Spatial distribution of schistosomiasis and geohelminthiasis cases in the rural areas of Pernambuco, Brazil

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ABSTRACT

Introduction: The prevalence and intensity of geohelminth infections and schistosomiasis remain high in the rural areas of *Zona da Mata, Pernambuco* (ZMP), Brazil, where these parasites still represent a significant public health problem. The present study aimed to spatially assess the occurrences of schistosomiasis and geohelminthiasis in the ZMP. **Methods**: The ZMP has a population of 1,132,544 inhabitants, formed by 43 municipalities. An ecological study was conducted, using secondary data relating to positive human cases and parasite loads of schistosomiasis and positive human cases of geohelminthiasis that were worked up in Excel 2007. We used the coordinates of the municipal headquarters to represent the cities which served as the unit of analysis of this study. The Kernel estimator was used to spatially analyze the data and identify distribution patterns and case densities, with analysis done in ArcGIS software. **Results**: Spatial analysis from the Kernel intensity estimator made it possible to construct density maps showing that the northern ZMP was the region with the greatest number of children infected with parasites and the populations most intensely infected by *Schistosoma mansoni*. In relation to geohelminths, there was higher spatial distribution of cases of *Ascaris lumbricoides* and *Trichuris trichiura* in the southern ZMP, and greater occurrence of hookworms in the northern/central ZMP. **Conclusions:** Despite several surveys and studies showing occurrences of schistosomiasis and geohelminthiasis in the ZMP, no preventive measures that are known to have been effective in decreasing these health hazards have yet been implemented in the endemic area.

Keywords: Schistosomiasis. Spatial analysis. Zona da Mata of Pernambuco.

INTRODUCTION

The prevalence and intensity of geohelminth infections and schistosomiasis remain high and it has been estimated that over 2 billion people worldwide (one third of the world's population) may be infected by one or more parasites. Of these people, 300 million suffer from severe clinical forms of parasitosis and 155,000 die every year because of these diseases. Among the hundreds of helminth species that infect humans, *Ascaris lumbricoides, Trichuris trichiura,* the hookworms *Necator americanus* and *Ancylostoma duodenale* and *Schistosoma ssp* are the most frequent human parasites, and these have been correlated with high levels of morbidity and mortality[1].

One tool that has been used to ascertain variations in occurrences of health problems in time and space is geographical information systems (GIS)[2-4]. By means of maps, this tool makes it possible to observe the spatial distribution of risk situations and health problems, thereby providing a panorama of environmental conditions of the population's health[5]. Location and quantification of spatial, environmental and sociodemographic risks using GIS also enables planning of sanitary and health surveillance actions[6].

An evaluation made by Favre et al.[7] on control actions against schistosomiasis implemented in the State of Pernambuco by national healthcare organizations since 1977 showed that the situation in the endemic area of the *Zona da Mata* of Pernambuco (ZMP) continues to cause concern, despite apparent reductions in prevalence in the municipalities. In a survey conducted by Barbosa et al.[8] in the ZMP, it was shown that there was an accumulated prevalence of schistosomiasis of 14.4%, and that for geohelminthiasis the prevalence was over 50% in some municipalities, thus proving that these parasites are a relevant public health issue in this state. Hence, the present study aimed to spatially assess occurrences of schistosomiasis and geohelminthiasis in the ZMP, using GIS as an auxiliary tool, with the intention of showing the epidemiological landscape of occurrences of these parasitoses, as a support for planning and applying effective prevention and control measures.

METHODS

Zona da Mata of Pernambuco occupies an area of 8,738km², which corresponds to 8.9% of the state's territory, and has a population of 1,132,544 inhabitants, which is equal to 15.9% of the state's population[9]. It is formed by 43 municipalities and is considered to be an endemic area for schistosomiasis and geohelminthiasis **(Figure 1)**.

