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ECOLOGY, BEHAVIOR AND BIONOMICS

Frequency of *Aedes sp*. Linnaeus (Diptera: Culicidae) and Associated Entomofauna in Bromeliads from a Forest Patch within a densely Urbanized Area

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Keywords

Mosquitoes, Macroinvertebrates, Abiotic variables, Forest fragment, Urban area

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Abstract

Little is known about the relationship between the presence of *Aedes*, abiotic factors and the entomofauna existing in phytotelmatas. The aim of this study was to identify biotic and abiotic factors associated with the presence of *Aedes* in bromeliads sites located in a forest fragment in Rio de Janeiro, Brazil. In the study area, eight bromeliads from the *Aechmea* genus were chosen and kept in landscape form. Physical and chemical variables were measured. Collected aquatic insects were identified according to the literature. A total of 3102 immature insects were collected. The presence of *Aedes aegypti* (Linnaeus) (2.29%) was rare. Few specimens were found concentrated in urban-adjacent areas during summer. On the other hand, *Aedes albopictus* (Skuse) (17.57%) was found throughout the year in 0%–80% of the sites, averaging 1.0 mosq/bromelia. *Aedes albopictus* was found predominantly in central sites of the forest fragment. The Canonical Correspondence Analysis indicates that most taxa had a moderate association with temperature, dissolved oxygen, and pH. The abiotic variables, such as temperature and dissolved oxygen, affect the distribution of the genus *Aedes* vectors, while most of the other variables did not.

Introduction

The Bromeliaceae family is characterized by the ability to store water, offering favorable conditions to house aquatic invertebrates (Frank 1983). In these phytotelmatas, colonization and maintenance of aquatic organisms are mediated by environmental processes, such as interactions among species (Richardson *et al* 2000). From the anthropic perspective, bromeliads are classified as natural or artificial containers. Some exist in the wild and others are cultivated for landscaping purposes, residences, and city parks (Forattini *et al* 1998). Several mosquito species use bromeliads as breeding sites; for example those of Sabetini (Forattini 2002) and of other groups which have been found naturally infected with arboviruses and other medically-important parasites (Consoli & Lourenço-de-Oliveira 1994, Lounibos *et al* 2003, Gadelha 1994).

In addition to the fact that the bromeliads capture rainwater passively, they can also actively change the physico-chemical conditions of their microcosm, absorbing nutrients through specialized trichomes (Benzing *et al* 1972, Inselsbacher *et al* 2007). Lopez *et al* (2009) proposed that this special micro environmental condition created by the physiology of bromeliads acts as an environmental filter that restricts the number of potential settlers. The pH of the water in the bromeliad also drops sharply, probably related to ion exchange mediated by the absorption of the bromeliad metabolism (Lopez *et al* 2009). The variation of abiotic factors is important for colonization and the development of aquatic biota in these phytotelmatas (Forattini 2002).

Ten arboviruses have recently been reviewed as important emergent disease agents in Brazil (Figueiredo 2007), of which *Aedes aegypti* (Linnaeus 1762) can transmit dengue virus (DENV), yellow fever virus (YFV), Chikungunya virus (CHIKV) (Figueiredo & Figueiredo 2014), Venezuelan equine encephalitis virus (VEEV) (Ortiz *et al* 2008), Mayaro virus (MAYV) (Aitken & Anderson 1959, Figueiredo & Figueiredo 2014) and Zika vírus (ZIKV) (Ioos *et al* 2014). The distribution and frequency of *Ae. aegypti* is associated with the presence of environments altered by man, being essentially characterized as a mosquito of peridomicile and human dwellings (Christophers 1960). This mosquito is considered rare in natural habitats, such as bromeliads (Consoli & Lourenço-de-Oliveira 1994). However, it is occasionally found in these natural containers in the Americas (Peryassú 1908, Forattini & Marques 2000, Marques *et al* 2001, Cunha *et al* 2002, O'Meara *et al* 2003, Varejão *et al* 2005, Maciel-de-Freitas *et al* 2007). *Aedes albopictus* (Skuse 1894) uses different natural breeding sites, such as the internodes of bamboo, tree holes, and a variety of species of bromeliads (Consoli & Lourenço-de-Oliveira 1994).

