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ORIGINAL ARTICLE

# SPATIAL DISTRIBUTION OF ENVENOMATION BY SCORPIONS IN PARÁ STATE, BRAZIL

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## ABSTRACT

Scorpionism is recognized by the World Health Organization as a neglected disease and, in Pará State, Brazil, it is considered a public health hazard. The objective of this study was to describe the spatial distribution of envenomation caused by scorpions in Pará. The data related to envenomation were collected from 2007 to 2014 and used for both descriptive and transversal studies. For those studies records obtained from ongoing investigations from the database of the National Notifiable Diseases Information System at the Public Health Department of Pará State were used. Envenomation occurs year round, most often in the first half of the year, in males from the countryside, aged 20 to 59 years and taking up to 3 hours to reach medical care. The deaths occurred from ages 15 to 59. Regarding the severity of the cases, class I cases were the most frequent and class III cases were the least frequent, accounting for only 5.1% of all cases. Of the 144 municipalities of Pará State, in 126 the frequency of envenomation ranged from 1 to 1,208 cases per municipality. Thirteen municipalities located in the lower Amazon region and in the southwest of Pará State presented higher occurences, including the highest number of deaths. Scorpionism is present throughout Pará State. However, there were differences in severity and incidence in the various regions, with higher frequency in the southwest of the State and in the lower Amazon region, corresponding to the Tapajós and Guyana endemic areas in the Brazilian Amazon.

KEY WORDS: Envenomation; scorpionism; spatial distribution; scorpion sting; epidemiology.

## INTRODUCTION

The World Health Organization considers Scorpionism a neglected disease (WHO 2007). According to Chippaux & Goyffon (2008), annually, about one million, two hundred thousand cases of envenomation are caused by scorpions, throughout the world. In Brazil, envenomation by

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scorpions is the most frequent public health hazard (Reckziegel & Pinto 2014) of all those caused by venomous animals. According to the National Notifiable Diseases Information System (SINAN), 462,024 accidents with scorpions were notified from 2007 to 2014, with an average 57,753 cases per year. In the North Region, the state of Pará presents the most scorpionism notifications (SINAN 2015).

Northern Brazil harbors about 44 species of scorpions (Lourenço 2002), and species such as *Tityus obscurus, Tityus metuendus, Tityus silvestris* and *Rhopalurus amazonicus* have been recorded as the cause of envenomation. However, *T. obscurus* is the species of greatest medical relevance (Martins et al. 2002, Pardal et al. 2003, 2014a,b, Fuentes-Silva et al. 2014, Coelho et al. 2016).

In the capital city of Pará State (Belém) Asano et al. (1999) and Martins et al. (2002) first reported a case of scorpion envenomation. Outside the capital city, there were envenomation reports in the municipalities of Itaituba (Pardal et al. 1999); Oriximiná (Pardal et al. 2001); Altamira, Brasil Novo (Sperotto et al. 2001) and Santarém (Pardal et al. 2003, 2014,b, Torrez et al. 2015).

The severity of the clinical manifestations in patients stung by scorpions depends on the amount of venom inoculated and the amount of chemical mediators released at the time of the accident. In Brazil, scorpion envenomation is classified as mild, moderate and severe (Brasil 2001), corresponding to Classes I, II and III (Khattabi et al. 2011) according to the Scorpion Consensus Expert Group. In Pará, depending on the region, scorpion envenomation might present different signs and symptoms.

In Pará State, there are four endemic areas (Tapajós, Xingú, Belém and Guyana (Fig. 1) (Silva et al. 2005). In two endemic areas in Pará State (Tapajós and Belém), a previous study (Pardal et al. 2014a,b) noted severe clinical manifestations caused by scorpion envenomation. These included, most importantly, myoclonias, dysarthria, ataxia and dysmetria. These signs and symptoms were only reported by patients from the lower Amazon region and by patients from southwestern Pará State, corresponding to the endemic areas of Tapajós and Guyana, suggesting that there is variation and diversity of venom toxicity in different areas of the Brazilian Amazon basin. For this reason, the present study was designed to describe the spatial distribution of envenomation caused by scorpions in Pará State.