In the coastal and ZMP regions of the state, a tropical climate is predominant, with a mean annual temperature of 24°C and mean annual rainfall of around 1,500mm. The vegetation was initially formed by tropical Atlantic Forest, characterized by large trees, but deforestation took place little by little, to give rise to sugarcane monoculture. Among the problems faced by this region, of an economic, social, environmental, political and cultural nature, are the following: distorted land ownership structure (on the one hand, large landowners exploiting sugarcane monoculture and, on the other hand, smallholders attempting to produce food); degraded natural environment, consisting of eroded soil and polluted rivers that are under the threat of ceasing to be perennial watercourses; high unemployment and underemployment levels; existence of the highest concentration of poverty in the state; and low levels of formal education and political participation[10].
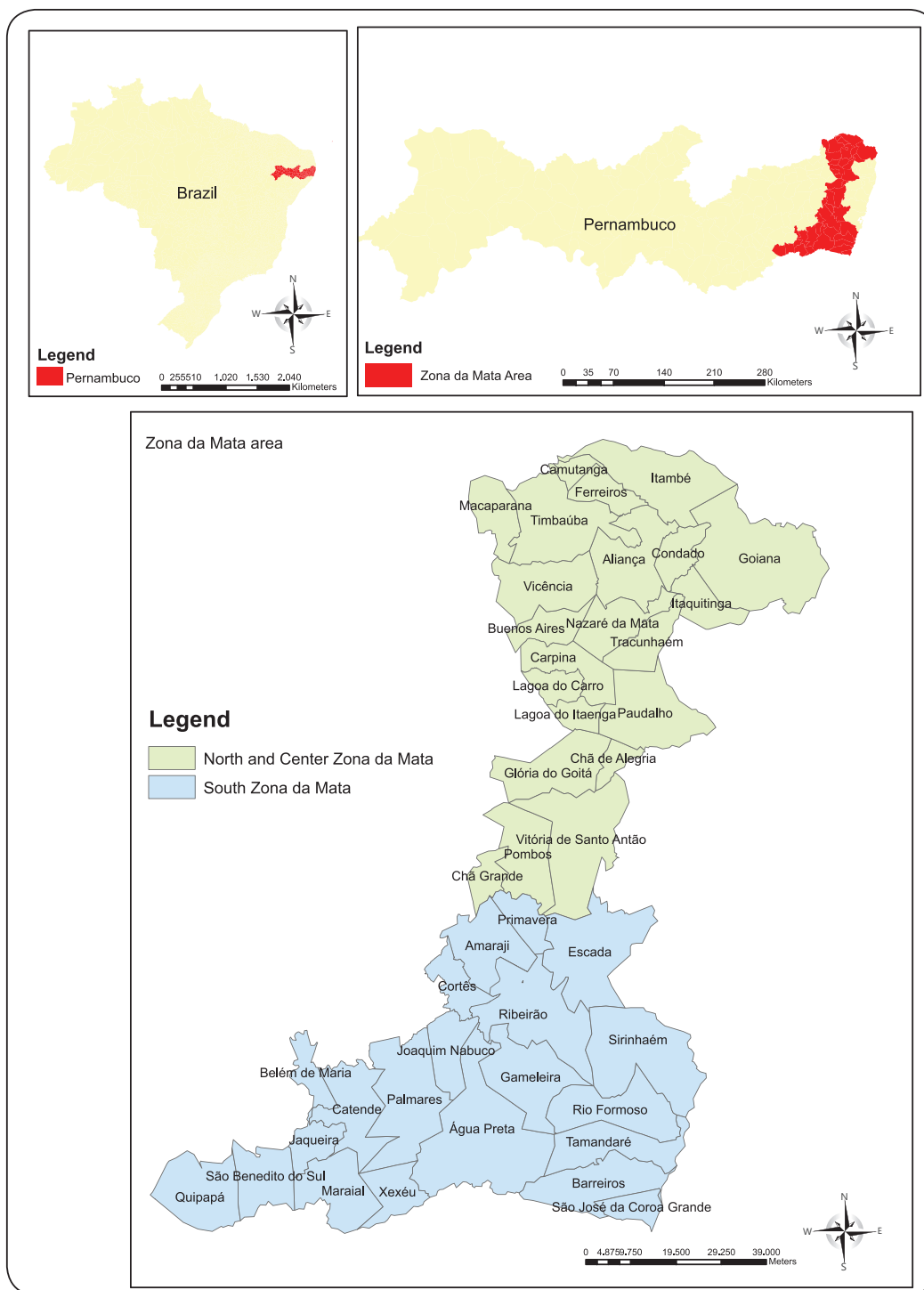
FIGURE 1 - Municipalities of *Zona da Mata*, Pernambuco, Brazil. **UTM:** Universal Transverse Mercator.