The presence of *Ae. albopictus* in the aquatic content of bromeliads in the urban and peri-urban environment in the Atlantic Forest was recorded by Natal *et al* (1997) and Marques *et al* (2001). Many studies have reported the presence of *Ae. aegypti* and *Ae. albopictus* in such plants only occasionally (Cunha *et al* 2002, O'Meara *et al* 2003, Maciel-de Freitas *et al* 2007, David *et al* 2009). In the study by Honorio *et al* (2009), *Ae. albopictus* was present in a forest fragment in a densely-urbanized area. However, little is known about the relationship between the presence of these two vectors and the influence of biotic and abiotic factors in the phytotelmatas. In terms of public health, ecological conditions that influence the abundance of mosquito diseases are of great interest because they may help define management strategies that, combined, minimize the risk to human health and the preservation of the environment (Chaves & Koenraadt 2010).

The aim of this study was to identify biotic and abiotic factors associated with the presence of *Ae. aegypti* and *Ae. albopictus* in bromeliad sites, located in a forest fragment imbedded in a densely-populated area endemic for dengue. In addition, this study assessed whether there is spatial and temporal variation in the presence and frequency of vectors in bromeliads.

Material and Methods

Study area

The study was conducted in a transition zone between an urban area and a forest area located on the campus of Oswaldo Cruz Foundation, Rio de Janeiro, Brazil (22°52′30″ S, 43°14′53″W; 697.000 m^2). This region has a heterogeneous vegetation cover characterized by low, medium, and high vegetation, consisting of species of the Atlantic Forest biome and introduced species of landscape form, under constant management actions. The surrounding area consists of slums (Lenzi *et al* 2000, Costa & Fernandes 2009). The climate in Rio de Janeiro is tropical, with a dry winter (May to September) and rainy summer (November to March). In the study area, eight sites of bromeliads of the genus *Aechmea* belonging to a landscape were chosen and surveyed. These sites were referenced as A through H and were located in areas with different degrees of vegetation and urbanization (Fig 1 and Table 1).

Sampling

Immature Culicidae were collected fortnightly from August 2011 to February 2012, comprising a total of 14 samples collected during the winter of 2011, spring 2011 and summer 2012. At each site, a sample of ten bromeliads was randomly selected, and properly identified according to genus level by a specialist in these plants. During data collection, the total volume of liquid contained in each bromeliad was removed with sucking and/or pipet and filtered with the aid of a tulle. The retained immature forms (larvae and pupae) were stored in falcon tubes identified according to date and place and transported to the Sentinel Operational Unit Mosquito Vectors-NosMove (DIRAC Partnership, IOC, VPAAPS). At the time of collection, which was consistently between 8 and 11 am, water temperature and dissolved oxygen (DO) (mg O2/l) were measured using a portable oximeter (YSI F-1550 model). Of the total volume removed, 126 water samples (500 ml) were stored, transported and refrigerated for later analysis at the Laboratory of Evaluation and Promotion of Environmental Health, Oswaldo Cruz Foundation. pH and alkalinity were evaluated (Gran method Camourze-Mod 1994); electrical conductivity and salinity were assessed using the electrometric method with multi-parameter; calcium, magnesium, chloride, and nitrite were measured using methods described by FUNASA 2006; and ammonia concentration was measured using the method described by Bower & Holm-Hansen (1980).