## MATERIALS AND METHODS

Epidemiological data related to envenomation by scorpions in patients from Pará State were collected from 2007 to 2014, and used for both descriptive and transversal studies. For the present study, records obtained from the data base of the National Notifiable Diseases

Information System (SINAN) of the Public Health Department of the Pará State (SESPA) were used.

Pará State is located in northern Brazil with a land area of 1,247,954.32 km². The terrain is low and flat: The altitude of 58% of the territory is less than 200 meters. The weather in the state is hot and humid throughout the year with an average annual temperature of $27^0$C. The population in 2014 numbered 8,073,924 inhabitants, with a population density of 60.7 inhabitants / km² (IBGE 2015).

Among the variables collected from SINAN were: gender, age, time to reach medical care, severity of envenomation, municipality of occurrence, spatial distribution, seasonality, deaths and lethality.

The clinical classification of severity was based on the Scorpion Consensus Expert Groups as follows: Class 0, asymptomatic patients; Class I, envenomation with manifestations only at the bite site; Class II, envenomation with minor systemic manifestations, not life threatening and Class III, severe manifestations in which life was threatened (Khattabi et al. 2011).

For data analysis, descriptive statistics were performed through absolute and relative frequency measures analyzed using the TabWin323.6b, Epi Info7.1.3.3 and Microsoft Excel 2010 programs. The calculation of the incidence rate was set for each year separately by multiplying the result by 100,000. Mortality was calculated by multiplying the results by 1000 and lethality was obtained by calculating the rate of deaths resulting from envenomation caused by scorpions and the number of people who suffered scorpion stings. The spatial distribution was determined using the TabWin32 program while the number of people at risk was found according to an estimate of the resident population in Pará State, provided by the website of the Brazilian Institute of Geography and Statistics (IBGE 2015).

This study was conducted according to secondary data collected publicly, without identifying the names and addresses of subjects. It was approved by the Research Ethics Committee of the João de Barros Barreto University Hospital, document CAAE: 49802415.5.0000.0017, as stipulated by the National Health Council (CNS) Resolution No. 466 of December 12, 2012 and with written consent from the state manager for the availability of data provided by SESPA.

RESULTS

According to SINAN (2015), in the states of the northern region of Brazil 22,697 cases of envenomation by scorpions were recorded from 2007 to 2014. Of all seven states of the northern region, the state of Pará registered most of the cases (59.3%), with an incidence of 21.91 per $10^6$ inhabitants, a mortality rate of 2.45 per $10^3$ inhabitants and a lethality rate of 0.23% (Table 1). Envenomation occurs year round, but most often in the first half of the year.

*Table 1*. Distribution of the frequency of cases of scorpion envenomations, its incidence, number of deaths and lethality rate in the Pará State, Brazil, from 2007 to 2014, registered in the National Notifiable Diseases Information System. SINAN, 2015.

| YEARS | CASES | INCIDENCE* | DEATHS | LETHALITY (%) |
|---|---|---|---|---|
| 2007 | 1,335 | 18.9 | 5 | 0.4 |
| 2008 | 1,536 | 20.7 | 5 | 0.3 |
| 2009 | 1,665 | 21.8 | 6 | 0.4 |
| 2010 | 1,526 | 19.9 | 5 | 0.3 |
| 2011 | 1,771 | 22.8 | 1 | 0.1 |
| 2012 | 1,821 | 23.2 | 6 | 0.3 |
| 2013 | 1,934 | 24.3 | 1 | 0.1 |
| 2014 | 1,865 | 23.1 | 3 | 0.2 |
| Total | 13,453 | 21.9 | 32 (2.5)** | 0.2 |

Legend: *Incidence rate per 100,000 inhabitants. ** Mortality per 1000 inhabitants

The frequency distribution regarding gender, area in which the accidents occurred, age group, time to reach medical care and deaths related to age group is shown in Table 2. Table 3 shows severity related to age group while the spatial distribution of envenomation related to the municipalities with higher incidence of envenomation and the areas of endemism in the Amazon with higher incidence and severity of envenomation are in Figure 1, whereas Figures 2 and 3 shows the Spatial distribution of the municipalities that registered deaths in Pará State.

