Distribution of Vector Sandflies Leishmaniasis from an Endemic Area of Venezuela

Elisa Nieves1*, Luzmary Oraá1, Yorfer Rondón1, Mireya Sánchez1, Yetsenia Sánchez1, María Rujano1, Maritza Rondón1, Masyelly Rojas1, Nestor Gonzalez2 and Dalmiro Cazorla2

1 LAPEX-Laboratorio de Parasitología Experimental, Departamento de Biología, Facultad de Ciencias, Universidad de Los Andes, Mérida-Venezuela
2 LEPMET-Laboratorio de Entomología, Parasitología y Medicina Tropical, Universidad Nacional Experimental Francisco de Miranda, Falcón- Venezuela

Abstract

Background: Sandflies distribution is associated with different factors linked to climate changes that might cause alterations in their distribution and increase the risk of leishmaniasis transmission.

Present work aims to determine the composition and structure of sandflies from an endemic area of Venezuela and its relationship to environmental variables.

Method: Various locations were sampled, four sandflies capture methods were used and weather variables capture site, altitude, temperature and relative humidity were recorded. Specimens were identified. Abundance, dominance and species richness was estimated and multivariate analysis was performed.

Results: L. youngi is the main species associated with sandfly transmission of Leishmania in the highlands (≥ 600 m asl), while L. gomezi, L. ovallesi and L. walkeri were found in lower altitudes and higher temperatures, prevailed in the lowlands (≤ 600 m. asl). Sandflies in the warmer lower altitudes showed greater species richness, greater biodiversity, and lower dominance than those at higher altitudes.

Conclusion: The sandflies composition and structure changed according to climate factors, showing a species-specific dispersion pattern. Relevant data for sandfly vectors species of Leishmania are provided that should be considered in implementing control and prevention measures.

Keywords: Leishmania; Lutzomyia; Climate; Disease transmission

Introduction

The appearance of leishmaniasis cases has been correlated to the presence of Leishmania-transmitting sandflies. Various epidemiologic leishmaniasis transmission patterns are caused by ecological and environmental conditions that lead to sandflies population dynamics [1-3]. Sandflies life cycles are affected by climate variations due to natural processes, especially weather conditions (e.g., precipitation, temperature, humidity, etc.) [4]. Agricultural development and changes in climate conditions could favour new habitats for vector insects [5-8]. Increases in sandflies dispersion may lead to higher human-vector contact [9-13] and, therefore, higher risk of leishmaniasis transmission [3,14]. Zorilla et al. correlated the presence of cutaneous leishmaniasis to environmental and socioeconomic variables in population of Yaucaño Valley in Perú, the adaptability of sandflies to the human environment may lead to an increase in the number of leishmaniasis cases [15]. However, studies in dry climate regions have presented controversial results, such as a lack of correlation between climate variables and sandflies density [16,17]. Temperature increases may also affect sandflies populations [18-20]. Rodriguez et al. suggested that changes in ecological and climate conditions in Mérida, Venezuela from events such as flash flooding along stream beds at Mocotíes Valley may have affected the occurrence of leishmaniasis cases [7]. Thus, it is necessary to characterize the conditions that affect Leishmania-transmitting sandflies populations [4]. The goal of this study was to characterize the composition and structure of sandflies at endemic area of Mocotíes Valley in Mérida, Venezuela, and to determine the relationship between these characteristics with environmental variables.

Materials and Methods

Study area

The selected area for this study was Zea Municipality State Mérida, Venezuela located in the southeastern quadrant of the State (latitude 8º20’20” to 8º33’00”, longitude 71º42’10” to 71º49’20”), the transition zone between Mocotíes Valley and the southern edge of Lake Maracaibo, located between the mountains and Escalante and Guaruríes rivers. An area of 135 km² at 600 m above sea level (ASL) has lower mountain tropical rainforest vegetation. The annual average temperature is 22°C, with annual rainfall of 1390 mm and comprises two Parishes, El Caño Tigre and Zea.

