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Original Article
*Small Animal Diseases*


# Differentials in the epidemiological profile of canine visceral leishmaniasis in the semi-arid region of Paraíba, Brazil[1]

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**ABSTRACT.**- Silva R.B.S., Franco-Silva L.F., Lima D.A., Fonseca S.S., Ferreira M.A.S., Silva R.C., Lira M.A.A. & Melo M.A. 2021. **Differentials in the epidemiological profile of canine visceral leishmaniasis in the semi-arid region of Paraíba, Brazil**. *Pesquisa Veterinária Brasileira 41:e06773, 2021*. Universidade Federal de Campina Grande, Campus Patos, Av. Universitária s/n, Santa Cecília, Patos, PB 58708-110, Brazil. E-mail: raizzabss@hotmail.com

The objective of this study was to estimate the prevalence of canine visceral leishmaniasis (CVL) and to identify the differences in associated factors to its occurrence in urban area and countrysides in the municipality of Santa Luzia located in the semi-arid region of Paraíba. In the years 2015 and 2016, 779 blood samples from dogs were collected. The prevalence was determined by three serological techniques, ELISA-S7® Kit, DPP® Rapid Test and EIE-LVC® Kit, considering positive the samples that reacted in at least two assays. Associated factors were determined by univariate and multivariate analyzes of the guardians' responses to the epidemiological questionnaire. The prevalence of anti-*Leishmania infantum* antibodies in the studied municipality was 15.00% (117/779), being higher in the urban area (15.20%) than in the countryside (13.60%). The neighborhood with the highest prevalence was Frei Damião with 26.40% (33/125), being considered a hotspot (OR 1.245, $p$=0.007). Other associated factors were the semi-domiciliary breeding (OR 1.798, $p$=0.025), in the urban area, and hunting dog (OR 18.505, $p$=0.016), contact with cattle (OR 17.298, $p$=0.022) and environment where the dog is raised (OR 4.802, $p$=0.024) in the countryside. In the municipality of Santa Luzia, the prevalence of canine visceral leishmaniasis is high and the disease is widely distributed. Epidemiological differences between urban area and the countryside could be observed demonstrating the need for more adequate control measures for each locality and proving the urbanization process.

INDEX TERMS: Canine visceral leishmaniasis, epidemiological profile, *Leishmania infantum*, neglected diseases, prevalence, associated factors, semi-arid region, zoonoses, Brazil.

**RESUMO.- [Diferenciais no perfil epidemiológico da leishmaniose visceral canina no semiárido da Paraíba, Brasil.]** O objetivo desta pesquisa foi estimar a prevalência da leishmaniose visceral canina (LVC) e identificar as diferenças nos fatores relacionados à sua ocorrência nas zonas urbana e rural do município de Santa Luzia, localizado no semiárido paraibano. Nos anos de 2015 e 2016, coletaram-se 779 amostras de sangue de cães. A prevalência foi determinada através de três técnicas sorológicas, Kit ELISA-S7®, teste rápido DPP® e Kit EIE-LVC®, considerando positivas as amostras que

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reagiram em, pelo menos, dois ensaios. Os fatores relacionados foram determinados por meio das análises estatísticas uni e multivariada das respostas dos tutores ao questionário epidemiológico. A prevalência de anticorpos anti-*Leishmania infantum* encontrada no município estudado foi de 15,00% (117/779), sendo maior na zona urbana (15,20%) do que na rural (13,60%). O bairro que apresentou maior prevalência foi o Frei Damião com 26,40% (33/125), sendo considerado um *hotspot* (OR 1,245; *p*=0,007). Outros fatores relacionados encontrados foram a criação semidomiciliar (OR 1,798; *p*=0,025), na zorna urbana, e cão de caça (OR 18,505; *p*=0,016), contato com bovinos (OR 17,298; *p*=0,022) e ambiente onde o cão é criado (OR 4,802; *p*=0,024), na zona rural. Verifica-se a elevada prevalência da leishmaniose visceral canina e a sua ampla distribuição no município de Santa Luzia. Diferenças epidemiológicas entre as zonas urbana e rural puderam ser observadas, demonstrando a necessidade de medidas de controle mais adequadas para cada localidade e comprovando o processo de urbanização.