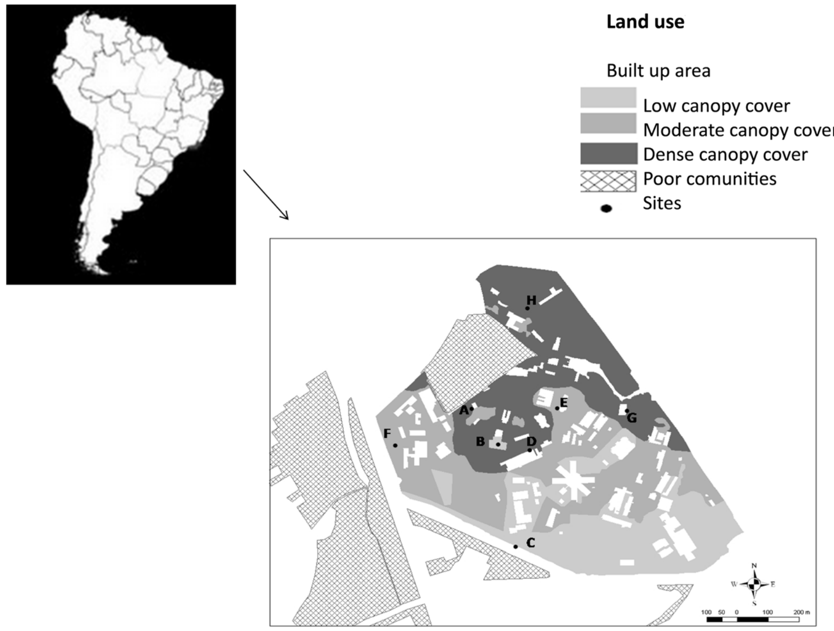

Fig 1 Distribution of the eight bromeliads sites (A, B, C, D, E, F, G, H) located on the campus of Fiocruz, Manguinhos, Rio de Janeiro.

Identification of immature forms

All the collected aquatic insects were identified to the family level. Those of the family Culicidae were identified to the genus level and those of the genus *Aedes* to species level. The identification was carried out using a stereomicroscope, using dichotomous key (Lane 1953a, b, Forattini 1965a, b, Consoli & Lourenço-de-Oliveira 1994, Forattini 2002, Motta *et al* 2007).

Data analysis

In order to describe the bromeliads' parameters, descriptive statistics of abiotic and biotic data, as the mean and standard deviation, were presented as graphs using the R 2.8.1 software (R Core Team 2014). Hypothesis tests were performed (ANOVA) to determine whether there was a variation of abiotic factors of water (sample volume, temperature, dissolved oxygen, pH, alkalinity, conductivity, salinity, concentrations of calcium, magnesium, chloride, nitrite, and ammonia) over time, between sites, and the interaction between the two. Chi-square tests were used to determine whether there were differences in the distribution of the abiotic rates found among sites. A null model test was used to identify co-occurring species using Ecosim 7.0 software (Gotelli & Entsminger 2009) to test the hypothesis that the observed patterns of species distribution were due to chance. We used the C-score index (Stone & Roberts 1990), which measures the units "checkerboard" between all possible pairs of species. In a community structured by competition, the C-score should be significantly smaller than expected for the null hypothesis. The following parameters were used in the null model: fixed line sums represent the abundance of individuals, the option whereby the total observed in the rows are kept in the simulation, so that the number of occurrences of each species in the null communities is the same as in the

Table 1 Characterization of eight bromeliads sites included in the study.

Sites	Characterization
A	Place in the sun, near the border of the forest fragment and human habitations
B	Densely wooded and shaded place and central area of the forest fragment
C	Place in the sun, near the border of the forest fragment and polluted river with human habitations around
D	Densely wooded and shaded place and central area of the forest fragment
E	Densely wooded and shaded place and central area of the forest fragment
F	Sparsely wooded and shaded place, near the forest fragment limit
G	Densely wooded and shaded place, near the border of the forest fragment and a road with much traffic flow
H	Densely wooded and shaded place, near the border of the forest fragment and a road with much traffic flow

original data; and sums of equiprobable columns, configuration in which each column (or site), has equal probability of being represented. Canonical Correspondence Analysis (CCA) using CANOCO software (Ter Braak & Smilauer 2002), relating abiotic factors, was used to measure the rate distribution. To test the significance of each environmental variable, Monte Carlo experiments with 5000 permutations were performed in the significant models ($p < 0.05$). Principal Coordinates Analysis (PCO) was used to identify possible distribution gradients of the aquatic community at different sites using the PAST program (Hammer *et al* 2001).

Results

Abiotic variables

The eight evaluated sites varied in their abiotic characteristics throughout the months. In summer, the average water temperature (28.54°C) and dissolved oxygen (0.49 mL/L) were higher; in winter, values of 23.16°C and 0.42 mL/L, respectively, were observed. In winter, the average electrical conductivity (203 S/cm) and ammonia (1.75 mmol/L) were higher than in the hottest period (64.3 S/cm and 0.78 mmol/L), and the other variables (sample volume, pH, electrical conductivity, calcium concentrations, magnesium, chloride, nitrite) showed no clear seasonal patterns (Table 2). However, a significant spatial variation of values for all variables was observed except temperature, conductivity, and magnesium concentrations.