Environmental variables

The altitude of each sampled location was recorded with an altimeter. Measurements were grouped into two altitude ranges: below 600 m ASL, corresponding to Caño El Tigre Parish, and above 600 m ASL, corresponding to Zea Parish. Temperature and relative humidity (RH) were measured with a digital thermo-hygrometer. Four measurements were measured made during a 1-hour period between 19:00 and 20:00. Two average temperature ranges, below 25°C (19-25°C) and above 26°C (26-33°C), and three RH ranges, below 60%, between 60% and 80%, and above 80% were defined.

*Corresponding author: Elsa Nieves, LAPEX-Experimental Parasitology Laboratory, Biology Department, Faculty of Science, University of Los Andes-Venezuela, Mérida, Venezuela, Tel: 02742401244; 5101; E-mail: nevesbela@gmail.com

Received March 24, 2015; Accepted April 27, 2015; Published May 04, 2015

Citation: Nieves E, Oraá L, Rondón Y, Sánchez M, Sánchez Y, et al. (2015) Distribution of Vector Sandflies Leishmaniasis from an Endemic Area of Venezuela. J Trop Dis 3: 157. doi:10.4172/2329-891X.1000157

Copyright: © 2015 Nieves E, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.
Sandflies capture and dissection

To catch sandflies four methods were performed, Shannon trap, light trap attractant (CDC), oiled Trap and capture oral direct aspiration [8]. The specimens under a stereoscopic microscope were dissected. Quick identification on fresh species by comparative morphology of the extracted digestive systems were observed to determine the presence of Leishmania promastigotes. Parasite development pattern in the intestine for identification of the subgenus was determined [22]. The body segments, head and terminalia of sandflies dissected clarified in intestine for identification of the subgenus was determined [22]. The specimens under a stereoscopic microscope were dissected.

Statistical Analysis

The dominance, abundance and biodiversity Margalef index were determined [23]. Analysis of variance with a confidence level of 0.05 was performed. A simple correlation analysis and Pearson’s correlation coefficient Sig = 0.005 were calculated, using the IBM SPSS Statistics, available for download free software http://ibm-spss-statistics.softonic.com.

Results

In Zea Municipality, 21 species of Lutzomyia from a total of 963 captured sandflies were identified, 82.7% female and 17.3% male. The most abundant species were L. youngi (38.42%), L. gomezi (28.87%), L. ovallesi (18.07%), L. walkeri (3.2%), and L. spinicrassa (3.1%). Other species were present at levels below 1.9%. The results showed dominance and biodiversity values for Zea Municipality of λ=0.27 and % Nat Inf. = 2%. In 17 of the captured sandflies, a natural infection rate of 2%.

In terms of environmental variables, 56.28% of Lutzomyia were present at temperatures below 26°C, predominantly L. youngi (37.49%), L. gomezi (23.36%) and L. ovallesi (12.77%) were prevalent above 26°C, Table 2.

Four species were identified below 60% RH, with L. gomezi (0.8%) being most abundant. At 60% to 80% RH, 19 species, predominantly L. gomezi (17.7%), L. youngi (14%), and L. ovallesi (14%) were identified. Above 80% RH, 16 species, predominantly L. youngi (24.1%) and L. gomezi (10.4%) were identified, Table 3.

Altitudes 600m ASL, corresponding to El Caño Tigre Parish, 16 species were identified, predominantly L. gomezi (51%) and L. ovallesi (31.6%). In Zea Parish, 12 species were identified, with L. youngi (87%) being the most abundant. Only five species occurred in both municipalities and altitude levels, Table 4. An ANOVA test comparison between altitudes revealed significant differences (F=1121; GL= 22; Sig=0.000).

Figure 1 show values for biodiversity, dominance, and species richness for sandflies populations in El Caño Tigre Parish (<600 m ASL) and Zea Parish (>600 m ASL). Sandflies in the warmer lower altitudes showed greater species richness, greater biodiversity, and lower dominance than those at higher altitudes.

Linear correlation analysis showed that altitude was directly proportional to L. youngi (p=+0.765) and inversely proportional to L. gomezi (p=-0.494); temperature was inversely proportional to L. spinicrassa (p=-0.598), Table 5.

