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Urban transmission of schistosomiasis: new epidemiological situation in the forest area of Pernambuco

Transmissão urbana da esquistossomose: novo cenário epidemiológico na Zona da Mata de Pernambuco

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ABSTRACT: ***Introduction:*** Schistosomiasis is considered an endemic disease in Vitória de Santo Antão, Pernambuco, a district which has presented both high incidence and prevalence of it for decades. Poor environmental conditions lead to contamination of water sources in rural areas, which are used by the population during daily activities, resulting in typical transmission. Recently, there has been evidence of vector snails in urban areas, which could set a new model for schistosomiasis transmission in this district. ***Objective:*** To identify the new epidemiological situation for the urban transmission of schistosomiasis in Vitória de Santo Antão, Pernambuco. ***Methods:*** A malacological survey was conducted in all water sources in the city limits to investigate schistosomiasis vector snails (*Biomphalaria* spp.). The collected snails were examined for taxonomic identification and *Schistosoma mansoni* infection. All breeding sites were georeferenced to build risk maps through the TrackMaker PRO program and ArcGIS software. ***Results:*** We identified 22 *Biomphalaria straminea* breeding sites and collected 1,704 snails. One of these breeding sites was identified as a source of transmission and seven as potential sources of transmission. The designed maps identified two risk areas of urban transmission of schistosomiasis and expansion areas for breeding sites, establishing an increased risk of transmission to the population. ***Conclusion:*** This study verified the existence of a new epidemiological situation in which the possibility of the urban transmission of the disease was confirmed.

Keywords: Schistosomiasis. Transmission. *Biomphalaria*. *Schistosoma mansoni*. Urban sanitation. Epidemiological profile.

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RESUMO: ***Introdução:*** A esquistossomose é considerada uma endemia em Vitória de Santo Antão, Pernambuco, o qual apresenta há décadas altas incidências e prevalências para essa doença. Nesse município ocorre a transmissão clássica da doença por meio do contato da população de áreas rurais com águas contaminadas durante o desenvolvimento de suas atividades de vida diárias. Recentemente surgiram indícios da presença do caramujo vetor na área urbana da cidade, o que pode configurar um novo modelo de transmissão para esquistossomose nesse município. ***Objetivo:*** Identificar novo cenário epidemiológico para ocorrência da transmissão urbana da esquistossomose em Vitória de Santo Antão, Pernambuco. ***Métodos:*** Foi conduzido um inquérito malacológico, investigando-se todas as coleções hídricas do perímetro urbano quanto à presença do caramujo vetor da esquistossomose *(Biomphalaria spp.)*. Os caramujos coletados foram examinados para identificação taxonômica e de infecção pelo *Schistosoma mansoni*. Todos os criadouros (CRs) foram georreferenciados para construção de mapas de risco por meio dos *software TrackMaker-Pro e ArcGIS*. ***Resultados:*** Foram identificados 22 CRs da espécie *Biomphalaria straminea,* nos quais foram coletados 1.704 caramujos. Desses CRs, um foi identificado como foco de transmissão da doença e sete como focos potenciais para transmissão. Os mapas construídos identificaram duas áreas de risco para transmissão urbana da esquistossomose, bem como áreas de expansão dos CRs, configurando um aumento no risco de transmissão para a população. ***Conclusão:*** Os resultados constatam a existência de um novo cenário epidemiológico, no qual a possibilidade de transmissão urbana dessa doença foi confirmada.

Palavras-chave: Esquistossomose. Transmissão. *Biomphalaria*. *Schistosoma mansoni*. Saneamento urbano. Perfil epidemiológico.

INTRODUCTION

Schistosomiasis ranks second among the most prevalent infectious and parasitic diseases in the world, affecting about 240 million people in 76 countries[1]. In Brazil, schistosomiasis continues to be a public health problem; seven to eight million people are estimated to be infected with *Schistosoma mansoni* (*S. mansoni*)[1-3]. This is a neglected disease that has been fought by health services at all government levels for decades, primarily through the Schistosomiasis Control Program (SCP). However, although control strategies have had positive effect regarding the reduction in prevalence in many regions of the country[4,5], its control and elimination still seem a distant reality, given the appearance of new areas of disease transmission.