Biotic variables

We collected a total of 3102 immature insects belonging to two orders: 57 (1.84%) of Odonata and 3045 (98.16%) of Diptera (Table 3). All specimens of the Odonata belonging to the Megapodagrionidae family and those of Diptera, on the other hand belonging to several families: Chironomidae (44%), Culicidae (41.14%), Psychodidae (12.24%) and Syrphidae (0.78%). There were 1309 immature individuals of three genera in Culicidae: *Wyeomyia* (79.68%), *Aedes* (19.86%) and *Toxorhynchites* (0.46%). Regarding location, Syrphidae, *Toxorhynchites*, Odonata, Psychodidae, Chironomidae and *Wyeomyia* were more abundant in central sites with high vegetation.

Two species of the genus *Aedes* were found. *Aedes aegypti* (2.29%) was rare and few specimens were found in the summer at the sites A, B, and F. The percentage of positive sites for *Ae. aegypti* varied from 0 to 40%, with an average of 0.5% (Fig 2).

Aedes albopictus (17.57%) was collected throughout the months in 0–80% of the sites, with an average of 1.0%, being

Table 2 Average values of the abiotic variables measures in water ten bromeliads in eight sites (A to H) of urban forest fragment from August 2011 to February 2012, Rio de Janeiro. The significance values are for the hypothesis tests (ANOVA) variation of abiotic factors over time, between sites, and the interaction between the two. (** $p < 0.01$).

	Site A	Site B	Site C	Site D	Site E	Site F	Site G	Site H	*p*-value (time)	*p*-value (site)	*p*-value (time x site)
Temperature(°C)	25.78 ± 4.02	25.78 ± 3.79	26.53 ± 3.67	25.87 ± 3.48	25.41 ± 3.97	26.30 ± 3.99	25.68 ± 3.51	26.48 ± 3.57	**		**
DO (ml.L)	0.44 ± 0.07	0.57 ± 0.10	0.50 ± 0.10	0.48 ± 0.09	0.46 ± 0.08	0.56 ± 0.10	0.57 ± 0.08	0.53 ± 0.10		**	**
Volume (ml)	307.5 ± 107.7	284.3 ± 81.8	230.3 ± 79.5	388.0 ± 83.9	351.8 ± 94.6	206.9 ± 92.4	227.7 ± 111.5	354.7 ± 113.9		**	**
Ph	6.08 ± 0.59	6.09 ± 0.56	6.89 ± 0.72	6.33 ± 0.26	6.13 ± 0.56	6.63 ± 0.48	6.70 ± 0.37	6.32 ± 0.31	**	**	**
Alkalinity (mEq.L)	69.39 ± 87.18	38.33 ± 8.44	143.07 ± 55.27	70.02 ± 93.62	37.08 ± 13.71	79.51 ± 14.83	61.47 ± 28.57	48.46 ± 10.61		**	**
Conductivity (µS/cm)	176.4 ± 199.7	79.8 ± 38.6	204.7 ± 137	117.8 ± 116.4	139.6 ± 210.6	122.7 ± 45.3	121.1 ± 61.6	78.6 ± 44.2	**		**
Salinity	0.06 ± 0.10	0.01 ± 0.03	0.51 ± 0.93	0.04 ± 0.06	0.05 ± 0.10	0.07 ± 0.04	0.04 ± 0.04	0.02 ± 0.04	**	**	**
Ca (mg/l)	14.68 ± 11.82	10.18 ± 4.88	36.91 ± 15.51	14.80 ± 9.08	14.97 ± 8.48	16.54 ± 5.69	19.10 ± 8.17	11.88 ± 6.37	**	**	**
Mg (mg/l)	5.15 ± 3.06	4.39 ± 3.50	5.65 ± 3.85	4.95 ± 2.63	3.44 ± 1.64	6.18 ± 4.84	7.14 ± 6.27	4.82 ± 2.43	**		**
Chlorides (mg/l)	12.26 ± 10.87	12.46 ± 6.76	22.24 ± 10.05	15.12 ± 14.45	11.22 ± 8.27	9.94 ± 6.81	8.48 ± 7.72	7.81 ± 9.64	**	**	**
Nitrite (mg/l)	0.06 ± 0.03	0.04 ± 0.02	0.09 ± 0.10	0.02 ± 0.01	0.06 ± 0.05	0.04 ± 0.02	0.03 ± 0.03	0.02 ± 0.01	**	**	**
Ammonia (µMol/l)	0.55 ± 0.18	0.75 ± 0.19	0.88 ± 0.12	0.48 ± 0.20	0.62 ± 0.13	0.67 ± 0.09	0.50 ± 0.15	0.45 ± 0.14	**	**	**

Table 3 Immature collection at sites in forest fragment (August 2011 to February 2012). The significance values are for the chi-square test of difference in the distribution of bromeliads rate between sites.