The primary sandflies species fell into two population groups: L. youngi and L. spinicrassa were distributed across higher altitudes and lower temperatures, whereas L. gomezi, L. ovallesi, and L. walkeri were found in lower altitudes and higher temperatures. RH did not show precise distribution patterns, Figure 2.

| Species         | ♂ | % | % | Nat Inf. | % | N | % | pi | (A) |
|-----------------|---|---|---|---------|---|---|---|---|----|
| L. youngi*      | 370| 46| 0 | 7 | 1 | 370| 38.42| 0.38| 0.15|
| L. gomezi*      | 209| 26| 69| 41| 5 | 278| 28.87| 0.29| 0.08|
| L. ovallesi*    | 152| 19| 22| 13| 4 | 174| 18.07| 0.18| 0.03|
| L. walkeri*     | 9  | 1 | 22| 13 | 0.42| 31| 3.22 | 0.03| 0   |
| L. spinicrassa* | 2  | 0 | 28| 17 | 0 | 30| 3.12 | 0.03| 0   |
| L. trinidadensis| 9  | 1 | 10| 6  | 0 | 19| 1.97 | 0.02| 0   |
| L. panamensis*  | 11 | 1 | 0 | 0  | 0 | 11| 1.14 | 0.01| 0   |
| L. hernandezi** | 6  | 1 | 2 | 1  | 0 | 8 | 0.83 | 0.01| 0   |
| L. nunezovari*  | 7  | 1 | 0 | 0  | 0 | 7 | 0.73 | 0.01| 0   |
| L. venezulensis | 5  | 1 | 3 | 2  | 0 | 7 | 0.73 | 0.01| 0   |
| L. atroclavata* | 1  | 0 | 4 | 2  | 0 | 5 | 0.52 | 0.01| 0   |
| L. migonei*     | 5  | 1 | 0 | 0  | 0 | 5 | 0.52 | 0.01| 0   |
| L. shanoni      | 2  | 0 | 2 | 1  | 0 | 4 | 0.42 | 0   | 0   |
| L. puntigeniculata | 0   | 0 | 2 | 1  | 0 | 2 | 0.21 | 0   | 0   |
| L. serrana      | 1  | 0 | 1 | 1  | 0 | 2 | 0.21 | 0   | 0   |
| L. dubitans     | 0  | 0 | 2 | 1  | 0 | 2 | 0.21 | 0   | 0   |
| L. lichyi*      | 2  | 0 | 0 | 0  | 0 | 2 | 0.21 | 0   | 0   |
| L. cayennensis  | 1  | 0 | 0 | 0  | 0 | 1 | 0.1  | 0   | 0   |
| L. olmeca nociva| 1  | 0 | 0 | 0  | 0 | 1 | 0.1  | 0   | 0   |
| L. pilosa       | 1  | 0 | 0 | 0  | 0 | 1 | 0.1  | 0   | 0   |
| no_identificada | 3  | 0 | 0 | 0  | 0 | 3 | 0.31 | 0   | 0   |
| Total species: 21 | 797| 100| 167| 100| 17 | 2 | 963| 100| 1   |

Table 1: Sandflies species identified at Zea Municipality Merida State.
Discussion

Topographic relief is an important factor in climate differences, especially in intertropical zones where there are different climate plateaus depending on altitude [17, 24]. The results confirmed that sandflies fauna fell into two populations, with differences in composition and structure, between the two Parish that divided geopolitically the Municipality, perhaps motivated to that these two areas are ecologically different. Knowledge of the distribution and other behavioural aspects of the sandfly species that occur in this region are of great importance for the entomology and biodiversity. A diversified and

