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Brief Original Article

Cutaneous leishmaniasis: Spatial distribution and environmental risk factors in the state of Pará, Brazilian Eastern Amazon

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Abstract

Introduction: Cutaneous leishmaniasis is an infectious disease transmitted by phlebotomine sandflies and is considered a great environmental and public health problem. Thus, this work presents initial results of the analyses about the relationship between the spatial distribution of this disease and its environmental risk factors in three municipalities, in the state of Pará, Brazil, from 2012 to 2016.

Methodology: It was used data from the Ministry of Health, the National Institute for Space Research and the Brazilian Institute of Geography and Statistics. The statistical and spacial analysis of the variables were done using G-test goodness-of-fit, kernel interpolation technique and the Bivariate Global Moran Index (I).

Results: The analyses showed that the most affected individuals were males, adults, low schooling, residents in rural areas and small farmers. The disease spatial distribution was not homogeneous in the municipalities and it was associated to different relationships between the land use and occupation and the notificated cases density, with direct spatial autocorrelation.

Conclusions: The deforestation was the most significant risk factor linked to the cases occurrence in all the studied area. We emphasize the need of intensification of epidemiological and environmental surveillance actions in the studied areas.

Key words: Leishmaniasis; deforestation; spatial analysis; environmental health.

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Introduction

Cutaneous Leishmaniasis (CL) is an infectious disease caused by protozoa of the genus Leishmania, affecting the skin and mucosa. The disease can have different vectors, depending of the worldwide geographical location, however in Brazil the most comun is the Phlebotominae, of the *Lutzomyia* genus, that are popularly known as mosquito-palha, tatuquira, birigui, among others. Being the man the principal reservoir of epidemiological interest, due to the impact on the work capacity of the same [1,2].

CL affects about 1.5 million people each year in 88 countries, 72 of which are in development. In the Americas, about 21 countries have this disease among their six major endemic parasitosis. In this context, over the last decades a large number of cases have been reported in Colombia, Venezuela and Brazil. This fact has pointed to a relationship between the environmental characteristics of these territories and the occurrence of the disease. However, the evidences of the relationship between CL and its conditioning variables has not been frequently studied at local geographic scales, implicating in few production of contextualized and precise epidemiological scenarios of the disease. [3,4].

This disease has been reported throughout the Brazilian territory and has great epidemiological relevance in the Amazon, where it is considered endemic [1]. The occurrence of CL has been linked to developmentalist projects carried out into the last decades, such as policies for the regional occupation, that occurred without the concept of sustainability. This has led to deforestation and migratory flows, causing the proliferation of risk areas of infection [1,5].

Nowadays, the northeastern region of the state of Pará, in the Brazilian Eastern Amazon, has been undergoing a significant increase of the cases number of the disease. Thus, in the period from 2012 to 2016, there was an increase of approximately 42% of the

number of CL cases in the region, compared to the previous five years, as well as a significant increase of environmental changes. This fact, points to the evidence of relation between the cases recorded and the deforestation, due to disordered urbanization, wood extraction and pastures for livestock production, among other reasons [5,6].

The spatial statistical analysis (SSA) has been used in epidemiological studies to analyze the geographical distribution of diseases and their risk factors. In this context, it can enable the identification of patterns of the spatial distribution of CL, since this disease does not occur homogeneously in Brazilian territories, due to its different social, economic and environmental characteristics. Among the principal techniques of SSA, there is the Bivariate Global Moran Index, which is used to assess spatial autocorrelations, such as the occurrence of deforestation and CL cases in one same geographic region. This technique assumes the hypothesis of inverse autocorrelation ($I < 0$), randomness ($I = 0$) and direct ($I > 0$) and the technique of Kernel estimation, which is used to evaluate the spatial density of a variable, such as the occurrence of disease cases in one territory [7,8]

Considering that the study of CL spatial distribution at local scales can contribute to the formulation of health surveillance policies, as well as its environmental monitoring, this study presents a preliminary analysis of the spatial distribution of this disease, discussing its relationship with environmental risk factors in three municipalities of the northeastern region of the State of Pará, Brazilian Eastern Amazon, from 2012 to 2016.

