The distribution pattern of *Lutzomyia longipalpis* (Diptera: Psychodidae) in the peridomiciles of a sector with canine and human visceral leishmaniasis transmission in the municipality of Dracena, São Paulo, Brazil

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The specimen distribution pattern of a species can be used to characterise a population of interest and also provides area-specific guidance for pest management and control. In the municipality of Dracena, in the state of São Paulo, we analysed 5,889 Lutzomyia longipalpis *specimens collected from the peridomiciles of 14 houses in a sector where American visceral leishmaniasis (AVL) is transmitted to humans and dogs. The goal was to analyse the dispersion and a theoretical fitting of the species occurrence probability. From January-December 2005, samples were collected once per week using CDC light traps that operated for 12-h periods. Each collection was considered a sub-sample and was evaluated monthly. The standardised Morisita index was used as a measure of dispersion. Adherence tests were performed for the log-series distribution. The number of traps was used to adjust the octave plots. The quantity of* Lu. longipalpis *in the sector was highly aggregated for each month of the year, adhering to a log-series distribution for 11 of the 12 months analysed. A sex-stratified analysis demonstrated a pattern of aggregated dispersion adjusted for each month of the year. The classes and frequencies of the traps in octaves can be employed as indicators for entomological surveillance and AVL control.*

Key words: American visceral leishmaniasis - log-series distribution - dispersion index - *Lutzomyia longipalpis*

American visceral leishmaniasis (AVL) is a serious public health problem in Brazil. In the state of São Paulo (SP), the first case was reported in 1999. Since September 2009, there have been 3,720 suspected cases of the disease, of which 1,612 cases were confirmed (SESSP 2010).

In Dracena (SP), *Lutzomyia longipalpis* was first detected in 2003 and canine and human cases have been detected since 2005 (D'Andrea et al. 2009). Actions to control the vector and the reservoir have been directed toward transmission areas. These areas are determined by stratifying the city into sectors or groups of sectors according to the Control Programme of *Aedes aegypti* in SP (MS/SVS 2009).

In AVL transmission areas, light-baited traps (LTs) have been frequently used to detect and monitor the abundance of *Lu. longipalpis* in peridomicile and intradomicile areas. Major contributions to this field of research were made in Araçatuba (SP) by Camargo Neves (2004), in Belo Horizonte, state of Minas Gerais, by Rezende et al. (2006) and in Campo Grande (SP) by Silva et al. (2007). In previous research, several indexes have been used, with the absolute number and the arithmetic mean of the specimens being most frequently used, followed by the distribution of frequencies in percentages and trap indexes. Researchers have demonstrated the importance of the peridomicile as a location with greater specimen abundance compared with intradomicile.

Dispersion indexes and models of theoretical probability distribution contribute to our understanding of the spatial distribution of organisms and can be obtained from counting data. According to published research, an understanding of the habitat of a species is essential (McGill et al. 2007). Such information is necessary for developing the sampling methods used for making surveillance and vector control decisions (Almeida et al. 2006, Costa et al. 2006).

To accommodate the random standards of a species, an analysis of the dispersion index and the probability distribution should be conducted (Maruyama et al. 2002, Almeida et al. 2006, Costa et al. 2006), which has not been reported for *Lu. longipalpis*. The goals of this study are to analyse the dispersion pattern and associate the probability distribution of *Lu. longipalpis* in the peridomiciles of a sector with human and canine AVL transmission in the municipality of Dracena to improve entomological surveillance and vector control.

MATERIALS AND METHODS

Characteristics of the municipality of study - The city of Dracena is considered by the Health Ministry to be an area with a high AVL transmission rate. It is located among the Aquapeí, Peixe and Paraná rivers and is located at latitude 21º28'57"S and longitude 51º1'58"W.

