



# Revista Prevenção de Infecção e Saúde

The Official Journal of the Human Exposome and Infectious Diseases Network

ORIGINAL ARTICLE

DOI: <https://doi.org/10.26694/repis.v8i1.2343>

## Phlebotomine in urban foci of Visceral and American Cutaneous Leishmaniasis in a municipality in the Brazilian Northeast

Flebotomíneos em focos urbanos de Leishmaniose Visceral e Tegumentar Americana em um município do Nordeste

Flebótomos en focos urbanos de Leishmaniasis Visceral y Tegumentaria Americana en un municipio del Nordeste

Mauriely Paiva de Alcântara e Silva<sup>1</sup> , Raimundo Leoberto Torres de Sousa<sup>2</sup> , Sílvia Alcântara Vasconcelos<sup>3</sup> , Vagner José Mendonça<sup>4</sup> 

### How to cite this article:

Silva MPA, Sousa RLT, Vasconcelos SA, Mendonça VJ. Phlebotomine in urban foci of Visceral and American Cutaneous Leishmaniasis in a municipality in the Brazilian Northeast. *Rev Pre Infec e Saúde* [Internet]. 2022;8:2343. Available from: <http://periodicos.ufpi.br/index.php/repis/article/view/2343>. DOI: <https://doi.org/10.26694/repis.v8i1.2343>

<sup>1</sup> University of São Paulo at Ribeirão Preto College of Nursing Ribeirão Preto. Ribeirão Preto, São Paulo, Brazil.

<sup>2</sup> Oswaldo Cruz Institute, Oswaldo Cruz Foundation, Department of Parasitology. Rio de Janeiro, Rio de Janeiro, Brazil.

<sup>3</sup> Oswaldo Cruz Institute, Oswaldo Cruz Foundation, Department of Parasitology. Teresina, Piauí, Brazil.

<sup>4</sup> Federal University of Piauí, Department of Parasitology and Microbiology. Teresina, Piauí, Brazil.

### ABSTRACT

**Introduction:** The Visceral and American Cutaneous Leishmaniasis are a public health problem in the Americas, in the municipality of Altos, state of Piauí, are considered endemic. **Aim:** To carry out a faunal survey of the phlebotomine species in the areas of transmission of visceral and cutaneous, both human and canine, leishmaniasis, in the municipality of Altos, Piauí. **Outlining:** It was carried out through entomological survey, it encompassed capture, separation, identification, and analysis of phlebotomine species in determined regions in the municipality of Altos, Piauí, between August 2017 and July 2019. **Results:** The most found species was *Lutzomyia longipalpis*, with 1,399 sandflies captured, 1,299 males and 140 females. Some other species were also found, such as *Nyssomyia whitmani*, *Lutzomyia dispar*, *Evandromyia evandroi*. **Implications:** The research helps to provide data that can contribute to the formulation of surveillance and control actions for these vectors, enabling responsible entities to develop public policies to control leishmaniasis.

### DESCRIPTORS

Surveillance; Insect Vectors; Public Health; Leishmaniasis.

### Corresponding author:

Mauriely Paiva de Alcântara e Silva  
Address: University of São Paulo at Ribeirão Preto College of Nursing (EERP-SP). Bandeirantes' Avenue, 3900, neighborhood Monte Alegre.  
ZIP-Code: 14.040-902 Ribeirão Preto, SP, Brazil.  
Phone: +55 (16) 3315-3474  
E-mail: [mauriely99@hotmail.com](mailto:mauriely99@hotmail.com)

Submitted: 2022-01-03  
Accepted: 2022-03-17  
Published: 2023-01-11

## INTRODUCTION

The leishmaniasis are worldwide distributed pathologies, which have high prevalence in the Americas and Brazil that, besides of being an anthroponosis, they highlight an intense distribution and urbanization in all regions of the country.<sup>1</sup> Their etiologic agent is the protozoa parasite of the genus *Leishmania* (Kinetoplastida: Trypanosomatidae), these parasites are transmitted through the sting of the female of several species of phlebotomine (Diptera: Psychodidae).<sup>2</sup>

In the last years, 1,026 species of phlebotomine were catalogued around the world, of which 546 occur in countries of the Americas.<sup>3</sup> In Brazil, about 230 species, amongst them *Nyssomyia intermedia*, *Migonemyia migonei*, and *Nyssomyia whitmani*, are evidenced as vectors of species of *Leishmania* which cause American Cutaneous Leishmaniasis (ACL), beyond that, the species *Lutzomyia longipalpis* and *Lutzomyia cruzi* are known vectors of *Leishmania* that causes Human Visceral Leishmaniasis (HVL).<sup>4</sup>

