological surveys about behaviour and dynamics of rodents populations and about abiotic and biotic factors which act upon these hosts; (c) research on the genetics of populations of schistosomes related either to man or to rodents or both.

This approach, integrating the various level of the system environment/host/parasite (individual population, focus, meta-population) carried out by multidisciplinary teams, including zoologists, ecologists, geneticists, would be a good method to analyse the way the system operates and to contribute to setting up strategies taking into account the existence of these unfortunate animal reservoirs.

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