Acta Tropica 125 (2013) 262–268

Contents lists available at SciVerse ScienceDirect

Acta Tropica

journal homepage: www.elsevier.com/locate/actatropica

Study of sand flies (Diptera: Psychodidade) in visceral and cutaneous leishmaniasis areas in central western of Minas Gerais state – Brazil

Bruno Warlley Leandro Nascimento[a], Lara Saraiva[a], Rafael Gonçalves Teixeira Neto[a], Paula Cavalcante Lamy Serra e Meira[a], Cristiani de Castilho Sanguinette[a], Gabriel Barbosa Tonelli[a], Helbert Antônio Botelho[d], Vinícius Silva Belo[b], Eduardo Sérgio da Silva[c], Célia Maria Ferreira Gontijo[d], José Dilermando Andrade Filho[a,*]

[a] *Centro de Referência Nacional e Internacional para Flebotomíneos – Centro de Pesquisas René Rachou/FIOCRUZ, Avenida Augusto de Lima, 1715 Barro Preto, CP 1743, CEP: 30190-002 Belo Horizonte, MG, Brazil*
[b] *Escola Nacional de Saúde Pública-ENSP/FIOCRUZ. CEP: 21041-210, Rua Leopoldo Bulhões, 1480 Manguinhos, Rio de Janeiro, RJ, Brazil*
[c] *Universidade Federal de São João del Rei/Campus Dona Lindu. CEP: 35501-296. Av. Sebastião Gonçalves Coelho, 400 Chanadour, Divinópolis, MG, Brazil*
[d] *Laboratório de Leishmanioses–Centro de Pesquisas René Rachou/FIOCRUZ, Avenida Augusto de Lima, 1715 Barro Preto, CEP: 30190-002 Belo Horizonte, MG, Brazil*

ARTICLE INFO

Article history:
Received 8 August 2012
Received in revised form 30 October 2012
Accepted 11 November 2012
Available online 21 November 2012

Keywords:
Sand flies
Leishmaniasis
Lutzomyia longipalpis
Divinópolis city

ABSTRACT

The transmission of *Leishmania* involves several species of sand flies that are closely associated with various parasites and reservoirs, with differing transmission cycles in Brazil. A study on the phlebotomine species composition has been conducted in the municipality of Divinópolis, Minas Gerais, Brazil, an endemic area for cutaneous leishmaniasis (CL), which has intense occurrence of visceral leishmaniasis (VL) cases. In order to study the sand flies populations and their seasonality, CDC light traps (HP model) were distributed in 15 houses which presented at least one case of CL or VL and in five urban parks (green areas). Collections were carried out three nights monthly from September 2010 to August 2011. A total of 1064 phlebotomine specimens were collected belonging to two genera and seventeen species: *Brumptomyia brumpti, Lutzomyia bacula, Lutzomyia cortelezzii, Lutzomyia lenti, Lutzomyia sallesi, Lutzomyia longipalpis, Lutzomyia migonei, Lutzomyia intermedia, Lutzomyia neivai, Lutzomyia whitmani*, *Lutzomyia christenseni, Lutzomyia monticola, Lutzomyia pessoai, Lutzomyia aragaoi, Lutzomyia brasiliensis, Lutzomyia lutziana*, and *Lutzomyia sordellii. L. longipalpis*, the main vector of *Leishmania infantum* in Brazil, was the most frequent species, accounting for 76.9% of the total, followed by *L. lenti* with 8.3%, this species is not a proven vector. Green and urban areas had different sand flies species composition, whereas the high abundance of *L. longipalpis* in urban areas and the presence of various vector species in both green and urban areas were also observed. Our data point out to the requirement of control measures against phlebotomine sand flies in the municipality of Divinópolis and adoption of strategies aiming entomological surveillance.

1. Introduction

The leishmaniasis are the most severe and common sand fly-borne diseases. The phlebotomine sand flies are notorious vectors of human diseases caused by *Leishmania* (Young and Duncan, 1994). Over the last decade, the number of cases and the geographical spread of visceral and cutaneous leishmaniasis has increased considerably within Brazil. Currently, the disease constitutes one of the most serious problems faced by the public health authorities (Brasil, 2006).

Visceral leishmaniasis (VL) is the most severe form of the disease owing to its high mortality rate. VL presents peri-urban and urban patterns of occurrence in many Brazilian cities including Belo Horizonte, Campo Grande, São Luís, and Teresina (Silva et al., 2001; Felipe et al., 2011; Soares et al., 2011; Oliveira et al., 2012). Regarding about the 27 Brazilian states, 19 have reported autochthonous VL cases. Recently, the expansion of the disease has been observed in the Amazon basin as a result of human activities such as deforestation, establishment of field plantations, mining, and new settlements (Silva-Nunes et al., 2008).

Cutaneous leishmaniasis (CL) is a disease with a range of etiological agents, reservoirs, vectors and transmission patterns. Comprehension about this zoonotic disease is still limited in certain

* Corresponding author Tel.: +55 31 3349 7756; fax: +55 31 3349 7795.
E-mail addresses: brunowarlley@hotmail.com (B.W.L. Nascimento), delphinapteruslara@gmail.com (L. Saraiva), rafaelgtn@cpqrr.fiocruz.br (R.G.T. Neto), paula-lamy@hotmail.com (P.C.L.S.e. Meira), cristianics@hotmail.com (C.d.C. Sanguinette), tonelli.gabriel@gmail.com (G.B. Tonelli), helbert.bio@hotmail.com (H.A. Botelho), viniciusbelo4@hotmail.com (V.S. Belo), silvaedu@ufsj.edu.br (E.S.d. Silva), gontijo@cpqrr.fiocruz.br (C.M.F. Gontijo), jandrade@cpqrr.fiocruz.br (J.D.A. Filho).