| Species                  | 19-25°C |   | 26-33°C |   |
|--------------------------|---------|---|---------|---|
|                          | N       | % | N       | % |
| L. youngi                | 361     | 66.6 | 9 | 2.1 |
| L. gomezi                | 53      | 9.7  | 225 | 53.4 |
| L. ovalesi              | 51      | 9.4  | 123 | 29.2 |
| L. walkery              | 8       | 1.4  | 23  | 5.4  |
| L. spinicrassa          | 30      | 5.5  | -   | -   |
| L. trinidadensis        | 8       | 1.4  | 11  | 2.6  |
| L. panamensis           | 1       | 0.1  | 10  | 2.3  |
| L. hernandezi           | 2       | 0.3  | 6   | 1.4  |
| L. nuneztovari         | 7       | 1.2  | -   | -   |
| L. venezuelensis        | 6       | 1.1  | 2   | 0.4  |
| L. atroclavata          | 2       | 0.3  | 3   | 0.7  |
| L. migonei              | 2       | 0.3  | 2   | 0.4  |
| L. shanoni              | 1       | 0.1  | 3   | 0.7  |
| L. puntigeniculata      | 1       | 0.1  | 1   | 0.2  |
| L. serrana              | 2       | 0.3  | -   | 0    |
| L. dubitans             | 1       | 0.1  | 1   | 0.2  |
| L. lichyi               | 2       | 0.3  | -   | -    |
| L. cayennensis          | -       | -    | 1   | 0.2  |
| L. olmeca nociva        | 1       | 0.1  | -   | -    |
| L. pilosa               | -       | -    | 1   | 0.24 |
| no_identificada         | 3       | 0.5  | -   | -    |
| **Total species**       | 542     | 100  | 421 | 100  |

Table 2: Distribution of sand fly species identified at Zea Municipality in relation to temperature ranges.

| Species                  | < 60% | % | 60-80% | % | 80 % > | % |
|--------------------------|-------|---|--------|---|---------|---|
|                          | N     |   | N      |   | N       |   |
| L. youngi                | -     | - | 138    | 26.7 | 232     | 53.3 |
| L. gomezi                | 8     | 66.7 | 170 | 32.9 | 100     | 23  |
| L. walkery              | 0     | 0   | 28     | 5.4  | 3       | 0.7 |
| L. ovalesi              | 1     | 8.3  | 137    | 26.5 | 36      | 8.3 |
| L. spinicrassa          | -     | -   | 4      | 0.8  | 26      | 6   |
| L. atroclavata          | -     | -   | 2      | 0.4  | 3       | 0.7 |
| L. cayennensis          | -     | -   | -      | -    | 1       | 0.2 |
| L. dubitans             | -     | -   | 1      | 0.2  | 1       | 0.2 |
| L. hernandezi           | -     | -   | 5      | 1    | 3       | 0.7 |
| L. lichyi               | -     | -   | 1      | 0.2  | 1       | 0.2 |
| L. migonei              | -     | -   | 2      | 0.4  | 3       | 0.7 |
| L. nuneztovari         | -     | -   | -      | -    | 7       | 1.6 |
| L. olmeca nociva        | -     | -   | 1      | 0.2  | -       | -   |
| L. panamensis           | -     | -   | 7      | 1.4  | 4       | 0.9 |
| L. pilosa               | -     | -   | 1      | 0.2  | -       | -   |
| L. puntigeniculata      | -     | -   | 2      | 0.4  | -       | -   |
| L. serrana              | -     | -   | 2      | 0.4  | -       | -   |
| L. shanoni              | -     | -   | 2      | 0.4  | 2       | 0.5 |
| L. trinidadensis       | 2     | 16.7 | 9      | 1.7  | 8       | 1.8 |
| L. venezuelensis        | 1     | 8.3  | 2      | 0.4  | 5       | 1.1 |
| no_identificada         | -     | -   | 3      | 0.6  | -       | -   |
| **Total species**       | 12    | 100  | 514   | 100 | 435     | 100 |

Table 3: Distribution of sand fly species identified at Zea Municipality in relative humidity ranges.
Table 4: Composition of sandflies recorded in El Caño Tigre Parish Flat altitudinal low (≤ 600 m asl) and Zea Parish Altitudinal High (≥ 600 m asl).