TERMOS DE INDEXAÇÃO: Leishmaniose visceral canina, perfil epidemiológico, *Leishmania infantum*, doenças negligenciadas, prevalência, fatores relacionados, região semiárida, zoonoses, Brasil.

## INTRODUCTION

Visceral leishmaniasis (VL) is a neglected tropical disease, of zoonotic nature, caused by the protozoan *Leishmania infantum* (sin. *L. chagasi*), which affects the mononuclear phagocyte system of humans, canids and other mammals (WHO 2010).

The VL is transmitted by phlebotomine insects and the main transmitter species in Brazil is *Lutzomyia longipalpis*. This zoonosis has a broad worldwide distribution occurring in Asia, Europe, Middle East, Africa and in the Americas (Brasil 2014). In the year of 2015, 15.00% (3456) of the world's new cases of VL occurred in the Americas, and Brazil was responsible for 3336 (96.50%) of these cases (WHO 2017a), with only one Units of the Federation, Acre, without any registers of autochthonous cases of VL from 2007 to 2019, according to data of the Sinan Net (Brasil 2020).

In Brazil, visceral leishmaniasis has been expanding and urbanizing since the 1980's. These phenomena are related to the conditions in which the dogs and their guardians live (disorganized occupations and precarious living conditions), the migration of human beings and their pets, climate changes and deforestation, in addition to the dispersion and urbanization of the vector (WHO 2002, Costa 2008, Salomón et al. 2015).

The control strategies of the VL in Brazil, according to the "Programa de Vigilância e Controle da Leishmaniose Visceral" (PVCLV - Visceral Leishmaniasis Surveillance and Control Program), are based on the early diagnosis and treatment of the human cases, on the control of the vectors with the use of insecticides and in the detection of infected dogs, by serological analysis, with subsequent euthanasia of the positive animals (Brasil 2014), since the dog is considered the main reservoir of the disease in endemic urban areas. For the diagnosis of the canine visceral leishmaniosis (CVL), the "Ministério da Saúde" (Ministry of Health) recommends the use of DPP® rapid test (Bio-Manguinhos), for screening, and the EIE-LVC® (Bio-Manguinhos) as confirmatory test (Brasil 2011).

In 2016, the first drug for the treatment of the CVL was registered in the "Ministério da Agricultura, Pecuária e Abastecimento" (MAPA - Ministry of Agriculture, Livestock and Food Supply) and in 2017 started to be commercialized in Brazil. However, it is not indicated as a public health measure for the control of the disease (Brasil 2016). According to the Interministerial Ordinance no. 1.426, of 11th July 2008, the treatment of CVL with products of human use or not registered in the MAPA is still prohibited. This decision of the "Ministério da Saúde" and the MAPA has as main fundaments: the possibility of dogs in treatment remaining as reservoirs and sources of infection for the vector, and the existence of risk of selection of strains resistant to the drugs available for the treatment of leishmaniasis in humans (Brasil 2008).

In Paraíba, in 2015, the incidence of human VL was of 1.2 cases per 100,000 inhabitants (Brasil 2020). In April of the same year, in the municipality of Santa Luzia/PB, the death of a five-year old child due to visceral leishmaniasis, resident in the São Sebastião neighborhood, was registered. According to the Health Surveillance Agency of the Santa Luzia Municipal Government, after the identification of this autochthonous case, actions recommended by the "Ministério da Saúde" were conducted in the vicinity of the human case (São Sebastião and Nossa Senhora de Fátima neighborhoods), such as: entomological investigation, spraying with insecticides, environmental sanitation, canine serological survey, and euthanasia of the reagent dogs. Due to the lack of knowledge of CVL in other areas of the municipality, the objective of the study was to estimate the prevalence of the disease in the municipality of Santa Luzia to identify possible associated factors, so that measures for the control and prevention of new cases could be taken.

