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Spatial characterization and identification of chiroptera shelters and their relation to cases of rabies in production animals in semi-arid, Brazil, from 2007 to 2015

Caracterização espacial e identificação de abrigos de quirópteros e sua relação com os casos de raiva em animais de produção no semiárido, Brasil, de 2007 a 2015

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Abstract

The rabies virus propagates through several epidemiological cycles, which makes it difficult to control and predict. Thus, this study was structured with the aim of establishing the geospatial characterization of bat shelters in different semi-arid mesoregions of the state of Paraíba, Northeastern region of Brazil. Data provided by the Secretaria de Estado do Desenvolvimento da Agropecuária e da Pesca da Paraíba (SEDAP-PB), from 2007 to 2015 and data from digital platforms were used. The geographic representation was produced using the software QGIS 2.16.0 - Nodebo. To verify virus circulation sites, buffers were plotted within a 10-km radius from the registered shelters and rabies incidence sites in the state. A registry of 93 shelters in the period between 2007 and 2015 were distributed in 22 municipalities and 15 microregions. All mesoregions were represented, though 47.31% of the bat shelters were located in Agreste Paraibano. Of the total registered shelters, 66 (71%) are classified as artificial, and 27 (29%) as natural. The underreporting of rabies occurrences reveals the need to improve the registration of hematophagous bat shelters, specifically those for the *D. rotundus* species.
Key words: *Desmodus rotundus*. GIS. Zoonosis. Virus. Rabies. Spatialization.

Resumo

O vírus rábico se propaga por vários ciclos epidemiológicos dificultando seu controle e previsibilidade de ocorrência. Desta forma, o objetivo desse estudo foi realizar a caracterização geoespacial dos abrigos

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de morcegos nas diferentes mesorregiões do semiárido paraibano, região Nordeste do Brasil. Foram utilizados dados fornecidos pela Secretaria de Estado do Desenvolvimento da Agropecuária e da Pesca da Paraíba (SEDAP-PB), do período entre 2007 à 2015 e dados de plataformas digitais. A representação geográfica foi produzida por meio do software QGIS 2.16.0 - Nodebo. Foram plotados buffers com raio de 10 km dos abrigos cadastrados e das ocorrências de raiva no Estado para verificar os possíveis locais de circulação do vírus, com o cadastro de 93 abrigos no período entre 2007 e 2015. Foram amostrados abrigos distribuídos em 22 municípios, 15 microrregiões e representados em todas as mesorregiões, em destaque a do Agreste Paraibano concentrando 47,31% do total de abrigos do morcego *Desmodus rotundus*. Do total de abrigos cadastrados 66 (71%) estão classificados como artificiais e 27 (29%) como naturais. As subnotificações das ocorrências de raiva na Paraíba revelam à necessidade de aumentar o trabalho de cadastramento de abrigos de morcegos hematófagos, com ênfase para a espécie *Desmodus rotundus*.

Palavras-chave: *Desmodus rotundus*. SIG. Zoonose. Vírus. Raiva. Espacialização.

Rabies is a disease that causes severe encephalitis and kills 100% of the affected hosts, infecting predominantly mammals. Although it is endemic throughout the Brazilian territory, the occasional cases are correlated to certain geopolitical regions (BRASIL, 2009). The control of this zoonosis is difficult due to the participation of wild species and to its interconnection with other cycles of the disease (ACHA; SZYFRES, 2003), contributing to the permanence of the virus over time. The rural cycle is the one that most affects the agricultural sector, due to the non-harmonic interaction between the hematophagous bat *Desmodus rotundus* and herbivorous animals, especially cattle (KOTAIT et al., 2010).

D. rotundus is widely distributed in Latin America, including Brazil, which has suitable environmental for the virus, particularly in the semi-arid region (ANDRADE et al., 2016). Of all Brazilian biomes, the Caatinga, which is typical of the semi-arid region, is the least protected region and the most vulnerable to plant and animal diversity loss (LEAL et al., 2005). *D. rotundus* is widely distributed and capable of adapting to different environments, so it lives closer to human-inhabited areas. It is found mostly in sites near native vegetation and in rural regions ((NOVAES, 2008).

In Paraíba, a considerable amount of soil is used in the production of livestock, with agriculture accounting for about 4.4% of local gross domestic product (GDP) (IDEME, 2016). This activity is present in more than 92 thousand agricultural establishments (IBGE, 2009), with cattle, buffaloes, horses, pigs, goats and sheep over 2,54 million head (IBGE, 2016). Cattle breeding is an important activity in all mesoregions of the state, present in small and large properties (CLEMENTINO et al., 2015).

A large area of land in Paraíba is used for livestock farming, which accounts for 2% of the local gross domestic product, with more than 167,000 small to large (CLEMENTINO et al., 2015) agricultural establishments (BRASIL, 2009) and more than 1.1 million heads of cattle (BRASIL, 2013).