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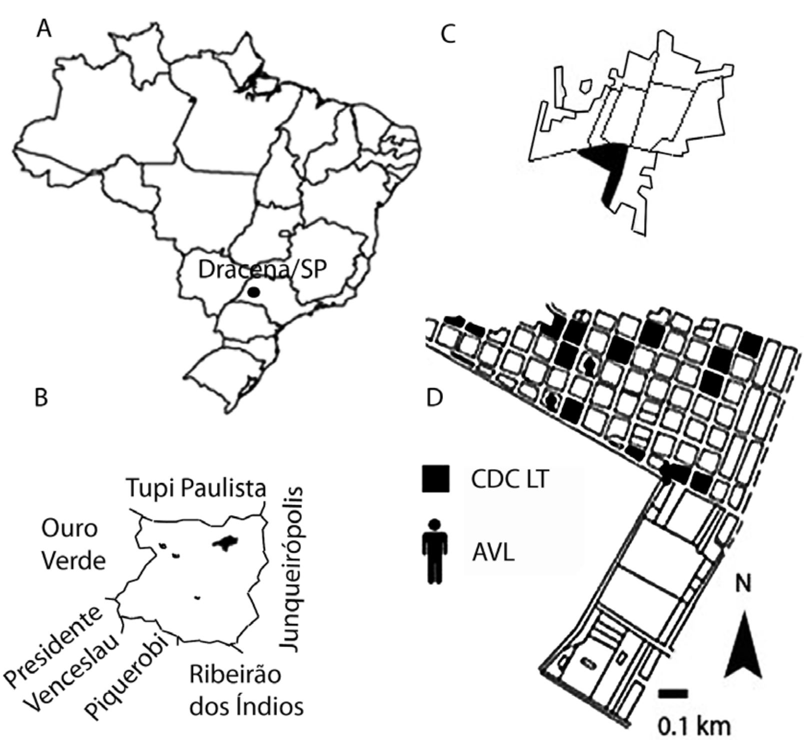
Dracena has a land area of 488.04 km^2 and is at an altitude of 421 m on the northern Brazilian plateau in western SP (Figure). In 2005, there was an estimated population of 38,206 urban inhabitants and 3,818 in the rural areas. The Koöppen climate classification is Aw type, with cold dry winters and hot rainy summers (Tremocoldi & Brunini 2008). Since 2005, human AVL cases have been reported in all of the city sectors.

Characteristics of the study site - The study location is one sector with 82 blocks and an average of 24.6 houses per block. Most of the buildings (86%) are residential, with approximately 4,712 inhabitants. In 2005, a canine census survey was conducted and showed that 33.3% (284/852) of the dogs were AVL positive (SESSP 2005). The tests were performed according to the standard criteria set by the Ministry of Health, with a positive result from an indirect fluorescent antibody test, using the Biomanguinhos/Oswaldo Cruz Foundation (Rio de Janeiro, Brazil) kit, as a confirmation criterion (D'Andrea et al. 2009). In July and August 2006, an environmental diagnosis was conducted by the Municipal Health Secretary; it was determined that animals were present in 33.5% of the households. The most frequently reported animals were cats (43.6%) and chickens (27.9%).

Methods and data analysis - We randomly selected 14 blocks and chose 14 residences, one per block, with environmental characteristics conducive to the occurrence of *Lu. longipalpis*. These characteristics included the presence of vertebrate animals, trees and peridomiciles with a size equal or greater than 200 m^2. These characteristics were standardised to homogenise the peridomiciles surveyed.

From January-December 2005, weekly systematised collections were conducted. CDC-type LT-baited traps (Sudia & Chamberlain 1962) were installed in the peridomiciles and were considered as the collection point, with a ratio of one trap per peridomicile. A 12-h collection period (06:00 pm-06:00 am) was used. The LTs were installed 1 m above the ground and in proximity to domestic animal shelters to standardise the capture location and to attain a location favourable to the vector's occurrence (SESSP 2006). The number of specimens captured in each collection was considered a sub-sample and was evaluated monthly. Male and female specimens were analysed separately using the same methodology. The standardised Morisita index (Ip) was used as a dispersion measurement. The index value indicated a standard pattern when Ip was less than or equal to -0.50, an aggregate pattern when Ip was greater than or equal to 0.50 and a random pattern when the Ip value was between -0.50-0.50 (Krebs 1989). The data were adjusted for a log-series distribution (Fisher 1943) and considered the number of specimens acquired per trap in each collection. For the adjustment, it used the number of traps in octaves, which refers to the abundance of geometric intervals and is equivalent to the logarithmic scale base$_2$ (Preston 1948). A calculation of the expected number of traps in this range was made according to the number of specimen occurrences (0-1, 1-2, 2-4, 4-8, 8-16, 16-



Geographical location of Dracena, state of São Paulo (SP), and sector of study: A: Brazil; AVL: American visceral leishmaniasis; B: municipality of Dracena; C: urban area; D: sector of study; LT: light-baited trap.

31 and so on). Adherence tests were conducted to compare the observed to the expected values. A chi-square statistical test that included a class number of at least one degree of freedom at a 5% probability was used. The statistical analyses were performed using two software programmes Biodap (Thomas & Clay 2010) and *R* (Oksanem et al. 2010).