Those insects live in varied habitats and their life cycles are influenced by multiple factors related to the seasonality, as temperature, precipitation and relative humidity, beyond speed of the wind and moon lighting. The immature forms of the phlebotomine develop in humid, terrestrial environments, rich in organic matter and of low light density.<sup>5</sup> Amongst the various known reservoirs, the dog is an important host of the called Canine Visceral Leishmaniasis (CVL) and represents a high risk for the population that lives in endemic regions with peridomestic circulation of those animals.<sup>6</sup>

The HVL is an infectious disease of elevated lethality and incidence, the protozoa *Leishmania infantum* is its etiologic agent, and the *Lutzomyia longipalpis* is its epidemiologically most important vector in Brazil.<sup>7</sup> The ACL is a dermatologic infection which can either be asymptomatic or generate immunological and clinical manifestations, besides of possessing the potentiality to cause deformities.

Brazil has 96.5% of HVL and 40% of ACL cases of the Americas.<sup>8</sup>

In the state of Piauí, in 1980, an epidemic occurred in a large part of the territory, mainly in the capital Teresina.<sup>9</sup> The municipality of Altos, a city neighboring the state capital, is a region that needs attention due to the high number of cases of leishmaniasis in relation to other municipalities in Piauí, according to data from the Ministry of Health.<sup>10</sup> A detection rate of 7.57 cases per 100,000 inhabitants was encountered in the municipality, an index superior to both state and national indexes, 5.11 and 1.47, respectively.

As it is an endemic area, with a large number of cases and lack of studies on the subject matter, this study was carried out aiming to conduct a faunal survey on the species of phlebotomine in the areas of transmission of Cutaneous and Visceral Leishmaniasis, both human and canine, in the municipality of Altos, besides that, it was sought to verify which areas of the municipality displayed higher prevalence of cases of HVL, ACL, CVL, and, from that, to correlate the findings with the species of vectors encountered in the region.

## METHOD

The study was carried out to observe the faunal density through the capture and identification of species of phlebotomine, from August 2017 to July 2019, in the municipality of Altos, Piauí. The municipality of Altos has an estimated population of 39,715 inhabitants, a 957,655 km<sup>2</sup> territory, 40.54 inhabitants per km<sup>2</sup>. Its annual average temperature comes to 30°C, with hot and tropical weather. The average rainfall ranges from 800 to 1600 mm, with the raining season occurring during half of the year, and the dry season happening during the other half.<sup>11-12</sup>

A survey of the number of notifications of ACL and HVL cases from 2013 to 2017 was carried out in the Brazilian National Disease Reporting Information System (SINAN).<sup>13</sup> The places were tabulated in

databases with year of notification and quantity of cases. Next, the resultant table was compared to the localities which presented cases of CVL. These areas were selected for the study, in order to catch species of phlebotomine which are maintaining the leishmaniasis cycle in these localities.

For the catch of phlebotomine, the places were defined in accordance with the notified cases and, then HP model light traps were installed, houses with environmental features which favored the appearance of the vector had been chosen, the traps were installed at 5 pm and collected around 7 am the following day. The captured insects were taken to the laboratory and were frozen.

The screening was carried out as follows: after separating phlebotomine into males and females, the insects were doused in a 10% Potassium hydroxide (KOH) solution for 3 hours, and soon after were doused in a 10% acetic acid (CH<sub>3</sub>COOH) solution for 30 minutes, and, after washing the insects with alcohol, they were subjected to 24 hours immersion in lactophenol in order to identify the species, following Galati's identification methodology.<sup>14</sup>

The weather conditions were obtained from National Institute of Meteorology (INMET) data. The study was conducted to relate the density of catch phlebotomine with abiotic climatic factors (pluviometry, relative humidity, and temperature). To determine the size of one specie's population, the relative species abundance calculation and simple frequency were brought into play. Microsoft Excel® was used to organize the information and the calculations were performed in the version 25.0 of IBM SPSS.

## RESULTS

Between August 2017 and July 2019, 22 collects were carried out in regions previously selected after the data collect as to the regions with higher incidence of confirmed HVL, ACL and CVL cases. The most found species was *Lutzomyia longipalpis*, with 1,399 phlebotomine captured, 1,299 males and 140 females. Some other species were also found, such as *Nyssomyia whitmani*, *Lutzomyia dispar*, *Evandromyia evandroi* (Table 1).