In Pernambuco, schistosomiasis is considered an endemic disease in the state forest area, being present in the 43 districts of the region[6]. Among them, the district of Vitória de Santo Antão stands out, as it has recorded high incidence and prevalence of the disease for years; it is considered a priority district for actions aimed at epidemiological surveillance and the control of parasitic diseases by the State Department of Health[7,8]. A study conducted with a community of small rural farmers in this district found a 35.1% prevalence of schistosomiasis[9], which is high according to the parameters of the Ministry of Health. The occurrence of schistosomiasis in the region is closely related to substandard social and environmental conditions in rural areas[9].

The lack of sanitation is a determinant for schistosomiasis, as it enables fecal contamination of water sources — natural breeding sites of the vector snail —, initiating the disease transmission cycle[7,10]. In addition, the migration of parasitized people has spread schistosomiasis to unaffected areas, such as urban centers of inland cities and coastal towns of the state of Pernambuco[11,12]. In this context, a process of disordered urban occupation on the city outskirts is observed, being identified by the lack of sanitation infrastructure, where organic sediments from wastewater and open sewage as well as food sources for the mollusk enable the maintenance of peridomestic sources of transmission and, consequently, the maintenance of schistosomiasis[11,13].

Seasonal climate variations also influence the disease transmission process, since periods of heavy rains facilitate the spread of temporary and permanent *Biomphalaria* ssp. breeding sites, increasing chances of contact with man, and, therefore, disease transmission[14]. Such environmental conditions have been implicated in an epidemic of the parasitic disease in the population of Porto de Galinhas / Ipojuca, Pernambuco[15], aiding the emergence of a new endemic area for schistosomiasis transmission on the coast of the state[16].

In the forest area of Pernambuco, this environmental and epidemiological scenario can occur in urban areas of the districts, considering the increasing development of cities and the seasonal flooding caused by overflowing rivers that flow through the city, leaving much of their urban areas submerged. Hence, vector snails can be transported to these locations, establishing new *Biomphalaria* ssp. breeding sites or sources of schistosomiasis transmission. Therefore, the objective of this study is to identify the peridomestic presence of these sources, proving the risk of the urban transmission of this parasitic disease.

METHODS

This is an epidemiological study based on a malacological survey, conducted between September 2014 and August 2015 in the district of Vitória de Santo Antão, Pernambuco, located 53 km away from the capital, Recife. According to data from the Brazilian Institute of Geography and Statistics (IBGE), this district has a land area of 372,637 km². It occupies the 10th place among the most populated districts in the state and its population in 2014 was estimated at 134,871 inhabitants.

Initially, the geographical survey of the area was conducted to determine the city limits, using the identification of the district urban sprawl, based on satellite images. During the survey, the main access routes were identified and the mapping of the main water sources found was carried out. Subsequently, a malacological survey was conducted through active search of the breeding sites of *Biomphalaria* spp. snails in all as water sources — either natural or artificial, permanent or temporary — within city limits, such as ditches, streams, creeks, rain drainage channels, and sewage. All breeding sites found were georeferenced and marked as collection stations.

These breeding sites were subclassified as source of transmission — when the collected snails released *S. mansoni* cercaria through a light-exposure technique — and potential source — when *S. mansoni* DNA was detected in the collected snails through a molecular biology technique.

There were two collections in each breeding site: the first during the dry season (September to February) and the second during the rainy season (March to August), with a view to assessing the influence of rainfall on the density of snails. Snails were collected with sieves and forceps for 15 minutes in each selected breeding site and properly stored in plastic containers dampened with paper towels, all aired and identified[17] for transport to the Schistosomiasis Laboratory and Reference Service at the Aggeu Magalhães Research Center of the Oswaldo Cruz Foundation (CPqAM/Fiocruz). Approximately 5% of the snails collected in each breeding site were randomly selected for taxonomic identification through the dissection of the genital tract to determine species[18].

