Vertical stratification of sand flies (Diptera: Psychodidae) in riparian forests between the Amazon and northeast Brazil

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The subfamily Phlebotominae Rondani is an ancient group of psychodid dipterans distributed widely around the globe. Traditionally, sand flies are grouped into five genera: Phlebotomous Rondani and Berte and Sergentomyia França are present in the Old World; Brumptomyia França & Parrot, Lutzomyia Franç, and Warliya Hertigi occur in the New World. In the Americas, the genus Lutzomyia is of veterinary importance because the hematophagous females are vectors of Leishmania Ross (Trypanosomatidae, Kinetoplastida) protozoa, which cause cutaneous (CL) and visceral leishmaniasis (VL) in humans and domestic animals.

Species of Lutzomyia are known throughout Brazil. Some of this knowledge comes from entomological surveys conducted in forests, especially at the ground level. However, only a small number of studies have collected in the tree canopy using vertical stratification methods. Some Lutzomyia species are able to blood-feed on mammals in the upper strata of forests. A good example is Lutzomyia umbratilis Ward & Fraiha that blood-feed on Choleoeus didactylus Linnaeus and Tandandua tetractyla Linnaeus at night (Lainson and Shaw 1998). During the daytime when the females descend and rest on tree trunks, they can transmit CL to humans if disturbed (Ready et al. 1985). Therefore, knowledge of the occurrence of Lutzomyia in different stratification levels may help us to understand the epidemiological profile of CL in forests.

Brazilian studies of Lutzomyia in the upper strata of forests started in the 1970s in the state of Pará, eastern Amazon, and intensified in the 1980s in the state of Amazonas, central Amazon (Dias Lima et al. 2002). However, in the state of Maranhão, none of the surveys of Lutzomyia conducted in forested areas (Rebêlo et al. 2010) have studied its vertical distribution, although this method is useful for revealing new aspects of the behavior and habits of these dipterans. Therefore, the present study is the first to report the occurrence of Lutzomyia species at heights of over 1.5 m in the state of Maranhão. The objective of the present study was to investigate the richness and abundance of Lutzomyia species in the sub-canopy and canopy of riparian forests.

The study was conducted in two areas of riparian forest in the municipalities of Icatu (2°44′ S, 44°01′ W) and Morros (02°53′ S, 44°03′ W). These two municipalities were selected because they have preserved forests and records of CL cases from 2000 to 2011: 107 and 146 in Icatu and Morros, respectively. Four trees with similar size and height (±15 m) located 20 m from each other were chosen in each area. Only one CDC light trap was set in each tree. Traps 1 and 2 were set in the sub-canopy at 5 m high in two trees and traps 3 and 4 were set in the canopy at 10 m in the other two trees. The traps remained suspended in the tree branches and were set for 12 h from 18:00 to 6:00 the following morning, once a month from July, 2010 to June, 2011. The sampling effort included four traps x two areas x 12 h x 12 months, totaling 1,152 h of sampling.

The collected sand flies were transported to the Laboratory of Entomology and Vectors of the Federal University of Maranhão where they were identified with the dichotomous key proposed by Young and Duncan (1994). Cluster analysis using the Bray-Curtis dissimilarity index was used to compare the composition of the sand fly fauna between strata. The non-parametric MANOVA (permutational multivariate analysis of variance) approach was used to test the existence of similarities in species composition between strata (Anderson 2001).

A total of 784 individuals of 16 species of sand flies was captured: 13 species of the genus Lutzomyia and one of the genus Brumptomyia. Species richness was similar between areas, 13 in Icatu and 12 in Morros (Table 1). In the canopy, the dominant species were Lu. antunesi (54.8%), Lu. migonei (19%), Lu. wellcomei (7.6%), Lu. flaviscutellata (5.9%), Lu. infraspinosa (4.8%), Lu. paraensis (2.1%), Lu. furcata (1.7%), and Lu. sordellii (1.7%). In the sub-canopy, the dominant species were Lu. antunesi (34.6%) followed by Lu. wellcomei (28.9%), Lu. infraspinosa (13.4%), Lu. flaviscutellata (6.9%), Lu. whitmani (4.8%), Lu. migonei (3.6%), Lu. furcata (2.8%), and Lu. sordellii (1.4%).

There was greater similarity between the strata within an area than between the same strata of different areas (df = 1, f = 2.46, p = 0.03). This occurred because the conditions of the sampling sites in the same area are more similar due to proximity, particularly when using the same method. The sub-canopy site Ps1 (Morros) was the only sampling site with four dominant species, therefore there was a greater difference between the results at this site and the other sub-canopy sites, including those in the same area (Figure 1, Table 1).

The occurrence of Lutzomyia at 10 m indicates that the local species have the ability to exploit the forest canopy (10 m), particularly the lower strata (5 m). The concomitant and significant