Methodology

In this ecological study, the studied area is contained in the northeast region of the State of Pará, Brazil, and is composed by three municipalities. The first one is Viseu that has an area of 4,939,254 km², divided into 4 administrative districts, with estimated population of 61,049 inhabitants. The second is Bragança, which has an area of 2,090,234 km², divided into 6 districts, with estimated population of 166,753 inhabitants. The third is Augusto Correa with area of 889,2 km², divided into 4 districts, with estimated population of 45,516 inhabitants.

It was studied 234 confirmed autochthonous cases of CL, with immunological laboratory tests, reported with no relapses, in the period from 2012 to 2016. The epidemiological, cartographic and environmental data were obtained from the Brazilian Ministry of Health (MS), the Brazilian Institute of Geography and Statistics (IBGE) and the National Institute for Space Research (INPE), respectively.

The depuration process of the original data was performed using TabWin 36b software. The households of the CL cases were georeferenced subsequently, in two excursions to the field of research, using a GPS receiver, for the creation of the geographic database with the TerraView 4.2.2 software.

For each municipality studied, in the statistical analysis of sociodemographic variables (gender, age, education level, occupation, residence area and occupational disease) the percentages of these were calculated, in addition to their significance using the G test, assuming if level $\alpha = 0.05$ (5%) and p value < 0.05, using BioEstat 5.3 software. This test was used because more than 20% of the expected frequencies of the variables groups were ≤ 5, very low for comparisons between observed and expected scores, according to Sokal and Rohlf [9] and Noh-Quinones [10].

Concerning the environmental variable, the percentage of deforestation in each administrative district was calculated by the sum of the information classes 'land use and cover' utilized in the TerraClass project (urban area, occupation mosaic, annual agriculture, clean pasture, dirty pasture, mining, reforestation, pasture regeneration, deforestation, and others), and divided by the total area of each district of the municipality in analysis.

In the spatial statistics analysis the Bivariate Global Moran Index (I) was used to evaluate the spatial autocorrelation between deforestation and the occurrence of CL cases in the studied areas, with a $p < 0.05$ indicating spatial statistical significance. This p-value (< 0.05) was used in accordance with the international literature, which takes into account the spatial proximity matrix weighted by the average between 0.001 and 0.05 of the interpolations of the areas. Spatial autocorrelation was considered strong when indices were close to one of the defined variation limits (-1, 1), this representation form is recurrent in several scientific works with similar objectives. It was also used the kernel interpolation technique, with a distance of 333 meters between the georeferenced points, in order to evaluate the density of the cases [11].

This work was aproved, with favorable opinion 3.245.271/2019, by the Research Ethics Committee of the Pará State University, with no conflits of interests in accordance with resolution 466/2012.

Results

It was analyzed the spatial distribution of 234 cases of CL in the municipalities of Bragança (153), Augusto

Corrêa (49) and Viseu (32). In general, those three municipalities showed similarities regarding the cases epidemiological profile, in relation to gender, age group and occupation zone. Thus, the highest percentages of CL cases were men, adults and inhabitants of rural areas. However, individuals with elementary-level schooling and small farmers had a higher percentage of cases, except in Viseu, where results for these variables were ignored. In regards to work as a risk factor for the disease, the highest percentages occurred in Bragança and Viseu. In Augusto Corrêa, the highest percentage related to this variable was ignored. The frequencies of the analyzed variables were statistically significant (Table 1).

The land use and cover spatial analysis pointed very high percentages of deforestation in the three municipalities studied. However, this anthropic relationship was more concentrated in the municipalities of Bragança (83.8%) and Augusto Corrêa (67.8%), in the area of Caeté river basin where the highest percentages of CL cases were notified (Figure 1).