## MATERIALS AND METHODS

The cross-sectional study was conducted in the urban area and countrysides of Santa Luzia (06°52'S and 36°55'W), a municipality of the semi-arid region of the State of Paraíba (Fig.1), with an area of 455km$^2$. In 2016, the estimated population was 15,341 inhabitants, with more than 90% residing in the urban area, according to the "Instituto Brasileiro de Geografia e Estatística" (IBGE - Brazilian Institute of Geography and Statistics). Considering the existence of one dog for every seven inhabitants, the estimated canine population was of 2,191 animals. The number of animals used was determined

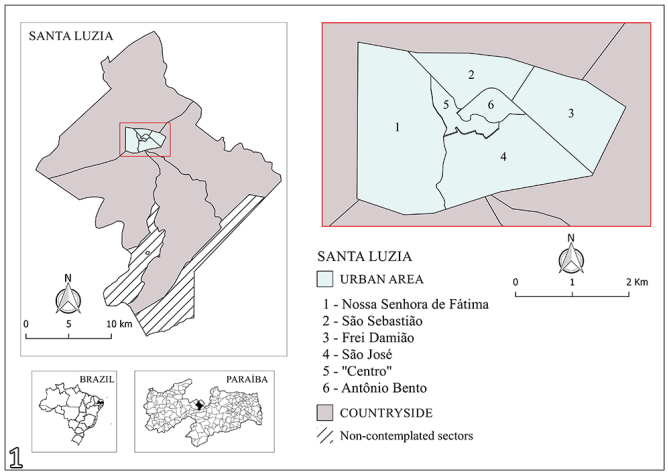


Fig.1. Location map of the municipality of Santa Luzia/PB, Brazil, categorized by areas.

by the calculation formula for simple random samples, as proposed by Thrusfield (2007), considering an expected prevalence of 50%, 99% confidence level and sampling error of 4%. The minimum estimated number of animals was of 706, but as a security measure, an additional 10% was added to the sample number.

The survey was carried out from July 2015 to July 2016 in dogs over six months of age and without distinction of breed or gender.

In the urban area, sampling was carried out for convenience at a collection point in each neighborhood after wide dissemination on local radio and by Endemic Control Agents (ECA) and Health Agents (HA). The sampling in the countryside was by conglomerates and the collection was carried out in 16 rural communities by random raffle, being contemplated all the houses and all the dogs of the raffled localities.

The blood was obtained by jugular vein or cephalic vein venipuncture, with the aid of 5mL syringes and sterile 25x8mm needles of individual use. A total of 5mL of blood was immediately deposited in a tube containing 4% sodium citrate. After collection, the material was sent to the "Laboratório de Biologia Molecular do Semiárido" of the "Universidade Federal de Campina Grande" (LBMSA-UFCG), University Campus in the municipality of Patos/PB. The samples were centrifuged at 2000 rotation per minute (rpm), for 5 minutes, for the separation of the plasma, which was stored in 1.5mL microtubes, identified and stored at -20°C until the serological assays were performed.

The serological tests used for the diagnosis of the CVL were: ELISA-S7® Kit (Biogene Ind. e Com. Ltda) performed by the team of the LBMSA-UFCG; DPP® (Bio-Manguinhos) Rapid Test, carried out by the Endemic Disease Control Agents of the Health Department of Santa Luzia; and as recommended by the "Ministério da Saúde", only positive samples in DPP® were tested by immunoenzymatic assay (EIE-LVC® Kit, Bio-Manguinhos) at the "Laboratório Central de Saúde Pública" (LACEN - Central Public Health Laboratory) in the state of Paraíba. All the assays were conducted according to the protocols proposed by the manufacturers. The animal was considered positive when it reacted in two serological tests.

The dog guardians answered an epidemiological questionnaire to identify the socio-environmental conditions that act as possible associated factors for the disease. The analysis of the factors associated to the seropositivity was carried out in two stages: univariate and multivariate analysis. The independent variables were categorized and codified and those which presented a *p*-value of ≤0.20 by the chi-square test or Fisher's exact test (Zar 1999) were used in the multivariate analysis by multiple logistic regression (Hosmer & Lemesho 2000). The level of significance adopted in the multiple analysis was of 5%. The analysis was carried out with the IBM SPSS Statistics Base 22.0 software.

The work was approved by the Ethics Committee of the Health and Rural Technology Center (CSTR), of the UFCG, under the protocol no. 283/2015.