Sites										
Groups	A	B	C	D	E	F	G	H	Total areas	Test (chi-sq)
Aedes albopictus	17	11	16	24	31	92	38	1	230	$p < 0.001$
Aedes aegypti	8	10	2	0	0	10	0	0	30	$p < 0.001$
Wyeomyia sp.	46	22	27	49	670	50	137	42	1043	$p < 0.001$
Toxorhynchites sp.	1	0	0	0	2	0	1	2	6	$p = 0.2244$
Psychodidae	23	23	45	80	12	158	21	11	373	$p < 0.001$
Chironomidae	105	94	118	330	386	49	143	114	1339	$p < 0.001$
Syrphidae	18	5	3	7	2	2	0	20	24	$p < 0.001$
Megapodagrionidae	10	11	0	0	0	0	0	3	57	$p < 0.001$
Mosquitoes total	72	43	45	73	703	152	176	45	1309	
Total (associated fauna)	156	133	166	417	400	209	164	148	1793	

predominantly found at sites E, F, and G, which contributed with 70% of the total specimens of this species. .

The distribution of all insects studied in bromeliads, according to the null model, was not random. It follows a structured distribution [observed index =0. 46, with a mean of simulated indexes =1.25, variance in the rates of simulated =0.09, *p* (observed ≤ expected) = 0.01, *p* (observed ≥ expected) = 0.98] (Fig 3).

Association with abiotic variables

CCA indicates that most taxa (*Ae. albopictus*, Syrphidae, Megapodagrionidae, *Toxorhynchites* sp., Psychodidae, and Chironomidae) are positively associated with temperature, dissolved oxygen, and pH (Fig 4); mainly *Ae. albopictus* on the temperature variable. However, this species was negatively associated with the other variables, such as nitrite, ammonia, and electrical conductivity. The *Wyeomyia* genus was positively associated with these variables (nitrite, ammonia, conductivity). *Aedes aegypti* was unrelated to any of the abiotic variables measures. The variation explained by axis 1 was 0.31 and the Axis 2 is 0.28.

PCO (Fig 5) revealed a gradient of diversity of organisms in different sites locations. Through the distribution of organisms, a diversity gradient is observed in areas near the spot boundary limits of most central areas. The variation explained by axis 1 was 0.47 and by Axis 2, 0.24. The quantitative index used was Bray-Curtis.

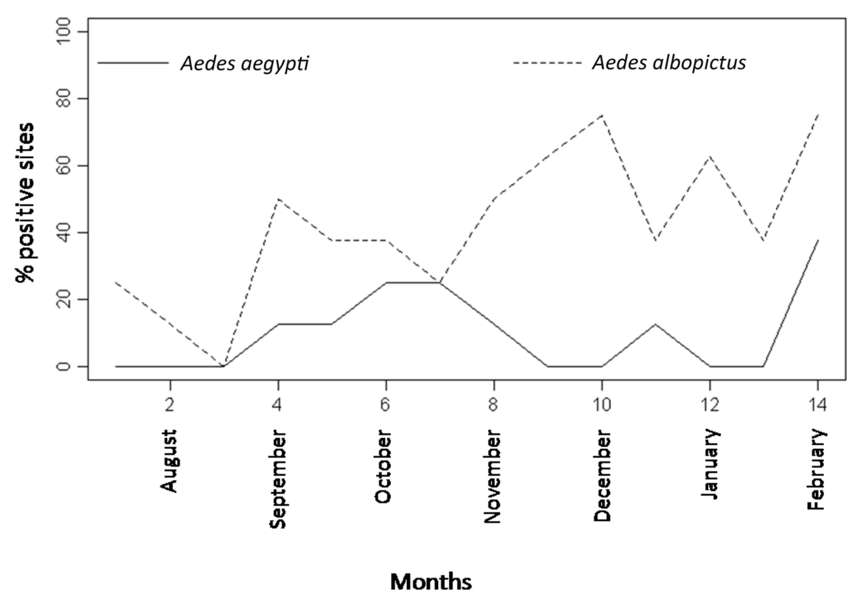

Fig 2 Temporal variation of percentage of positive sites of *Aedes aegypti* and *Aedes albopictus* (*n* = 80 bromeliads sites).