Considering the administrative districts of the studied municipalities the Global Moran Index (I) analyzes showed significant spatial relationships between areas with deforestation and cases location. Thus, a direct autocorrelation between these two variables was observed, with positive ($I > 0$) and significant ($p < 0.0001$) indices. The spatial autocorrelations were strong in the districts of Augusto Corrêa and Emboraí (municipality of Augusto Corrêa); Almoço and Caratateua (municipality of Bragança); Fernandes Belo and São José do Piriá (municipality of Viseu) (Table 2).

Table 1. Social-epidemiological profile of Cutaneous Leishmaniasis, in the municipalities of Augusto Corrêa, Bragança, and Viseu, State of Pará, Brazilian Eastern Amazon (2012 to 2016).

		Augusto Corrêa			**Bragança**			**Viseu**		
		n	**%**	**p-value**	**n**	**%**	**p-value**	**n**	**%**	**p-value**
Gender	Males	**33**	**67.3**	**0.0067**	**113**	**73.9**	**< 0.0001**	**23**	**71.9**	**0.0197**
	Females	16	32.7		40	26.1		9	28.1	
Age group	Children (≤ 12)	7	14.3	**< 0.0001**	10	6.5	**< 0.0001**	2	6.2	**< 0.0001**
	Adolescent (13 a 17)	2	4.1		20	13.1		3	9.4	
	Adult (18 a 59)	**36**	**73.5**		**109**	**71.2**		**27**	**84.4**	
	Elderly (≥ 60)	4	8.1		14	9.2		-	-	
Schooling	Illiterate	2	4.1	**< 0.0001**	7	4.6	**< 0.0001**	1	3.1	**< 0.0001**
	Elementary school	**20**	**40.8**		**103**	**67.3**		5	15.6	
	High school	2	4.1		12	7.8		-	-	
	Higher educations	1	2.0		-	-		-	-	
	Ignored	22	44.9		28	18.3		**25**	**78.2**	
	Not apply	2	4.1		3	2.0		1	3.1	
Occupation	Farmer	**25**	**51.1**	**< 0.0001**	**108**	**70.6**	**< 0.0001**	-	-	**< 0.0001**
	Student	-	-		11	7.2		-	-	
	Retired	-	-		6	3.9		-	-	
	Fisherman	-	-		1	0.7		-	-	
	Community agent	1	2.0		-	-		-	-	
	Independent professional	5	10.2		4	2.6		-	-	
	Ignored	18	36.7		23	15.0		**32**	**100.0**	
Area	Rural	**42**	**85.7**	**< 0.0001**	**130**	**85.0**	**< 0.0001**	**29**	**90.6**	**< 0.0001**
	Urban	7	14.3		23	15.0		3	9.4	
Laboral disease	Yes	14	28.6	**< 0.0001**	**98**	**64.1**	**< 0.0001**	**25**	**78.1**	**< 0.0001**
	No	13	26.5		10	6.5		1	3.1	
	Ignored	**22**	**44.9**		45	29.4		6	18.8	

Source: Research Protocol/EpiGeo/DSCM/CCBS/UEPA, 2018; * p-value < 0.05 (G test, goodness-of-fit); * Unavailable: (-).