RESULTS

In total, 4,613 male and 1,276 female *Lu. longipalpis* specimens were captured. Further, five female and three male *Nissomyia neivai* specimens were captured. No other sandfly species were captured. The analyses were performed using the *Lu. longipalpis* specimens.

TABLE I

Number of individuals collected per month and the collection point (cp), standardized Morisita Index (Ip) in 2005, Dracena, state of São Paulo

cp	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2	3	2	0	4	9	4	1	1	1	5	1
2	1	32	39	123	73	63	3	1	1	5	25	32
3	0	36	11	17	2	35	6	22	3	58	11	0
4	28	30	21	20	7	10	2	2	3	19	4	2
5	9	10	23	176	72	21	39	40	19	39	87	44
6	8	17	6	86	5	7	4	2	1	2	4	4
7	2	3	7	0	5	3	2	0	0	3	3	0
8	43	49	22	77	11	42	10	4	2	16	13	1
9	11	12	24	30	3	22	1	4	0	2	0	0
10	7	19	31	34	18	62	13	32	9	8	3	0
11	17	65	9	36	13	11	2	2	1	8	3	11
12	37	212	33	81	55	83	43	19	13	21	26	51
13	1	2	3	0	3	5	0	2	0	1	1	3
14	72	147	247	605	302	450	333	318	95	135	47	97
Total	238	637	478	1,285	573	823	462	449	148	318	232	246
Ip	0.537	0.536	0.528	0.537	0.548	0.527	0.585	0.643	0.618	0.603	0.532	0.554

TABLE II

Number of individuals (male) collected per month and the collection point (cp), standardized Morisita index (Ip) in 2005, Dracena, state of São Paulo

cp	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2	1	2	0	2	7	1	1	0	0	4	0
2	1	25	36	96	63	54	2	0	0	5	19	21
3	0	28	7	11	1	29	6	20	1	45	8	0
4	24	20	12	12	5	6	0	2	2	14	3	2
5	6	6	18	133	53	15	31	29	16	29	63	35
6	6	5	1	48	3	2	3	0	1	2	2	3
7	2	2	4	0	3	1	1	0	0	0	2	0
8	27	27	13	51	7	31	4	2	1	10	9	1
9	4	5	18	22	3	14	1	4	0	2	0	0
10	6	13	18	17	15	36	3	17	7	5	2	0
11	14	52	5	25	12	10	2	2	1	6	1	8
12	33	183	25	58	51	65	29	15	10	15	19	38
13	0	2	2	0	3	2	0	0	0	1	1	3
14	67	124	201	508	257	360	298	285	82	111	32	79
Total	192	493	362	981	478	632	379	375	121	245	165	190
Ip	0.543	0.544	0.533	0.544	0.550	0.530	0.601	0.670	0.625	0.614	0.532	0.556

TABLE III

Number of individuals (female) collected per month and the collection point (cp), standardized Morisita index (Ip) in 2005, Dracena, state of São Paulo

cp	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	2	0	0	2	2	2	0	1	1	1	1
2	0	7	3	27	10	9	1	1	1	0	6	11
3	0	8	4	6	1	6	0	2	2	13	3	0
4	4	10	9	8	2	4	2	0	1	5	1	0
5	3	4	5	43	19	6	8	11	3	10	24	9
6	2	12	5	38	2	5	1	2	0	0	2	1
7	0	1	3	0	2	2	1	0	0	3	1	0
8	16	22	9	26	4	11	6	2	1	6	4	0
9	7	7	6	8	0	8	0	0	0	2	0	0
10	1	6	13	17	3	26	10	15	2	3	1	0
11	3	13	4	11	1	1	2	2	0	2	1	3
12	4	29	8	23	4	18	14	4	3	6	7	13
13	1	0	1	0	0	3	0	2	0	0	0	0
14	5	23	46	97	45	90	35	33	13	24	16	18
Total	46	144	116	304	95	191	83	74	27	73	67	56
Ip	0.528	0.528	0.513	0.520	0.541	0.523	0.530	0.552	0.575	0.566	0.526	0.542

TABLE IV

Adherence test of traps expected frequencies (exp) and observed (obs) in each octave on the log series model of abundance

