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Inventory

Composition and diversity of mosquitoes (Diptera: Culicidae) in urban parks in the South region of the city of São Paulo, Brazil

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Abstract: Many parks in the city of São Paulo contain remnants of Atlantic Forest. Of the 30 municipal parks in the South of the city, we investigated two in this study (Santo Dias Park and Shangrilá Park) in order to survey their mosquito fauna and investigate the presence of potential bioindicators of environmental conditions and vectors of human pathogens. Mosquitoes were collected monthly between March 2011 and February 2012 using aspirators, Shannon and CDC traps for adult mosquitoes and larval dippers and suction samplers for immature forms. Sampling effort was evaluated by plotting a species accumulation curve, and total richness was estimated using the first-order jackknife. To compare the diversity between the two parks Shannon and Simpson diversity indexes were calculated. Species similarity was compared by the Sorensen similarity index. In all, 8,850 specimens were sampled in both parks. Collections in Santo Dias Park yielded 1,577 adult mosquitoes and 658 immature individuals distributed in seven genera (*Aedes, Anopheles, Culex*, *Limatus*, *Mansonia*, *Toxorhynchites* and *Wyeomyia*) and 27 taxonomic units. Among the adult mosquitoes collected, *Culex nigripalpus* .and *Aedes fluviatilis* were the most abundant, while the most abundant immature forms were *Cx. imitator*, *Wy. davisi*, *Wy. galvaoi* and *Ae. albopictus.* Collections in Shangrilá Park yielded 4,952 adult specimens and 1,663 immature forms distributed in eight genera (*Aedes*, *Anopheles*, *Culex*, *Limatus*, *Mansonia*, *Toxorhynchites*, *Uranotaenia* and *Wyeomyia*) and 36 taxonomic units. Species accumulation curves in both parks were close to the asymptote, and the total richness estimate was close to the observed richness. Although the observed species richness was higher in the Shangrilá Park, there was no statistically significant difference between the diversity indexes measured. Regarding species composition, the two sites shared 16 species, including those of epidemiological importance such as *Culex nigripalpus*, *Cx. quinquefasciatus*, *Aedes albopictus* and *Ae. aegypti*. As some of the mosquito taxa found are bioindicators of environmental conditions and have epidemiological potential to carry pathogens, we recommend that urban parks should be included in official mosquito surveillance programs, and regular surveys carried out to detect circulating arboviruses.

Keywords: *Diversity, mosquitoes, composition, urban parks*

Composição e diversidade de mosquitos (Diptera: Culicidae) em parques urbanos localizados na região Sul do município de São Paulo, Brasil

Resumo: Parques urbanos do município de São Paulo contêm remanescentes de Mata Atlântica. No sul da cidade há 30 parques municipais, sendo os parques Santo Dias e Shangrila alvos deste estudo. Este estudo teve a proposta de levantamento da fauna de culicídeos desses dois parques no sul da cidade de São Paulo e avaliar a presença de potenciais bioindicadores e espécies vetoras de patógenos aos seres humanos. Os mosquitos foram coletados mensalmente entre março de 2011 e fevereiro de 2012, com aspiradores, armadilhas de Shannon e CDCs para mosquitos adultos e conchas entomológicas e bombas manuais de sucção para os imaturos. O esforço amostral foi avaliado por traçar uma curva de acumulação de espécies, e a riqueza total foi estimada pelo método jackknife de primeira ordem. Para comparar a diversidade entre os dois parques, foram calculados os índices de diversidade de Shannon e de Simpson. A similaridade na composição de espécies foi comparada pelo índice de similaridade de Sorensen. Foram coletados um total de