## RESULTS

Of the 779 blood samples collected from dogs in the municipality of Santa Luzia for the serological survey, 676 were from dogs in the urban area, and 103 from the countryside. Considering as positive the dogs that reacted in at least two serologies, the CVL seroprevalence in the municipality of Santa Luzia was 15.02% (117/779, 95% CI 12.51-17.53%), of which 103 positive dogs were from urban areas and 14 from countryside, resulting in prevalence of 15.24% (103/676, 95% CI 12.53-17.95%) and 13.59% (14/103, 95% CI 6.97-20.21%), respectively. There was no significant difference in the positivity of the dogs from both areas ($p$=0.774).

Most of the guardians of the seropositive dogs had a family income of less than two minimum salaries (63.47%). It was possible to observe that as the economic status of the family increases, lower is the prevalence of CVL. In relation to the canine population with visceral leishmaniasis, 61.54% (72/117) were male, 25.64% (30/117) were aged between two to four years, 74.36% (87/117) were mongrels, without significant difference between the categories of these variables ($p$>0.05).

Most guardians raise dogs in a semi-household manner (68.29%, 532/779), that is, the animal is loose on the street at certain times of the day, among them, 83.76% (98/117) were positive. The contact of the dogs with other animals, such as other dogs, cats, equine, ruminants, birds and/or wild animals was reported by 67.27% (524/779) of the guardians; 71.79% (84/117) of the positive dogs maintained some contact with other animals, among these stood out other dogs (n=60), birds (n=30) and cats (n=26). The cleaning of the outside pet area was performed by 90.50% (705/779) of the guardians, but the frequency of this cleaning varied from daily to monthly; the prevalence of CVL increased with the increase in the period without cleaning. Only 7.70% of the dogs (60/779) had used an insecticide-impregnated collar and none of the dogs had been vaccinated against CVL; at the time of collection, no animals were wearing this type of collar.

The analysis of the associated factors was carried out to determine the differences between the urban area and countryside, the results obtained are expressed in the Table 1 and 2. The associated factor of the urban area were the type of rearing (semi-household manner), and the neighborhood (Frei Damião) was considered a hotspot. Regarding the canine population with VL and resident in the Frei Damião neighborhood, it was observed that 90.00% of them were raised in a semi-domicile regime and all positive dogs had their place of residence cleaned monthly; 75.80% of the responsible for these dogs had a family income of less than two minimum wages. The associated factors for the countryside were hunting dogs, contact with bovine and keep the dog in the backyard partially covered with concrete and partially with soil.

## DISCUSSION

The prevalence of canine infection is an important risk indicator for the occurrence of human VL (Oliveira et al. 2008, Araújo et al. 2013, Teixeira-Neto et al. 2014) and its rates can vary widely among Brazilian municipalities, with values between 0.17% in São José do Rio Preto, São Paulo (Da Nardo et al. 2011), to 75.30% in Anastácio, Mato Grosso do Sul (Cortada et al. 2004). The discrepancy between these values is a consequence of the characteristics of the region and the population studied, and the diagnostic methods used in each survey. Prevalence like those obtained in Santa Luzia were observed in municipalities with similar physiographic and socioeconomic characteristics, such as in Petrolina, Pernambuco (Pimentel et al. 2015), and in municipalities in the semi-arid region of Paraíba (Fernandes et al. 2016, Silva et al. 2016, Silva et al. 2018), making clear the influence of socio-environmental factors on the prevalence of the disease (Rondon et al. 2008, Dantas-Torres 2009, Ursine et al. 2016).