	Jan		Feb		Mar		Apr		May		Jun	
Octave	exp	obs	exp	obs	exp	obs	exp	obs	exp	obs	exp	obs
1	15.96	19	16.20	18	21.38	21	11.66	6	14.82	21	18.59	21
2	5.63	5	6.08	3	7.8	10	4.48	4	5.56	4	7.00	5
3	5.37	3	6.29	7	7.77	8	4.78	9	5.75	5	7.29	4
4	4.31	4	5.96	8	6.82	6	4.83	6	5.43	3	6.98	10
5	2.62	3	5.01	4	4.94	4	4.6	3	4.55	3	5.99	8
6	1.1	1	3.44	3	2.54	1	4.05	7	3.1	2	4.29	0
7	-	-	2.01	2	0.75	2	3.09	3	1.44	2	2.84	5
8	-	-	-	-	-	-	1.8	1	0.35	1	-	-
9	-	-	-	-	-	-	0.72	1	-	-	-	-
X^2	1.78		2.8		3.91		9.97		6.53		10.29	
p	0.878		0.833		0.688		0.267		0.479		0.112	
	Jul		Aug		Sep		Oct		Nov		Dec	
Octave	exp	obs	exp	obs	exp	obs	exp	obs	exp	obs	exp	obs
1	10.55	14	9.73	15	8.85	10	12.83	18	18.68	21	7.02	10
2	3.97	6	3.67	1	3.16	4	4.71	5	6.46	7	2.62	0
3	4.13	3	3.83	1	3.05	3	4.74	1	5.99	5	2.70	1
4	3.95	2	3.68	5	2.52	0	4.23	5	4.55	2	2.52	1
5	3.39	1	3.18	4	1.62	2	3.17	1	2.49	3	2.07	5
6	2.42	1	2.31	1	0.67	0	1.74	1	0.83	1	2.04	2
7	1.23	2	1.21	0	0.13	1	0.54	0	-	-	-	-
8	0.36	1	0.38	1	-	-	0.06	1	-	-	-	-
X^2	7.58		10.53		9.74		22.5		2.06		10.02	
p	0.371		0.16		0.136		0.002		0.84		0.746	

TABLE V

Adherence test (male) of traps expected frequencies (exp) and observed (obs) in each octave on the log series model of abundance

	Jan		Feb		Mar		Apr		May		Jun	
Octave	exp	obs	exp	obs	exp	obs	exp	obs	exp	obs	exp	obs
1	14.63	16	15.49	19	18.77	18	12.05	10	13.21	19	16.71	17
2	5.09	6	5.76	4	6.78	12	4.61	6	4.94	3	6.26	5
3	4.76	3	5.90	8	6.66	3	4.89	6	5.09	3	6.47	4
4	3.68	2	5.45	3	5.68	4	4.87	4	4.78	3	6.10	10
5	2.09	3	4.37	2	3.89	4	4.53	3	3.95	4	5.09	5
6	0.75	1	2.74	3	2.20	3	3.80	6	2.62	2	3.44	2
7	-	-	1.28	2	-	-	2.63	2	1.41	2	1.94	3
8	-	-	-	-	-	-	1.61	2	-	-	-	-
X^2	2.20		4.91		6.85		3.22		5.22		4.88	
p	0.821		0.556		0.232		0.864		0.516		0.559	
	Jul		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
Octave	exp	obs	exp	obs	exp	obs	exp	obs	exp	obs	exp	obs
1	7.93	13	7.96	11	8.24	11	12.26	19	17.62	19	6.57	8
2	3.00	3	3.00	0	2.90	1	4.44	2	5.85	4	2.43	1
3	3.13	2	3.14	5	2.76	3	4.38	3	5.13	5	2.47	1
4	3.01	1	3.02	3	2.21	2	4.76	3	3.50	4	2.26	2
5	2.62	1	2.62	3	1.33	0	2.61	0	1.56	1	1.77	4
6	1.93	0	1.92	0	0.55	1	1.24	1	0.34	1	1.48	1
7	1.37	3	1.02	0	-	-	0.31	1	-	-	-	-
8	-	-	0.33	1	-	-	-	-	-	-	-	-
X^2	9.86		9.62		3.91		9.81		2.26		5.04	
p	0.131		0.211		0.562		0.133		0.812		0.411	

During March, June, September and November, five weekly collections were conducted instead of four, as in the other months, due to the occurrence of more collection days in these months. In total, 728 samples were collected during 8,736 h of trap exposure time.

Table I shows the number of *Lu. longipalpis* specimens collected per month and per collection site and the values of the standardised Ip. In April, the largest number of specimens was collected; the smallest number was collected in September. The proportions of males and females maintained in these months were equivalent (Tables II, III). In total, we collected 5,889 *Lu. longipalpis* specimens. The Ip values showed aggregated patterns for each month. In August, the index was the highest; in June, the lowest value was observed. Male specimens maintained a constant proportion (Table II), whereas for the female specimens, the largest Ip was observed in September and the lowest in March (Table III).