0001-706X
http://dx.doi.org/10.1016/j.actatropica.2012.11.005

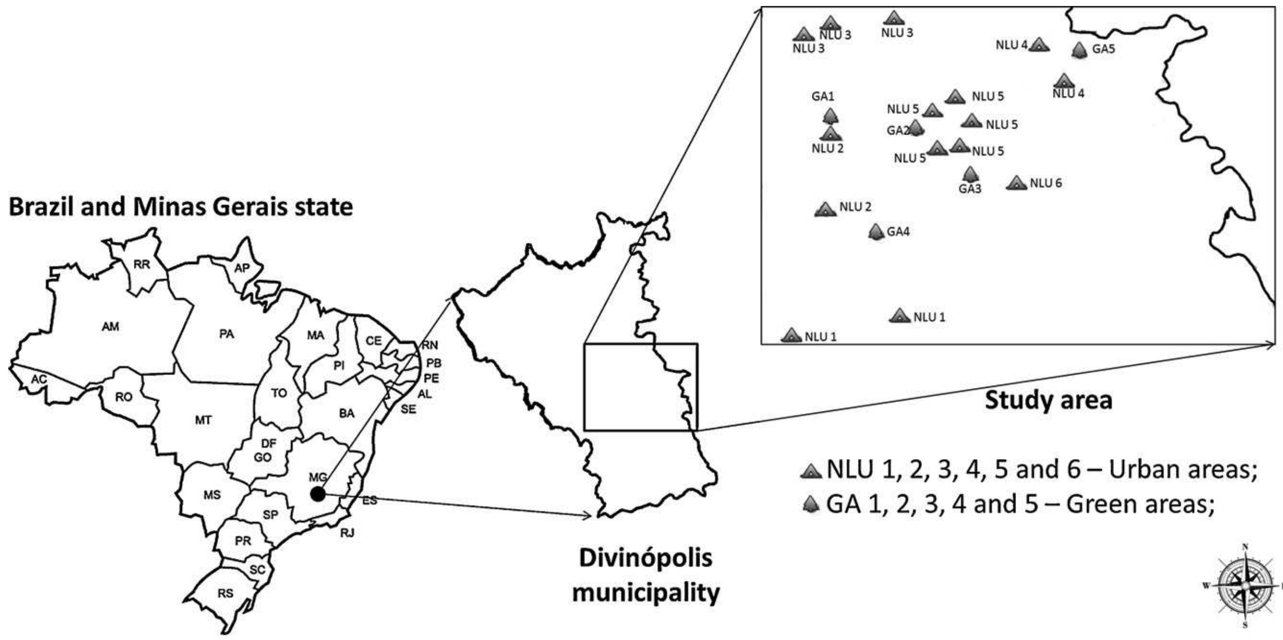

Fig. 1. Divinópolis municipality map, showing the collection places of sand flies – NLU 1 to NLU 6 – Urban localities, GA: Green areas—from September 2010 to August 2011.

aspects, which makes it difficult to control. World Health Organization considers CL one of the six most important infectious diseases due to its high detection rates and the potential to cause deformities in patients (World Health Organization, 2010).

The zoonosis is widely disseminated in Brazil, which reports cases in all regions. From 1985 to 2005, there was an average annual rate of 28,568 autochthonous cases recorded and a medium detection rate of 18.5 cases per 100,000 inhabitants (Brasil, 2007). The first records of CL cases in Minas Gerais state were associated to deforestation to construction of roads and to agricultural activities (Orsini, 1940). However the transmission of the disease in Minas Gerais has changed with outbreaks occurring in rural settlements and in peri-urban and urban areas, as in other Brazilian regions (Lainson, 1989; Brasil, 2007; Gontijo et al., 2002).

An important aspect of the leishmaniasis in Brazil is the adaptation of proven vectors of different species of *Leishmania* to urban areas of many municipalities. For instance *Lutzomyia longipalpis* (Lutz & Neiva, 1912), the main vector of *Leishmania infantum*, *Lutzomyia intermedia* (Lutz & Neiva, 1912) and *Lutzomyia whitmani* (Antunes & Coutinho, 1939) vectors of *Leishmania braziliensis* are commonly collected in urban areas (Barata et al., 2005; Gontijo et al., 2005; Carvalho et al., 2009; Saraiva et al., 2011).

Divinópolis municipality is considered an endemic region of CL. In the 1990 decade 135 human cases of American cutaneous leishmaniasis were reported. From 2000 to 2011, 52 cases were recorded by Health Authorities (DEDCH, 2012). Considering the occurrence of VL in the municipality, four cases were registered in 2011. According to the classification of Ministry of Health in Brazil for areas to surveillance and control of visceral leishmaniasis, the Divinópolis is ranked as a moderated transmission area whereas the average number of VL human cases was between 2.4 and 4.4 cases in the last five years. Until now, 21 species of sand flies were reported in the municipality of Divinópolis (Andrade Filho et al., 2008; Margonari et al., 2010).

This classification indicates the necessity of epidemiological surveillance measures with respect to VL, once other cities in Minas Gerais state have had the same historical profile, currently are areas of intense transmission of VL, for instance Belo Horizonte and Santa Luzia municipalities (PBH, 2011).

Disorganized growth of Divinópolis can favor the proximity of suburban areas and areas of residual forest. This fact can promote the occurrence of transmission cycles of leishmaniasis. Nevertheless there are no concluded studies on the epidemiology of leishmaniasis in the municipality. As stated by Silva et al. (2001) several zoonoses have assumed increasing public health importance due to their urbanization. However these urban rates have increased without the incidence of the diseases being reduced in rural areas. Alterations in rural environments and the constant migratory movements of the population to the periphery of cities have facilitated this process.

The aim of this study was to provide information about the diversity, abundance and seasonality of sand flies vectors in the municipality, focusing the development of control measures well targend and entomological surveillance.

2. Materials and methods

2.1. Study area

Divinópolis has 213,000 inhabitants in a total area of 708 km^2 (IBGE, 2011). The municipality coordinates are 20° 8′21″S e 44° 53′17″W, the altitude ranges from 600 to 850 m above sea level. Divinópolis is located in the metallurgical zone, in the region called “Alto São Francisco River” in Minas Gerais state, Brazil (Fig. 1). The municipality benefits from a humid subtropical climate (Cwa – Koppen climate classification), warm weather with a distinctly dry winter. The average annual temperature is 16 °C and an average rainfall varies from 1200 to 1700 mm/year. The average annual humidity of the air varies around 72%. The predominant vegetation in the municipality is the Brazilian Savannah called “Cerrado”. Main degradation factors in the area include the pastoral activity, due to the extensive cattle raising, and the urban occupation (SEPLAN/PMD, 1998).

2.2. Sample collection and identification of phlebotomines

Sampling was performed every month between September 2010 and August 2011, using CDC light traps, HP model (Pugedo et al., 2005) located in fifteen houses and in five green areas.

Table 1
Collected sand flies per species, sex and area of study (urban and green areas) in Divinópolis municipality from September 2010 to August 2011.