**Table 1. Univariate analysis of the factors associated to the seropositivity to canine visceral leishmaniasis in the urban and rural areas of Santa Luzia, Paraíba, from 2015 to 2016**

| Variable | Urban area | | | Rural area | | |
|---|---|---|---|---|---|---|
| | Total no. of animals | Positive animals (%) | *p*-value | Total no. of animals | Positive animals (%) | *p*-value |
| Neighborhood | | | 0.001* | | Not applicable | |
| Centro | 79 | 7 (8.9%) | | | | |
| São Sebastião | 98 | 9 (9.2%) | | | | |
| Nossa Senhora de Fátima | 86 | 8 (9.3%) | | | | |
| Antônio Bento | 61 | 7 (11.5%) | | | | |
| São José | 226 | 39 (17.3%) | | | | |
| Frei Damião | 125 | 33 (26.4%) | | | | |
| Family income | | | | | | |
| Less than 2 minimum salaries | 417 | 63 (15.1%) | 0.562 | 68 | 10 (14.7%) | 0.496 |
| 2 to 4 minimum salaries | 211 | 35 (16.6%) | | 22 | 2 (9.1%) | |
| 4 to 6 minimum salaries | 31 | 3 (9.7%) | | 3 | 1 (33.3%) | |
| More than 6 minimum salaries | 16 | 1 (6.3%) | | 0 | 0 | |
| Gender | | | | | | |
| Male | 384 | 64 (16.7%) | 0.235 | 62 | 8 (12.9%) | 0.802 |
| Female | 292 | 39 (13.4%) | | 41 | 6 (14.6%) | |
| Age (months) | | | | | | |
| 6 - 12 | 106 | 11 (10.4%) | 0.560 | 21 | 0 | 0.088* |
| 13 - 24 | 150 | 27 (18.8%) | | 20 | 1 (5.0%) | |
| 25 - 48 | 170 | 25 (14.7%) | | 22 | 5 (22.7%) | |
| 48 - 72 | 133 | 21 (15.8%) | | 24 | 4 (16.7%) | |
| > 72 | 117 | 19 (16.2%) | | 16 | 4 (25.0%) | |
| Breed | | | | | | |
| With defined breed | 253 | 27 (10.7%) | 0.011* | 11 | 3 (27.3%) | 0.170* |
| Mongrel | 423 | 76 (18.0%) | | 92 | 11 (12.0%) | |
| Type of rearing | | | | | | |
| Domiciled | 192 | 11 (5.7%) | 0.000* | 3 | 0 | 0.521 |
| Semi-domiciled | 458 | 89 (19.4%) | | 74 | 9 (12.2%) | |
| Free | 26 | 3 (11.5%) | | 26 | 5 (19.2%) | |
| Contact with animals | | | | | | |
| No | 251 | 32 (12.7%) | 0.167* | 4 | 1 (25.0%) | 0.448 |
| Yes | 425 | 71 (16.7%) | | 99 | 13 (13.1%) | |
| Contact with equine | | | | | | |
| No | 664 | 102 (15.4%) | 1.000 | 62 | 8 (12.9%) | 0.802 |
| Yes | 12 | 1 (8.3%) | | 41 | 6 (14.6%) | |
| Contact with wild animals | | | | | | |
| No | 670 | 101 (15.1%) | 0.229 | 86 | 11 (12.8%) | 0.698 |
| Yes | 6 | 2 (33.3%) | | 17 | 3 (17.6%) | |
| Contact with feline | | | | | | |
| No | 534 | 80 (15.0%) | 0.720 | 86 | 11 (12.8%) | 0.698 |
| Yes | 142 | 23 (16.2%) | | 17 | 3 (17.6%) | |
| Contact with dogs | | | | | | |
| No | 404 | 55 (13.6%) | 0.152* | 9 | 2 (22.2%) | 0.353 |