**Table 1** - Species of phlebotomine captured in collections carried out in rural and urban areas. Altos, Piauí, 2019.

| Genus              | Species                | Male  | Female | Total        |
|--------------------|------------------------|-------|--------|--------------|
| <i>Lutzomyia</i>   | <i>Lu. longipalpis</i> | 1,299 | 140    | 1,399        |
|                    | <i>Lu. dispar</i>      | 1     | -      | 1            |
| <i>Evandromyia</i> | <i>Ev. evandroi</i>    | -     | 1      | 1            |
| <i>Nyssomyia</i>   | <i>Ny. whitmani</i>    | 3     | -      | 3            |
| <b>TOTAL</b>       |                        |       |        | <b>1,404</b> |

Source: Direct search.

The municipality of Altos, Piauí, considered as an endemic area, has registry of 31 notified cases of leishmaniasis between 2013 and 2017, 12 ACL cases and 19 HVL cases, according to the Municipal Health Department, besides a high incidence of dogs with leishmaniasis.

Still according to data obtained by municipality's health surveillance, between 2013 and 2019, 19 cases were registered in the neighborhoods São Luís, Bom Gosto, Bacurizeiro, Tranqueira, Centro, community Boca de Barro, Boa Fé, Boa Vista and Serra do Cedro.

In relation to the ACL cases, in the same period, 12 cases were distributionally registered in the neighborhood Tranqueira, in the community Surubim, Bacurizeiro, Centro, in the community Boca de Barro, Retiro, in the community Formosa, in the community Quilombo, in the community Poço dos Negros and Passagem da Roça.

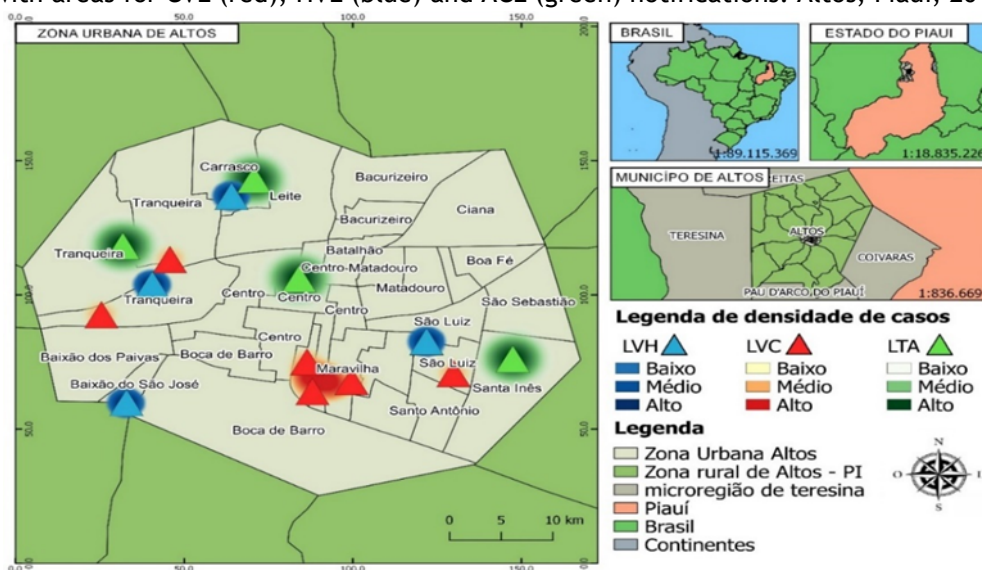
Considering only the 2017 to 2018 period, 88 cases of CVL were registered in Altos, distributed in the neighborhoods Centro, Batalhão, Maravilha, Tranqueira, Boa Fé, São Sebastião, São Luís,

Bacurizeiro, Boca de Barro, Santa Inês, Sete Buritis, Serra Negra, Matadouro e Santo Antônio.

By correlating the localities with leishmaniasis cases, a map with the areas that represent a higher risk to the population was made. Red indicates CVL cases, blue indicates HVL cases and green indicates ACL cases.

Figure 1 indicates the diffuse distribution of leishmaniasis cases which occurred in both central areas and in more peripheral regions, also indicates a predominance of cases over the analyzed years without epidemic peaks, highlighting the presence of the vector in urban and precarious home structure addresses, unpaved streets, animals scattered through the streets, open air garbage and open sewer.

Figure 1 - Map with areas for CVL (red), HVL (blue) and ACL (green) notifications. Altos, Piauí, 2019.



Source: Autors.

As to the sociodemographic data regarding ACL and HVL, illustrated in tables 2 and 3, it was observed higher occurrence in young adults and most of the

cases occurring in male, which remits a probable labor exposition of the confirmed cases, it was not possible to define whether the household was the focus of the presence of the vector.