Species	Total of collected specimens per sex (%)		Total of collected specimens per area (%)		Total (%)
	♀	♂	Urban	Green	
Brumptomyia brumpti	–	5 (0.5)	–	5 (0.5)	5 (0.5)
Lutzomyia aragaoi	13 (1.2)	10 (0.9)	3 (0.3)	20 (1.9)	23 (2.2)
Lutzomyia bacula	1 (0.1)	–	–	1 (0.1)	1 (0.1)
Lutzomyia braziliensis	1 (0.1)	1 (0.1)	1 (0.1)	1 (0.1)	2 (0.2)
Lutzomyia christenseni	2 (0.2)	–	–	2 (0.2)	2 (0.2)
Lutzomyia cortelezzii	1 (0.1)	13 (1.2)	14 (1.3)	–	14 (1.3)
Lutzomyia intermedia	–	4 (0.4)	–	4 (0.4)	4 (0.4)
Lutzomyia lenti	27 (2.5)	61 (5.7)	4 (0.4)	84 (7.9)	88 (8.3)
Lutzomyia longipalpis	100 (9.4)	718 (67.5)	812 (76.3)	6 (0.6)	818 (76.9)
Lutzomyia lutziana	2 (0.2)	2 (0.2)	1 (0.1)	3 (0.3)	4 (0.4)
Lutzomyia migonei	1 (0.1)	–	–	1 (0.1)	1 (0.1)
Lutzomyia monticola	4 (0.4)	2 (0.2)	3 (0.3)	3 (0.3)	6 (0.6)
Lutzomyia neivai	3 (0.3)	5 (0.5)	1 (0.1)	7 (0.7)	8 (0.8)
Lutzomyia sallesi	23 (2.2)	7 (0.7)	28 (92.6)	2 (0.2)	30 (2.8)
Lutzomyia sordelli	2 (0.2)	2 (0.2)	3 (0.3)	1 (0.1)	4 (0.4)
Lutzomyia pessoai	–	1 (0.1)	1 (0.1)	–	1 (0.1)
Lutzomyia whitmani	18 (1.7)	35 (3.3)	20 (1.9)	33 (3.1)	53 (5.0)
Total (%)	198 (18.6)	866 (81.4)	891 (83.7)	173 (16.3)	1064 (100)

The sampling sites comprised 15 residences in which at least one human case of VL or CL was reported in 2009, and five segments of green areas located in the city, called urban parks.

The analyses were performed by grouping the urban sampling sites according to geographical proximity on six areas: NLU1 (two traps), NLU2 (two traps), NLU3 (three traps), NLU4 (two traps), NLU5 (five traps), NLU6 (one trap). Green areas were analyzed together (ten traps) (Fig. 1). This procedure has been made to enhance the analytical power. The comparison between the areas was carried out through the average number of collected sand flies specimens since the number of traps in each area was different.

A total of 25 traps were employed, with one trap in each residence and two in each green area. The traps were exposed between 6:00 p.m. and 06:00 a.m. during three nights of collection. Sampling time per trap was 432 h and the total sampling hours was 10,800. Trapped specimens were identified according to the classification proposed by Young and Duncan (1994).

2.3. Analyses

Data were organized through Excell 97/2003 which was used to the descriptive statistics. Graph Pad Prisma 4.0 was used for statistical analyses. The climatological data were obtained from the Health Secretary of Divinópolis Muncipality.

3. Results

Phlebotomine specimens belonging to eight genera and seventeen species were collected and identified: sixteen species of *Lutzomyia* i.e. *Lutzomyia bacula* (Martins, Falcão & Silva, 1965), *Lutzomyia. cortelezzii* (Brèthes, 1923), *Lutzomyia lenti* (Mangabeira, 1938), *Lutzomyia sallesi* (Galvão & Coutinho, 1939); *L. intermedia* (Lutz & Neiva, 1912), *Lutzomyia. neivai* (Pinto, 1926), *L. whitmani* (Antunes & Coutinho, 1939), *Lutzomyia christenseni* (Young & Duncan, 1994), *Lutzomyia monticola* (Costa Lima, 1932), *Lutzomyia pessoai* (Coutinho & Barretto, 1940), *Lutzomyia aragaoi* (Costa Lima, 1932), *Lutzomyia brasiliensis* (Costa Lima, 1932), *Lutzomyia lutziana* (Costa Lima, 1932), *Lutzomyia longipalpis* (Lutz & Neiva, 1912), *Lutzomyia migonei* (França, 1920) and *Lutzomyia sordellii* (Shannon e Del Ponte, 1927). Regarding the other genera, *Brumptomyia*, only one species of genus was collected. Respectively: *Brumptomyia brumpti* (Larrousse, 1920), (Table 1).

A total of 1064 specimens were collected. Urban sites displayed a much higher abundance of phlebotomines than the green areas, respectively 83.7% and 16.3% of the total were collected in each area. *Lutzomyia longipalpis* accounted for 76.9% of the total number of specimens collected, followed by *L. lenti* (8.3%), *L. whitmani* (5.0%), *L. sallesi* (2.8%) and *L. aragaoi* (2.2%). With regard to the ratio of genders 81.4% of the specimens were males and 18.6% were females (Table 1).

Green areas displayed a little higher specific richness of phlebotomines than the urban sites; 15 phlebotomine species were identified; 12 species were collected in urban sites (Table 1). From the total collected in urban areas (891 specimens), 91% (812 specimens) belong to *L. longipalpis* species. This species was mainly collected in urban areas 99.3% of specimens and only 0.7% were collected in green areas. It is important to point out that from the specimens of *L. longipalpis* collected in urban areas 85% come from a single house located in NLU4 (Table 2).

With respect to *L. lenti*, 95.5% (84) of specimens were collected in green areas and 4.5% (4) were collected in urban areas, while *L. whitmani*, 37.7% (20) of the specimens were collected in urban areas and 62.3% (33) in green areas. Some species were collected exclusively in the green areas: *B. brumpti*, *L. bacula*, *L. christenseni*, *L. intermedia*, *L. migonei*. The species *L. cortelezzii* e *L. pessoai* were recorded only in urban areas.

The six urban areas studied showed different patterns of richness and abundance of sand flies species. In the area NLU1, five species were collected with the predominance of *L. sallesi* although *L. longipalpis* was not found at this location.

In the areas NLU 2 and 4, six species were collected with the predominance of *L. longipalpis*. In the area NLU 4, *L. longipalpis* has reached the highest average of specimens collected among all locations of the study. The location NLU 3 had a richness of eight species with the predominance of *L. sallesi*. In the localities NLU 5 and 6, the richness was five and three species, respectively, and the predominant species was *L. longipalpis* in these two areas (Table 2).

Green areas had a richness of 15 species and the predominant ones were: *L. lenti*, *L. whitmani* and *L. aragaoi*, respectively (Table 2). Differences in the proportions of species collected in the two types of environment (urban and green areas) were statistically significant ($p < 0.0001$) (Table 3).

The curve representing the seasonal variation in the numbers of sand flies captured (Fig. 2) peaked in April and May 2011. *L. whitmani* and *L. longipalpis* were the only species collected in all months of the study, *L. sallesi* has not been collected only in July. The presence of a greater number of phlebotomines coincided with the periods during and after the rainfalls, which were characterized by higher relative humidity and milder temperatures.

Table 2
Average of collected specimens per light trap in each area of study in Divinópolis municipality from September 2010 to August 2011.