| Yes | 272 | 48 (17.6%) | | 94 | 12 (12.8%) | |
| Contact with swine | | | | | | |
| No | 671 | 102 (15.2%) | 0.564 | 81 | 9 (11.1%) | 0.172* |
| Yes | 5 | 1 (20.0%) | | 22 | 5 (22.7%) | |
| Contact with small ruminants | | | | | | |
| No | 661 | 102 (15.4%) | 0.713 | 52 | 12 (23.1%) | 0.008* |
| Yes | 15 | 1 (6.7%) | | 51 | 2 (3.9%) | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Contact with bovine | | | | | | |
| No | 671 | 102 (15.2%) | 0.564 | 46 | 3 (6.5%) | 0.083* |
| Yes | 5 | 1 (20.0%) | | 57 | 11 (19.3%) | |
| Contact with birds | | | | | | |
| No | 529 | 83 (15.7%) | 0.534 | 24 | 4 (16.7%) | 0.734 |
| Yes | 147 | 20 (13.6%) | | 79 | 10 (12.7%) | |
| Environment where is reared | | | | | | |
| Soil | 288 | 50 (17.4%) | 0.270 | 97 | 12 (12.4%) | 0.197* |
| Cement | 271 | 34 (12.5%) | | 1 | 0 | |
| Soil and cement | 117 | 19 (16.2%) | | 5 | 2 (40.0%) | |
| Cleaning of the outside pet area | | | | | | |
| No | 18 | 3 (16.7%) | 0.746 | 56 | 10 (17.9%) | 0.249 |
| Yes | 658 | 100 (15.2%) | | 47 | 4 (8.5%) | |
| Frequency of the cleaning | | | | | | |
| Daily | 478 | 59 (12.3%) | 0.020* | 5 | 0 | 0.158* |
| Weekly | 159 | 35 (22.0%) | | 29 | 1 (3.4%) | |
| Fortnightly | 10 | 3 (30.0%) | | 13 | 3 (23.1%) | |
| Monthly | 11 | 3 (27.3%) | | 0 | 0 | |
| Presence of ticks | | | | | | |
| No | 106 | 17 (16.0%) | 0.803 | 20 | 2 (10.0%) | 1.000 |
| Yes | 570 | 86 (15.1%) | | 83 | 12 (14.5%) | |
| Always lived in Santa Luzia | | | | | | |
| No | 78 | 7 (9.0%) | 0.102* | 6 | 0 | 1.000 |
| Yes | 598 | 96 (16.1%) | | 97 | 14 (14.4%) | |
| Adopted | | | | | | |
| No | 19 | 6 (31.6%) | 0,122* | 36 | 3 (8.3%) | 0.205 |
| From the streets | 179 | 29 (16.2%) | | 31 | 7 (22.6%) | |
| From another owner | 470 | 68 (14.5%) | | 36 | 4 (11.1%) | |
| Hunting dog | | | | | | |
| No | 616 | 92 (14.9%) | 0.484 | 87 | 9 (10.3%) | 0.025* |
| Yes | 60 | 11 (18.3%) | | 16 | 5 (31.3%) | |
| Place used for sleeping | | | | | | |
| Indoors | 135 | 16 (11.9%) | 0.279 | 3 | 0 | 1.000 |
| Peri-domiciliar | 526 | 86 (16.3%) | | 100 | 14 0%) | |
| In the street | 15 | 1 (6.7%) | | - | - | |
| How the dog spends the night | | | | | | |
| Free | 460 | 66 (14.3%) | 0.348 | 46 | 8 (17.4%) | 0.312 |
| Tied-up | 216 | 37 (17.1%) | | 57 | 6 (10.5%) | |
| Made use of repellent collar | | | | | | |
| No | 618 | 97 (15.7%) | 0.278 | 101 | 14 (13.9%) | 1.000 |
| Yes | 58 | 6 (10.3%) | | 2 | 0 | |