8.850 espécimes de culicídeos em ambos os parques. Coletas no parque Santo Dias renderam 1.577 mosquitos adultos e 658 imaturos, distribuídos em sete gêneros (*Aedes, Anopheles, Culex, Limatus, Mansonia, Toxorhynchites* e *Wyeomyia*) e 27 unidades taxonômicas: *Culex nigripalpus*, e *Aedes fluviatilis* foram as mais abundantes unidades taxonômicas coletadas como adultos, enquanto em formas imaturas, as espécies mais abundantes coletadas foram *Cx. imitator*, *Wy. davisi, Wy. galvaoi* e *Ae. albopictus*. Coletas no parque Shangrilá renderam 4.952 espécimes como adultos e 1.663 formas imaturas, distribuídas em oito gêneros (*Aedes*, *Anopheles*, *Culex*, *Limatus*, *Mansonia*, *Toxorhynchites*, *Uranotaenia* e *Wyeomyia*) e 36 unidades taxonômicas.. As curvas de acúmulo de espécies em ambos os parques ficaram perto da assíntota, e as estimativas de riqueza total foram próximas às riquezas observadas. Apesar da riqueza observada ter sido maior no parque Shangrilá, não houve diferença estatisticamente significante entre os índices de diversidade mensurados. Em relação à composição de espécies os dois locais compartilharam 16 espécies, incluindo as de maior importância epidemiológica como *Culex nigripalpus, Cx. quinquefasciatus, Aedes albopictus* e *Ae. aegypti*. Alguns táxons de culicídeos são bioindicadores de condições ambientais nas áreas ou possuem potencial para veicular patógenos. Atenção deve ser dada a parques urbanos, com inclusão destes locais nos programas oficiais de vigilância entomológica e investigações periódicas na circulação de arbovírus.

Palavras-chave: *Diversidade, mosquitos, composição, parques urbanos*

Introduction

São Paulo, in southeast Brazil, is the largest city in South America and one of the largest megalopolises in the world. It is characterized by an extensive urban sprawl and has a population of around 12 million people (IBGE 2016). The municipal parks in the city contain remnants of Atlantic Forest (including lakes and springs), which provide shelter for mammals, birds and arthropod vectors (Medeiros-Sousa et al. 2013), and are intended to meet the human population's need for pleasant leisure spaces and compensate for the massiveness of urban structures (Kliass 1993).

According to the 2014 São Paulo Municipal Guide, there are 30 municipal parks in the south of the city. Two of these, Santo Dias Park and Shangrilá Park, were selected for this study. Both provide refuge for several species of mosquito and suitable conditions for maintenance of their populations (Medeiros-Sousa et al. 2013, 2015, Ceretti-Junior 2016), allowing human-mosquito contact and increasing the risk of the emergence of infectious diseases, especially those caused by arboviruses (Fernandes et al. 2016).

Currently, there are about 3,552 valid species of mosquitoes described worldwide, some of which are of public health importance as they can act as vectors of pathogens to the human and animal population (Harbach 2016). In Brazil, approximately 500 mosquito species have already been described (Harbach 2016). A descriptive study of blood meal sources in mosquitoes collected in municipal parks in the city of São Paulo showed that several species of vertebrates (birds, dogs, cats, rodents, humans and other primates) are a source of blood for mosquitoes and may sustain transmission chains for pathogens of public health importance (Carvalho et al. 2014).

Because of their epidemiological importance, a knowledge of mosquito species in these locations and assessment of their potential as vectors of pathogens are crucial. In addition, surveys of mosquito species composition in urban parks highlights the need to preserve these spaces in urban areas and identify their biological richness in order to help find potential bioindicator species, which are useful for assessing environmental quality (Montes 2005, Anjos and Navarro-Silva 2008, Medeiros-Sousa et al. 2015). The present study therefore sought to survey the mosquito (Diptera: Culicidae) composition and diversity of two parks in the south region of the city of São Paulo and investigate the presence of potential bioindicators and vector species that can transmit pathogens to humans.

Material and Methods

1. Study area

The study areas are fragments of Atlantic Forest in two urban parks in the outh of the city of São Paulo. Santo Dias Park (23°39'47"S, 46°´21'46"W) and Shangrilá Park (23°76'11"S, 46°66'43"W) were chosen for the study because of their size and the large number of people who visit them every month (Figure 1).

Inaugurated in November 1992, Santos Dias Park extends over 134,000m^2 and is home to a spring as well as remnants of the Atlantic Forest. Lying on a steep slope covered by woods, it has a central clearing and is bordered by houses, a food-manufacturing company, an educational institution (São Paulo Adventist University Center) and a stream (Takahashi et al. 1993). Eighty-four species of vertebrates have been reported in the park, of which seventy-five are birds (Prefeitura de São Paulo 2014).