New technologies have been effectively helping to monitor and control the occurrence of diseases, aiming to improve and maximize the work of health surveillance institutions. Many geotechnologies have been associated with epidemiology for some time, and researchers have already reported their contribution to public health (NARDI et al., 2013). This study is aimed at the geospatial characterization of bat shelters in the different mesoregions of the state of Paraíba and seeks to understand the transmission chain and incidence of rabies in the state related to epidemiological landscape aspects and its association with areas at risk for virus circulation.

Data from 2007 to 2015 were provided by the Secretaria de Estado do Desenvolvimento da

Agropecuária e da Pesca da Paraíba (SEDAP). These data included registration of shelters for hematophagous bats of the *D. rotundus* species, as well as rabies notifications, including the source and period, for production animals. The source of the notifications was obtained from information collected from landowners, the Animal sanitary Defense, and other parties such as neighbors and independent veterinarians.

Geographic representation was produced using the software QGIS 2.16.0 - Nodebo with cartographic maps in shapefile format from the IBGE (Instituto Brasileiro de Geografia e Estatística) and INPE do Instituto Nacional de Pesquisas Espaciais) digital platforms, as well as the AESA (Agência Executiva de Gestão das Águas do Estado da Paraíba). Buffers were plotted within a 10-km radius from the registered shelters to verify virus circulation sites. The shelters were classified into two categories: artificial, the ones located within a radius of 10 km of highways and roads; and natural, the ones located within a radius of 10 km of rivers and other main drainage routes. These classifications were made considering that *D. rotundus* bats fly on average 10 km from their resting place to feed and that, in general, rural rabies can be identified more than 10 km away from the shelter (SOUZA et al., 2007; BRASIL, 2009).

The points where rabies cases occurred were plotted on the spatial representation of the registered shelters to identify the possible sources of the reported cases. Physical aspects such as vegetation, soil, and water reservoirs, characterized by the climatic variation of the region, were analyzed according to the INPE image mosaic in one of the maps to identify the influence of these variables on the spatial distribution of bat shelters.

A total of 93 bat shelters were registered between 2007 and 2015, distributed in 24 municipalities and 15 microregions. All mesoregions of Paraíba were represented. Of those shelters, 66 (71%) were classified as artificial, 27 (29%) were classified as natural, and the presence of *D. rotundus* was verified in 51 (54.8%).

Brain tissues were sent to laboratory diagnosis in the Laboratório Nacional Agropecuário (LANAGRO - Recife-PE), using the direct immunofluorescence and confirmation by mouse inoculation. Of the 85 samples submitted, 51 (60%) were positive for rabies. It was possible to perform the spatial characterization of 46 cases distributed in 28 municipalities (Figure 1). The greatest number of cases was reported in in 2010, with 17 cases (16 positive samples of bovine and one of equine). In 2014, there were no notifications. The source of reports ranged among owners, surveillance and third-party sources, with the highest number of positive notifications registered by owners (51%), followed by third-parties with 23 (45.1%) and surveillance with two (3.9%) reports. Of the total number of notifications, only two species were diagnosed with rabies: horses, with three cases (5.9%) and cattle, with 48 cases (94.1%).

Of the 93 shelters identified by the SEDAP, 88 were properly georeferenced and represented on the produced maps. The coverage areas for rabies virus transmission were determined according to the location of registered shelters and the displacement capacity of the *D. rotundus* species.

Figure 2 shows 17 cases found within shelter buffers and nine cases less than 5 km from the buffer radius, which accounts for 56.5% of all 46 cases. Shelters were heterogeneously distributed and could be found in all vegetation physiognomies and climatic variations of Paraíba. At least one *D. rotundus* shelter was registered in each area, from forest to wilderness.

Figure 1 shows the cases distributed in all mesoregions of the state of Paraíba, with the largest number of reported cases 46 (34.8%) in Sertão Paraibano. This is most likely associated with the fact that the mesoregion represents an area with a higher density of cattle farm properties (CLEMENTINO et al., 2015). The Agreste Paraibano mesoregion

accounts for more than 47% of the registered shelters; this percentage can be associated with the local geography, as most of the mountain ranges are located on the Borborema Plateau, with an average elevation of 600 m. These sites provide natural shelters such as caves and caverns, considered suitable for bat shelters. The presence of *D. rotundus* was verified in more than 50% of the registered shelters. The species *D. rotundus* prefers natural vegetation landscapes located next to properties that offer resources essential for their survival, such as food and shelter. The species prefers to feed from large mammals, such as cattle (BRASIL, 2009).

Figure 1. municipalities where cases of animal rabies were reported from 2007 to 2015, Paraíba, Brazil.