The biological variables chosen for this study were: positive human cases and parasite loads of schistosomiasis and positive human cases of geohelminthiasis. An ecological study was conducted, using secondary data relating to a survey conducted among schoolchildren aged 9-12 years living in the ZMP in 2005 were worked up. Was applied Kato-Katz coproscopic tests in the schoolchildren, being a total of 11,234 examinations performed. The database was made available by the Schistosomiasis Laboratory and Reference Service of the Aggeu Magalhães Research Center (*Centro de Pesquisa Aggeu Magalhães/*

Fundação Oswaldo Cruz - CPqAM/FIOCRUZ) and, using the Excel 2007 software, spreadsheets were set up dividing the ZMP into northern/central and southern ZMP regions. We used the coordinates of the municipal headquarters to represent the cities which served as the unit of analysis of this study. The Kernel estimator was used for data analysis and for identifying distribution patterns and case densities. This is a nonparametric technique that provides statistical smoothing and generates chromatic gradients with hot spots according to the density concentration of events per area in each cell of a regular grid that

covers the region studied. The gradient level was controlled through selecting a parameter, known as bandwidth, which indicated the area to be considered in the calculation and reflected the geographical scale of the hypothesis of interest, along with the previous knowledge of the event studied. In the present study, over a radius of 17,500m around the centroid of each municipality, the following attributes were analyzed: I) prevalence of schistosomiasis; II) intensity of schistosomiasis infection; III) prevalence of hookworm; IV) prevalence of trichuriasis; and V) prevalence of ascaridiasis. These analyses were performed in the ArcGIS (ArcInfo package, ESRI) environment, using *Arc Tool Box > Spatial Analyst Tools > Kernel Density*. Through smoothing, Kernel generated a density surface for visual detection of event concentrations, i.e. agglomerations over the space distribution. The point distribution was transformed into a continuous risk surface for occurrences of schistosomiasis and geohelminthiasis[11].

RESULTS

To construct regional thematic maps, the ZMP was stratified into two categories: northern/central ZMP and southern ZMP.

The survey among schoolchildren conducted in 22 municipalities in the northern/central ZMP covered 143 schools, and 6,532 individuals aged 9-12 years were examined, thus revealing mean positivity of 12% for *Schistosoma mansoni*, and characterizing this area as presenting a medium endemic level for schistosomiasis. The geometric mean of

66.4 eggs per gram of feces (epg), suggests that the general situation was one of mild infection[12]. **Figure 2** shows that in some municipalities in this region, such as Aliança, Buenos Aires, Chã de Alegria, Condado, Itambé, Itaquitinga, Nazaré da Mata, Timbaúba and Vicência, over 10% of the population was infected by *S. mansoni* and that some municipalities had significant parasite load rates for this helminth, such as Aliança, Condado, Itambé and Tracunhaém. The northern/central ZMP showed medium endemicity, significantly for the geohelminths *Ascaris lumbricoides*, hookworms and *Trichuris trichiura* (respectively, 21.8%, 10.8% and 20.1%).

In the southern ZMP, 21 municipalities and 128 schools were sampled, and 4,703 schoolchildren were examined, showing mean positivity of 17% for *S. mansoni* and geometric mean of 69.5 eggs per gram of feces (epg). **Figure 3** shows some municipalities with over 10% positivity for schistosomiasis (Água Preta, Barreiros, Belém de Maria, Catende, Cortês, Escada, Gameleira, Jaqueira, Maraial, Palmares, Primavera, Quipapá, Ribeirão, Rio Formoso, São Benedito do Sul and Xexéu), and highlights that municipalities such as Escada and Rio Formoso had infection intensities for *S. mansoni* that were higher than 50%. In relation to the geohelminths, the mean prevalences for *A. lumbricoides*, hookworms and *T. trichiura* (respectively 34.9%, 9.4% and 35.9%) indicate that there was a considerable risk of transmission and morbidity **(Figure 3)**.