Collected species	Places of collection													
	NLU1		NLU2		NLU3		NLU4		NLU5		NLU6		Green areas	
	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
Brumptomyia brumpti	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Lutzomyia aragaoi	–	–	–	–	1	–	–	–	–	–	–	–	2	2
Lutzomyia bacula	–	–	–	–	–	–	–	–	–	–	–	–	0.2	–
Lutzomyia braziliensis	–	–	–	0.5	–	–	–	–	–	–	–	–	0.2	–
Lutzomyia christenseni	–	–	–	–	–	–	–	–	–	–	–	–	0.4	–
Lutzomyia cortelezzii	–	–	–	1.5	–	–	–	1.5	0.2	1.4	–	–	–	–
Lutzomyia intermedia	–	–	–	–	–	–	–	–	–	–	–	–	–	0.8
Lutzomyia lenti	–	0.5	–	–	0.3	0.3	–	0.5	–	–	–	–	5.2	11.6
Lutzomyia longipalpis	–	–	1	4	0.3	0.7	36	310	4.4	11.2	2	27	0.2	1
Lutzomyia lutziana	–	0.4	–	–	0.3	–	–	–	–	–	–	–	0.2	–
Lutzomyia migonei	–	–	–	–	–	–	–	–	–	–	–	–	0.2	–
Lutzomyia monticola	–	–	–	0.3	0.7	–	–	–	–	–	–	–	0.4	0.2
Lutzomyia neivai	–	–	–	–	–	–	–	0.5	–	–	–	––	0.6	0.8
Lutzomyia sallesi	1.5	–	0.5	–	1	0.3	1	1.5	2.6	0.4	–	–	0.2	0.2
Lutzomyia sordelli	0.5	–	–	–	–	–	–	–	–	0.2	–	1	0.2	–
Lutzomyia pessoai	–	–	–	–	–	0.3	–	–	–	–	–	–	–	–
Lutzomyia whitmani	–	0.5	0.5	–	0.3	0.7	3	2	–	0.2	1	3	1.8	4.8

Table 3
Proportion of collected sand flies specimens per species and urban and green areas in Divinópolis muncipality from September 2010 to August 2011.

Studied areas	*L. lenti*	*L. sallesi*	*L. longipalpis*	*L. whitmani*	*L. aragaoi*	Other species
Urban areas	0.4	2.6	76.2	1.9	0.3	2.3
Green areas	7.9	0.2	0.6	3.1	1.9	2.6
Total	8.3	2.8	76.7	5.0	2.2	4.9

P-value < 0.0001, Chi-square test.

4. Discussion

Leishmaniasis are considered eco-epidemiological events extremely complex. Currently, urbanization adds up to this complexity, thus them represent a challenge to global public health. An increase in the number of cases of all forms of leishmaniasis occurred in the world over the past twenty years. Some experts consider them emerging diseases in some areas, and reemerging in others (Ashford, 2000).

Seventeen species of sand flies were collected in the studied area, which represent high species richness while compared to results found in other endemic urban areas for leishmaniasis in Minas Gerais State. For instance nine species of sand flies were collected in a study carried out in Belo Horizonte city and exclusively seven species were collected in the city of Santa Luzia (Carvalho et al., 2010; Saraiva et al., 2011).

From the 17 collected species, seven are proven or suspicious vectors of *Leishmania*. The main vector of *L. infantum*, *L. longipalpis*

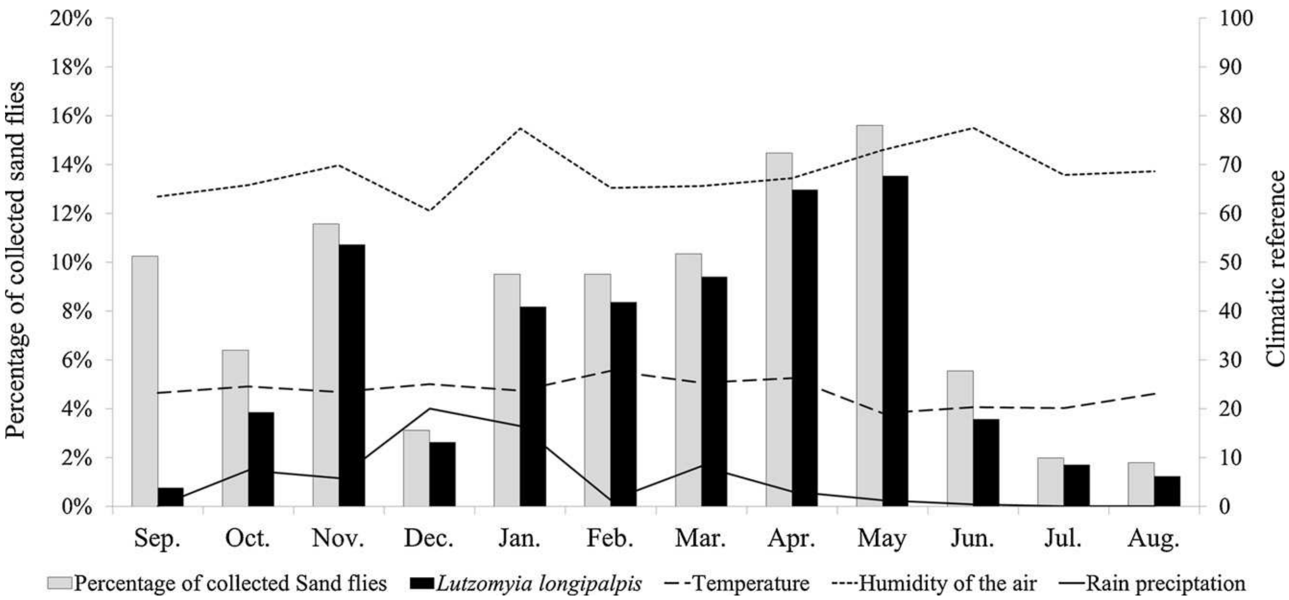

Fig. 2. Monthly amount of phlebotomine species captured in the Divinopolis municipality in comparison with the weekly mean of temperature, total rainfall and mean relative humidity of the air from September 2010 to August 2011.

was the most abundant species (76.9%). The species *L. intermedia* (0.4%), *L. neivai* (0.8%), *L. whitmani* (5.0%), and *L. migonei* (0.1%) were collected in small amount of numbers, all of them are related to the *L. braziliensis* transmission (Pita-Pereira et al., 2005; Andrade Filho et al., 2007; Costa et al., 2007).

Gender ratio represented 84.6% of males and 18.6% of females. These numbers can be understood considering the behavior of theses insects during feeding and copulation. Males are active on searching for hosts. After finding them, the males release sexual pheromones which attract females (Brazil and Brazil, 2003).

The highest species richness has occurred in green areas (15 species), however, the highest abundance of specimens have occurred in the peridomiciles (83.7% of the total). This fact illustrates the adaptation of sand flies to anthropically modified environment, where some species are found in high abundance. The adaptability of *L. longipalpis* to the urban environment has been investigated since the decade of 1930, when the cycle of VL started to be elucidated. Presence of this species in peridomiciles and their opportunistic feeding habits were reported (Lainson and Rangel, 2005). One of the determinants of VL urbanization process in the Americas is the adaptability of this vector species to the anthropically modified environment (Lainson, 1989; Lainson and Rangel, 2005, Shaw et al., 2003).