Shangrilá Park is located near the Billings reservoir and extends over 75,000m^2 in the Bororé-Colônia environmental protection area. The park was created to preserve the city's environmental heritage through the acquisition of green areas, to preserve and enrich the city's biodiversity and to protect the reservoir. Between invertebrates (mosquitoes, butterflies and spiders) and vertebrates (frogs, reptiles, marsupials, primates and 90 species of birds) there are 109 species of fauna. There are various gardens and eucalyptus trees with an understory where tree seedlings have been planted (Prefeitura de São Paulo 2014).

2. Collection methods

Mosquito collections were carried out once a month in each park from March 2011 to February 2012. Four different collection methods were used: (i) Shannon traps, from which specimens were collected for two hours starting at evening twilight by two individuals wearing personal protective equipment; (ii) CDC light traps (baited with 200 g of dry ice) placed 1 m above the ground (two traps) and in the canopy 5 m above the ground (two traps) for three hours; (iii) three 12V battery-powered aspirators used in a standardized 20-minute collection effort (Nasci 1981) and (iv) an active search for immature specimens in breeding sites using a 400 mL larval dipper or suction samplers or by pipetting/emptying containers, depending on where the collection was being carried out. Sampling effort throughout the study period totaled about 240 hours in each park, divided as follows: 12 hours of aspiration, 24 hours of Shannon traps, 144 hours of CDC light traps and 60 hours of active search for immature forms.

3. Identification and data analysis

After the collections, the adult mosquitoes were killed using chloroform and stored in labeled plastic pots containing silica gel. Immature specimens were transported in labeled 200 mL plastic pots containing water from the breeding site. All the sampling material was transported to the Entomology Laboratory at the Faculty of Public Health, University of São Paulo, where the specimens were identified. Immature individuals were kept in the laboratory until they reached the adult stage. Morphological identification

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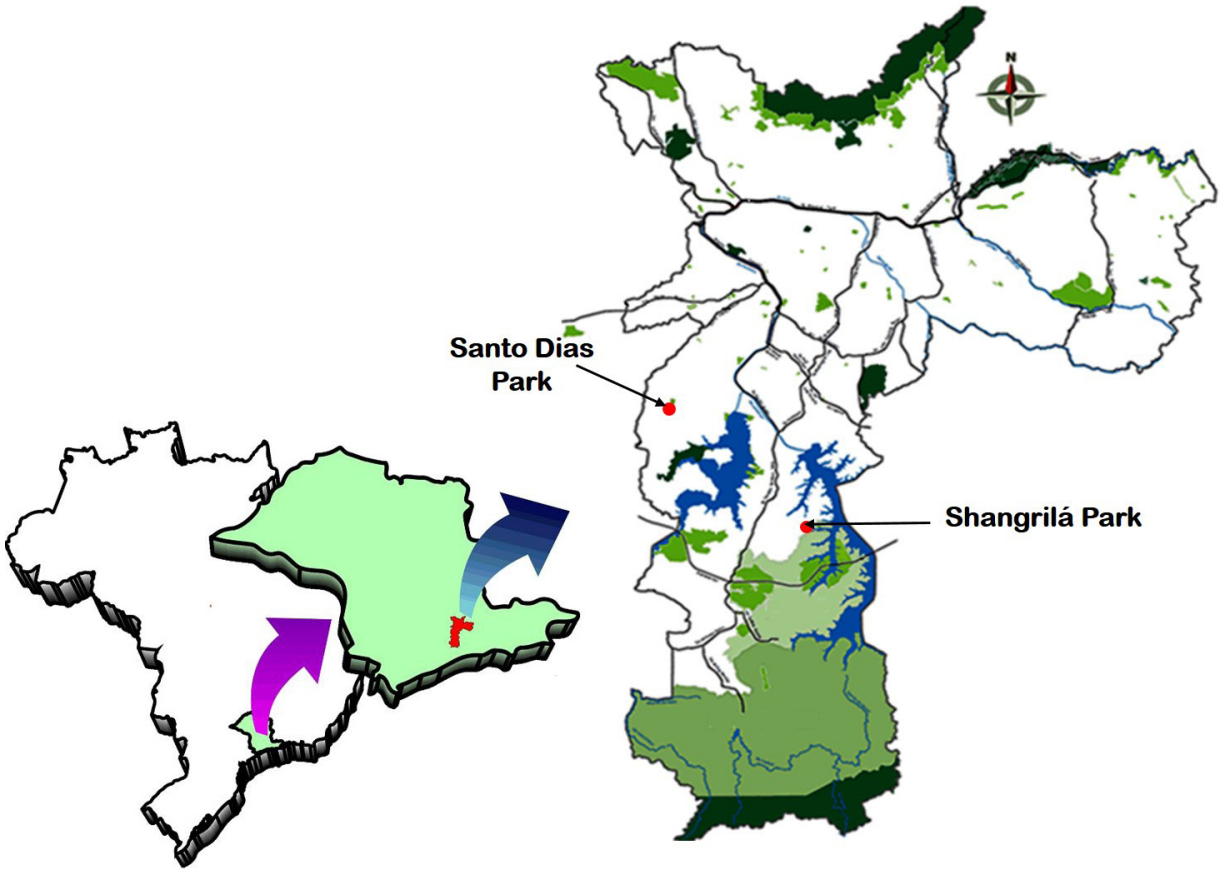