* Variables used in the multiple logistic regression.

**Table 2. Associated factors for canine visceral leishmaniasis per areas of the municipality of Santa Luzia, Paraíba, estimated by multiple logistic regression, from 2015 to 2016**

| Area | Associated factors | Odds ratio | CI 95%[a] | p-value |
|---|---|---|---|---|
| Urban | Type of rearing (Semi-domiciled) | 1.80 | 1.08-3.01 | 0.025 |
| Rural | Hunting dog (Yes) | 18.51 | 1.71-200.35 | 0.016 |
| | Contact with bovine (Yes) | 17.30 | 1.50-199.28 | 0.022 |
| | Environment where the dog is reared (Soil and cement) | 4.80 | 1.23-18.76 | 0.024 |

[a] CI 95% = confidence interval of 95%.

CVL is generally more prevalent in rural areas than in urban areas (Amóra et al. 2006, Almeida et al. 2012). However, in some regions changes in this pattern occurred, with the expansion of the disease to urban areas (França-Silva et al. 2003, Guimarães et al. 2017), which was also observed in the present study. This urbanization process has occurred since the 1980s and is associated with several phenomena such as the migration of humans and their pets from the countryside to the urban area (associated with disorderly occupation and precarious living conditions), climate change and deforestation, in addition to the dispersion and adaptation of the vector (WHO 2002, Costa 2008, Salomón et al. 2015). In Santa Luzia, the peripheral neighborhoods grow in a disorganized way, as is the case of the Frei Damião neighborhood, a hotspot that features remnant areas of Caatinga (Fig.2-3). Araujo et al. (2016) found that the presence of a green area near the residence behaves as a risk factor for CVL in Petrolina/PE, Northeastern Brazil. In addition to the presence of forest, there are areas with deforestation (Fig.2-3), further favoring the contact of wild and vector reservoirs with people and dogs. In addition, the presence of shrubs, weeds and the accumulation of organic matter is frequent in backyards and in vacant lots close to homes. These environmental changes caused by humans generate an increase in the amount of decomposing organic matter that, associated with the precariousness of sanitary conditions, favors the sandfly life cycle, and contributes to the expansion of the disease (Aversi-Ferreira et al. 2014, Teles et al. 2015). In fact, the influence of anthropic actions on the epidemiology of VL has been reported in studies carried out in the Northeast region of Brazil. Cerbino Neto et al. (2009), in a study on human VL in Teresina/PI, and Cesse et al. (2001), in the city of Petrolina/PE, observed a higher occurrence of the disease in peripheral areas of the cities with rapid and recent urban occupation, demonstrating the presence of VL associated to environmental changes due to the anthropic action.

Associated with environmental conditions, most of the dog guardians in the Frei Damião neighborhood had an income of less than two minimum salaries and, according to the World Health Organization (WHO 2017b), leishmaniasis is strongly associated to the lack of financial resources, being known as a disease which affects low-income populations. In Belo Horizonte, Southeast Brazil, human VL was correlated with low family income (Araújo et al. 2013), and this characteristic was even pointed out as an associated factor for the occurrence of canine disease (Coura-Vital et al. 2011).

The highest proportion of positive dogs in the Frei Damião neighborhood (26.40%) in relation to the São Sebastião neighborhood (9.18%) was probably due to the canine survey and the euthanasia of positive dogs rallied shortly after the occurrence of the case as recommended by the PVCLV. The canine survey was also carried out in the Nossa Senhora de Fátima neighborhood (9.30%), and a cohort study was indicated to ascertain the incidence and real risk of becoming ill due to visceral leishmaniasis in the neighborhoods of Santa Luzia.

Another associated factor to urban area was the breeding of dogs on a semi-domestic basis, in which dogs roam freely on the street for part of the day. This is a common practice in the region, where guardians let their dogs loose all day, locking them up only at night around the premises of the house. Most guardians release the dogs in the late afternoon and early evening, a period of milder weather, but which corresponds to the greater activity of the vector *Lutzomyia longipalpis*, which presents twilight and nocturnal habits (Brasil 2014). Fernandes et al. (2016) and Costa et al. (2018) also found this association, and Belo et al. (2013) observed that the chances of acquiring *Leishmania* sp. it is lower in strictly domestic animals. Veloso et al. (2021) indicate that some peridomestic characteristics, such as the absence of barriers that allow dogs free access to the street, can contribute to the maintenance of the infection cycle in urban areas.

In the rural area, the dog's permanence in spaces with areas containing both natural soil and waterproofed with cement was identified as an associated factor, a result also found by Fernandes et al. (2016). Raising animals in these conditions can make it difficult to clean the area and favor the accumulation of organic matter, which promotes an ideal habitat for the oviposition and proliferation of the vector. Garbage can also attract synanthropic animals, such as rodents, which have already been identified as possible