Resende et al. (2006) reported *L. longipalpis* in the intra and peridomiciles from 1997 to 1999 in Belo Horizonte city. In this study, *L. longipalpis* represented 69% of the total collected specimens. Research conducted by Souza et al. (2004), also in Belo Horizonte city, from 2001 to 2003, *L. longipalpis* accounted for 68% of the collected sandflies. *L. longipalpis* was extremely abundant in the peridomiciles (99.3%) whereas few specimens were collected in green areas (0.7%) in Divinópolis municipality. *L. sallesi* is commonly recorded in the Minas Gerais State. This species has been found naturally infected by *L. infantum* (Saraiva et al., 2009), although Mayrink et al. (1979) had previously observed specimens of this species infected with trypanosomatids in eastern region of Minas Gerais state (Martins et al., 1978). In this work 30 specimens of *L.sallesi* were collected, representing 2.8% of the sand flies.

L. cortelezzii has been collected in low numbers (14 specimens) and only in urban areas, however, it is necessary to point out its occurrence, since Carvalho et al. (2008) have found that species infected by *Leishmania (L.) infantum* in the metropolitan region of Belo Horizonte city. Furthermore, in Belo Horizonte city one female of the *cortelezzii* complex was found infected by *L. braziliensis* (Saraiva et al., 2010). Although the authors cannot incriminate these species as a vector in the transmission of *Leishmania*, they do not reject the possibility of this species to be involved in the cycles of CL and VL. Recently, this species were found infected with *L. infantum* in Mato Grosso do Sul state, Brazil (Andrade et al., 2011)

L. lenti represented 8.3% of the collected sand flies, second most abundant species. This finding deserves to be highlighted in view of the fact that this species eagerly bites humans, horses and dogs. Moreover, *L. lenti* has been found naturally infected by promastigotes in Jacobina city, Bahia state (Sherlock, 1996). Recently, in Divinópolis municipality, natural infection of *L. lenti* by *L. braziliensis* it been reported in a study using molecular biology techniques (Margonari et al., 2010). It is valuable to mention that the last study was conducted in the Gafanhoto Park, one of the green areas that have taken part of the present study. Therefore, the possible epidemiological role of *L. lenti* needs to be clarified.

L. aragaoi accounted for 2.2% of the sand flies. The highest abundance occurred in green areas and a few specimens in peridomestic area. This species has already been found naturally infected by *Leishmania* sp. Margonari et al. (2010) in a study carried out in a green area (Gafanhoto Park) in Divinópolis municipality.

L. whitmani has a wide geographic distribution and high level of adaptation to various ecological niches with populations displaying different behavioral patterns. This species inhabits primary forest areas in the Amazon region, regions of remaining forests and peridomiciliary areas in northeastern and southeastern Brazil (Rangel et al., 1996). Several authors have shown high abundance of *L. whitmani* in the peridomicile, especially in southeastern Brazil (Brazil et al., 2006). This species is considered one of the main vectors of the etiological agent of cutaneous leishmaniasis in many regions of Brazil (Queiroz et al., 1994; Teodoro et al., 1991).

Ryan et al. (1990) have isolated and characterized specimens of *L. whitmani* naturally infected by *L. braziliensis*. Carvalho et al. (2008) have found *L. whitmani* naturally infected by *L. (Viannia)* spp. using molecular techniques. Saraiva et al. (2010) and Margonari et al. (2010) have reported the infection of *L. whitmani* by *L. infantum* also employing molecular methods.

Twenty specimens of *L. whitmani* were captured in the peridomestic area in Divinópolis municipality. This fact might indicate a tendency to urbanization of this species. According to some authors, this species shows a pattern of peridomestic colonization already acknowledged (Leonardo and Rebêlo, 2004). Nevertheless, recent researches suggest the urbanization of *L. whitmani* (Souza et al., 2005; Carvalho et al., 2006; Teodoro et al., 2003; Saraiva et al., 2011).

L. intermedia represented 0.4% of the total of collected specimens. This species was collected exclusively in green areas. Occurrence of *L. intermedia* merits to be discussed due to its epidemiological importance, especially in the Southeast of Brazil (Andrade Filho et al., 2007; Marcondes et al., 1997). Lutz and Neiva (1912) have registered a high frequency of *L. intermedia* in residences in the description of the species. This species has been found naturally infected by *L. braziliensis* (Rangel et al., 1996) and it is incriminated to transmit *L. braziliensis* in several localities of Brazil (Andrade Filho et al., 2003; 2007; Gontijo et al., 2002; 2005).

L. neivai accounted for 0.8% of the total of sand flies. Only a single specimen was collected in the urban area in the present study. This species is related to *L.* (*Viannia*) *braziliensis* transmission in Brazil (Queiroz et al., 1991; Luz et al., 2000; Andrade Filho et al., 2007). Saraiva et al. (2009) reported the natural infection of *L. neivai* by *L. infantum* in the northern of Minas Gerais state, whereas Margonari et al. (2010), reported this species naturally infected by *Leishmania* sp. in a green area (Gafanhoto Park) in Divinópolis municipality.

One specimen of *L. migonei* and one of *L. pessoai* were collected in this study. Despite the low abundance, it is important to report that the former was incriminated as the vector of *L. braziliensis* and occurs frequently in foci of CL (Queiroz et al., 1994; Pita-Pereira et al., 2005; Rangel and Lainson, 2003; Saraiva et al., 2006). The latter species is anthropophilic and presents high density in endemic regions for CL and has been found naturally infected by promastigote forms considered as *Leishmania* (Pessôa and Coutinho, 1940).

Forattini (1960) studied the seasonal variation of sand flies and verified that in warm and humid months (From December to February), the number of captured specimens was higher, while in colder and drier months (From June to August), the population density became considerably reduced. The same seasonal profile was reported by Barata et al. (2004) in the municipality of Porteirinha, Minas Gerais state, an endemic area for CL.

The pattern of seasonal occurrence of phlebotomine species in the study area was basically determined by the numbers of *L. longipalpis* captured. Collection peaks were observed after periods of intense rainfall and the abundance of sand flies have increased during the following months (from January to May), with a trend to decrease during the colder and drier months. The low number of specimens collected in December might be explained by the fact that immature stages of the sand flies does not develop in drenched places (Lainson, 1982).

Souza et al. (2004) have observed that *L. longipalpis* and *L. whitmani* undergo notable increases in the populations after rainy periods (March and April) in an endemic area for cutaneous and visceral leishmaniasis in the state of Minas Gerais. This fact can be explained by favorable environmental conditions of the microhabitats.

Sherlock (1996) reported a higher occurrence of *L. longipalpis* in both the warmest and the coldest rainy months. These authors have established a correlation among the seasonal occurrence of *L. longipalpis*, human cases of VL and the peridomestic frequency of opossums which demonstrates the importance of knowing the seasonal profile of vector species in each locality.