Figure 1. Location of Santo Dias Park and Shangrilá Park in the South of the city of São Paulo, SP, Brazil.

was based on Lane (1953) and Forattini (2002). The abbreviations for genera and subgenera used here follow the standardization proposed by Reinert (2001).

Sampling effort was estimated by plotting a species accumulation curve, and the first-order jackknife method (Burnham and Overton 1979) was used to estimate total richness. In both cases, EstimateS (Colwell et al. 2004) was used with 1,000 randomizations without replacement and a confidence interval of 95%. To compare the diversity between the two parks, the Shannon's (H ') and Simpson's (D) diversity indices were calculated for each monthly sample (N = 12 samples / park). Since the data did not showed evidence of normal distribution deviation and heteroscedasticity, it was applied a T-test to verify if the mean diversity observed for the two areas differ statistically. Species composition similarity was measured by the Sorensen's similarity index.

Results

We collected 8,850 mosquito specimens in both parks (Tables 1 and 2). Collections in Santo Dias Park yielded 1,577 adult mosquitoes and 658 immature forms (a total of 2,235 individuals) distributed in 7 genera (*Aedes* Meigen, *Anopheles* Meigen, *Culex* Linnaeus, *Limatus* Theobald, *Mansonia* Blanchard, *Toxorhynchites* Theobald, *Wyeomyia* Theobald) and 27 taxonomic units. *Culex* (*Cux.*) *nigripalpus* (34.12%), and *Aedes* (*Och.*) *fluviatilis* (14.65%) were the most abundant taxonomic units among the adults, while *Cx.* (*Mcx.*) *imitator imitator* (67.33%), *Wy.* (*Pho*) *davisi* (8.97%), *Wy.* (*Pho.*) *galvaoi* (8%) and *Ae.* (*Stg.*) *albopictus* (7.75%) were the most abundant among the immature forms (Table 1).

Collections in Shangrilá Park yielded 4,952 adult specimens and 1,663 immature forms (a total of 6,615 individuals) distributed in 8 genera (*Aedes*, *Anopheles*, *Culex*, *Limatus*, *Mansonia*, *Toxorhynchites*, *Uranotaenia* Lynch Arribálzaga and *Wyeomyia*) and 36 taxonomic units. The most abundant taxonomic units among the adult specimens were, *Culex* (*Cux.*) *nigripalpus* (27.87%) and *Cx.* (*Cux.*) *chidesteri* (14.30%), while *Ae.* (*Stg.*) *albopictus* (34.16%), *Cx.* (*Cux.*) *quinquefasciatus* (32.23%) and *Li. durhami* (18.34%) were the most abundant among the immature specimens (Table 2).