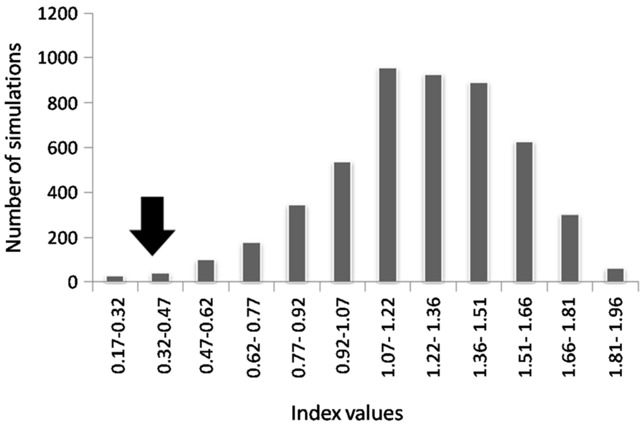

Fig 3 Null model for co-occurrence of immatures [observed index =0.46, average of simulated indices =1.25, variance of simulated indices =0.09, *p* (observed ≤ expected) = 0.01, *p* (observed ≥ expected) = 0.98] .The arrow indicates the value of the co-occurrence index from actual data.

Discussion

Abiotic variables

In this study, we observed a variation of physicochemical properties in the water of bromeliads during the study and among sites with interaction between time and space. In terms of vectors, *Ae. albopictus* individuals were related positively to intermediate temperature variable values (between 26 and 28°C). *Aedes aegypti* did not reveal significant patterns. In their study on the development of immature *Ae. albopictus*, Calado & Navarro-Silva (2002) revealed the most appropriate track to maintain this stage under laboratory conditions as between 20°C and 30°C, consistent with the current study. Abiotic factors may influence the presence of mosquitoes in bromeliads, but, owing to the low number of individuals of *Ae. Aegypti*, it was impossible to investigate this association.

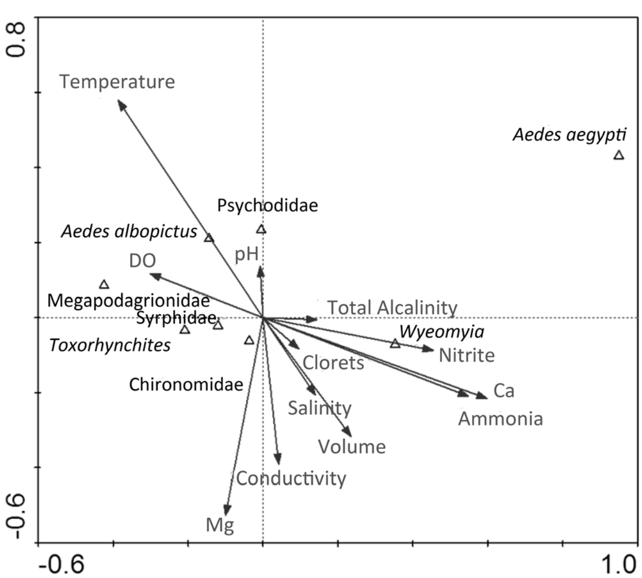

Fig 4 Ordination diagrams extracted by canonical correspondence analysis of the 8 groups entomofauna distribution in relation to habitat variables found significant ($p < 0.05$) (axis 1: eigenvalues =0.31; axis 2: eigenvalues =0.28).

Biotic variables

Among 1309 mosquito larvae collected in bromeliads 80% of them belong to *Wyeomyia* genus, characterizing these plants as their preferred habitat. Two endemic mosquito species of southern Florida, *Wyeomyia vanduzzei* Dayer & Knab and *Wyeomyia mitchellii* (Theobald), are also prevalent in bromeliads (Frank 1983). The leaves of trees falling in bromeliads provide a nutritional organic base for larval growth of these species (Frank & O'Meara 1985). Another possible reason for the accumulation of *Wyeomyia* larvae collected in phytotelmatas may be attributed to the delay in their development due to nutritional factors. The larvae can remain in this stage for weeks or months until they locate new food resources in their microhabitat (Frank & Curtis 1977, Frank 1983).