Table 2 - LVH cases according to age group, residence, and gender, for the period from 2013 to 2018. Altos, Piauí, 2019.

| Notification year | Age range |       |       | Residence |             | Gender |    |
|-------------------|-----------|-------|-------|-----------|-------------|--------|----|
|                   | 0-20      | 21-39 | 40-69 | Urb.      | Countryside | M      | F  |
| 2013              | 2         | 4     | 1     | 3         | 4           | 3      | 4  |
| 2014              | 3         | 5     | 1     | 4         | 5           | 9      | 6  |
| 2015              | 1         | 3     | 0     | 2         | 2           | 2      | 2  |
| 2017              | 0         | 1     | 0     | 0         | 1           | 1      | 0  |
| 2018              | 1         | 0     | 0     | 1         | 0           | 1      | 0  |
| TOTAL             | 7         | 13    | 2     | 10        | 12          | 16     | 12 |

Source: Direct search.

As to the HVL distribution, although most of the notified cases had occurred in countryside, there was no important difference comparing to urban

area, as displayed in Table 1. In the ACL cases, it is observed relevant difference, with higher occurrence in countryside, accordingly data in Table 2.

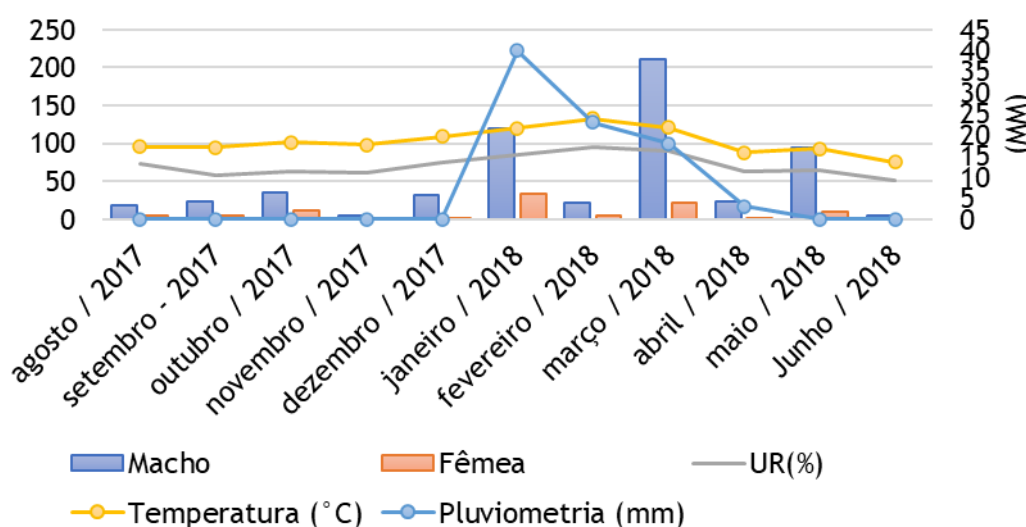
**Table 3** - ACL cases according to age range, residence, and gender, for the 2013 to 2018 period. Altos, Piauí, 2019.

| Notification year | Age range |       |       | Residence |             | Gender |   |
|-------------------|-----------|-------|-------|-----------|-------------|--------|---|
|                   | 0-20      | 21-39 | 40-69 | Urb.      | Countryside | M      | F |
| 2013              | 1         | 4     | 0     | 2         | 3           | 4      | 1 |
| 2014              | 0         | 2     | 0     | 0         | 2           | 2      | 0 |
| 2015              | 1         | 3     | 2     | 1         | 5           | 5      | 1 |
| 2017              |           |       |       | SILENT    |             |        |   |
| 2018              |           |       |       | SILENT    |             |        |   |
| TOTAL             | 2         | 9     | 2     | 3         | 10          | 11     | 2 |

Source: Direct search.

In Figure 2, it was observed the relation between *Lutzomyia longipalpis* and weather factors, temperature variation, pluviometry and relative humidity were analyzed. This association presents temperature variations between 22°C and 38.5°C. The average monthly rainfall reached 23,58mm and the oscillations in the relative humidity were from

51% to 89.5%, including all the months the collection was performed. Although portrays a short interval for the analysis of seasonal variables, it is observed the increase of caught specimens in the period of higher pluviosity and immediately after the rains, with no visible relation with humidity and temperature.

**Figure 2** - Relationship between the amount of *Lutzomyia longipalpis* and pluviometry (mm), temperature (°C) and relative humidity (%), in the August 2017 to June 2018 period. Altos, Piauí, 2019.