Mosquito species accumulation curves for both parks were close to an asymptote at the end of the 12-month collection period. The first-order jackknife total richness estimator indicated that the curve stabilized at between 20 and 30 species for Santos Dias Park (Figure 2A) and 30 to 50 species for Shangrilá Park (Figure 2B). The average Shannon (H') diversity index for Santo Dias Park was 1.691 (1.565-1.817 CI 95%) and for Shangrilá Park was 1.690 (1.534-1.845). The T-test indicated no statistically significant difference between the two areas (t=0.015, p=0.988). Similarly, there was also no statistically significant difference between the mean Simpson's dominance index (t =-0.480, p=0.636), as the mean value presented by the Santo Dias Park was D=0.258 (0.219-0.298 95% CI) and Shangrila Park was D=0.272 (0.223-0.321). Regarding species composition, the two sites shared 16 species, including those of greater epidemiological importance such as *Culex nigripalpus*, *Cx. quinquefasciatus*, *Aedes albopictus* and *Ae. aegypti*. Another 24 species occurred only in one of the two parks. Sorensen's similarity index between the mosquito assemblages of the parks was 0.571.

Table 1. Distribution of adult and immature mosquitoes collected in Santo Dias Park in the city of São Paulo between March 2011 and February 2012 by collection technique.

Taxonomic units	Adults					Immature individuals				Total
	Aspiration	Shannon traps	CDC traps in canopy	CDC traps on ground	Subtotal	Dipping	Pipetting/ emptying	Suction	Subtotal	
Cx. (*Cux.*) *nigripalpus* Theobald	94	147	234	63	538					538
Culex (*Cux.*) spp. Linnaeus	105	31	218	105	459					459
Ae. (*Och.*) *fluviatilis* (Lutz)	43	116	8	64	231					231
Cx. (*Cux.*) *chidesteri* Dyar	28	2	67	8	105					105
Ae. (*Och.*) *scapularis (*Rondani*)*	21	33	2	13	69					69
Cx. (*Cux.*) *declarator* Dyar & Knab	56				56					56
Cx. (*Cux.*) *quinquefasciatus* Say	37	2	7		46		22		22	68
Cx. (*Cux.*) *bidens* Dyar	18				18					18
Ae. (*Och.*) *albopictus (*Skuse)	8			5	13		2	49	51	64
Cx. (*Mcx.*) *imitator* group Theobald	9	1		1	11	3		440	443	454
Cx. (*Cux.*) *eduardoi* Casal & Garcia								2	2	2
Cx. (*Cux.*) *lygrus* Root	5	3			8					8
Cx. (*Cux.*) *coronator* group Dyar & Knab	1	2	3	1	7					7
Wy. (*Pho.*) *galvaoi* Corrêa & Ramalho	3				3			53	53	56
Li. durhami Theobald	1	1		1	3		3	4	7	10
Cx. (*Cux.*) *dolosus/ eduardoi/bilineatus*	2				2					2
Cx. (*Cux.*) *saltanensis* Dyar	1				1					1
Wy. serratoria Lutz								1	1	1
Wy. (*Pho.*) *davisi* Lane & Cerqueira	1				1			59	59	1
Ma. (*Man.*) *indubitans* Dyar & Shannon	1				1					
Ae. (*Stg.*) *aegypti (*Linnaeus*)*			1		1			13	13	14
Cx. (*Cux.*) *coronator* Dyar & Knab	1				1					1
Wyeomyia (*Pho.*) spp. Theobald	1				1					1
Cx. (*Mel.*) *Melanoconion* section	1				1					1
Toxorhynchites spp.								7	7	7
An. (*Nys.*) *evansae* (Bréthes)	1				1					1
Total	**438**	**338**	**540**	**261**	**1,577**	**3**	**27**	**628**	**658**	**2,235**