| Species          | Zea Parish Altitudinal High (≥ 600 m asl) | Caño El Tigre Parish Flat altitudinal low (≤ 600 m asl) |
|------------------|-------------------------------------------|--------------------------------------------------------|
|                  | n   | %     | Nat Inf. | %     | pi   | (λ)    | n   | %     | Nat Inf. | %     | pi   | (λ)    |
| L. youngi        | 367 | 87.17 | 7       | 2     | 0.87 | 0.76   | 3   | 0.55  | -       | -     | 0.01 | 0      |
| L. spinicrassa   | 29  | 6.9   | -       | -     | 0.07 | 0      | 1   | 0.18  | -       | -     | 0     | 0      |
| L. nuneztorvai   | 7   | 1.66  | -       | 0.02  | 0    | 0      | -   | -     | -       | -     | -     | -      |
| L. migonei       | 3   | 0.71  | -       | 0.01  | 0    |         | -   | -     | -       | -     | -     | -      |
| L. ovallesi      | 2   | 0.48  | -       | 0     | 0    |         | 172 | 31.68 | 4       | 0.74  | 0.32  | 0.1    |
| L. serrana       | 2   | 0.48  | -       | 0     | 0    |         | -   | -     | -       | -     | -     | -      |
| L. venezulensis  | 2   | 0.48  | -       | 0     | 0    |         | 6   | 1.1   | -       | -     | 0.01  | 0      |
| L. dubitans      | 2   | 0.48  | -       | 0     | 0    |         | -   | -     | -       | -     | -     | -      |
| L. lichyi        | 2   | 0.48  | -       | 0     | 0    |         | -   | -     | -       | -     | -     | -      |
| L. atrovillata   | 1   | 0.24  | -       | 0     | 0    |         | 4   | 0.74  | -       | -     | 0.01  | 0      |
| L. gomezi        | 1   | 0.24  | -       | 0     | 0    |         | 277 | 51.01 | 5       | 0.92  | 0.51  | 0.26   |
| L. walkery       | -   | -     | -       | -     | -    | -       | 31  | 5.71  | 1       | 0.18  | 0.06  | 0      |
| L. trinidadensis | -   | -     | -       | -     | -    | -       | 19  | 3.5   | -       | -     | 0.03  | 0      |
| L. panamensis    | -   | -     | -       | -     | -    | -       | 11  | 2.03  | -       | -     | 0.02  | 0      |
| L. hernandezii   | -   | -     | -       | -     | -    | -       | 8   | 1.47  | -       | -     | 0.01  | 0      |
| L. shannoni      | -   | -     | -       | -     | -    | -       | 4   | 0.74  | -       | -     | 0.01  | 0      |
| L. migonei       | -   | -     | -       | -     | -    | -       | 2   | 0.37  | -       | -     | 0     | 0      |
| L. puntigeniculata| -  | -     | -       | -     | -    | -       | 2   | 0.37  | -       | -     | 0     | 0      |
| L. cayennensis   | -   | -     | -       | -     | -    | -       | 1   | 0.18  | -       | -     | 0     | 0      |
| L. olmeca nociva | -   | -     | -       | -     | -    | -       | 1   | 0.18  | -       | -     | 0     | 0      |
| L. pilosa        | -   | -     | -       | -     | -    | -       | 1   | 0.18  | -       | -     | 0     | 0      |
| no_identificada  | 3   | 0.71  | -       | 0.01  | 0    |         | -   | -     | -       | -     | -     | -      |
| Total            | 421 | 100   | 7       | 2     | 0.77 |         | 543 | 100   | 10      | 1.84  | 1     | 0.37   |

Table 4: Composition of sandflies recorded in El Caño Tigre Parish Flat altitudinal low (≤ 600 m asl) and Zea Parish Altitudinal High (≥ 600 m asl).

Figure 1: Distribution of main species of sandflies in Zea Municipality in relation to climatic parameters.
widely distributed sandfly fauna represents a significant transmission risk of leishmaniasis.

In Zea Parish (high zone, ≥ 600 m ASL), L. youngi, L. spinicrassa, and L. nuñeztovari were most abundant, whereas L. gomezi, L. ovallesi, L. walkeri, and L. trinidadensis predominated in El Caño Tigre Parish (low zone, ≤600 m ASL). Only five species were found at both altitude levels and parish. Our analysis showed correlation directly proportional of L. youngi and L. spinicrassa with high altitude and low temperature, whereas L. gomezi one correlation inversely proportional to low altitude and warm temperature.