It is worth paying attention to high percentage of specimens of *L. longipalpis* (84.6%) collected in the locality NLU4. The collection place was a hen house which was used to hang up the trap. Although domestic hens does not have ability to be infected by *Leishmania* and do not act as reservoirs of this parasite. These animals represent an important bond in the epidemiological chain of the VL since they constitute a source of supply to females of *L. longipalpis* (Alexander et al., 2002).

Environmental surveillance based on arthropod vectors provides bases for appropriate interventions in controlling diseases. Indicators delineated by vectors surveillance need to consider the diversity of enzootic activity, the abundance of the species and their rates of natural infection (Gomes, 2002). Regarding to these aspects, the important presence of *L. longipalpis* and species vectors of *L. braziliensis* point out to the necessity to elaborate an intensive entomological surveillance for prevention and control of visceral and cutaneous leishmaniasis in the municipality of Divinópolis.

Acknowledgements

The authors are grateful to the community of the Divinópolis for their collaboration in the field sampling process. The authors are indebted to CAPES, FAPEMIG and CNPq for scholarships. Technical support from LALEI CRNIF/FIOCRUZ and UFSJ/CCO are gratefully acknowledged.

References

Alexander, B., Carvalho, R.L., McCallum, H., Pereira, M.H., 2002. Role of the domestic chicken (*Gallus gallus*) in the epidemiology of urban visceral leishmaniasis in Brazil. Emerg Infect Diseases 8, 1480–1485.

Andrade, A.R.O., Dorval, M.E.M.C., Andrade, S.M.O., Marques, A., Júnior, M.S.C.L., Silva, B.A.K., Andreotti, R., 2011. First report of natural infection of phlebotomines for Leishmania (Leishmania) chagasi captured in Ponta Porã, on the border between Brazil and Paraguay. Asian Pacific J. Trop. Disease 1, 253–258.

Andrade Filho, J.D., Galati, E.A.B., Falcão, A.L., 2003. Redescription of *Nyssomyia intermedia* (Lutz & Neiva, 1912) and *Nyssomyia neivai* (Pinto, 1926) (Diptera: Psychodidae). Memorias do Instituto Oswaldo Cruz 98, 1059–1065.

Andrade Filho, J.D., Oliveira, R.C., Fonseca, A.R., 2008. Flebotomíneos (Diptera: Psychodidae) Coletados com Armadilha Malaise no Centro-Oeste de Minas Gerais. Neotrop. Entomol. 37 (1), 104–106.

Andrade Filho, J.D., Galati, E.A.B., Falcão, A.L., 2007. Nyssomyia intermedia (Lutz & Neiva, 1912) and Nyssomyia neivai (Pinto, 1926) (Diptera: Psychodidae: Phlebotominae) geographical distribution and epidemiological importance. Memorias do Instituto Oswaldo Cruz 102, 481–487.

Ashford, R.W., 2000. The leishmaniasis as emerging and reemerging zoonoses. Int. J. Parasitol. 30, 1269–1281.

Barata, R.A., Franca-Silva, j.C., Costa, R.T., Fortes-Dias, C.L., Silva, J.C., Vieira, E.P., Prata, A., Michalsky, E.M., Dias, E.S., 2004. Phlebotomine sandflies in Porteirinha, an endemic area of American visceral leishmaniasis in the state of Minas Gerais, Brazil. Memórias do Instituto Oswaldo Cruz 99 (5), 481–487.

Barata, R.A., Franca-Silva, J.C., Mayrink, W., Silva, J.C., Prata, A., Lorosa, E.S., Fiúza, J.A., Gonçalves, C.M., Paula, K.M., Dias, E.S., 2005. Aspectos da ecologia e do comportamento de flebotomíneos em área endêmica de leishmaniose visceral, Minas Gerais. Revista da Sociedade Brasileira de Medicina Tropical 38, 421–425.

Brasil, 2006. Ministério da Saúde Manual de Vigilância e Controle da Leishmaniose Visceral.

Brasil, 2007. Ministério da Saúde Manual de Vigilância da Leishmaniose Tegumentar Americana. Editora MS, Brasília.

Brazil, P.P., Brazil, B.G., 2003. Biologia de flebotomíneos neotropicais. In: Rangel, E.F., Lainson, R. (Eds.), Flebotomíneos do Brasil. Fiocruz, Rio de Janeiro, pp. 257–274.

Brazil, R.P., Passos, W.L., Fuzari, A., Falcão, A.L., Andrade Filho, J.D., 2006. The peridomiciliar sand fly fauna (Diptera:Psychodidae) in areas of cutaneous leishmaniasis in Além Paraiba, Minas Gerais, Brazil. J. Vector Ecol. 31, 418–420.

Carvalho, G.M.L., Brazil, R.P., Falcão, A.L., Andrade Filho, J.D., 2009. Distribuição geográfica do complexo cortelezzii (Diptera: Psychodidae: Phlebotominae) no Brasil. Neotrop. Entomol. 38, 876–879.

Carvalho, G.M.L., Gontijo, C.M.F., Falcão, A.L., Andrade Filho, J.D., 2010. Study of phlebotomine sand flies (Diptera: Psychodidae) collected in a *Leishmania*-endemic area of the metropolitan region of Belo Horizonte, Brazil. J. Med. Entomol. 47 (6), 972–976.

Carvalho, M.L., Andrade Filho, J.D., Falcão, A.L., Rocha Lima, A.C.V.M., Gontijo, C.M.F., 2008. Naturally Infected Lutzomyia sand ßies in a leishmania-endemic area of Brazil. Vector Borne and Zoonotic Disorder 8, 407–414.

Carvalho, G.M.L., Falcão, A.L., Andrade Filho, J.D., 2006. Taxonomic revision of phlebotomine sand fly species in the series davisi and panamensis of the subgenus Psychodopygus Mangabeira, 1941 (Diptera: Psychodidae: Phlebotominae). Memórias do Instituto Oswaldo Cruz 101, 129–136.

Costa, S.M., Cechinel, M., Bandeira, V., Zanuncio, J.C., Lainson, R., Rangel, E.F., 2007. *Lutzomyia* (Nyssomyia) *whitmani* s.l. (Antunes & Coutinho, 1939) (Diptera: Psychodidae: Phlebotominae): geographical distribution and the epidemiology of American cutaneous leishmaniasis in Brazil—mini-review. Memórias do Instituto Oswaldo Cruz 102, 149–153.

DEDCH – Department of Epidemiology, Divinópolis City Hall, 2012. Leishmaniasis records. DEDCH, Divinópolis, Brazil.

Felipe, I.M., Aquino, D.M., Kuppinger, O., Santos, M.D., Rangel, M.E., Barbosa, D.S., Barral, A., Werneck, G.L., Caldas, A.J., 2011. Leishmania infection in humans, dogs and sandflies in a visceral leishmaniasis endemic area in Maranhão, Brazil. Memorias do Instituto Oswaldo Cruz 106 (2), 207–211.