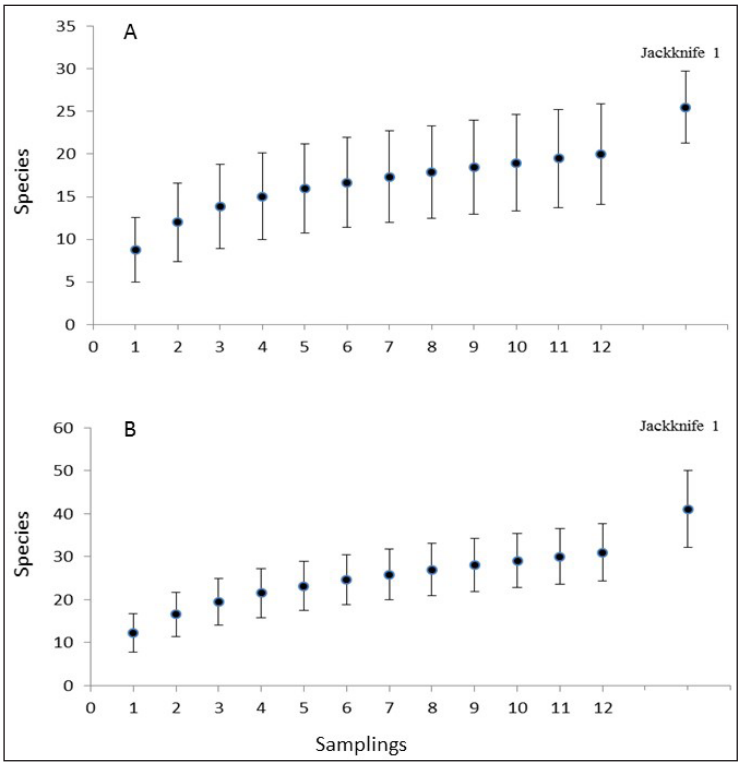

Figure 2. Sample-based species accumulation curves (jackknife 1) with a 95% confidence interval for Santo Dias Park (A) and Shangrilá Park (B) based on collections between March 2011 and February 2012.

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Table 2. Distribution of adult and immature mosquitoes collected in Shangrilá Park in the city of São Paulo between March 2011 and February 2012 by collection technique.

Taxonomic units	Adults					Immature individuals				Total
	Aspiration	Shannon traps	CDC traps in canopy	CDC traps on ground	Subtotal	Dipping	Pipetting/ emptying	Suction	Subtotal	
Culex (*Cux.*) spp. Linnaeus	632	57	424	478	1,591					1,591
Cx. (*Cux.*) *nigripalpus* Theobald	768	242	183	127	1,320	31			31	1,351
Cx. (*Cux.*) *chidesteri* Dyar	281	19	233	175	708	26		6	32	740
Cx. (*Cux.*) *declarator* Dyar & Knab	487			2	489					489
Cx. (*Cux.*) *bidens* Dyar	169				169	3			3	172
Ae. (*Och.*) *fluviatilis* (Lutz)	99	36	6	9	150	3		11	14	164
Ae. (*Stg.*) *albopictus* (Skuse)	113	2	2	1	118	193	37	338	568	686
Cx. (*Cux.*) *quinquefasciatus* Say	77		6	22	105	58	5	536	599	704
Cx. (*Mel.*) *aureonotatus* Duret & Barreto	13	23	9	13	58					58
Cx. (*Mel.*) *vaxus* Dyar		2	5	44	51					51
Ae. (*Och.*) *scapularis* (Rondani)	32	4	2	4	42					42
Ma. (*Man.*) *wilsoni* (Barreto & Coutinho)	15	10	1	5	31					31
Cx. (*Cux.*) *dolosus/ eduardoi/ bilineatus*	22			1	23					23
Cx. (*Mel.*) *ribeirensis* Forattini & Sallum	1	17			18					18
Ma. (*Man.*) *titilans* (Walker)	2	3	1	9	15					15
Cx. (*Cux.*) *saltanensis* Dyar	15				15					15
Cx. (Cux.) lygrus Root	10				10					10
Wy. (*Prl.*) *confusa* Lutz	1		3	3	7					7
Ur. (*Ura.*) *nataliae* Lynch Arribálzaga								1	1	1
Ur. (*Ura.*) *lowii* Theobald	4			2	6					6
Li. durhami Theobald	4		1		5	79	205	21	305	310
Cx. (*Mel.*) *delpontei* Duret	1		2		3					3
Cx.(*Cux.*) *coronator* group Dyar & Knab		3			3	36			36	39
Ma. (*Man.*) *indubitans* Dyar &Shannon	2				2					2
Ad. (*Ady.*) *squamipennis* Lynch Arribálzaga			2		2					2
Cx. (*Phc.*) *corniger* Theobald	2				2					2
Ae. (*Stg.*) *aegypti* (Linnaeus)	2				2					2
Cx. (*Cux.*) *dolosus* Lynch Arribálzaga				1	1					1
Cx. (*Cux.*) *coronator* Dyar & Knab	1				1					1
Ur. (*Ura.*) *calosomata* Dyar & Knab	1				1					1
Cx. (*Mcx.*) *pleuristriatus* group Theobald								1	1	1
Cx. (*Mel.*) *melanoconion* section	1				1					1
An. (*Nys.*) *strodei* Root	1				1					1
Ae. (*Pro.*) *terrens* (Walker)	1				1					1
Cx. (*Cux.*) *eduardoi* Casal & Garcia						30	0	33	63	63
Toxorhynchites spp.						7		3	10	10
Cx. (*Cux.*) *brami* Forattini, Rabelo & Lopes	1				1					1
Total	**2,758**	**418**	**880**	**896**	**4,952**	**466**	**247**	**950**	**1,663**	**6,615**