L. youngi is considered the primary Leishmania transmission species in Mérida State [25], although L. gomezi predominates at 300m ASL [26]. Feliciangeli [27] measured low abundance of L. gomezi in the State of Carabobo at 85 m ASL. In Trujillo and Táchira States, L. gomezi is the most prevalent species at high altitudes (>1,000 m ASL) [28, 29]. Cazorla found this species as the main Leishmania vector at higher altitudes in Falcón State [30]. L. gomezi can distribute itself across a large altitude range [21]. In Venezuela, L. gomezi is naturally infected with L. braziliensis promastigotes [31]. It is considered an alternate vector for tegumentary leishmaniasis in the north-central and other regions of Venezuela [6]. This study, L. gomezi with natural Leishmania infection below 600 m ASL were found; thus, we must consider L. gomezi an important species in Leishmania transmission in the low zones of Mérida State.

L. walkeri, the third species in order of abundance in the low zones, has a great capacity for adaptation to biotopes found at low altitudes

Table 5: Simple linear correlation between key species and environmental variables studied.

| Species     | Altitude | Temperature Pearson Correlation Sig. (bilateral) | Relative Humidity |
|-------------|----------|-------------------------------------------------|-------------------|
| L. youngi   | 0.765    | -0.674                                          | 0.293             |
|             | 0        | 0.038                                          | 0.138             |
| L. gomezi   | -0.494   | 0.309                                          | -0.046            |
|             | 0        | 0.245                                          | 0.821             |
| L. spinicrassa | 0.591  | -0.598                                          | -0.401            |
|             | 0        | 0                                              | 0.038             |

Figure 2: Composition and community structure of sandflies identified in Zea and El Caño Tigre Parish.
The presence of this species in Venezuela has not been well-documented, and its role as a vector for Leishmania is still under discussion [6]. However, in our study we identified a specimen naturally infected with promastigotes that exhibited biological and morphological characteristics similar to Leishmania. The Zipayare region at Zulia State, a high density of L. Walkeri was reported as the dominant species over L. Gomezi. L. Walkeri, is characterized as being able to exploit new biotic resources, with a fluctuating population dynamic at RH levels of 70%-90%, temperatures of 28-32°C, and altitude of 150 m ASL [33].

L. Ovallesi was detected at both high and low altitudes, being more abundant at high altitudes; similar results were reported by a number of researchers [6,28,34]. L. Ovallesi is considered to be an important vector of Le. braziliensis, Le. braziliensis vector of Leishmaniasis tegumentaria is considered to be important at high altitudes; similar results were reported by a number of studies [6,31,35]. L. Youngi, L. Gomezi, L. Ovallesi, and L. Walkeri are identified as the dominant species in the state of Paraná, Brazil. De Oliveira C, Legriffon C, Ross, K, Castro R, et al. (2012) Sandfly frequency distribution and abundance of sandfly species (Diptera: Phlebotominae) in a clean and well-organized rural environment in the state of Paraná, Brazil. Revista de la Sociedad Brasileira de Medicina Tropical 45: 77-82.

Zorilla V, Arguero M, Caceres M, Tejada A, et al. (2005) Factores de riesgo que determinan la transmisión de la leishmaniasis cutánea en el valle Yaucau, Chota-Cajamarca. Anales de la Facultad de Medicina 66: 33-42.

Condino M, Sampayo S, Henriques L, Galati E, et al. (1998) American cutaneous leishmaniasis: sandflies from the transmission area in the two of Teodoro Sampaio, the southeastern region of Sao Paulo state, Brazil. Rev Soc Bras Med Trop 31: 355-360.

Michalsky E, Fortes-Dias C, França-Silva J, Fonseca M, et al. (2009) Association of Lutzomyia longipalpis (Diptera: Psychodidae) population density with climate variables in Montes Claros, an area of American visceral leishmaniasis transmission in the state of Minas Gerais, Brazil. Mem Inst Oswaldo Cruz 104: 1191-1193.