Fonte: Autores.

## DISCUSSION

The high prevalence of *Lutzomyia longipalpis* in the municipality of Altos reflects species' strong dominance, adaptation and urbanization, which represented almost 100% of the samples captured, which is similar to other studies carried out in Piauí and neighboring states.<sup>15-17</sup> It is a region with scarce prevention activities and proper screening for risk factors of the disease, so the infected ones end up in capital city for diagnosing and treatment, and in view of this the problem settles in the municipality.<sup>18</sup>

It is foregrounded that the municipality has a significant cases' underreporting, once the results of the study demonstrate a reduced quantitative of cases as to the data of municipality's health surveillance, by its turn, SINAN has a lower number of reported, being 22 HVL cases and 13 ACL cases in the 2013 to 2017 period, contrasting with the 2018 to 2020 period, which has no reported notifications. On the other hand, in 2019 there is a notification of HVL in DATASUS.

With these data, it is possible to observe a deficient notification of cases, with divergent

notifications, so that the epidemiological data result in imprecise analyzes and influence the identification of a possible epidemiological emergency in these places, since the main sources of health information are health data seekers.

According to the reported cases, it is noted that they are located in the central portion of the municipality represent risk areas, due to the finding of a greater number of ACL, HVL and CVL confirmed, pointing out the relation and the proximity of the places with notification of leishmaniasis cases and the places with confirmed cases of dogs with kala-azar, the neighborhoods Centro, Maravilha, São Luís and Tranqueira are the regions with the highest number of cases, showing close to an intersection. This congruence of cases evidences the transmission cycle of leishmaniasis between their natural and accidental hosts.<sup>19</sup>

As to the incidence of the gender, it was possible to verify that there was a superior registration of male in the age range of young adult, which is a finding similar to the epidemiological data found in study carried out in the state of Ceará and to research carried out in the Piauí.<sup>20-21</sup> The ACL data point out to urbanization of VL vectors, portrayed in some entomological inquiries already done in other municipalities of the state of Piauí and neighboring states.<sup>22,16</sup>

A study carried out in Teresina, located 28km from the municipality of Altos, found housing conditions similar to those found in this work, demonstrating an aspect of vulnerability when analyzing the spatial distribution of HVL cases and found an association between the incidence of the disease and precarious living conditions, social, household and urban structure.<sup>23</sup>

The literature reveals association of the capture in greater abundance of specimens with weather factors, instance in research carried out in the state of Tocantins which found a positive correlation between HVL and temperature, humidity and precipitation.<sup>24</sup> In 2017, a study carried out in in

the state Ceará showed a higher density of sandflies was associated with the rainy season.<sup>16</sup>

In addition, it was possible to verify an increasing in the amount of phlebotomine in January, March, and May 2018. Similar results can be observed in a study which related the temperature and the amount of phlebotomine. It was identified that the average rainfall amongst December 2017 and April 2018 exceeded the expected average for the period, thus, studies demonstrate that this difference can influence in the eating and reproductive habits of the phlebotomine, limiting the production of eggs.<sup>25</sup>

Thus, the months before the rains influence the abundance of phlebotomine. This relationship tends to indicate that the period after the rains improves the conditions of the environment, favoring the larval development of these insects.<sup>26</sup> The data presented in this work show the importance of entomological research with vectors that transmit pathogens. Research with phlebotomine helps to provide data that can support surveillance and control actions of these vectors, allowing competent bodies to create public policies to control the vector of HVL and ACL in the municipality of Altos-PI.

## LIMITATIONS OF THE STUDY

Some limitations found in the current study would be the limited availability of phlebotomine traps, once the traps are expensive and their maintenance is also expensive. Thus, the low quantity of available traps limited the amount of performed collections. Beyond, it was not possible to carry out collections in all neighborhoods which had notifications, because the residents of those localities did not allow the traps to be placed in their residences.

## CONCLUSION

The distribution of confirmed cases of both human and canine leishmaniasis in the central portion of the city highlights the presence of potential leishmaniasis vectors in the urban area of the

municipality of Altos, what awakes the need to adopt monitoring health policies and control by local surveillance. It would be ideal the creation of a committee for leishmaniasis control, formed by the representatives of the health and community, with support of state surveillance, it would be ideal to enhance the preventive measures, to orient the local population and ensure the precocious detection and effectiveness screening both in the human and canine

cases, which are reservoirs and signal the presence of vector activity at the local level.