Discussion

Ecological changes produced by human activities in recent decades have been identified as one of the causes of the geographic expansion of vectors and arboviruses (Daszak et al. 2001, Vasconcelos et al. 2001, Kruse et al. 2004, Medeiros-Sousa et al. 2015, Fernandes et al. 2016). In light of this, the present inventory of mosquito species in two parks was undertaken to investigate the presence of species that are of medical importance and have an impact on public health, whether because they transmit pathogens to humans and animals or because they represent a nuisance to the human population. The results of the inventory are expected to help public health authorities in the planning and implementing of surveillance, monitoring and control measures for mosquito-borne diseases.

Medeiros-Sousa et al. (2013) performed specific single mosquito collections in a preliminary investigation of Culicidae diversity in parks in the city of São Paulo and the epidemiological role of these species in pathogen transmission. While they identified four genera of Culicidae in Santo Dias Park and Shangrilá Park together, we found seven genera in the former and eight in the latter. This indicates that monthly monitoring using a range of strategies to collect adult specimens and active searches for immature forms in breeding sites in different collection points in these parks is essential for a more complete sampling of their mosquito fauna.

Comparing our findings with those of Medeiros-Sousa et al. (2013), in twelve months of collections in Santo Dias Park, 27 mosquito species were identified, of which 13 were reported by Medeiros-Sousa et al (2013). In Shangrilá Park, 36 species were found, of which 14 were already recorded by Medeiros-Sousa et al (2013). This difference in the number of species between the two studies shows the advantages of studying this type of environment for longer periods. As significant seasonal changes occur during the year in the city of São Paulo and these are reflected in mosquito richness and abundance, surveys over longer periods are needed to gain a better understanding of the Culicidae fauna in the city.

The species accumulation curve for Shangrilá Park showed that the sampling effort was sufficient and the collection points suitably located to estimate total species composition in the area, whereas for Santos Dias Park the estimators indicated that the collection points and the same sampling effort used in Shangrilá Park were insufficient for total coverage of the species that inhabit the park. The difference in species richness found in both areas may be due to the fact that Shangrila Park is on the edge of the Billings reservoir and Environmental Protection Area Bororé Colonia (which extends about 90 km^2), and there are fewer houses in its vicinity than in the vicinity of Santo Dias Park.

Despite the difference in species richness, diversity (ie, the balance between richness and equability in species abundances) was similar between the two parks, as shown statistically for the Shannon and Simpson indices. The species similarity between the assemblages was moderate with the two areas sharing mainly species of greater abundance or better adapted to the urban environment, it is necessary to emphasize the abundant presence of *Cx. nigripalpus* in the two parks, besides other epidemiologically important species as *Cx. quinquefasciatus*, *Ae. albopictus* and *Ae. aegypti*.

The finding of *Cx. nigripalpus* colonizing both parks has epidemiologic relevance, because t this species has been incriminated as the vector of St. Louis encephalitis virus (Foratinni 2002), which has been found in birds living in green areas in the Tietê Ecological Park in the city of São Paulo (Pereira et al. 2001). In addition, Carvalho et al. (2014) described a range of hosts that serve as blood-meal sources for this species in parks in the city, and in the two parks studied here there are plentiful blood-meal sources such as birds, humans, dogs and rodents.