Spatial analysis from the Kernel intensity estimator made it possible to construct density maps showing the three ZMP regions
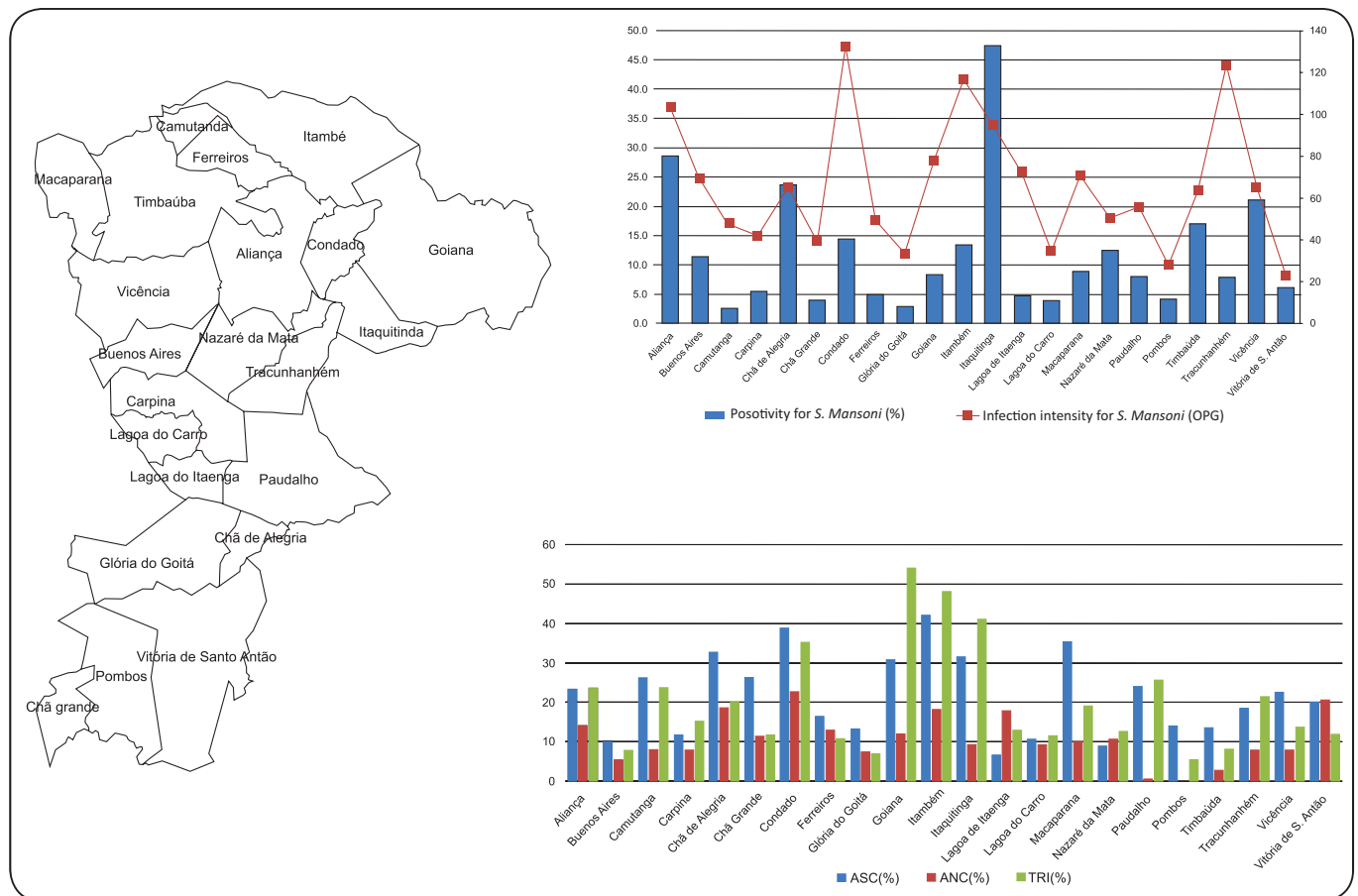