For the diagnosis of *S. mansoni* infection and the detection of sources of transmission, snails were exposed to artificial lighting for 1 to 2 hours for cercariae release[19]. Snails that tested negative for the infection through this technique were submitted to DNA extraction in a pool of snails by breeding site, through an extraction technique using phenol:chloroform:isoamyl alcohol; subsequently, the molecular biology method of nested polymerase chain reaction (PCR) was performed, which was specific and efficient for *S. mansoni* DNA identification[20]. The density of snails by breeding site was established as the total number of snails collected by site during the study period.

In the breeding sites, data related to fecal contamination were collected both by observation of the sewage released directly into water sources and the presence of total coliforms, fecal coliforms, and *Escherichia coli* (*E. coli*), using the Colitag™ test kit. To use the kit, water samples were obtained from the same mollusk collection stations in 100-mL sterile containers. The chromogenic reagent was added to the container of collected water, homogenized for further incubation for 24 hours at a temperature of 35 °C. The first assessment was performed using the direct method, in which samples that migrated from a natural color to a vibrant yellow went to phase two. The second assessment was carried out with the aid of a Loccus™ Biotechnology photo-documentation imager (L-Pix), which irradiated samples with a beam of ultraviolet light to determine the presence of *E. coli*.

To design thematic and risk maps for schistosomiasis transmission, all breeding sites were georeferenced with the aid of a Garmin eTrex GPS receiver. The TrackMaker-Pro program and the ArcGIS 10.1 software were used for spatial analysis of data. A kernel intensity estimator identified the areas of greatest risk of schistosomiasis transmission, based on geolocation and the number of snails by breeding site. The kernel intensity estimator is a simple alternative to analyze behavior standards of locations throughout the study area. Therefore, the following parameters were considered:

1. stratification of quantile data; and
2. bandwidth set with adaptive radius established at 230 m, which is more suitable for the analysis of focus studies.

A buffer map with a 50-m radius was also designed from the location of each breeding site and/or source of transmission for the expansion simulation of risk areas, representing floods in the city.

This study did not require approval by the Research Ethics Committee as human beings were not used as subjects.

RESULTS

During the study period, we identified 22 breeding sites within the city limits of Vitória de Santo Antão, where 1,704 snails of the *Biomphalaria straminea* (*B. straminea*) species were collected (Table 1). Figure 1 shows a thematic map with the boundaries of the study area, in which the distribution of *B. straminea* breeding sites, schistosomiasis potential sources, and sources of transmission is observed. Most breeding sites were located at the sides of the PE-60 Highway that cuts the city, a commercial area with heavy movement of people. From the 22 breeding sites, seven were classified as potential sources (site nos. 1, 5, 7, 10, 13, 18, and 20) and one as a source of transmission (site no. 15), verifying the real risk of urban transmission of schistosomiasis (Figure 1). Breeding site no. 20 (potential source) was the only one that presented the greatest number of snails in the two collected samples (n = 323). Breeding site no. 14, however, was the one with the lowest density (Table 1).

A description of the breeding sites is shown in Table 2, where they are quantified by type — 8 are natural and 14 artificial — periodicity — 14 are permanent and 8 temporary — and type of contact with man — 8 as work and leisure activities and 15 as accidental contact. For the latter, the same breeding site has been classified in both categories (breeding site no. 2). Regarding sources, 75% of the breeding sites are artificial and permanent and 62.5% expose man to accidental contact with *S. mansoni*. The source of transmission (breeding site no. 15) was classified as artificial and permanent, with accidental contact.

The largest number of snails was collected in the dry season (September to February). During the rainy season (March to August), snails were not found in some of the previously identified breeding sites. However, it was during this period that the only active source of disease transmission was identified — breeding site no. 15 (Table 1). All collected water samples tested positive for total coliforms, fecal coliforms, and *E. coli*, which establishes the contamination of breeding sites by sewage and wastewater.

