

Geospatial Analysis of *Aedes aegypti* Breeding Sites and Basic Sanitation Conditions in the Municipality of Pinheiro, Maranhão, Brazil, Using Citizen Science and GLOBE Protocols

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Abstract

Arboviral diseases represent a major public health challenge in Brazil, especially in regions affected by socio-environmental vulnerabilities. This study presents the geospatial monitoring of mosquitoes of epidemiological importance in the municipality of Pinheiro, Maranhão, Brazil, using citizen science and GLOBE Program protocols. The research integrated qualitative and quantitative approaches, involving students from basic and higher education trained to identify mosquito breeding sites, perform photographic records, and georeference locations using the GLOBE Observer application, specifically the Mosquito Habitat Mapper protocol. Data were collected between September 2024 and March 2025 at 39 sampling points across the municipality. The collected information was organized into electronic spreadsheets and analyzed using geospatial tools, allowing the generation of thematic maps and heat maps. The results revealed a non-random spatial distribution of breeding sites, with higher concentrations in areas characterized by environmental and infrastructural deficiencies. The study highlights the effectiveness of combining geospatial technologies with citizen science to support environmental monitoring, public health surveillance, and community engagement. This approach contributes to the identification of critical areas and supports decision-making processes aimed at reducing mosquito-borne disease risks.

Research Question

How are mosquito breeding sites spatially distributed in the municipality of Pinheiro, Maranhão, and how do local environmental conditions influence this distribution?

Introduction

Mosquito-borne diseases such as dengue, Zika, and chikungunya remain a persistent public health problem in Brazil. The proliferation of vector mosquitoes is strongly influenced by environmental conditions, urban occupation patterns, and climate. In tropical regions, these factors interact to create favorable conditions for mosquito reproduction, especially in urban and peri-urban areas (Costa & Natal, 1998; Flauzino et al., 2009). Pinheiro, located in the Maranhão lowlands, presents climatic characteristics such as intense rainfall and flood-prone areas, which favor the persistence of mosquito breeding sites throughout the year. The use of geospatial tools and citizen science initiatives has become essential for identifying breeding sites and supporting vector surveillance actions. In this context, the GLOBE Program provides standardized protocols that allow students to participate actively in environmental monitoring and scientific data production (Cavalcante et al., 2013; Baixo et al., 2021).

Research Methods

Field activities were conducted using the Mosquito Habitat Mapper protocol of the GLOBE Observer application. Trained students inspected domestic and peridomestic environments, identifying water-holding containers such as tires, plastic bottles, buckets, water tanks, and areas near open sewage. Each breeding site was photographed, georeferenced, and described according to container type, presence of water, and observation of larvae or adult mosquitoes. The data were submitted to the GLOBE platform and later analyzed using geospatial techniques, including thematic and heat map generation.

Results

A total of 39 sampling points were analyzed, with most breeding sites associated with artificial containers. Sixteen locations were classified as critical areas due to the recurrent presence of mosquito breeding sites. The spatial analysis revealed a heterogeneous distribution of breeding sites across the municipality, with clusters observed in areas subject to environmental vulnerability. *Aedes aegypti* was primarily associated with small containers containing clean water, while *Culex* species were more frequently observed in environments with organic matter (Flauzino et al., 2009; Lima-Camara, 2024).

Discussion

The results demonstrate that mosquito breeding sites in Pinheiro are strongly influenced by environmental and infrastructural conditions rather than being randomly distributed. Similar patterns have been observed in other Brazilian cities, where urban characteristics and inadequate environmental management favor mosquito proliferation (Costa & Natal, 1998; Cavalcante et al., 2013). The use of citizen science allowed broader spatial coverage and access to areas often not reached by traditional surveillance. Student participation contributed both to data quality and to environmental awareness, reinforcing the role of education as a complementary tool for vector control (Baixo et al., 2021; Silva & Witt, 2024).ity.

Map of Study Site(s)

The study was conducted in the municipality of Pinheiro, Maranhão, Brazil, located in the Baixada Maranhense. The region is characterized by extensive floodplains, high rainfall, and urban and peri-urban areas with heterogeneous infrastructure, which influence the formation and persistence of mosquito breeding sites.