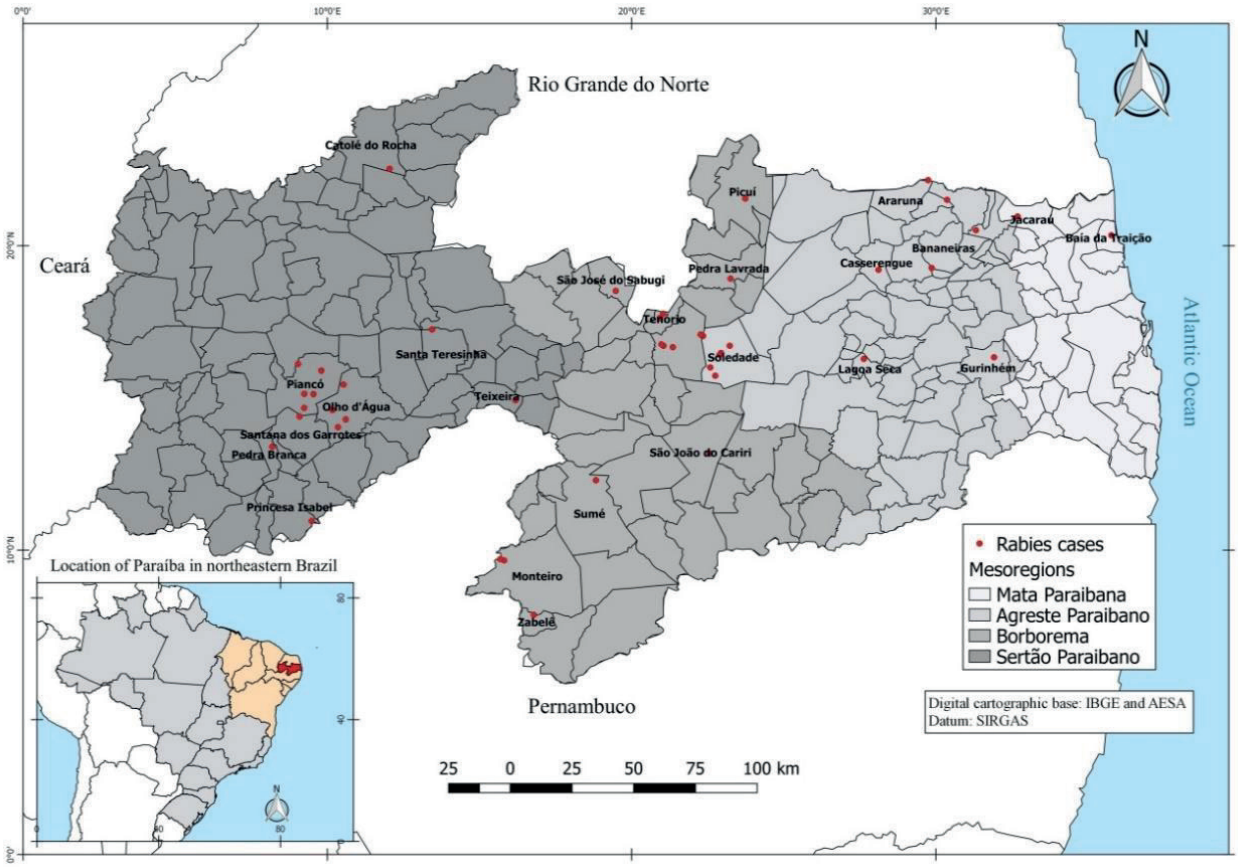
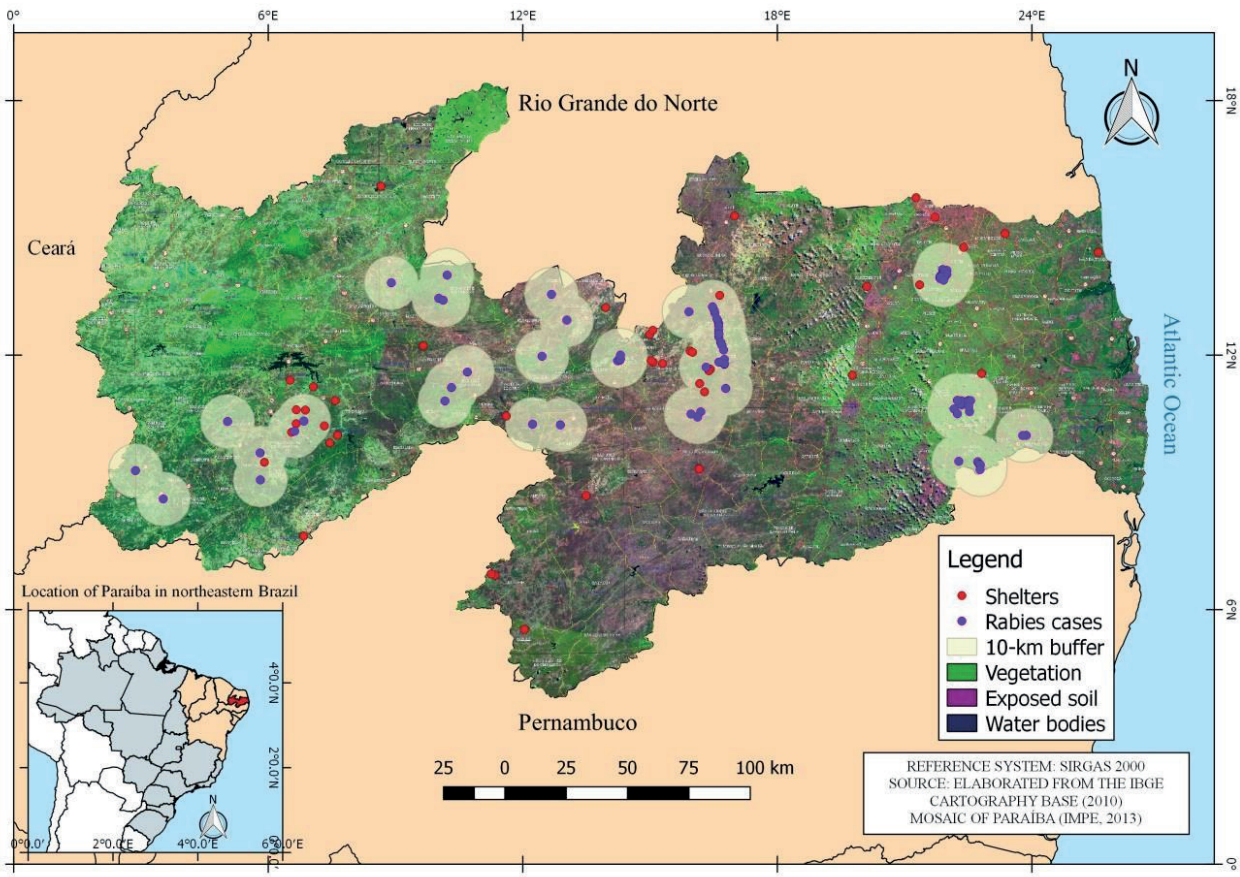


