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Ecology and coexistence of *Aedes aegypti* (Linnaeus 1762) and *Aedes* (*Ste*.) *albopictus* (Skuse 1894) in two state parks in Cuiabá, MT, Brazil

Ecologia e coexistência de *Aedes aegypti* (Linnaeus 1762) e *Aedes* (*Ste*.) *albopictus* (Skuse 1894) em dois parques estaduais em Cuiabá, MT, Brasil

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ABSTRACT

Scientific investigation of disease vectors is indispensable for knowledge of its Ecology, as they affect the health of human population. In this work, we present the results of the distribution and abundance of *Aedes aegypti* and *Ae. albopictus* in Massairo Okamura and Mãe Bonifácia state parks, Cuiabá-Mato Grosso, Brazil, to understand how changes in the rainy season interfere with their proliferation in natural wild areas located in urban regions. The focus was to investigate the coexistence of these species in the capture sites. The collections were carried out in eight campaigns within a period of 11 months of the year 2019, through ovitraps, with a total of 10 traps for each park. The results of the variables abundance (n) and relative humidity (%) were analyzed by the Statistic 7.0 program using factorial ANOVA. The 7117 quantified larvae produced 1462 adults for the two parks, with significant variability in mean abundance values between months and between sampling points. The record of the co-occurrence of *Ae. aegypti* and *Ae. albopictus* resulted in their coexistence and use of similar breeding sites under advantageous conditions for their colonization. The results presented showed that the parks have vulnerabilities in relation to the proliferation of vectors, and the environments must go through constant epidemiological surveillance. Faced with a serious situation in relation to arboviruses, it is essential to adopt strategies with greater investments in adequate methods, which provide sustainability to the actions established by surveillance networks.

Keywords: abundance; conservation units; Culicidae vectors; mosquitoes.

RESUMO

A investigação científica de vetores de doenças é indispensável para o conhecimento de sua ecologia, pois eles afetam a saúde da população humana. Neste trabalho, apresentamos os resultados da distribuição e abundância de *Aedes aegypti* e *Ae. albopictus* nos parques estaduais Massairo Okamura e Mãe Bonifácia, em Cuiabá (MT), Brasil, para compreender como as alterações antropogênicas da paisagem interferem em sua proliferação nas áreas naturais silvestres inseridas nas áreas urbanas. O principal foco foi o de investigar a coexistência dessas espécies nos locais de captura. As coletas foram realizadas em oito campanhas em um período de 11 meses do ano de 2019, por meio de ovitrampas, com o total de dez armadilhas para cada parque. Os resultados das variáveis abundância (n) e umidade relativa do ar (%) foram analisados pelo programa Statistic 7.0 usando a análise de variância (ANOVA) fatorial. As 7.117 larvas quantificadas produziram 1.462 adultos para os dois parques, com variabilidade significativa nos valores médios de abundância entre os meses e entre os pontos de amostragem. O registro da coocorrência de *Ae. aegypti* e *Ae. albopictus* resultaram em sua coexistência e no uso de criadouros análogos sob as condições vantajosas para sua colonização. Os resultados apresentados mostraram que os parques apresentam vulnerabilidades com relação à proliferação de vetores e os ambientes deverão ter constante vigilância epidemiológica. Diante de um quadro grave quanto às arboviroses, torna-se imprescindível a adoção de estratégias com maiores investimentos em métodos adequados, que forneçam sustentabilidade às ações estabelecidas pelas redes de vigilância.

Palavras-chave: abundância; mosquitos; unidades de conservação; vetores culicídeos.

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Introduction

Parks implanted in urban areas correspond to a complex environment with a large number of niches, and the adaptability of faunal populations varies between microhabitats. In urbanized environments, vectors of arboviruses can be found all over the world (Wilk-da-Silva et al., 2018; Huynh and Minakawa, 2022) and Devi et al. (2020) detailed the prevalence of dengue mosquito vectors in a state in India, showing the presence of *Ae. aegypti* and *Ae. albopictus* in urban and rural areas with wide distribution of this vector.