Forattini, O.P., 1960. Novas observações sobre a biologia de flebótomos em condições naturais (Diptera: Psychodidae). Arq Hig Saude Publica 25, 209–221.

Gomes, A.C., 2002. Vigilância Entomológica 11 (2), 79–90.

Gontijo, C.M.F., Silva, E.S., Fuccio, M.B., Souza, M.C.A., Pacheco, R.S., Dias, E.S., Andrade Filho, J.D., Brazil, R.P., Melo, M.N., 2002. Epidemiological studies of an outbreak of cutaneous leishmaniasis in the Rio Jequitinhonha Valley, Minas Gerais, Brazil. Acta Tropica 81, 43–50.

Gontijo, C.M.F., Silva, E.S., Pacheco, R.S., Dias, E.S., Oliveira, F.S., Michalsky, E.M., Margonari, C.S., Melo, M.N., 2005. Molecular epidemiology of cutaneous leishmaniasis in the municipality of Araçuaí, Minas Gerais state, Brazil. Rev. Soc. Iberoam. Inform. Cient (SIIC).

IBGE – Instituto Brasileiro de Geografia e Estatística, 2011. Cidades@ IBGE.

Lainson, R., 1989. Demographic changes and their influence on the epidemiology of the American leishmaniasis. In: Service, M.W. (Ed.), Demography of Vector-borne Diseases. CRC Press, Boca Raton, FL, pp. 85–106.

Lainson, R., Rangel, E.F., 2005. Lutzomyia longipalpis and the ecoepidemiology of American visceral leishmaniasis, with particular reference to Brazil: a review. Memorias do Instituto Oswaldo Cruz 100, 811L 827.

Lainson, R., 1982. The American leishmaniasis: some observations on their ecology and epidemiology. Roy. Soc. Trop. Med. Hyg. 77, 569–596.

Leonardo, F.S., Rebêlo, J.M.M., 2004. A periurbanização de *Lutzomyia whitmani* em área de foco de leishmaniose cutânea, no Estado do Maranhão, Brasil. Revista da Sociedade Brasileira de Medicina Tropical 37, 282–284.

Lutz, A., Neiva, A., 1912. Contribuição para o conhecimento das espécies do gênero *Phlebotomus* existentes no Brasil. Memorias do Instituto Oswaldo Cruz 4, 84–95.

Luz, E., Membrive, N., Castro, E.A., Dereure, J., Pratlong, E., Dedety, A., Pandey, A., 2000. Soccol T. *Lutzomyia whitmani* (Diptera: Psychodidae)as vector of *Leishmania* (V.) *braziliensis* in Paraná State, southern Brazil. Ann Trop Med. Parasitol. 94, 623–631.

Marcondes, C.B., Day, J.R., Ready, P.D., 1997. Introgression between *Lutzomyia intermedia* and both *Lu. neivai* and Lu.*whitmani*, and their role as vectors of *Leishmania braziliensis*. Trans. Roy. Soc. Trop. Med. Hyg. 91 (6), 125–126.

Margonari, C., Soares, R.P., Andrade Filho, J.D., Xavier, D.C., Saraiva, L., Fonseca, A.L., Silva, R.A., Oliveira, M.E., Borges, E.C., Sanguinette, C.C., Melo, M.N., 2010. Phlebotomine sand flies (Diptera: Psychodidae) and *Leishmania* infection in Gafanhoto Park, Divinópolis, Brazil. J. Med. Entomol. 47 (6), 1212–1219.

Martins, A.V., Williams, P., Falcão, A.L., 1978. American Sand Flies (Diptera: Psychodidae: Phlebotominae). Editora da Academia Brasileira de Ciências, Rio de Janeiro, 195 pp.

Mayrink, W., Williams, P., Coelho, M.V., Dias, M., Martins, A.V., Magalhães, P.A., Costa, C.A., Falcão, A.R., Melo, M.N., Falcão, A.L., 1979. Epidemiology of dermal leishmaniasis in the Rio Doce Valley, State of Minas Gerais, Brazil. Ann. Trop. Med. Parasitol. 73, 123–137.

Oliveira, E.F., Silva, E.A., Fernandes, C.E., Paranhos Filho, A.C., Gamarra, R.M., Ribeiro, A.A., Brazil, R.P., Oliveira, A.G., 2012. Biotic factors and occurrence of *Lutzomyia longipalpis* in endemic area of visceral leishmaniasis, Mato Grosso do Sul, Brazil. Memorias do Instituto Oswaldo Cruz 107 (3), 396–401.

Orsini, O., 1940. Leishmaniose em Minas Gerais. Brasil Médico 54, 762–765.

Pita-Pereira, D., Alves, C.R., Souza, M.B., Brazil, R.P., Bertho, A.L., de Figueiredo Barbosa, A., Britto, C.C., 2005. Identification of naturally infected Lutzomyia intermedia and Lutzomyia migonei with *Leishmania* (Viannia) *braziliensis* in Rio de Janeiro (Brazil) revealed by a PCR multiplex non-isotopic hybridisation assay. Trans. Roy. Soc. Trop. Med. Hyg. 99, 905–913.

PBH, 2011. Prefeitura de Belo Horizonte - Secretaria Municipal de Saúde-Leishmaniose Visceral–Available in <PBH–Prefeitura Municipal de Saúde–Secretarias–Saúde–Leishmaniose Visceral 2011. Accessed in January 12, 2011.