Kuhn K (1999) Global warming and leishmaniasis in Italy. Trop Med Int Health 7: 1-2.

Gilheko A, Lindsay S, Confalonieri U, Patz J (2000) Climate change and vector-borne diseases: a regional analysis. Bull World Health Organ 78: 1136-1147.

Fischer D, Thomas D, Beierkuhnlein C (2010) Temperature-derived potential for the establishment of phlebotomine sandflies and visceral leishmaniasis in Germany. Geospat Health 5: 59-69.

Lainson R, Shaw J (1979) The Role of animals in the epidemiology of South American leishmaniasis. Biology of the Kinetoplastida London Academic Press 1-116.

Young D, Duncan M (1994) Guide to the identification and geographic distribution of Lutzomyia sandflies in Mexico, the West Indies, Central and South America (Diptera: Psychodidae). Mem Amer Entomol 54: 779-881.

Magurran A (1988) Ecological diversity and its measurement. Croom Helm limited. Londres (Gran Bretaña) 7-30.

Ataroff M, Sarmiento L (2004) Las unidades ecológicas de los Andes de Colombia. Biogeo 9-26.

Nieves E, Villarreal N, Rondón M, Sánchez M, et al. (2008) Evaluación de conocimientos y prácticas sobre la leishmaniasis tegumentaria en un área endémica de Venezuela. Biomédica 28: 347-356.

Añez N, Nieves E, Cazorla D, Oviedo M, et al. (1994) Epidemiology of cutaneous leishmaniasis in Mérida, Venezuela. Ill. Altitudinal distribution, age structure, natural infection and feeding behaviour of sandflies and their relation of the risk of transmission. Ann Trop Med Parasitol 88: 279-287.

Feliciangeli D (1988) La fauna flebotómica (Diptera: Psychodidae) en Venezuela. I Taxonomía y distribución geográfica. Bol Dir Malarol San Amb 28: 34.

Mogollon J, Manzanilla P, Scorzana J (1977) Distribución altitudinal de nueve especies de Lutzomyia (Diptera: Psychodidae) en el estado Trujillo, Venezuela. Bol Dir Malarol San Amb 17: 206-229.

Perruolo G (1984) Ecología de los flebotomos (Diptera: Psychodidae) y su influencia sobre la leishmaniasis tegumentaria en zonas endémicas del estado Táchira, Venezuela. Cimarron 12: 74-92.

Cazorla D (2006) Estudio taxonómico y ecologico de los vectores de leishmaniasis tegumentaria y visceral en focos endémicos del estado Falcón-Venezuela. Tecnica American University 6-14.

Feliciangeli M, Rodríguez N, Bravo A (1994) Vectors of cutaneous leishmaniasis in north-central Venezuela. Med Vet Entomol 8: 317-324.

Añez N, Nieves E, Cazorla D, Chatting B et al. (1988) Epidemiología de la leishmaniasis tegumentaria en Mérida, Venezuela. I. Diversidad y dispersión de especies flebotomina en tres pisos altitudinales y su posible rol en la...
transmisión de la enfermedad. Mem Inst Oswaldo Cruz 83: 455-463.

33. Corona F, Garrido R, Chirinos A, Urdaneta I, et al. (2000) Flebotomos (Diptera, Psychodidae) encontradas en Zipayare, Municipio Valmore Rodríguez del Edo. Zulia, Venezuela. Rev. Cient. FCV-LUZ. 10: 410-416.

34. Añez N, Cazorla D, Nieves E (1989) Registro de especies flebotominas en focos endémicos para leishmaniasis en el estado Mérida, Venezuela. Bol. Dir. Malaria Saneam Ambient 29: 12-34.

35. Rabinovich JE, Feliciangeli MD (2004) Parameters of Leishmania braziliensis transmission by indoor Lutzomyia ovallesi in Venezuela. Am J Trop Med Hyg 70: 373-382.

36. Rowton E, De Mata M, Rizzo N, Navin T, et al. (1991) Vectors of Leishmania braziliensis in the Peten, Guatemala. Parassitologia 33: 501-504.