Furthermore, it is strongly recommended that adequate record-keeping and documentation systems for leishmaniasis are initiated by health authorities at the local level, in order to identify outbreaks of leishmaniasis and so that control measures can be initiated in time.

## RESUMO

**Introdução:** As leishmanioses Visceral e Tegumentar Americana são um problema de saúde pública nas Américas, no município de Altos, estado do Piauí, são consideradas endêmicas. **Objetivo:** Realizar um levantamento faunístico das espécies de flebotomíneos em áreas de transmissão de Leishmaniose visceral e tegumentar, humana e canina no município de Altos PI. **Delineamento:** Foi realizado por meio de levantamento entomológico, compreendeu as atividades de captura, separação, identificação e análise das espécies de flebotomíneos em determinadas regiões no município de Altos, Piauí, entre agosto de 2017 e julho de 2019. **Resultados:** A espécie mais encontrada foi *Lutzomyia longipalpis*, com 1.399 flebotomíneos capturados, sendo 1.299 machos e 140 fêmeas. Também foram encontradas algumas outras espécies, como a *Nyssomyia whitmani*, *Lutzomyia dispar*, *Evandromyia evandroi*. **Implicações:** A pesquisa auxilia no fornecimento de dados que podem contribuir para a formulação de ações de vigilância e controle destes vetores, possibilitando que órgãos responsáveis elaborem políticas públicas de controle das leishmanioses.

## DESCRITORES

Vigilância; Insectos Vectores; Salud Pública; Leishmaniasis.

## RESUMEN

**Introducción:** Las leishmaniasis Visceral y Tegumentaria Americana son un problema de salud pública en las Américas, en el municipio de Altos, estado de Piauí, son consideradas endémicas. **Objetivo:** Realizar un relevamiento faunístico de especies de flebotomos en áreas de transmisión de *Leishmaniasis visceral* y tegumentaria, humana y canina en el municipio de Altos PI. **Diseño:** Se realizó a través de un levantamiento entomológico, que comprende las actividades de captura, separación, identificación y análisis de especies de flebotomos en ciertas regiones del municipio de Altos, Piauí, entre agosto de 2017 y julio de 2019. **Resultados:** Las especies más encontradas fue *Lutzomyia longipalpis*, con 1.399 flebotomos capturados, 1.299 machos y 140 hembras. También se encontraron algunas otras especies, como *Nyssomyia whitmani*, *Lutzomyia dispar*, *Evandromyia evandroi*. **Implicaciones:** La investigación contribuye a proporcionar datos que pueden contribuir a la formulación de acciones de vigilancia y control de estos vectores, permitiendo a los órganos responsables desarrollar políticas públicas para el control de las leishmaniasis.

## DESCRIPTORES

Vigilância; Insectos Vectores; Salud Pública; Leishmaniasis.

## REFERENCES

1. Carneiro LA, Santos TV, Lima LVR, Ramos PKS, Campos MB, Silveira FT. First report on feline leishmaniasis caused by *Leishmania (Leishmania) amazonensis* in Amazonian Brazil. *Vet Parasitol Reg Stud Rep* [Internet]. 2020 Jan [cited 2022 Mar 22];19:100360. Available from: <https://doi.org/10.1016/j.vprsr.2019.100360>
2. Toledo CRS, Almeida AS, Chaves SAM, Sabrozall PC, Toledoll LM, Caldas JP. Vulnerability to the transmission of human visceral leishmaniasis in a Brazilian urban area. *Rev Saude Publica* [Internet]. 2017 May [cited 2021 Apr 15];51:49. Available from: <https://doi.org/10.1590/S1518-8787.2017051006532>
3. Galati EAB, Galvis-Ovallos F, Lawyer P, Léger N, Depaquit J. An illustrated guide for characters and terminology used in descriptions of Phlebotominae (Diptera, Psychodidae). *Parasite* [Internet]. 2017 Jul [cited 2021 Jun 13];24:26. Available from: <https://doi.org/10.1051/parasite/2017027>
4. Elaagip A, Ahmed A, Wilson MD, Boakye DA, Hamid MMA. Studies of host preferences of wild-caught *Phlebotomus orientalis* and *Ph. papatasi* vectors of leishmaniasis in Sudan. *PLoS One* [Internet]. 2020 Jul [cited 2021 May 10];15(7):0236253. Available from: <https://doi.org/10.1371/journal.pone.0236253>
5. Casanova C. Vetor ou vetores? Capacidade vetorial e estratégias de controle. *Rev Inst Adolfo Lutz* [Internet]. 2018 Jun [cited 2021 Apr 09];77:1-8. Available from: <https://doi.org/10.53393/rial.2018.v77.34201>