FIGURE 2 - Positivity and infection intensity for *Schistosoma mansoni* and positivity for geohelminth in school-children of North and Center *Zona da Mata*, Pernambuco, Brazil - February to March of 2005. ASC: *Ascaris lumbricoides*; ANC: Hookworms; TRI: *Trichuris trichiura*.

where the largest number of children infected with parasites and the schoolchild populations most intensively infected by *S. mansoni* were concentrated, and these are shown as red agglomerations. The northern ZMP region stands out because of the larger number of schoolchildren with schistosomiasis and, moreover, it had the highest concentration of parasite load for the helminth *S. mansoni* **(Figure 4)**.

In relation to geohelminths, **Figure 5** shows that the cases of hookworms were distributed throughout the ZMP, and it highlights that the spatial distribution of cases of *A. lumbricoides* and *T. trichiura* into the southern ZMP was greater.
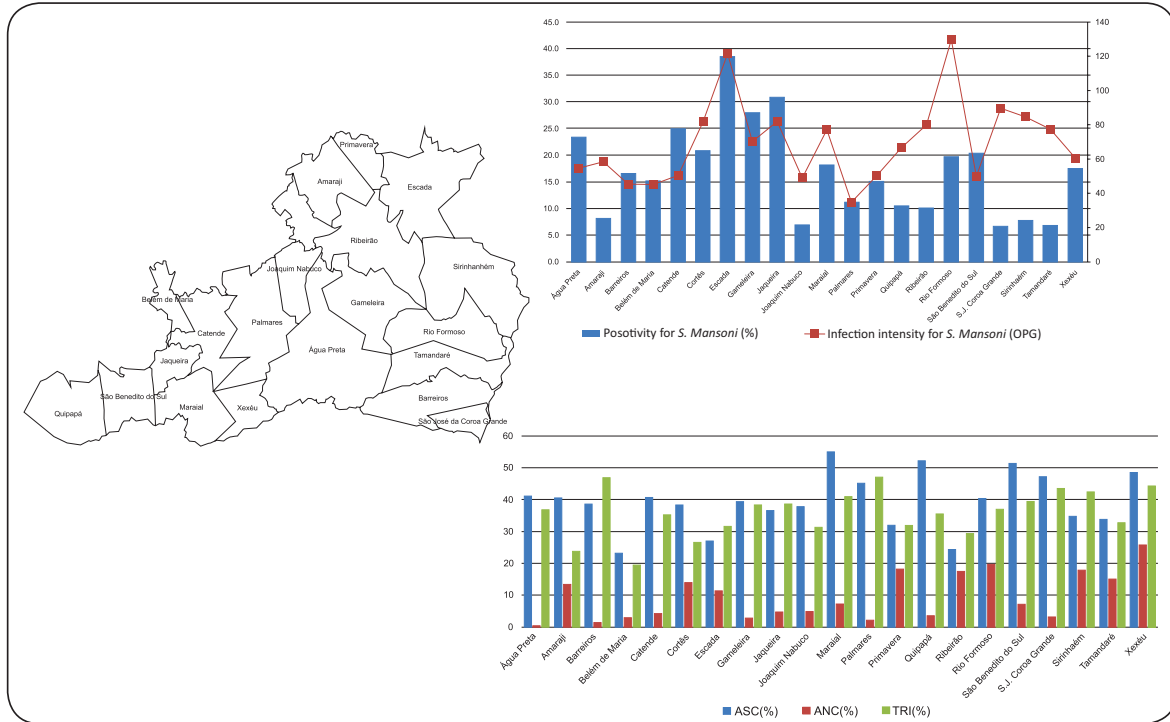