Figure 2 shows risk maps that represent the total number of breeding sites and sources of transmission (Figure 2(A)). A more intense sprawl is confirmed, comprising breeding site nos. 6 to 10 and 19. A lower potential for transmission is identified in areas surrounding breeding site nos. 11, 12, 15 to 18, 21 and 22. The absence of the risk sprawl for some breeding sites and sources of transmission is explained by the low number of snails detected in the area.

When analyzing potential schistosomiasis transmission, solely considering the number of snails by source (Figure 2(B)), it is established that:

1. the risk sprawl was intensified over potential source no. 20;
2. the source of disease transmission (breeding site no. 15) showed a small increase in the risk sprawl; and
3. breeding site nos. 5–10 presented moderate risk.

Table 1. Density of snails (*B. straminea)* by breeding sites and sources of schistosomiasis transmission. Vitória de Santo Antão, PE, 2014–2015.

Breeding site	Number of snails (First collection – September to February)	Number of snails (Second collection – March to August)	Total
1*	20	3*	23
2	8	12	20
3	2	3	5
4	8	3	11
5*	70	6*	76
6	120	62	182
7*	68	82*	150
8	87	62	149
9	77	54	131
10*	124	73*	197
11	40	0	40
12	43	0	43
13*	3*	0	3
14	1	0	1
15**	41	60**	101
16	2	0	2
17	60	0	60
18*	45	8*	53
19	45	42	87
20*	200*	123	323
21	10	4	14
22	30	3	33
Total	1,104	600	1,704

*Potential sources of transmission — snails with *S. mansoni* DNA; **source of transmission — snails that tested positive for infection with a *S. mansoni* light-exposure technique (releasing cercariae).

Figure 3 shows the expansion of breeding sites during the rainy season, when their areas merge and some may be contaminated by water from sources, like breeding site nos. 6 to 10, 19 and 20, which expanded up to 100 m, coming into contact with each other.

DISCUSSION

The identification of only one source of transmission (breeding site no. 15) through a light-exposure technique (Table 1) is what is expected in *B. straminea* breeding sites, considering the species resistance to release cercariae, even if infected[19]. This source of transmission consists of an open sewage channel that exposes the population to the risk of accidental infection when walking on the street. The use of a molecular biology method of nested-PCR[20] in the identification of the seven potential sources in the region was determinant to map the risk of urban transmission of the disease, which affects the population that lives and daily moves in the area, exposing themselves to these sources. Such results confirm the hypothesis that this population is at high risk of becoming infected with *S. mansoni*, as potential sources can transform into active sources, since the presence of parasite DNA in snails has been proven.