This slow development of larvae of the *Wyeomyia* genus can be related to the number of adults collected being lower than *Ae. albopictus*, which possibly emerges more quickly than the former, making it difficult to collect (Forattini 2002). However, Lounibos *et al* (2003) observed between bromeliad mosquitoes in Florida that the survival of *Ae. albopictus* had a significant inverse correlation with the presence of *Wyeomyia* larvae. This species are also observed in artificial containers and the holes of trees (Lounibos *et al* 2001 Juliano *et al* 2002).

Although the presence of *Ae. aegypti* in bromeliads in urban centers was reported, only a low amount of specimens was found in the examined bromeliads (Varejão *et al* 2005). The present study indicated that the largest presence of *Ae. aegypti* ocurred in the area located on the edge of the campus, close to the local community (Manguinhos region), corroborating observation of Tauil (2001) who commented that the uncontrolled spread of neighborhoods has contributed to vector proliferation. Nine to 14 *Ae. aegypti* individuals were observed in the samples during the summer months (December to February); these numbers decreased in winter (Fig 2), owing possibly to increased rainfall during that period, and, consequently, to an increase in artificial breeding. Another hypothesis is selection pressure (Christophers 1960), which posits that *Ae. aegypti* is more vulnerable to predation and cannibalism.

On the other hand, *Ae. albopictus* was found in abundance, predominantly at sites E, F, and G. The sites varied widely in the presence of *Ae. aegypti* and *Ae. albopictus* throughout the months, and among one another. The latter was represented by a larger number of positive plots relative to *Ae. aegypti*. The presence of *Ae. aegypti* was rare, and the few specimens found

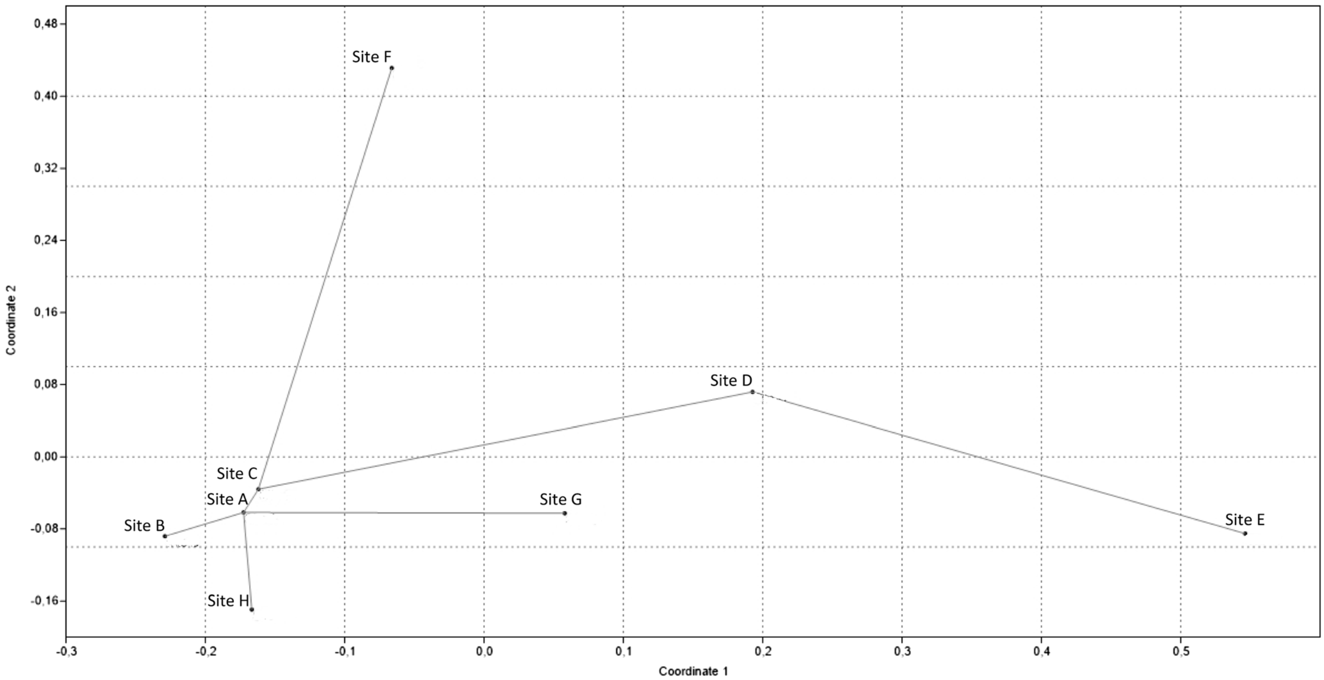

Fig 5 PCO performed using the abundances, where the first coordinate shows a set of sites with very similar entomofauna composition (sites A, B, C, H) and sites with distinct community structure (F, D, G, E).

in the summer were at sites A, B, and F, which are close to the campus boundary and in a predominantly-urbanized area.