FIGURE 3 - Positivity and infection intensity for *Schistosoma mansoni* and positivity for geohelminth in school-children of South *Zona da Mata*, Pernambuco, Brazil - February to March of 2005. ASC: *Ascaris lumbricoides*; **ANC:** Hookworms; **TRI:** *Trichuris trichiura*.
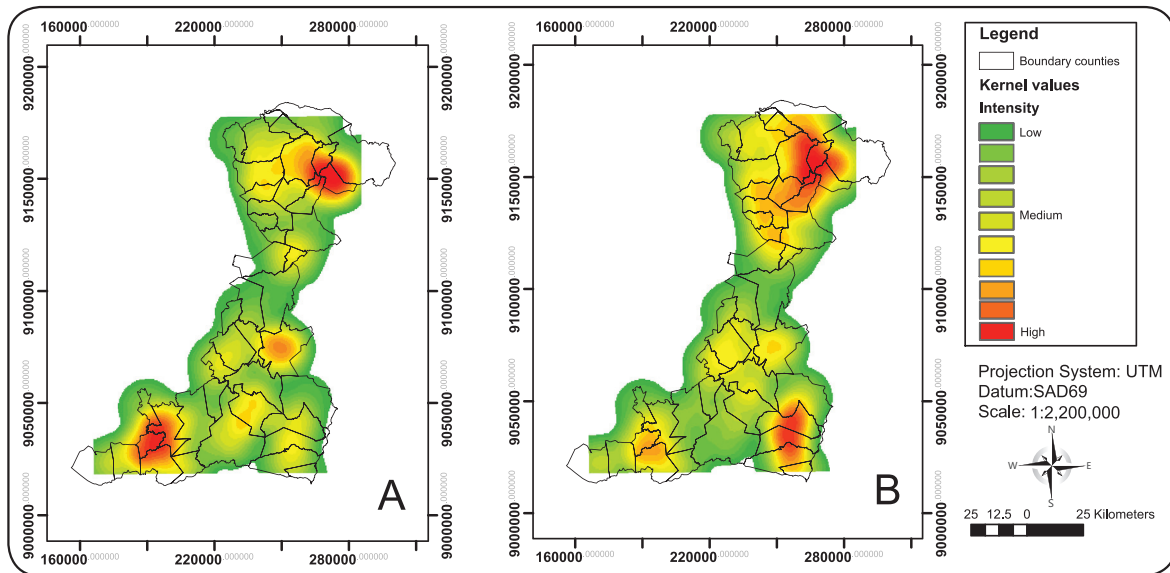