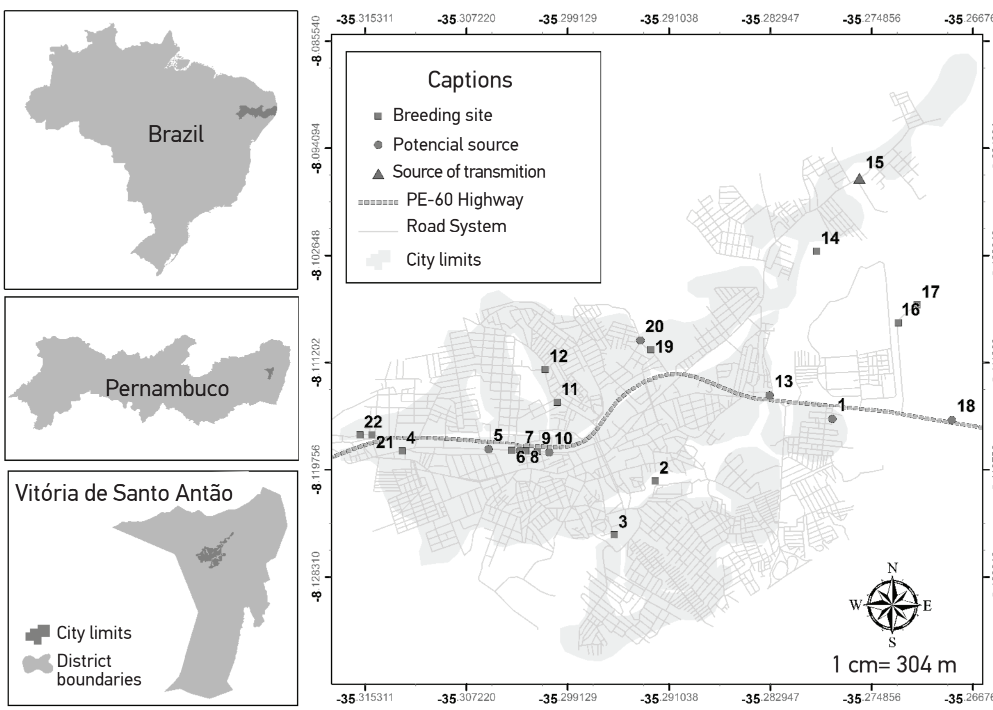

Figure 1. Distribution map of *B. straminea* breeding sites and sources of schistosomiasis transmission in Vitória de Santo Antão, PE.

All breeding sites tested positive for total coliforms, fecal coliforms, and *E. coli*; therefore, they maximize previous results, indicating that the triad of schistosomiasis transmission has all specifications necessary to establish themselves in this urban area — infected individuals from the rural area *vs.* lack of basic sanitation and contaminated environment *vs.* definitive

Table 2. Description of breeding sites and sources of schistosomiasis transmission. Vitória de Santo Antão, PE, 2014–2015.

Breeding site	Total of snails	Description of breeding sites					
		Type		Periodicity		Contact with man	
		Natural	Artificial	Permanent	Temporary	Leisure, work	Accidental
1*	23	x		x		x	
2	20	x		x		x	x
3	5	x		x		x	
4	11		x	x			x
5*	76		x		x		x
6	182		x	x			x
7*	150		x	x			x
8	149		x		x		x
9	131		x		x		x
10*	197		x		x		x
11	40		x		x		x
12	43		x		x		x
13*	3	x		x		x	
14	1	x		x		x	
15**	101		X	x			x
16	2	x		x		x	
17	60	x		x		x	
18*	53	x		x		x	
19	87		X		x		x
20*	323		X	x			x
21	14		X	x			x
22	33		X		x		x

*Potential sources of transmission — snails with *S. mansoni* DNA; **source of transmission — snails that tested positive for infection with a *S. mansoni* light-exposure technique (releasing cercariae).