Available in http://portalpbh.pbh.gov.br/pbh/ecp/comunidade.do?evento=portlet&pIdPlc=ecpTaxonomiaMenuPortal&app=saude&tax=12768&lang=pt_BR&pg=5571&taxp=0&
Pessôa, S.B., Coutinho, J.O., 1940. Infecção natural do Phlebotomus pessoai por formas em leptomonas, provavelmente da Leishmania braziliensis. Revista de Biologia e HIgiene 10, 139–142.
Pugedo, H., Barata, R.A., França-Silva, J.C., Silva, J.C., Dias, E.S., 2005. HP: um modelo aprimorado de armadilha luminosa de sucção para a captura de pequenos insetos. Revista da Sociedade Brasileira de Medicina Tropical 38, 70–72.
Queiroz, R.G., Vasconcelos, I.A.B., Vasconcelos, A.W., Pessoa, F.A.C., Souza, R.N., David, J.R., 1994. Cutaneous leishmaniasis in Ceará state in Northeastern Brazil: incrimination of *Lutzomyia whitmani* (Diptera: Psychodidae) as a vector of *Leishmania braziliensis* in Baturite municipality. Am. J. Trop. Med. Hyg. 50, 693–698.
Queiroz, R.G., Vasconcelos, A.W., Vasconcelos, I.A.B., Sousa, R.N., Pessoa, F.A.C., Alencar, J.E., David, J.R., 1991. Phlebotomine sandfly (Diptera: Psychodidae) fauna survey in an american cutaneous leishmanisis (ACL) focus in Baturité, Ceará State, Northeast Brazil. Parassitologia 33 (Suppl. 1), 159–167.
Rangel, E.F., Lainson, R., 2003. Ecologia das leishmanioses: transmissores de leishmaniose tegumentar americana. In: Rangel, E.F., Lainson, R. (Eds.), Flebotomíneos do Brasil. Editora Fiocruz, Rio de Janeiro, pp. 291–310.
Rangel, E.F., Lainson, R., Souza, A.A., Ready, P.D., Azevedo, A.C.R., 1996. Geographical variation in populations of *Lutzomyia* (Nyssomyia) *whitmani* (Antunes & Coutinho, 1939) (Diptera: Psychodidae: Phlebotominae) In Brazil. Memórias do Instituto Oswaldo Cruz 91, 43–50.
Resende, M.C., Camargo, M.C., Vieira, J.R., Nobi, R.C., Porto, M.N., Oliveira, C.D., Pessanha, J.E., Cunha, M. da C., Brandão, S.T., 2006. Seasonal variation of *Lutzomyia longipalpis* in Belo Horizonte, state of Minas Gerais. Revista da Sociedade Brasileira de Medicina Tropical 39, 51–55.
Ryan, L., Vexenat, A., Marsden, P.D., Lainson, R., Shaw, J.J., 1990. The importance of rapid diagnosis of new cases of cutaneous leishmaniasis in pin-pointing the sandfly vector. Trans. Roy. Soc. Trop. Med. Hyg. 84, 786.
Saraiva, L., Andrade Filho, J.D., Falcão, A.L., Carvalho, D.A.A., Souza, C.M., Freitas, C.R., Lopes, C.R.G., Moreno, E.C., Melo, M.N., 2011. Phlebotominae fauna (Diptera: Psychodidae) in an urban district of Belo Horizonte, Brazil, endemic for visceral leishmaniasis: characterization of favored locations as determined by spatial analysis. Acta Tropica 117, 137–145.
Saraiva, L., Carvalho, G.M., Gontijo, C.M., Quaresma, P.F., Lima, A.C., Falcão, A.L., Andrade Filho, J.D., 2009. Natural infection of *Lutzomyia neivai* and *Lutzomyia sallesi* (Diptera: Psychodidae) by *Leishmania infantum* chagasi in Brazil. J. Med. Entomol. 46, 1159–1163.
Saraiva, L., Andrade Filho, J.D., Silva, S.O., Andrade, A.S.R., Melo, M.N., 2010. The molecular detection of different *Leishmania* species within sand flies from a cutaneous and visceral leishmaniasis sympatric area in Southeastern Brazil. Memórias do Instituto Oswaldo Cruz, Rio de Janeiro 105 (8), 1033–1039.
Saraiva, L., Lopes, J.S., Oliveira, G.B.M., Batista, F.A., Falcão, A.L., Andrade Filho, J.D., 2006. Estudo dos flebotomíneos (Diptera: Psychodidae) em área de leishmaniose tegumentar americana nos municípios de Alto Caparaó e Caparaó, Estado de Minas Gerais. Revista da Sociedade Brasileira de Medicina Tropical 39, 56L 63.
SEPLAN/PMD, 1998. Secretaria municipal de planejamento. Prefeitura de Divinópolis. Available from: http://licht.io.inf.br/mg_mapas/mapa/cgi/iga_comeco1024.htm
Shaw, J., Rosa, A.T., Souza, A., Cruz, A.C., 2003. Os flebotomíneos brasileiros como hospedeiros e vetores de determinadas espécies. In: Rangel, E.F., Lainson, R. (Eds.), Flebotomíneos do Brasil. Fundação Oswaldo Cruz, Rio de Janeiro, pp. 337–351.
Sherlock, I.A., 1996. Ecological interactions of visceral leishmaniasis in the state of Bahia, Brazil. Memorias do Instituto Oswaldo Cruz 91, 671–683.
Silva, E.S., Gontijo, C.M.F., Pacheco, R.S., Fiuza, V.O.P., Brazil, R.P., 2001. Visceral Leishmaniasis in the Metropolitan Region of Belo Horizonte, State of Minas Gerais, Brazil. Memorias do Instituto Oswaldo Cruz 96 (3), 285–291.
Silva-Nunes, M., Cavasini, C.E., Silva, N.S., Galati, E.A.B., 2008. Epidemiology of cutaneous leishmaniasis and description of phlebotomine sand flies populations in the city of Acrelandia, Acre, Brazil. Revista Brasileira de Epidemiologia 11, 241–251.
Soares, M.R., Mendonça, I.L., Bonfim, J.M., Rodrigues, J.A., Werneck, G.L., Costa, C.H., 2011. Canine visceral leishmaniasis in Teresina, Brazil: relationship between clinical features and infectivity for sand flies. Acta Tropica 117 (1), 6–9.
Souza, C.M., Pessanha, J.E., Barata, R.A., Monteiro, E.M., Costa, D.C., Dias, E.S., 2004. Study on phlebotomine sand fly (Diptera: Psychodidae) fauna in Belo Horizonte, state of Minas Gerais, Brazil. Memorias do Instituto Oswaldo Cruz 99, 795–803.
Souza, N.A., Andrade, C.C.A., Peixoto, A.A., Rangel, E.F., 2005. Nocturnal activity rhythms of lutzomyia intermedia and *Lutzomyia whitmani* (Diptera: Psychodidae) in a transmission area of american cutaneous leishmaniasis in Rio de Janeiro State, Brazil. J. Med. Entomol. 42, 986–992.
Teodoro, U.D., Kühl, J.B., Santos, E.S., Santos, D.R., Santos, A.R., Oliveira, O., Silveira, T.G.V., Lonardoni, M.V.C., 2003. Ecologia de *Lutzomyia* (Nyssomyia) *whitmani* (Antunes & Coutinho, 1939) (Diptera, Psychodidae) em área urbana no sul do Brasil. Revista de Saúde Pública/Journal of Public Health 37 (5), 651–656.
Teodoro, U., Salvia Filho, L., Lima, E.M., Misuta, N.M., Silveira, T.G.V., Ferreira, M.E.M.C., 1991. Leishmaniose Tegumentar Americana: flebotomineos de área de transmissão no norte do Paraná, Brasil. Revista de Saúde Pública 25 (2), 129–133.
Young, D.G., Duncan, M.A., 1994. Guide to the identification and geographic distribution of Lutzomyia sand flies in Mexico, the West Indies, Central and South America (Diptera: Psychodidae). Memoirs of the American Entomological Institute 54, 1–881.
WHO- World Health Organization, 2010. Working to overcome the global impact of neglected tropical diseases, 184 p.