*Table 2.* Frequency gender, age group, time to reach medical care and deaths from envenomations by scorpions in the Pará State, from 2007 to 2014. SINAN, 2015.

| Parameters | Frequency | % |
|---|---|---|
| Gender | n=13,360 | |
| Male | 8,794 | 65.8 |
| Female | 4,566 | 34.2 |
| Occurence Area | n=13,453 | |
| Urban | 188 | 1.4 |
| Rural | 13,265 | 98.6 |
| Age Group | n=13,360 | |
| <1 to 14 | 2,705 | 20.2 |
| 15 to 19 | 1,270 | 9.5 |
| 20 to 39 | 5,159 | 38.6 |
| 40 to 59 | 3,189 | 23.9 |
| 60 or more | 1,037 | 7.8 |
| Time to Medical Care | n=12,980 | |
| 0 to 1 h | 4,880 | 37.6 |
| 1 to 3 h | 3,942 | 30.4 |
| 3 to 6 | 2,235 | 17.2 |
| 6 to 12 h | 1,067 | 8.2 |
| 12 or more | 856 | 6.6 |
| Age Group of Deaths | n=32 | |
| 1 – 14 | 11 | 34.4 |
| 15 – 59 | 21 | 65.6 |

*Table 3.* Frequency of severity related to the age group of envenomations by scorpions in Pará State from 2007 to 2014. SINAN, 2015.

| Severity/Age Group | <1 – 14 | 15 – 59 | 60 - > | Total |
|---|---|---|---|---|
| Mild (Class I) | 1,463 | 5,095 | 511 | 7,069 (55.8%) |
| Moderate (Class II) | 979 | 3,562 | 402 | 4,943 (39.1%) |
| Severe (Class III) | 135 | 438 | 68 | 641 (5.1%) |
| Total | 2,577 | 9,095 | 981 | 12,653 (100%) |

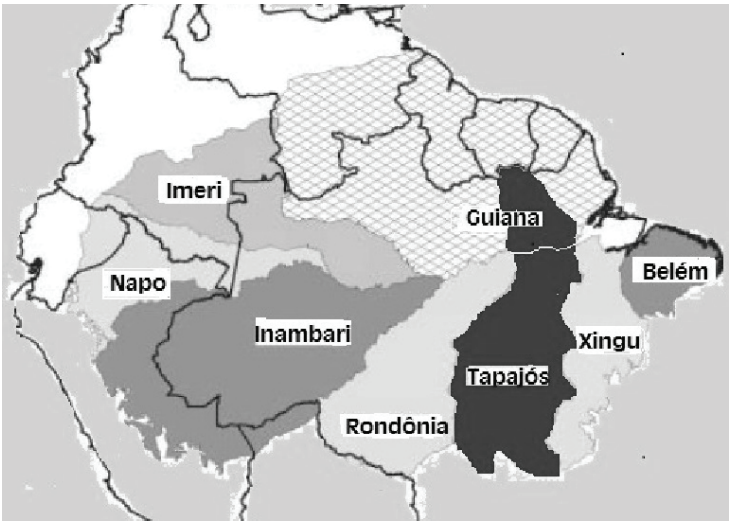


*Figure 1.* Endemic Areas in the Amazon Region, highlighted in dark are those of greater envenomation incidence and severity (adapted from Silva et al. 2005).