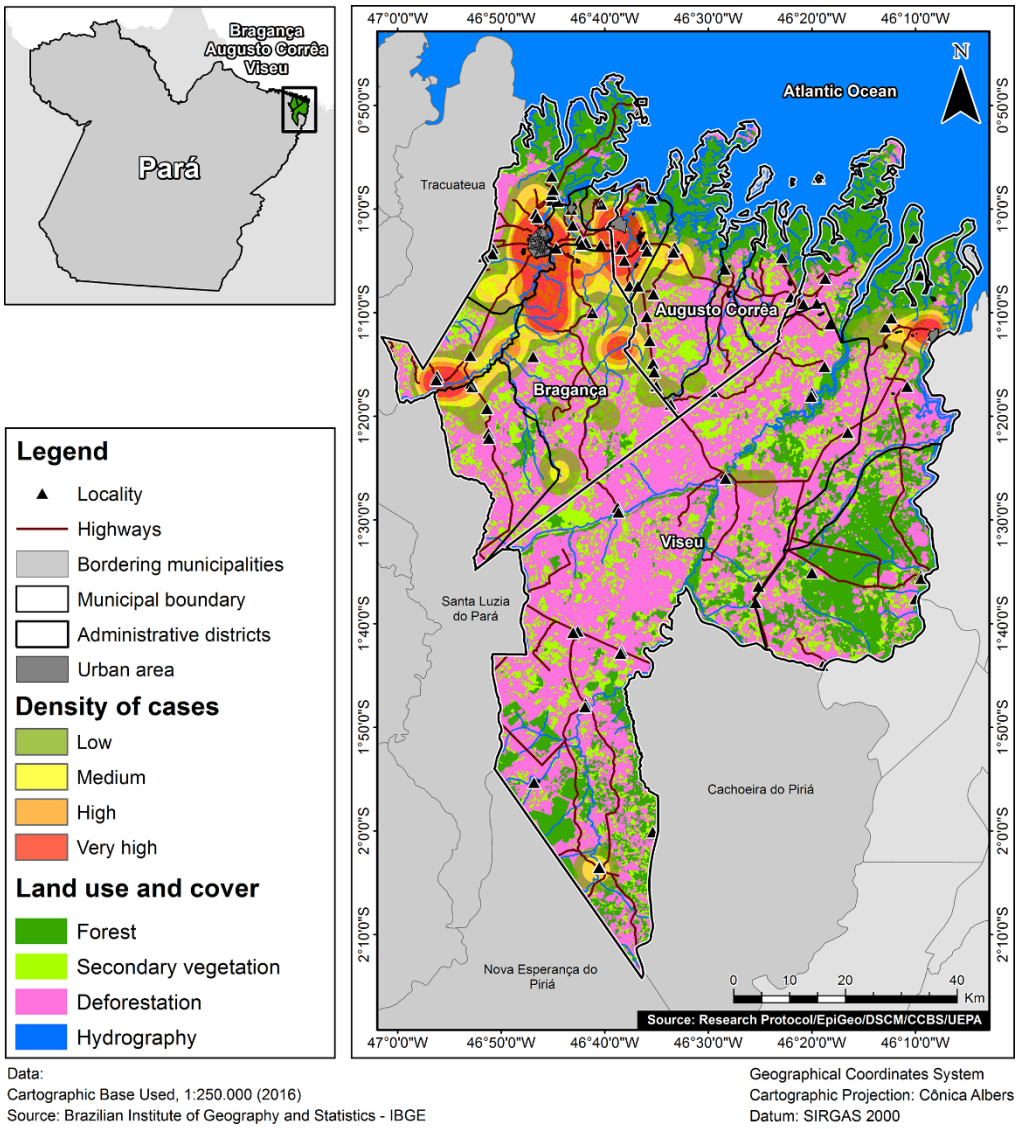

Figure 1. Cutaneous leishmaniasis density of cases, land use and cover in the municipalities of Augusto Corrêa, Bragança and Viseu, State of Pará, Brazilian Eastern Amazon (2012 to 2016).

Source: Research Protocol /EpiGeo /DSCM /CCBS /UEPA, 2018.

Table 2. Number of cases and percentage of deforestation in the administrative districts of the municipalities of Augusto Corrêa, Bragança, and Viseu, State of Pará, Brazilian Eastern Amazon (2012 to 2016).

