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Review

Wild and domesticated animals as reservoirs of *Schistosomiasis mansoni* in Brazil

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ABSTRACT

Natural infection with *Schistosoma mansoni* in wild vertebrates and domesticated animals in Brazil is described in this review from an epidemiological viewpoint. Some species of wild rodents are small-sized animals, with a short expectation of life, a limited territory, and present high infection rates under natural conditions. A successful maintenance of the parasite's life cycle under artificial conditions can be achieved with *Biomphalaria glabrata*. On the other hand, despite showing low natural infection rates, cattle are very susceptible to infection under experimental conditions (using calves of Holstein lineage, cross-bred with the Gir lineage). Due to their large size (just one calf may harbor a number of worms higher than a whole colony of aquatic rodents) and their longevity, cattle are a potential reservoir for the maintenance and dissemination of the disease. There is thus a need of new studies to gain a better understanding about the actual role of these animals in the epidemiology of *S. mansoni*.

Schistosomiasis mansoni is a zoonosis with the human as the main and definitive host (Nelson, 1960). *Schistosomiasis japonicum*, however, is classified as an anfixenosis disease because both men and other vertebrate animals play a similar role on the maintenance of the disease in endemic areas (Nelson, 1960). Although the importance of the man for the maintenance of the life cycle of *S. mansoni* is not questioned, there are a number of studies showing that other mammals may act as source of infection (Antunes et al., 1973; Barbosa et al., 1958, 1962; Borda, 1972; Coelho et al., 1979, 1982; Fenwick, 1969; Pitchford and Visser, 1962; Piva and Barros, 1966; Martins et al., 1955; McCully and Kuger, 1969; Nelson, 1960; Schwetz, 1953). Naturally infected vertebrate animals from the orders primates, carnivora, marsupialia, artiodactyla and rodentia have already been found (D'Andrea et al., 1999, 2000, 2002; Gentile et al., 2000; Silva et al., 1992; Amorim, 1953). Sire et al. (2001) states that differences in the ecological landscape and in the epidemiological determinants are important variables to be considered in studies concerning reservoirs of schistosomiasis. Interesting observations in Guadaloupe foci showed chronobiological patterns for cercarial release: early and intermediate (related mainly to human infection), and late or crepuscular (related to rodent infection). The behavior of cercariae shedding is dependent on the ecological type of foci (Théron, 1984; Théron and Pointier, 1995). In this way, a recent paper published by Morgan et al. in 2003, in Tanzania, Africa, found *S. mansoni* female cercariae and *S. mansoni*/*Schistosomiasis rodhaini* male, hybrid males in *Biomphalaria sudanica*. This cross-breeding evidence between *S. mansoni* and *S. rodhaini* point to a possible modification of species by introgression. In Brazil, some authors debate the possibility that in some foci schistosomiasis may be maintained by humans, animals or both of them. The persistence of the focus together with the potential of exposure to the disease emphasize that new strategies of control must be considered. Too little is known regarding the role of domestic animals in the process of transmission and maintenance of the disease. As for the bovines, there are few studies that have considered either natural or experimental infection of these animals.

The first description of cattle naturally infected with *S. mansoni* was by Barbosa et al. (1962), who found four adult animals with helminthes in the mesenteries, whereas one of them showed non-viable eggs in the feces. Piva and Barros (1966) observed eggs of *S. mansoni* in the liver of three adult bovines, a phenomenon that was also reported by (Mayaudon and Power, 1970) in Venezuela. A prevalence of among 3% was detected in an epidemiologic surveillance conducted by Coelho et al. (1982) in Minas Gerais State, southeastern Brazil. The authors also showed a surprising susceptibility of calves experimentally infected with cercariae of *S. mansoni*. The authors emphasize, however, that under certain conditions, the bovine species could act permanently in an endemic focus since in one of the farms studied, four among eight bull-calves eliminated viable eggs in the faeces. Also Saede

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et al. (1969) were able to infect calves with *S. mansoni*. Karoum and Amin (1985) evaluated the natural infection in cattle, goats, sheep, and canines in an endemic area in Sudan. From a total of 98 cattle examined through visceral inspection, only two bull-calves showed helminthes in the mesentery, including adult females of *S. mansoni* with eggs. Recently, Stothard et al. (2004) in a very intense transmission focus did not find *S. mansoni* worms in a sacrificed young heifer with a large number of *Schistosoma bovis*. Nevertheless, in spite of the absence of *S. mansoni* worms, it is important to note that the results were obtained with a single animal. It will be necessary to carry out studies in Africa with milk producing cattle (Holstein lineage and their crossbreeding descents with other lineages) that are more susceptible to *S. mansoni* infection (Modena et al., 1991). Modena et al. (1991) conducted rectal mucosal scrapes in 894 bull-calves from endemic areas of Minas Gerais, finding viable eggs in nine animals. Moreover, the authors examined 462 adult animals and none were positive to *S. mansoni* eggs in the faeces or mucosa. All positive animals belonged to small-holdings which were part of an subsistence economy. The laborers working on these farms were mostly family members. Bioecological conditions for the transmission of schistosomiasis were found in all surveyed properties. In a malacological survey of the area *Biomphalaria glabrata* specimens positive to cercariae and/or sporocysts of *S. mansoni* were observed. The human population showed the presence of *S. mansoni* eggs in the faeces. Modena et al. (1991) also showed that young animal (calves) of the Holstein lineage were very susceptible to *S. mansoni* infection and crossbreeding between Holstein and Gir lineage (most resistant) produced descendents with an intermediate degree of susceptibility.