The location of the phytotelmatas of these sites also enabled the distribution of these groups, as the proximity to the local community facilitates the presence of *Ae. aegypti* and *Ae. albopictus*. In more central areas of the campus with greater vegetation cover, *Ae. aegypti* and *Ae. albopictus* were not found; only characteristic forest area groups, such as wild mosquitoes of the *Wyeomyia* genus, were identified. This result reinforces the hypothesis that these *Aedes* species prefer laying eggs in artificial containers and that this contributes to the higher acidity of the bromeliad water (Lopez *et al* 2011).

Our results indicate that *Ae. albopictus* was more abundant in areas with high vegetation cover. These results are consistent with *Ae. aegypti* distribution patterns (in urban areas) and with *Ae. albopictus* (in more populated areas covered with vegetation) found in the literature (Lourenço-de-Oliveira *et al* 2004, Rey *et al* 2006, Lima-Camara *et al* 2006, Honorio *et al* 2009).

Urban environments seem to favor the presence of *Ae. aegypti*, since this species lays eggs and is frequently found inside the homes, known as endophytic habit. Furthermore, they feed on human blood, known as anthropophilic habit (Barata *et al* 2001, Thavara *et al* 2001). Rural areas seem to favor *Ae. albopictus*, in its exophilic character, as this species often lays eggs, rests, and performs bloodfeedings in environments in which the vegetation cover is greater (Hawley 1988).

These habits displayed by *Ae. aegypti* suggest that populations of this species maintain high contact with humans, which is an important parameter in determining the vectorial capacity for the transmission of dengue virus. A study conducted in Rio de Janeiro/Brazil, indicated that densely-populated neighborhoods located close to highways with intense traffic can facilitate the introduction and circulation of dengue viruses (Lourenço–de-Oliveira *et al* 2002, Lagrotta *et al* 2008).

In general, the richness of mosquito species present in bromeliads cups was less than that reported in the literature (O'Meara *et al* 2003, Marques & Forattini 2008, Mocellin *et al* 2009). Mocellin *et al* (2009) conducted a study near a rainforest region where they found 14 species of mosquitoes in bromeliads, and in the present study, only four species were found. This fact can be observed, whereas in stable ecosystems, such as rainforests, have high species diversity (Richardson 1999), in contrast to studies in small forest area in an urban area.

Association with abiotic variables

CCA analysis indicated a positive association between greater amounts of immature forms of insect fauna and higher water temperatures. This is probably caused by the activity of mating and egg-laying at higher temperatures (Forattini 2002). Abiotic factors, such as temperature and pH, affect the concentration of organic matter in the water (Esteves 1998). Urban substrates are rich in organic matter, which causes high chemical and biochemical oxygen consumption, decreased pH, and, consequently, increased nutrient reactions, showing toxicity affecting the aquatic biota (Allan 1995, Brigante & Espínola, 2003, Ometto *et al* 2004, Salomoni *et al* 2007). Therefore, the composition of the biota is taken as a parameter that reflects the environmental conditions and integrates the influences of water quality and habitat degradation (Lammert & Allan 1999).

Conclusion

Bromeliads in locations near human dwellings have higher rates of *Aedes* compared to areas with greater vegetation cover. During the summer months, *Ae. albopictus* proliferate in bromeliads. Abiotic variables, such as temperature and dissolved oxygen, positively influence the distribution of the genus *Aedes* vectors, while most other variables negatively influence this distribution. Owing to the low number of individuals, bromeliad is not a preferred breeding site for *Ae. aegypti*, not requiring the reduction of bromeliad populations as a preventive measure to mosquito control in the area of the present study. It is important to emphasize the need to improve vector control in infested municipalities with *Ae. aegypti*, since only this species in Brazil is, to date, associated with severe transmission of three arboviruses, dengue, Chikungunya, and Zika. Epidemiological surveillance faces an enormous challenge in the early detection of new areas of transmission to minimize the impact of these diseases in the population.

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