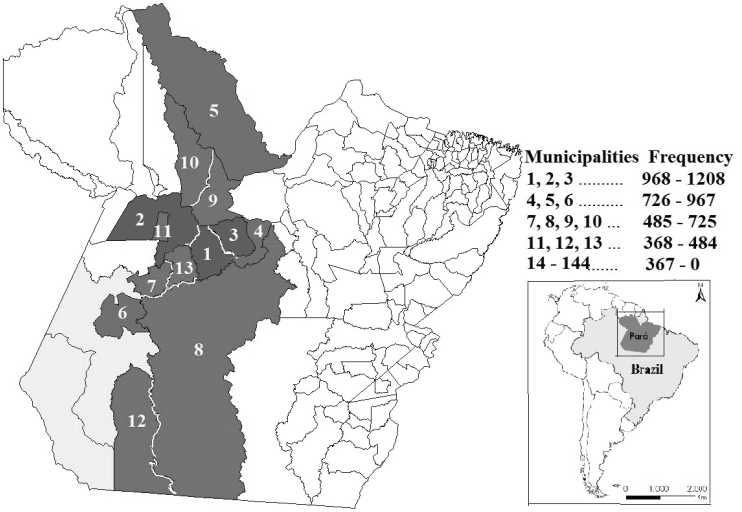


*Figure 2.* Spatial distribution of envenomation by scorpions in Pará State and the municipalities of greater occurrence from 2007 to 2014. SINAN, 2015. Municipalities: 1-Uruara, 2-Santarém, 3-Medicilândia, 4-Brasil Novo, 5-Almerim, 6-Trairão, 7-Rurópolis, 8-Altamira, 9-Prainha, 10-Monte Alegre, 11-Belterra, 12-Novo progresso, 13- Placas

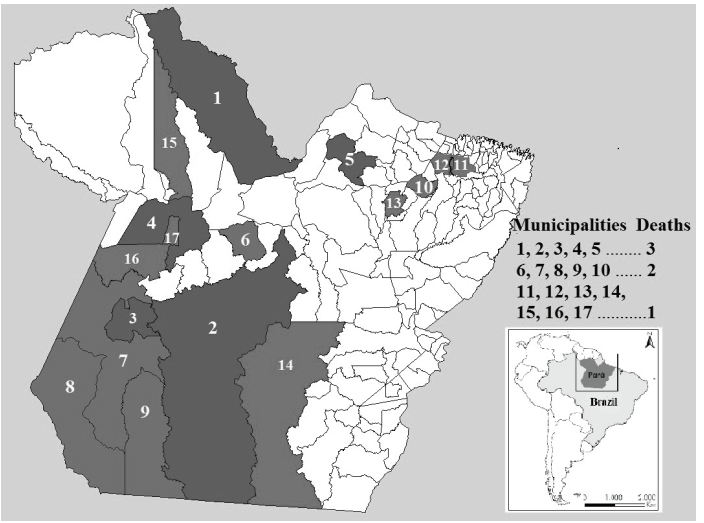


*Figure 3.* Spatial distribution of the municipalities that registered deaths in Pará State from 2007 to 2014. SINAN, 2015. Municipalities: 1-Almerim, 2- Altamira, 3-Trairão, 4- Santarém, 5- Breves, 6- Medicilândia, 7-Itaituba, 8- Jacareacanga, 9- Novo Progresso, 10-Abaetetuba, 1-Marituba, 12-Benevides, 13-Cametá, 14-São Felix do Xingu, 15-Alenquer, 16, Aveiro, 17-Belterra

## DISCUSSION

Envenomation by scorpions in this report shows high rates of incidence and mortality in the State of Pará. Previous studies by Asano et al. (1999) and Martins et al. (2002) showed scorpion envenomation as the second most frequent cause of accidents involving venomous animals in the region. However, Reckziegel & Pinto (2014) referred an incidence of 19.6 and mortality of 0.03 based on SINAN data from all the Brazilian states. In the state of Amazonas, Queiroz et al. (2015) found a low mortality rate (0.3%) and in Pará state, Maestri Neto et al. (2008) described a mortality of 0.6%.

The higher prevalence of scorpion stings in males in the study areas is probably due to the type of labor in which they were involved. Similar results were found in other Brazilian regions (Chippaux 2015).

Most of the scorpion stings were recorded in rural areas, while only 1.4% of the accidents happened in urban areas of the Pará state. However, in a previous report, Reckziegel & Pinto (2014) show that the Brazilian urban areas are the most affected. In the rural areas of Pará State, most scorpion stings occured in the lower Amazon and in the southwest of the state, especially in the municipalities of Santarém (1,114 cases), Uruará (1,208 cases) and Medicilândia (1,114 cases) respectively. These regions are located between the Tapajós river and the Xingu river, both of which belong to the Tapajós endemic area (Haffer 2008, Haseyama & Carvalho 2011).