FIGURE 4 - Spatial distribution of prevalence (A) and infecction intensity (B) for *Schistosoma mansoni* in *Zona da Mata*, Pernambuco, Brazil. UTM: Universal Transversa Mercator.
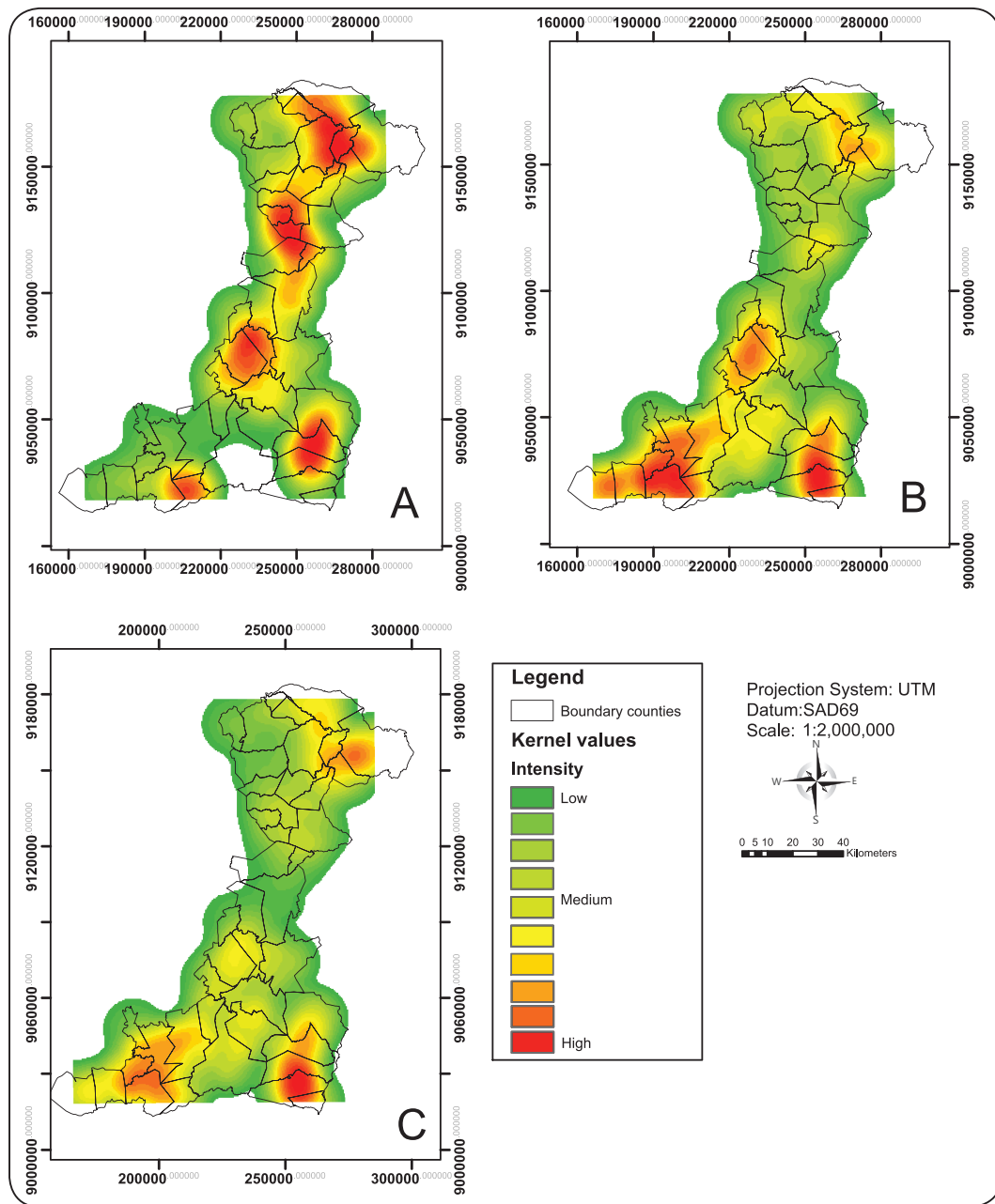
FIGURE 5 - Spatial distribution of Hookworms (A), *Ascaris lumbricoides* (B) and *Trichuris trichiura* (C) prevalence in *Zona da Mata*, Pernambuco, Brazil. **UTM:** Universal Transverse Mercator.

DISCUSSION

The results from this study show the worrying situation among children living in rural areas of Pernambuco. It can be considered that the occurrence and prevalence diagnosed among schoolchildren in the ZMP is an underestimate, given that the survey performed in 2006 only took a single feces sample and that the diagnostic technique used (Kato Katz)[13] did not allow detection of occurrences of other helminths (such as *Strongyloides* sp), or of protozoa.

Even with the limitations mentioned above, high parasite loads of *S. mansoni* were found among children living in the municipalities of Escada, Rio Formoso, Aliança, Condado, Itambé and Tracunhaém. This deserves special attention from the Schistosomiasis Control Program (PCE), so that schoolchildren living at these locations do not evolve to present severe and irreversible forms of schistosomiasis. Other municipalities did not present very high prevalence of *S. mansoni,* but there were high rates of other types of geohelminthiasis in places such as Aliança, Chã de Alegria, Itaquitinga, Vicência, Água Preta, Catende, Escada, Gameleira and Jaqueira (all with mean prevalence of over 20%). This requires a more careful socioenvironmental and cultural diagnosis in order to understand the factors involved in the production and maintenance of these high rates.