Forest fragments in urban areas perform several ecological functions, but despite their undeniable relevance in the formation of leisure environments and environmental protection (Silva et al., 2019), it is possible that such spaces group favorable conditions for the adaptive processes of insects in relation to their interactions with humans (Almeida et al., 2014). The Ecology of *Aedes* mosquitoes shows that urban populations of these vectors are heterogeneous in the distribution of "oviposition", across a variety of locations (Alonso and McCormick, 2018; Souza et al., 2022) that facilitate their propagation.

In this context, in addition to these areas being able to act as a shelter for vector mosquitoes from other areas, their proximity to human clusters makes them more vulnerable to negative anthropic interference, such as domestic waste and civil construction. These discards, as long as they retain water, can function as artificial breeding grounds for the Culicidae Diptera species. It is also important to consider the existence of natural breeding sites in these spaces that can also be useful for the procreation of vectors (Zequi et al., 2005). Investigating the ecological aspects of vectors can reveal the presence of species with epidemiological importance, in addition to assessing the impact of human activity on seasonal distribution, abundance (Silva, 2021) and density in different areas as a measure of arbovirus transmission control (Talbot et al., 2021; Silva et al., 2022).

When natural vegetation is removed, it fragments habitats, and changes are perceived in environmental characteristics, such as temperature, humidity, pollution and vector proliferation, which results in patterns of ecological succession, growth rate, population drift and behavioral changes of organisms (Townsend et al., 2010). Understanding how these changes interfere with the abundance of Culicidae and which species occur in these areas helps predict their abundance, spatial distribution and synanthropy in the face of urbanization, which provides important tools and urban planning (Kirik et al., 2021). This urbanization affects *Aedes aegypti* populations and modulates their population structure (Wilk-da-Silva et al., 2018; Dalpadado et al., 2022).

The study of Vector Ecology, considered as the central pillar of entomological surveillance, aims to contribute to the knowledge of environmental factors that regulate the life cycle of arbovirus-transmitting insects (Lira-Vieira et al., 2013), capable of acting as agents of its propagation to the human being (Marcondes and Ximenes, 2015). Controlling the trajectory of a rapidly evolving biological system, composed of various agents, including parasites, hosts and vectors, is a challenge (Cozzer et al., 2021). Hendy et al. (2020) investigated possible routes of exchange of mosquito-borne viruses between sylvatic cycles in urban forest parks with intense human traffic in Manaus, Brazil.

Several recirculation of mosquito vectors emerge under different landscape features, with the wild form of human exposure to infected mosquitoes being the most common (Zara et al., 2016). The basic life cycle of mosquitoes normally consists of egg, four larval instars, pupa and adult. Eggs can be laid in the transition between aquatic and terrestrial environments. From oviposition to adulthood, an average of 10 days elapse under favorable conditions of temperature and food availability.

Exotic species such as *Aedes* (*Stegomyia*) *aegypti* (Linnaeus, 1762), relevant to their epidemiological implications, have been biomonitored in Cuiabá, Mato Grosso, Brazil, and specific studies within urban areas have indicated a relatively high abundance of these vectors (Miyazaki et al., 2009; Rodrigues et al., 2021). Such records suggest that these species subsisted or adapted to the urbanization process in this capital, especially when it comes to deforestation of natural vegetation and garbage disposal.

The Massairo Okamura and Mãe Bonifácia state parks located in Cuiabá preserve remnants and fragments of the original Cerrado vegetation, contain lakes and serve as a shelter for birds and mammals, with continuous visits by people as leisure environments (Secretaria do Estado do Meio Ambiente, 2012, 2013). Pioneering research in these Conservation Units were developed by Guarim and Vilanova (2008), such as those that focused on the investigation of the fauna. There are other studies on economic valuation (Nascimento et al., 2013), on the analysis of its sustainable use (Pinheiro and Mendes, 2013), weather conditions (Barros et al., 2010; Novais et al., 2018) and soil markers (Alves et al., 2020). The "green islands" of these two parks maintain many insect populations, and some mosquito species are restricted to wild habitats, such as *Ae. albopictus*, or serve as a refuge for other vectors that infest the densely inhabited areas of the urban fabric, such as *Ae. aegypti*. Although the latter also manages to maintain a considerable population during the drier seasons (Butakka et al., 2019), it reproduces in semi-permanent breeding sites, independent of rainfall, such as water tanks, cisterns and barrels. In the rainy season, abundance increases significantly, and its direct relationship with temperature is commonly described, as the rate of metabolism and incidence of dengue fever increases in the hot months and its reproductive cycle becomes faster (Cesarino et al., 2014; Gabriel et al., 2018).