Municipality	Districts	Total area (Km²)	Deforestation		Deforestation parameter	Cases	(I)	Parameter (I)	p-value
			(km²)	(%)					
Augusto Corrêa	Augusto Corrêa	146.115	94.280	64.524	High	30	0.646	**Strong**	**< 0.0001**
	Emborai	204.904	169.157	82.554	Very high	4	0.841	**Strong**	
	Itapixuna	207.099	128.579	62.086	High	3	0.129	Low	
	Aturai	519.217	338.091	65.052	High	12	0.407	Low	
Bragança	Bragança	526.426	277.757	52.763	High	56	0.369	Low	**< 0.0001**
	V. do treme	43.526	27.517	63.219	High	3	0.415	Low	
	Tijoca	839.340	812.613	96.816	Very high	64	0.272	Low	
	Almoço	220.064	211.632	96.168	Very high	16	0.946	**Strong**	
	Caratateua	69.200	57.781	83.499	Very high	4	0.617	**Strong**	
	Nova Mocajuba	396.880	368.243	92.784	Very high	10	0.246	Low	
Viseu	Viseu	668.225	372.107	55.686	High	17	0.846	**Strong**	**< 0.0001**
	Fernandes Belo	283.308	95.829	33.825	Medium	0	0.772	**Strong**	
	S. José do Gurupi	821.115	383.765	46.737	Medium	2	0.135	Low	
	S. José do Piriá	3.143.443	2.626.626	83.559	Very high	13	0.629	**Strong**	

Source: Research Protocol/EpiGeo/DSCM/CCBS/UEPA, 2018.

Discussion

The epidemiological profile analysis showed that the majority of CL cases, in the municipalities of Bragança and Augusto Corrêa, involved male adults with low schooling, living in rural areas and small farmers [2,3,5]. In Viseu it was observed the smallest number of notifications. Those cases presented a high percentage of education until elementary school and small farmer occupation. However, the high percentage of ignored information is associated with the lack of data in SINAN. This data sub notification, observed by researchers of this work in the studied area, points to the inefficiency of the infectious disease notification service, as a Brazilian public health policy, and is due to the big distances and great difficult for accessing the households of the cases, in order to verify the environmental risk factors associated to the notifications in rural areas, when the realization of the active search of cases [12].

Those facts, observed in the laboratory and confirmed during fieldwork, indicates the socioeconomic production of the disease due to laboral activities, and it is in accordance with other studies about the lack of knowledge of the disease transmission way and the need of individual or collective protection against Phlebotomine sandflies in laboral activities, by small farmers [3,5,13-16]. The occurrence of the disease closer to the limits of the municipalities seats suggests that the vectors are adapting to residential and peri-residential areas, generating different spatial degrees of exposure to the CL, in the region [2,16].

The spatial analyses also showed that the distribution of CL cases in the studied municipalities occurred in a non-homogeneous manner, with clusters of cases possibly related to the environmental degradation of the Caeté river basin, in the municipalities of Bragança and Augusto Corrêa [5,16]. The disorderly occupation of these areas, over the last decades, has likely become conditioning of the development of the disease transmission cycles [14]. In this sense, the municipalities of Bragança and Augusto Corrêa, in addition to presenting the highest indicators of environmental change, also reported the highest numbers of CL cases [5,16].

It was observed that the relation between CL cases location and its risk factors goes beyond of the territorial dimensions of the municipalities administrative divisions, with a spatial contiguity that points to the establishment of an epidemiological corridor associated to the evidence of its vectorization related to the environmental degradation and disordered occupation, establishing favorable conditions for the proliferation of Phlebotomine sandflies, in the Caeté River basin [3,5,15].

The strong direct spatial autocorrelations observed between those two variables are related to the spatial dependence of the disease occurrence and deforestation in some places of the administratives districts of the municipalities. This fact was observed both in the laboratory and in the field and it is associated to differents stages of secondary vegetation ecological succession in those areas, marked by the presence of young and adult capoeiras, that indicate different environmental conditions of the disease transmission circuits production [1,8,16].

Conclusion

In this work, it was analysed the relation of CL and its risk factors in the administrative districts of three municipalities of the Pará State, Brazilian Eastern Amazon. It was observed, both in the laboratory and fieldwork, that environmental degradation and laboral activities were the most relevant risk factors linked to the cases occurrence. It was also observed a establishment of one epidemiological corridor vectorized by the deforestation and disordered occupation in the Caeté River basin. Thus, we emphasize the intensification need of epidemiological and environmental surveillance actions of the cutaneous leishmaniasis, in the studied area, in order to monitor its expansion. As well as the continuity of research projects in the interface of the health and environment in susceptible areas.

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