The number of deaths was higher among adults, reduced in those under 15 years of age. Similar results were found in Brazil (Reckziegel & Pinto 2014). However, in the study area, Maestri Neto et al. (2008) reported one infant death, while Pardal et al. (2014a,b) and Torrez et al. (2015) found none.

The time elapsed between envenomation and the first medical assessment to the victims in the study was under three hours. The same was reported in other regions of Brazil (Chippaux 2015, Queiroz et al. 2015) where envenomation in eastern Pará was similar (Pardal et al. 2014a,b) to the present results, whereas in the west of the state medical care was more delayed (Pardal et al. 2003, 2014a,b, Torrez et al. 2015). The latter was justified by greater transportation difficulties in rural areas. The number of scorpion stings in the study increased from January to July, during the heavy rainfall season. The same was noted in Amazonas State (Queiroz et al. 2015). In Brazil, the number of cases varies throughout the year, with a slight increase in October and November (Reckziegel & Pinto 2014).

In this study the majority of the victims from scorpion stings were found to be Class I with local signs and symptoms. 39.1% of the patients were Class II cases presenting the lowest frequency of systemic manifestations. 5.1% of the cases were Class III patients with the most severe systemic manifestations. Chippaux (2015) reported a difference in the severity of scorpion stings in the various geographical regions in the country. In northern Brazil 60% of the patients suffering from scorpion envenomation were asymptomatic (Class 0) or only presented mild symptoms and signs (Class I), against 80 to 90% of patients with Class 0 or Class I symptoms and signs in the other four regions of the country.

Most scorpion stings occurred in people over 15 years of age. Below this age the frequency noted was 20.4%. Similar results were found in Brazil by Reckziegel & Pinto (2014). In regard to the age group in class III patients the same trend was found: below 15 years of age the frequency was 21.1%. Previous reports in the same region corroborated these results (Pardal et al. 2003, 2014, Torrez et al. 2015). The mortality in the age group ranging from less than 1 to 15 years of age was 34.4%. Chippaux (2015) reported that scorpions were responsible for 30% of the deaths in Brazil. In the study region Torrez et al. (2015) reported six deaths from scorpion stings. The victims were four children under 10 years of age, while Pardal et al. (2014a,b) reported no deaths.

Of the 144 municipalities of Pará State, 126 recorded envenomation by scorpions in the study period, with a frequency on the spatial distribution of the accidents ranging from 1 to 1208 cases per municipality. The 13 municipalities with the highest number of accidents were located in the lower Amazon and southwest regions of Pará State, where the highest number of deaths was reported (23 deaths). These two regions are in the Tapajós and Guyana endemic areas (Haffer 2008, Haseyama & Carvalho 2011). The symptoms presented by

victims in these two areas differed from those symptoms found in other regions of Pará. Pardal et al. (2014b) classified envenomation in this region as Class I (35.8%) and Class II (64.2%) which was corroborated by Torrez et al. (2015). On the other hand, in the metropolitan region of Belém which encompasses five municipalities, Pardal et al. (2014b) found 76.5% of the cases in the Class I group and 23.5% of the cases in Class II, located in the Belém endemic area and also the lowest number of deaths (2 deaths).

The difference in severity and clinical manifestations found among regions such as the state of Pará may be related to the evolution of scorpion species influenced by weather, vegetation and geographic barriers, undergoing an evolutionary process in the various endemic areas in the northern region of Brazil (Haffer 2008, Haseyama & Carvalho 2011).

In conclusion, this study shows that envenomation by scorpions occurs throughout Pará State and that there are differences among regions, especially in the severity and incidence of the cases from the lower Amazon and southwestern region of the state. The lower Amazon region presents a higher frequency of severe clinical manifestations. These two regions are located in the Tapajós and Guyana endemic areas, which may influence the evolution of scorpion species, as well as the severity of the envenomation.

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