Aspects of the vector ecology of *Ae. aegypti* and *Ae. albopictus* have been investigated (Akiner et al., 2016) in the search for preferential behaviors and habits in nature and in the space inhabited by human beings. It has great adaptability in the face of various social, urban and environmental characteristics (Akhatar et al., 2016). These two species can co-occur, often sharing the same breeding grounds. This coexistence may be a transitory situation that may result in the displacement of one of the species. The decrease or population displacement of vector species residing in wild areas was observed in several countries after the introduction of *Ae. albopictus* (Custódio et al., 2019). Despite the great scientific advances achieved in recent decades, new diseases or even those that were thought to be controlled are often found as characters of new outbreaks (Campbell et al., 2015), such as the infestation of yellow fever in wild areas, and its displacement to other areas urban areas. In addition to yellow fever, *Aedes aegypti* is an important vector of other etiological agents in the world, such as dengue, chikungunya and Zika virus (Powell and Tabachnick, 2013). Parker et al. (2019) found that both species are competent vectors of a variety of arboviruses, including yellow fever, dengue, chikungunya, and zika.

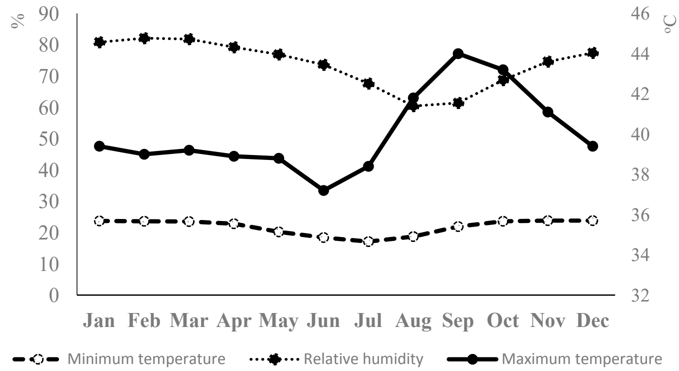
For its capture, the culicid fauna in several places in the country has been surveyed using oviposition traps, which have gained prominence in the control and monitoring of urban vectors (Miyazaki et al., 2009; Lima et al., 2021; Silva et al., 2022). Given the limits of data on these groups of insects in conservation units, a project was designed to investigate the population dynamics in the green areas represented in the two parks located in the urban region of Cuiabá.

The present work was carried out with the purpose of verifying the seasonal variation of *Aedes aegypti* and *Ae. albopictus* through the values of its abundance in different places of two parks located in Cuiabá, MT. The results may help predict the spatial distribution of domestic and peridomiciliary species in face of urbanization, providing important future tools for the control of these vectors and proposals for an ecologically healthy environment.

Material and Methods

The urban macrozone in the city of Cuiabá, Mato Grosso, has 252 km^2. Located in the Geodesic Center of South America, it is in the inter-tropical zone of the Planet, between geographic coordinates 15°35',56"S and 56°06'01"W of Greeenwich. It reaches 178 m above sea level, with a tropical climate classified as AW according to Köppen, and two well-defined seasons, a dry one, from April to October, and a rainy one, from November to March (Alvares et al., 2014). The average temperature is between 28 and 32°C (Guarim and Vilanova, 2008; Barros et al., 2010). Metric data from the meteorology institute (INMET, 2022) indicated an average annual rainfall of 1,378.7 mm for the period of 2019 in the region of Cuiabá. For relative air humidity, the data indicated maximum values of 82.1% in February, and minimum values between August (60.4%) and October (68.7%), the most critical periods with high temperatures (41,8 – 43,2°C), notably in October/2019 (44°C; Figure 1).

The Cuiabá — São Lourenço Corridor has approval from the Ministry of the Environment, a priority area for nature conservation within the precepts of the National System of Conservation Units (*Sistema Nacional de Unidades de Conservação da Natureza* — SNUC). With 10,091,600 hectares, this corridor extends through 25 municipalities, including the municipality of Cuiabá.



Source: Climatologia (2022).

Figure 1 – Maximum and minimum temperature values and relative air humidity for the year 2019 in the city of Cuiabá.