Table IV shows the adherence test results of the monthly frequencies of the expected and the observed traps arranged in octaves and modelled on a log-series distribution. October was the only month for which there was no adjustment to the distribution. The best fits were obtained for January, February, November and December. Adjustments for male and female specimens were made for all collection months, with no predominance of any period of the year (Tables V, VI).

DISCUSSION

In this study, the distribution pattern of *Lu. longipalpis* was analysed using peridomiciles as a scenario in which fundamental ecological characteristics, such as the birth, death and migration of specimens, occurred in an urbanised environment. This information describes the pattern of the organisms and was obtained by counting data, which makes it important to consider the limitations of the method used to obtain the specimens, beyond those issues inherent in a peridomicile.

The proportion of males is higher than that of females; this result is consistent with previously reported results obtained for LTs (Resende et al. 2006, Silva et al. 2007). The low number of other species may be due to the fact that the habitat studied was in an urban area, which is more favourable to *Lu. longipalpis*.

Galati et al. 1997 reported the limitations of using LTs in urban environments, i.e., mainly the attraction competition between the light trap and the brightness of the urban environment. Therefore, the true abundance of

TABLE VI

Adherence test (female) of traps expected frequencies (exp) observed (obs) in each octave on the log series model of abundance

	Jan		Feb		Mar		Apr		May		Jun	
Octave	exp	obs	exp	obs	exp	obs	exp	obs	exp	obs	exp	obs
1	15.53	16	21.01	19	24.95	25	14.11	10	12.73	16	20.87	19
2	3.35	2	6.54	8	6.89	6	5.13	5	4.04	1	6.90	8
3	1.69	2	5.28	6	4.74	5	5.10	8	3.35	2	6.02	7
4	0.42	1	3.06	3	2.35	3	4.44	5	2.04	3	4.07	4
5	-	-	1.1	1	-	-	3.17	5	0.82	1	1.78	1
6	-	-	-	-	-	-	2.02	1	-	-	0.37	1
7	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-
X^2	1.42		0.63		0.31		4.48		4.16		1.91	
p	0.709		0.960		0.958		0.482		0.385		0.861	

	Jul		Aug		Sep		Oct		Nov		Dec	
Octave	exp	obs	exp	obs	exp	obs	exp	obs	exp	obs	exp	obs
1	11.05	10	10.78	12	8.76	10	9.26	11	15.81	16	7.07	5
2	3.51	4	3.36	3	1.95	1	2.98	3	4.20	3	2.27	3
3	2.91	4	2.71	1	1.02	0	2.50	1	2.75	4	1.91	3
4	2.42	2	1.57	2	0.27	1	1.57	1	1.21	1	1.67	2
5	-	-	0.57	1	-	-	0.68	1	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-
X^2	0.65	1.7	3.60	1.59	0.95	1.52	-	-	-	-	-	-
p	0.884	0.791	0.309	0.812	0.813	0.678	-	-	-	-	-	-

the species could not be measured, only an approximation could be made using LTs in this environment. In this study, 728 samples were systematically collected; this number is comparable to that of other studies conducted under similar conditions (Oliveira et al. 2006).

Dispersion indexes, although not mathematically descriptive of a distribution, provide a more clear idea of the spatial arrangement of a given species. A variety of indexes are used in abundance studies. The standardised Ip has been used because of its easy interpretation and lack of significant influence from the average population density or sample size (Myers 1978). To describe the spatial distribution of an organism, it is essential to incorporate the data adjustment to the theoretical probability distribution. However, the use of indexes does not allow the knowledge of expected values for the sample classes.

The log-series distribution was created by Fisher (1943). This method was first used to analyse the relationship between the number of species and the number of specimens. Gradually, this method was expanded to other studies (Williams 1947, Buzas & Culver 1999). The log-series is a special type of negative binomial distribution (NDB), where values for k approach zero, allowing one to use a single parameter instead of two, as in most NDBs. In this study, an adjustment was obtained for 11 months (91.67%). When male and female specimens were analysed separately, adjustments were obtained for each collection month, which appears appropriate for adjusting the data and can contribute to our knowledge of the vector's population distribution. The data show that *Lu. longipalpis* has an aggregate pattern in time and space, with most samples containing few specimens. This information should contribute to the development of sampling plans and decision-making processes in vector control.

With the use of LTs in entomological programmes and vector control, it is critical to conduct research that can contribute to understanding the observable patterns obtained by using such traps in an urban environment, especially in peridomiciles, which are the sites in which disease control measures are usually performed. These findings may have an epidemiological significance that could contribute to understanding AVL transmission as it relates to surveillance measures and disease control.

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