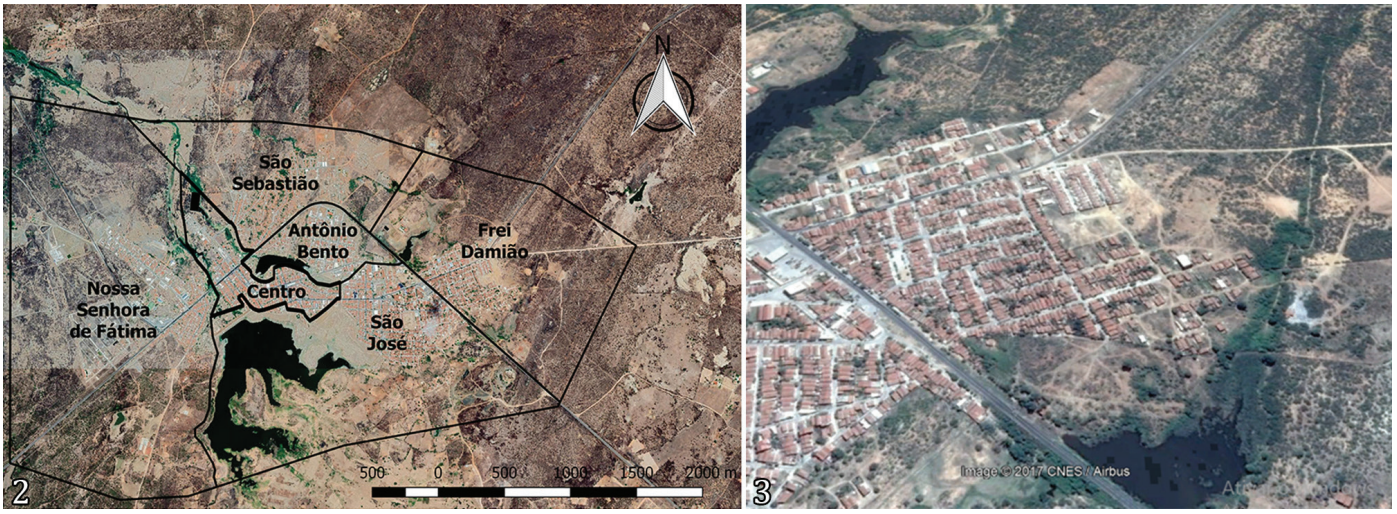


Fig.2-3. (**2**) Satellite image of the municipality of Santa Luzia, with the limitation of the neighborhoods. (**3**) Highlight of the Frei Damião neighborhood. Source: adapted from the Google Earth.

reservoirs (Lainson & Rangel 2005), thereby establishing the conditions for maintaining the domestic VL cycle.

According to Dantas-Torres (2009), the lifestyle of the animals is an important associated factor for CVL. Several studies have already shown that habit-related factors, such as guard function and the free access to the streets or exterior of the house, are factors associated to the risk of canine infection, as these expose the animals to a greater contact with the vector (Amóra et al. 2006, Almeida et al. 2012). In this context, the hunting activity may also expose the animals to a greater risk of infection, what happened in the countryside. This activity, common in the Northeast of Brazil, usually occurs at night, being another factor that favors contact with the vector. Maziero et al. (2014) observed in Santa Catarina, South of Brazil, a greater positivity among *Pampas Deerhound*, a Brazilian breed of hunting dog, suggesting that these animals would be more susceptible to the vector, due to the hunting activity in woods and forests. According to Rondon et al. (2008), regions with abundant vegetation favor the development and proliferation of the vector, facilitating canine infection.

Another associated factor for canine infection in countryside was the contact with cattle, which may be related to the presence of the feces of these animals since the sandfly females lay eggs in moist soil rich in organic matter (Troncarelli et al. 2012). Cattle have been associated with leishmaniasis in several other studies, being identified as one of the preferred food sources of *L. longipalpis* in an endemic area of Colombia (Morrison et al. 1993). In addition, the use of insecticides against ectoparasites in this species may favor the transfer of the feeding of sandflies to humans and dogs, increasing the risk of infection (Kolaczinski et al. 2008, Bern et al. 2010). On the other hand, the importance of the bovine species has been controversial, being associated with an increased risk in some studies and decreased in others, warning about the complexity of the effect of cattle breeding in regions endemic for leishmaniasis (Bern et al. 2010).

## CONCLUSIONS

The urbanization of visceral leishmaniasis (VL) occurs in the municipality of Santa Luzia, with epidemiological differences between the urban and rural areas.

Control and prevention measures must be prioritized based on the associated factors identified in each area, maximizing the efficiency of the program, and minimizing the chance of new cases.

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