6. Menegatti JA, Júnior GJOL, Silva CF, Oliveira A, Bica DLC, Santos PVBA et al. Fauna flebotomínica e soroprevalência para leishmaniose visceral canina em área urbana na região Centro-Oeste do Brasil. *Arq bras med vet zootec* [Internet]. 2020 Jul [cited 2021 Nov 04];72(4):1197-205. Available from: <https://doi.org/10.1590/1678-4162-11549>
7. Balaska S, Fotakis EA, Chaskopoulou A, Vontas J. Chemical control and insecticide resistance status of sand fly vectors worldwide. *PLoS Negl Trop Dis* [Internet]. 2021 Aug [cited 2021 Nov 18];15(8):e0009586. Available from: <https://doi.org/10.1371/journal.pntd.0009586>
8. Pan American Health Organization (PAHO). Leishmanioses: informe epidemiológico das Américas. Washington: Pan American Health Organization; 2014 [cited 2021 jul 28]. Available from: [https://iris.paho.org/bitstream/handle/10665.2/10069/Informe%20Leishmanioses 3%20 2015 prt.pdf?sequence=3&isAllowed=y](https://iris.paho.org/bitstream/handle/10665.2/10069/Informe%20Leishmanioses%202015prt.pdf?sequence=3&isAllowed=y)
9. Costa PL, Silva FJ, Andrade Filho JD, Shaw JJ, Brandão Filho SP. Bilateral anomaly in *Evandromyia evandroi* (Diptera: Psychodidae: Phlebotominae) captured in Vicência municipality, northern rainforest region of Pernambuco State, Brazil. *J Am Mosq Control Assoc* [Internet]. 2012 Jun [cited 2021 Nov 23];28(2):128-30. Available from: <https://doi.org/10.2987/11-6218R.1>
10. Ministério da Saúde (BR). Sala de Apoio à Gestão Estratégica. Indicadores Epidemiológicos de Leishmaniose Tegumentar. Brasília: Ministério da Saúde; 2015 [cited 2019 May 12]. Available from: <http://sage.saude.gov.br/#>
11. Brandão MLSM, Iwata BF, Alencar GS, Carvalho SP, Almeida KS, Silva CMA et al. Biomassa aérea e NDVI em zona ecotonal cerrado-caatinga da Flona de Palmares, Altos, Piauí, Brasil. *Rev Ibero Ameri Cien Amb* [Internet]. 2020 Aug [cited 2021 Dec 25];11(5):463-70. Available from: <http://doi.org/10.6008/CBPC2179-6858.2020.005.0042>
12. Instituto Brasileiro de Geografia e Estatística (IBGE). Panorama de Altos - PI [Homepage on the Internet]. Instituto Brasileiro de Geografia e Estatística; 2021 [cited 2021 Dec 8]. Available from: <https://cidades.ibge.gov.br/brasil/pi/altos/panorama>
13. Ministério da Saúde (BR). Casos confirmados notificados no Sistema de Informação de Agravos de Notificação [homepage on the internet]. Available from: <http://tabnet.datasus.gov.br/cgi/deftohtm.exe?sinannet/cnv/leishvpi.def>
14. Galati EAB. Morfologia e terminologia de Phlebotominae (Diptera: Psychodidae). Classificação e identificação de táxons das Américas [handout on the internet]. São Paulo: Faculdade de Saúde Pública da Universidade de São Paulo; 2018 [cited 2019 May 14]. 132p. Available from: [http://www.fsp.usp.br/egalati/wp-content/uploads/2018/07/Nova-Apostila-Vol-I\\_2018.pdf](http://www.fsp.usp.br/egalati/wp-content/uploads/2018/07/Nova-Apostila-Vol-I_2018.pdf)
15. Santos WS, Ortega D, Alves R, Garcez M. Flebotomíneos (Psychodidae: Phlebotominae) de área endêmica para leishmaniose cutânea e visceral no nordeste do estado do Pará, Brasil. *Rev Panamazonica Saude* [Internet]. 2019 Nov [cited 2020 May 16];10:1-8. Available from: <http://dx.doi.org/10.5123/s2176-62232019000059>
16. Silva JS, Caranha L, Santos FKM, Santos AP, Silva LOR, Rangel EF. Sand fly (Diptera, Psychodidae, Phlebotominae) abundance and diversity in áreas affected by the São Francisco River transposition Project in Ceará state, Brazil. *Parasit Vectors* [Internet]. 2017 Aug [cited 2020 Jul 14];10(1):1-13. Available from: <https://doi.org/10.1186/s13071-017-2333-z>
17. Rodgers MSM, Bavia ME, Fonseca EOL, Cova BO, Silva MMN, Carneiro DDMT et al. Ecological niche models for sand fly species and predicted distribution of *Lutzomyia longipalpis* (Diptera: Psychodidae) and visceral leishmaniasis in Bahia state, Brazil. *Environ Monit Assess* [Internet]. 2019 Jun [cited 2021 Nov 24];191(2):1-12. Available from: <https://doi.org/10.1007/s10661-019-7431-2>
18. Prefeitura Municipal de Altos. Secretaria Municipal de Saúde. Vigilância Sanitária. Registros dos casos de Leishmanioses e cães eliminados com confirmação de calazar. Altos: Vigilância Sanitária; 2018.
19. Estumano JC, Sá LL, Macêdo CG. Leishmaniose tegumentar americana: Análise epidemiológica de uma década no interior da Amazônia, Brasil. *Braz J Dev* [Internet]. 2020 Jun [cited 2021 May 18];6(6):36311-25. Available from: <https://doi.org/10.34117/bjd.v6i6.11478.g9577>
20. Cavalcante FRA, Cavalcante KKS, Florencio CMGD, Moreno JO, Correia FGS, Alencar CH. Human visceral leishmaniasis: epidemiological, temporal and spacial aspects in Northeast Brazil, 2003-2017. *Ver Inst Med Trop S Paulo* [Internet]. 2020 Feb [cited 2021 Oct 19];62:e12. Available from: <https://doi.org/10.1590/S1678-9946202062012>
21. Sousa FCA, Costa LLS, Neto FAS, Luz JSN, Nascimento THM, Silva WAS et al. Epidemiological aspects of visceral leishmaniasis in the state of Piauí, Brazil. *Res Soc Dev* [Internet]. 2021 Nov [cited 2022 Mar 22];10(15):e121101522690. Available from: <https://doi.org/10.33448/rsd-v10i15.22690>
22. Pareyn M, Dvorak V, Halada P, Houtte NV, Girma N, Kesel W et al. An integrative approach to identify sand fly vectors of leishmaniasis in Ethiopia by morphological and molecular techniques. *Parasit Vectors* [Internet]. 2020 Nov [cited 2021 Nov 08];13(1):1-13. Available from: <https://doi.org/10.1186/s13071-020-04450-2>
23. Silva KCB, Soares VR, Vaz JLS, Costa SCR, Verde RMCL, Macêdo KPC, Soares LF et al. Aspectos epidemiológicos da leishmaniose visceral em Teresina-PI, Brasil. *J Nurs Meas* [Internet]. 2020 Aug [cited 2020 Dec 23];52(5):e744. Available from: <https://doi.org/10.25248/reas.e744.2020>
24. Reis LL, Balieiro AA, Fonseca FR, Gonçalves MJ. Leishmaniose visceral e sua relação com fatores climáticos e ambientais no estado do Tocantins, Brasil, 2007 a 2014. *Cad Saúde Pública* [Internet]. 2019 Jan [cited 2021 Set 22];35(1):e00047018. Available from: <https://doi.org/10.1590/0102-311X00047018>