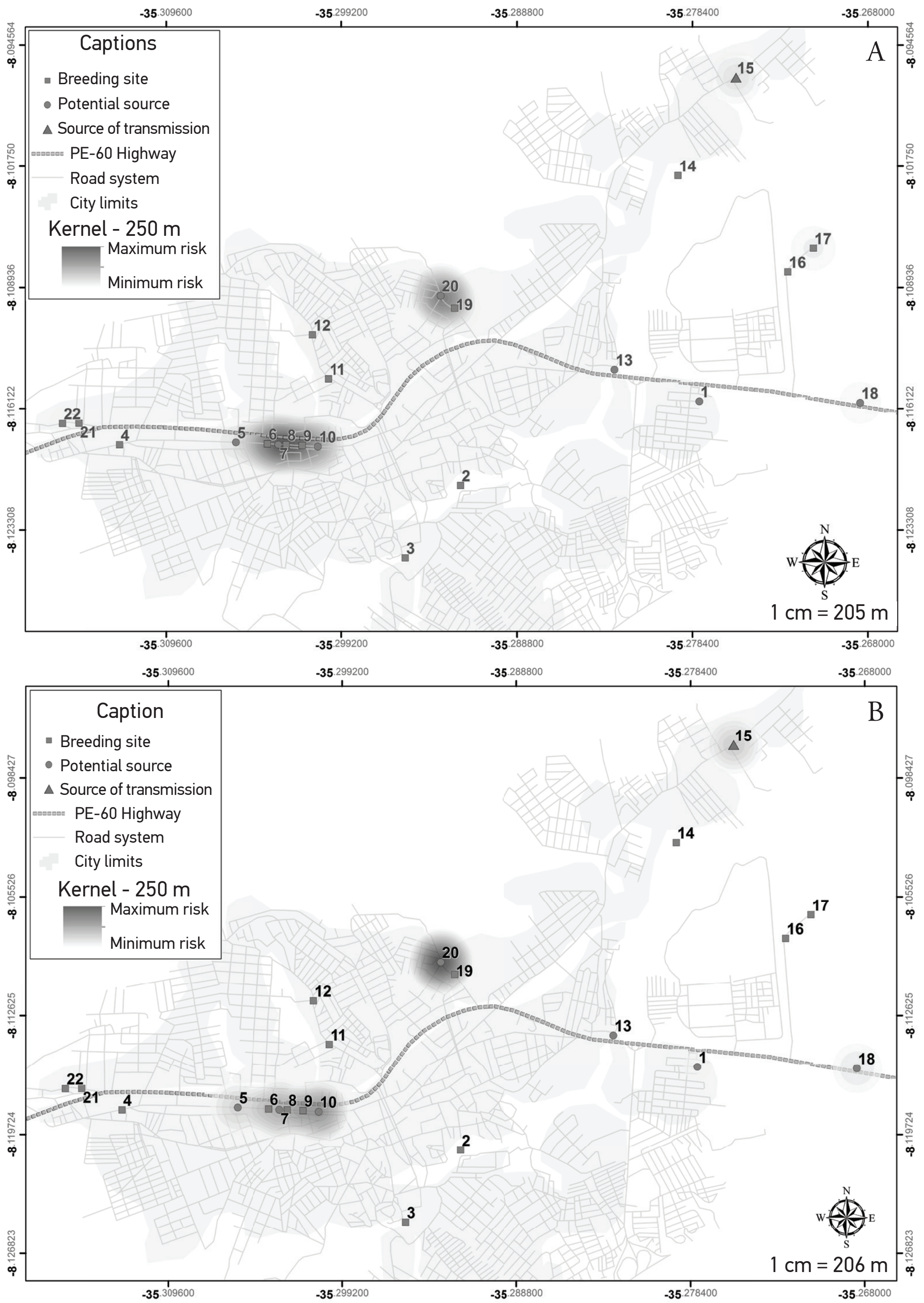

Figure 2. Kernel of the density of snails (*B. straminea*) by breeding sites (A) and sources of schistosomiasis transmission (B). Vitória de Santo Antão, PE.

and intermediate hosts exposed to the infection. In addition, most breeding sites (Table 2) are artificial and permanent, which shows a disordered occupation of the urban space and results in optimal sources of disease transmission and exposure areas for contact with man.

The absence of snails in six breeding sites and the lowest density recorded during the rainy season (Table 1) can be explained by the increased water flow that fosters the sweeping of these vectors to other sites[21,22]. Furthermore, the highest density of snails found in post-rain periods and the dry season corroborates the tropism of these animals by water ecotopes with low current or still waters[21,22].

The data found in this study comprise a new epidemiological situation of urban transmission of the disease. A district in which there was only rural typical transmission — linked to the presence of the infected snail in rivers used by men during work and leisure activities[9,23] — now has flooded breeding sites in the streets and within city limits; that fact may lead to human infection through accidental contact with peridomestic sources[14,15,24] during the movement of individuals in the city.

A similar epidemiological situation has been described in various urban locations in Brazil[12,25,26] and worldwide[27,28]. In Pernambuco, coastal areas have been the target of the migratory flow of individuals parasitized with *S. mansoni* for decades, which, in search of better living conditions, settle on the city outskirts, where the lack of basic sanitation is maintained. Furthermore, intermediate hosts in the coastal regions lead to the completion of the transmission cycle, enabling cases of the disease[12,13,17,24]. In this context, Porto de Galinhas can be mentioned as a model for the understanding of such epidemiological situation, where, in