Figure 2. Influence area of the *Desmodus rotundus* registered shelters and reported cases of animal rabies in the period from 2007 to 2015, Paraíba, Brazil.



Case notifications and shelter registrations provided a means to measure the possibility of virus circulation to other environments, such as the municipalities near the shelters. The 83 municipalities located within the buffers near the shelters are considered to be at greater risk, as well as some municipalities of the states of Pernambuco, Rio Grande do Norte, and Ceará, which are on the border with Paraíba and within the 10-km buffers.

It is worth noting that even though *D. rotundus* is the main reservoir for rabies in the northeastern semi-arid environment, it is not the only species to transmit the virus. Other species have tested positive for rabies virus (SODRÉ et al., 2010; BATISTA; ASSIS, 2012). In Brazil, between 2002 and 2009, from the 1,163 bat samples positive for rabies, 80% were from non-hematophagous bats, and only 20% from hematophagous bats (WADA et al., 2011). In Paraíba, other bat species were also captured in urban areas and easily accessible places and tested positive for the rabies virus (GOMES et al., 2012; ARAÚJO et al., 2014).

Bats are wild reservoirs for the virus and prefer natural environments. When these environments are preserved, they provide shelter and food for survival. However, when these sites undergo anthropic changes and suffer climatic consequences, some species try to survive by adapting to environments that are not in their original matrix, moving increasingly closer to the human population and their herds (ANDRADE et al., 2016). In this context, the hematophagous bat *D. rotundus* established itself as a synanthropic animal approaching anthropic areas (GOMES et al., 2012).

The spatial characterization allowed for the identification of shelter sites, and data analysis on the incidence of rabies raised the hypothesis that many areas with underreported records for bovine rabies cases exist in Paraíba, as well as non-identified shelters. Figure 2 shows rabies cases very distant from shelters. Other studies (ANDRADE et al., 2014; BRASIL, 2013) pointed to possibly silent areas in Paraíba that has rabies virus reservoirs. The creation of this model using geoprocessing tools enabled the production of epidemiological information to understand the health/disease process and the environment determinants associated with geographic and social aspects (BRASIL, 2009; NARDI et al., 2013).

This study allowed for the creation of a database to generate knowledge about the spatial characterization, identification, and distribution of bat shelters, highlighting the presence of *D. rotundus* in the semi-arid region of Paraíba. More active actions of the body responsible for surveillance and control in the State are necessary in order to register the largest number of shelters and to report not only cases of rabies but also cases of bites caused by *D. rotundus*.

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