The green areas of the Conservation Units (*Unidades de Conservação* — UCs), of the Massairo Okamura (PMO) and Mãe Bonifácia (PMB) state parks, and their hydrographic network belong to the Cuiabá River (Nascimento et al., 2013; Pinheiro and Mendes, 2013), and its tributaries define the predominant relief forms and the peculiar microclimatic conditions.

For each park, 10 sampling points were established, which are available in Figure 2. The description of each point is included in Table 1 within this figure and its geographic coordinates are available in Table 2. The perimeter of the buffer zone of the parks is part of the urbanization context of Cuiabá (Figure 2), and we recorded the sampling points presented in Figures 3 and 4.

In the context of the municipality, the PMO limits an area of 53.7 hectares, located in the transition sector with an average altimetric value of 212 m (± 28 m). This conservation unit is located on the limits of the distribution of the Cerrado biome, between coordinates 15°57'53" and 56°10'78" near the north end of the Pantanal biome (SEMA, 2012), in the Municipality of Cuiabá. The geomorphological mapping presented by the SIG Cuiabá project (CPRM, 2006) on a scale of 1:100,000 indicates that the PMO is inserted in a unit characterized by the occurrence of cliffs and convex hills. The sampling points are shown in Table 1 and illustrated in Figures 3 and 4.

The soil of the PMO is characterized as a Buffer Zone, delimited by the contour lines that form the Barbado Stream microbasin, a direct tributary of the Cuiabá River and which cuts through the park in a northerly direction. The two points close to the stream are defined: PMO-4 — Source of the Barbado Stream, and PMO-8 — Bridge/stream. The gently undulating relief of the park is characterized by river notches with an average depth of 70 cm to 1 m. Low slopes predominate in the park, in mostly less than 5% of the area, except along the streams, where they can reach values greater than 15% (Secretaria do Estado do Meio Ambiente, 2012). The existing plant physiognomies in the PMO area are the Mata de Galeria (alluvial and submontane seasonal semideciduous forest — small rivers) and the Cerradão (wooded savannah).