25. Uzcátegui YDVS, Santos TV, Silveira FT, Ramos PK, Santos EJM, Póvoa MM. Phlebotomines (Diptera: Psychodidae) from a urban park of Belém, Pará State, northern Brazil and potential implications in the transmission of American cutaneous leishmaniasis. *J Med Entomol* [Internet]. 2020 Jan [cited 2022 Mar 22];57(1):281-288. Available from: <https://doi.org/10.1093/jme/tjz153>
26. Uzcátegui YDVS, Santos TV, Póvoa MM. Morphological description of immature stages of *Trichophoromyia brachipyga* (Mangabeira)(Diptera: Psychodidae: Phlebotominae). *Zootaxa* [Internet]. 2021 Oct [cited 2022 Mar 22];5057(2):271-284. Available from: <https://doi.org/10.11646/zootaxa.5057.2.7>

#### COLLABORATIONS

MPAS, RLTS, SAV, VJM: Substantial contributions for the conception or design of the study; in the collection, analysis, and interpretations of data; in article's writing or its critical review; and in the final version to be published. **All authors agree and are responsible by the content of this version of the manuscript to be published.**

#### ACKNOWLEDGMENTS

To the Federal University of Piauí.

#### AVAILABILITY OF DATA

Not applicable.

#### FUNDING SOURCE

Not applicable.

#### CONFLICTS OF INTEREST

There are no conflicts of interest to declare.