Another species of epidemiological importance found in both parks in the present study is *Cx. quinquefasciatus*, which is recognized as the primary and main vector of bancroftian filariasis and secondary vector of Oropouche virus (which causes Oropouche fever) in Brazil. The following species were found in both parks: *Cx. bidens* Dyar, *Cx. brami* Forattini & Rabello, *Cx. coronator* Dyar & Knab, *Cx. coronator* group, *Cx. chidesteri* Dyar, *Cx. declarator* Dyar & Knab, *Cx. dolosus* Lynch Arribálzaga *eduardoi* Casal & Garcia, *Cx. lygrus* Root and *Cx. saltanensis* Dyar, among other taxa from the genus *Culex*. These mosquitoes are adapted to a wide range of breeding sites and shelters. Because of the feeding habits of this eclectic group, these species are considered potential vectors of human and animal arboviruses as well as a nuisance to people in the parks because of their bite. Also found in both parks were species of the subgenus *Melanoconion* of *Culex* (Tables 1 and 2), which can colonize natural and artificial breeding sites and exhibit eclectic blood-feeding behavior (Montes 2005). Of particular note is their potential for involvement in the natural cycles of some arboviruses, such as the Venezuelan equine encephalitis virus (Forattini 2002).

Four species of the genus *Aedes* were collected in both parks: *Ae. albopictus* Skuse, *Ae. aegypti* Linnaeus, *Ae. fluviatilis* Lutz and *Ae. scapularis* Rondani. Although these species were found in much smaller numbers than *Cx. nigripalpus* and *Culex* (*Cux.*) spp., this finding is very important for vector monitoring and control, since the first two *Aedes* species have been incriminated as potential vectors of dengue-causing arboviruses and Zika virus and Chikungunya virus, both recently introduced in Brazil. *Aedes scapularis* is a useful indicator of environmental changes (Dorvillé 1995) and has competitive advantages over other species of mosquitoes because it can colonize small temporary breeding sites in soil and its immature forms develop faster than other species of mosquitoes. The distribution of this species in the parks studied here is related to the blood-feeding habit of females on mammals (Forattini 2002).

Although Santo Dias Park and Shangrilá Park contain remnants of native forests, the fact that they are located within an urban environment where they suffer constant anthropogenic impacts means that the fauna and flora in them are subjected to significant environmental pressures. This is reflected in the finding of mosquitoes of the tribe Mansoniini, indicating highly degraded environments. When in their immature stages, these mosquitoes live in close association with macrophytes in lakes, obtaining air from their aerenchyma, and are therefore indicators of the presence of these plants, which in turn indicate the presence of eutrophied water (Consoli and Lourenço-de-Oliveira 1994).

Two anopheline species, *Anopheles evansae* Brethes and *An. strodei* Root were found in Santo Dias Park and Shangrilá Park, respectively. These species are generally associated with wild or rural environments (Forattini 2002) and are considered secondary or potential vectors of human malaria, despite having exophilic and zoophilic behavior (Consoli and Lourenço-de-Oliveira 1994).

Specimens of the subgenera *Microculex* Theobald, which belong to the genus *Culex*, were collected in Santos Dias Park, and individuals of the *Sabethini* tribe were captured in both parks. These species use tree holes, bromeliads and palm leaves, which are common in wild environments, as breeding sites. The small number of specimens of these species collected in our study indicates that anthropogenic changes and environmental degradation have occurred in both parks, adversely affecting survival of these mosquitoes (Forattini 2002, Medeiros Sousa et. al. 2015).

Some native species of the Atlantic forest from the genera *Aedeomyia*, *Uranotaenia* and *Wyeomyia* were found in both parks. The finding of indigenous Culicidae fauna in densely populated areas is important, as some of these species have shown vector competence and capacity for important pathogens (Smith et al. 2004, Guedes 2012). For example, *Ad. squamipennis*, has been proven to be a vector of Gamboa virus (*Orthobunyavirus*) and a wild vector of an avian malaria agent in Venezuela (Galbadon et al. 1977, Bicudo and Gomes 2007).

The observations of this research demonstrate the importance of including urban parks in official mosquito surveillance programs and regular arbovirus surveys, as they can develop epidemiological conditions that favor the spread of vector-borne diseases. On the other hand, although many mosquitos of degraded environments have been found, it is noted that these areas may harbor a relevant richness of species, functioning as biological diversity islands in the cityscape.

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Marcia Bicudo de Paula: substantial contribution in the species identification and contribution to critical revision of the manuscript.

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Conflicts of interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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