The PCE is responsible, at state level, for capacitating and guiding municipal healthcare services so that they are able to identify, diagnose and treat cases of schistosomiasis disease and identify vector mollusk foci. The PCE should encourage control actions, social

mobilization and health education. Data gathered by municipalities relating to positive human cases of *S. mansoni*, case treatments and the breeding sites and vector mollusk foci detected should be input to the PCE information system (SISPCE) and be sent for consolidation and analysis at central level, i.e. in the coordination offices of the PCE in each state. However, these data cannot be used as a reliable source of information, because the municipal localities selected as sampling components for the information system do not obey statistical criteria and, therefore, they do not express the prevalence of the disease in the municipality and do not faithfully show the real schistosomiasis situation in the State of Pernambuco.

According to Favre et al.[7] in the reports generated by SISPCE, the information on infection rates due to *A. lumbricoides* and hookworms in municipalities in Pernambuco is underestimated, according to the results from the various surveys that have been conducted in different localities within the ZMP. In this manner, the preliminary results from the National Schistosomiasis and Geohelminthiasis Survey (N Katz: unpublished data), which is being conducted in Pernambuco, have shown that schoolchildren in the municipalities of the northern ZMP, such as Vicência and Ferreiros, still show worrying prevalence of *A. lumbricoides*, hookworms and *T. trichiura*, and also parasite loads for *S. mansoni* of around 30 to 100epg.

Taking into consideration the results discussed above, which express the health situation among schoolchildren in some municipalities and localities in Pernambuco, along with the observation that it has been impossible for the PCE in Pernambuco to attain its goal of covering the endemic areas for schistosomiasis, we corroborate the propositions of Favre et al.[14] who showed that it is feasible to diagnose and treat at least the school-age children in the ZMP.

Even though various surveys and studies over the last 30 years have shown occurrences of schistosomiasis and geohelminthiasis in the ZMP[7,8,14,15] no preventive measures are known to have been effective in the endemic area for decreasing the numbers of cases and morbidity due to these health hazards among schoolchildren in the ZMP.

ABSTRACT IN PORTUGUESE

Distribuição espacial dos casos de esquistossomose e geohelmintoses em áreas rurais de Pernambuco, Brasil

Introdução: A prevalência e intensidade das infecções produzidas por geohelmintos e esquistossomose continuam elevadas na Zona da Mata de Pernambuco (ZMP), onde essas parasitoses se apresentam como relevante problema de saúde pública. O presente estudo objetivou espacializar a ocorrência da esquistossomose e geohelmintoses na ZMP. **Métodos**: A ZMP apresenta uma população de 1.132.544 habitantes, composta por 43 municípios. Um estudo ecológico foi desenvolvido, utilizando dados secundários referentes aos casos humanos positivos e cargas parasitárias para esquistossomose e casos humanos positivos para geohelmintoses que foram trabalhados no Excel 2007. Foram utilizadas as coordenadas das sedes municipais para representar o município o qual serviu de unidade de análise deste estudo. Para análise espacial dos dados e identificação de padrões de distribuição e densidade dos casos, foi adotado o estimador de *Kernel,* sendo as análises feitas no *software* ArcGIS. **Resultados**: A análise espacial, a partir do estimador de intensidade de Kernel, permitiu a construção de mapas de densidade mostrando a Mata Norte como a região onde se concentra o maior número de crianças parasitadas e as populações mais intensamente infectadas pelo *Schistosoma mansoni*. Com relação aos geohelmintos, há uma maior distribuição espacial dos casos de *Ascaris lumbricoides* e *Trichuris trichiura* na Mata Sul, destacando a maior ocorrência de ancilostomídeos entre as Matas Norte e Centro de Pernambuco. **Conclusões:** Apesar dos inquéritos e dos vários estudos mostrando a ocorrência de esquistossomose e geohelmintoses na ZMP ainda se desconhecem medidas preventivas que tenham sido implementadas na área endêmica mostrando efetividade na redução destes agravos.

Palavras-chaves: Esquistossomose. Análise espacial. Zona da Mata de Pernambuco.

ACKNOWLEDGMENTS

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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