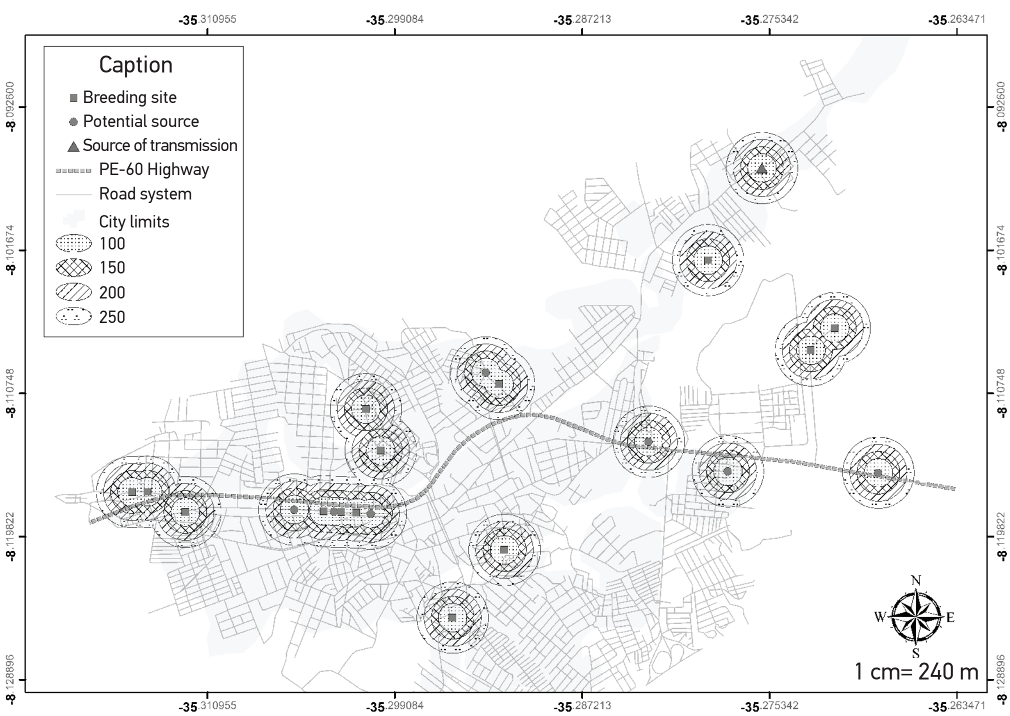

Figure 3. Risk map for the spread of breeding sites of *B. straminea* and sources of schistosomiasis transmission in Vitória de Santo Antão, PE.

a decade, the disease established itself and became endemic[11,14-16]. From that example, the situation for schistosomiasis transmission in Vitória de Santo Antão may be reaching a new phase, in which the disease is no longer solely rural and becomes an urban endemic disease, putting a huge portion of the population at risk of becoming infected.

The identification of the risk sprawl shown in Figure 2 (A)/(B) (breeding site nos. 6–10) indicates a higher concentration of breeding sites and snails in areas of pedestrian traffic. The detection of low-risk locations around breeding site no. 15 (Figure 2(B)) deserves special attention from Epidemiology Surveillance because it is a source of transmission, setting a high real risk of schistosomiasis transmission.

The rainy season has strong influence on the urban transmission of schistosomiasis by causing the overflow and dispersion of urban breeding sites of *Biomphalaria*[29]. In Vitória de Santo Antão, the floods experienced by the population seasonally lead to the transport of snails to city limits, where there are favorable ecotopes for fixation and maintenance in the environment, exposing residents to the risk of becoming infected.

CONCLUSION

This study verified the risk of urban transmission of schistosomiasis in Vitória de Santo Antão. Such epidemiological situation, although new to the district, may be repeating itself in other endemic districts in the state forest area with similar risk conditions to those presented in this study.

It is necessary to broaden malacological and epidemiological studies in the area; furthermore, it is essential that local health services create new research protocols for the early diagnosis of new cases. Therefore, a new conception of the disease is imperative, in which the origin and risk behavior are not only related to populations from the countryside and who had contact with river water, but also populations of urban areas, who can expose themselves to unintentional contact with sources of transmission of this parasitic disease.

Given the results presented here, we intended to expand research on urban transmission of schistosomiasis in Vitória de Santo Antão, in search of endemic cases of the disease through prevalence surveys in schools.

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