Agricultural production at the subsistence level leads to a health profile of both human and animal population, (specifically due to zoonoses), which is inferior when compared with other forms of production. The exposure to the hazards of contracting disease is potentiated through intensive use of the land combined with a population in which there is close contact between animals and humans, and through specific forms of labor (Kloos et al., 1998). Bethony et al. (2004) previously demonstrated that schistosomiasis tends to cluster within communities, at both the neighborhood and household levels, due to the characteristic focality of risk behavior and transmission. Therefore, the effect of the presence of cattle in communities may affect the transmission of the disease. In the studies of Coelho et al. (1982) and Karoum and Amin (1985) the finding that only young animals were infected may be due to the handling conditions adopted in subsistence economy, where there is a close and frequent water use shared by human population and animals. An analysis of natural infections in non-human hosts shows that the pattern of rodent infection differs fundamentally from that of the infection in cattle. Cattle eliminate about 10% of their body weight through their faeces and thus the environmental contamination is significant. Moreover, the cattle can disseminate the parasite during breeding and daily movement.

Evaluation of the role of cattle in natural transmission should not involve drug treatment. Coelho et al. (1990) showed that the drug oxamniquine was not effective in the treatment of experimental *S. mansoni*. The authors infected experimentally 10 bull-calves with 20,000 cercariae as described by Coelho et al. (1982). Sixty-seven days after animals were treated with 15 or 30 mg/kg of oral oxamniquine and were sacrificed 30 days after treatment. There are no reports of any drug which is effective against bovine schistosomiasis in the available literature. The organization of the environment and ethological aspects of different hosts should be taken into consideration in the transmission of *S. mansoni* (Combes et al., 1994; Théron, 1984, 1989). Other domestic animals were previously evaluated as definitive hosts by means of experimental infection. Coelho et al. (1989) concluded, using experimental infection, that *Bubalus bubalis* is a refractory host to infection with *S. mansoni*. Ocampo et al. (1981) also showed that swine (*Sus scrofa*) are naturally resistant to experimental infection. The transmission of *S. mansoni* under experimental conditions using the Bovine – *B. glabrata* – Bovine model, was carried out by Modena et al. (1993). The completion of the cycle gives evidence for the possibility of bovine species acting as a potential player in the maintenance and dissemination of the disease, independently from human population. In the same way, using wild rodents infected with *S. mansoni* and *B. glabrata* under natural conditions, it was also possible to complete the life cycle of parasite using *Nectomys squamipes* and *Holochilus brasiliensis* (Antunes et al., 1973 and Millward de Andrade et al., 1976, respectively). However, the wild rodents, because of their small size, limited territory and low life expectancy (maximum of 2 years) present limitations as an efficient reservoir for the maintenance of disease in endemic areas. In addition in all areas in which wild rodents were found with infections by *S. mansoni* it was possible to identify a human source of faecal pollution.

Considering the agricultural expansion into new areas in Brazil, there is an urgent need to make detailed studies on role of the bovine population on the maintenance of the disease in that country. It is speculated that new forms of organization of the agrarian space, with intense transit and greater confinement, may introduce cattle as a factor in the transmission of schistosomiasis in the endemic area. This pattern of cattle maintenance tends to amplify and, may be after a time, create sufficient conditions to produce new definitive hosts. However, the statement of Koskella and Lively (2007) should be pondered upon, i.e. “understanding host–parasite coevolution requires multigenerational studies in which changes in both parasite infectivity and host susceptibility are monitored”. By questioning general laws in parasitological ecology, Poulin (2007) states that in some patterns these laws are contingent, truthful only under particular circumstances, theoretical and empirical reflections previously distinguished by Mahmoud (2004), Kristt et al. (2000), Osnas and Lively (2004), Keeling et al. (2000), and Ovaskainen and Cornell (2006).

In conclusion, considering the degree of expansion of schistosomiasis in rural areas, there is an urgent need to increase and widen the studies of the role of bovines in the epidemiologic model of this disease.

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