Figure 1. Study area. Blue points correspond to the sampling locations

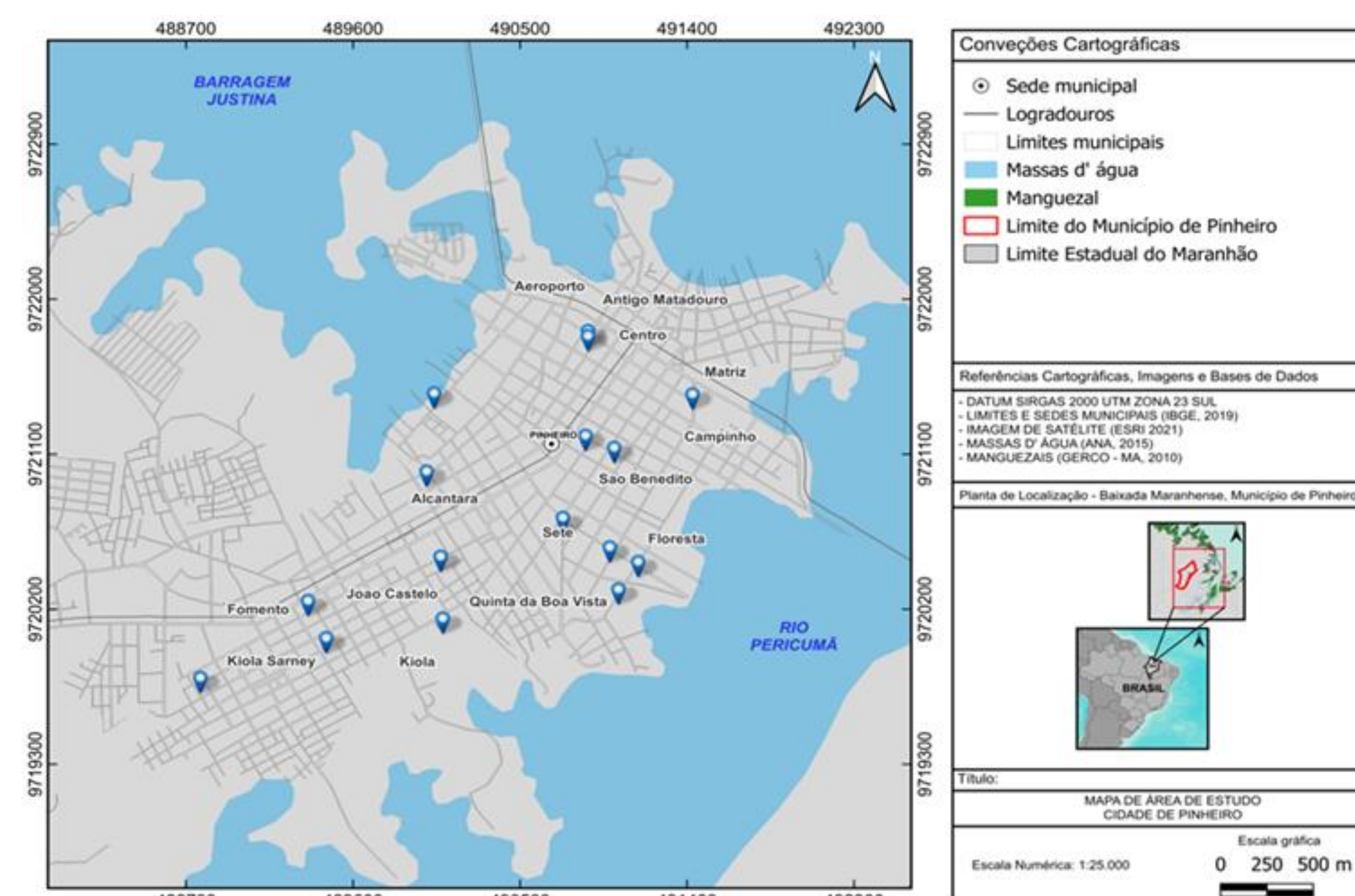


Figure 2. Types of containers and their respective indication regarding the presence of larvae and/or adult mosquito vectors of arboviral diseases.

Conclusions

The study confirms that geospatial monitoring combined with citizen science is an effective strategy for identifying mosquito breeding sites and critical areas in Pinheiro. The results support the use of GLOBE protocols as tools for environmental surveillance and public health planning. Future actions should expand monitoring efforts, strengthen community engagement, and integrate geospatial data into local decision-making processes to reduce mosquito-borne disease risks.

Bibliography

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