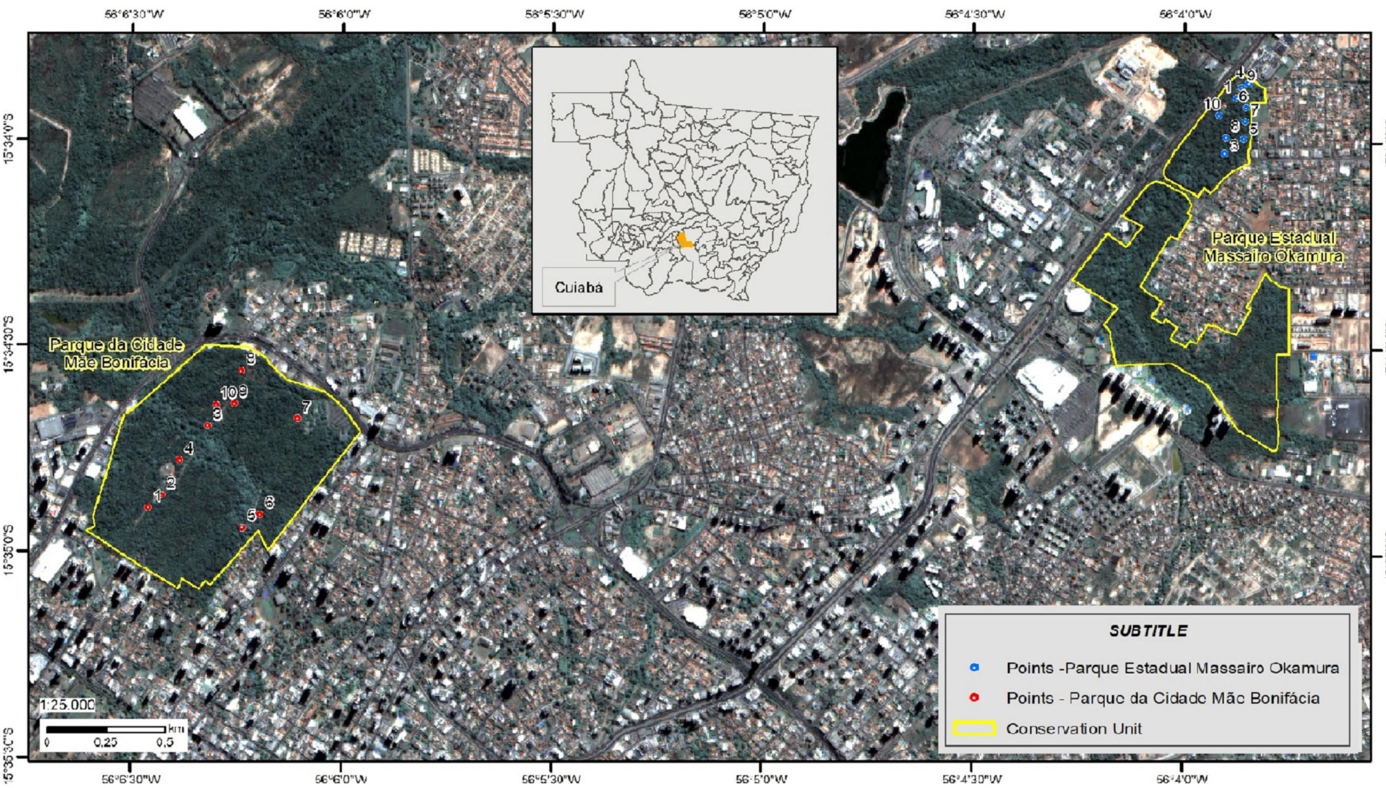


Figure 2 – Two Conservation Units (UCs) in the State of Mato Grosso, where the (A) Massairo Okamura and (B) Mãe Bonifácia state parks are located.

Table 1 – Sampling points and site characteristics of Massairo Okamura and Mãe Bonifácia parks.

Point	Site	Point	Site
PMO-1	Management building	PMB-1	Management building
PMO-2	Bleachers	PMB-2	Bridge/stream near the Administration building
PMO-3	Woods – curve	PMB-3	Near the Mãe Bonifácia stream
PMO-4	Source of the Barbado Stream	PMB-4	Second Support
PMO-5	Guava tree	PMB-5	Bridge trail
PMO-6	Green house	PMB-6	Third Support/sand trail
PMO-7	Trail	PMB-7	Behind the toilets
PMO-8	Bridge/stream	PMB-8	Debris of logs and scrap metal on the ground.
PMO-9	Big wall	PMB-9	To the left of the statue
PMO-10	Behind the administration building	PMB-10	In front of the statue

These start in small marshes or streams, in the form of alleys of Mauritia flexuosa L.F. (Buriti), forming paths (IBGE, 2002).

Along the water courses, the paths border the drainage lines and support tree species, such as *Cecropia pachystachya* Trécul (Embaúba), *Inga uruguensis* Hook. Et Arn. (Ingá), *Copaifera langsdorffii* Desf. (Copaiba-oil), *Tapirira guianensis* Aubl. (Tapiriri), *Ilex taubertiana* Loes. (Congonha), *Erythrina mulungu* Mart. ex Benth (Mulungu). Gallery forests are the most representative areas, with 49.82% of the park area, followed by the Cerrado, which covers 25.23% of the conservation unit, and the Cerradão, which occupies 16.39% of the park area. There are several sectors with areas that can be classified as degraded, containing clearings and exposed or disturbed soil near the green house (PMO-6), and behind the administration building (PMO-10). The anthropized areas cover the space occupied by the administration building (PMO-1), close to it in the bleachers (PMO-2) and big wall (PMO-9), Guava tree and trails (PMO-5, PMO-7, respectively), and mainly areas not regularly occupied by residences. More preserved areas were identified at points PMO-3 (Woods curve) and PMO-8. The area with the presence of garbage was monitored at point PMO-6.

Mãe Bonifácia Park (PMB), another conservation unit located in the municipality of Cuiabá (Pinheiro and Mendes, 2013), between the coordinates 15°34’44”S and 56°05’16”W, was created in 2000 (the first urban park in the state of Mato Grosso), as a way of preserving a large space of “cerrado” in the urban area of the city. It occupies an area of 77.16 ha of ecological conservation area (Secretaria de Estado do Meio Ambiente, 2013), in a region of great expansion of real estate developments, resulting, in part, from the existence of the park.

Table 2 – Geographic coordinates (latitude and longitude) at each sampling point in Massairo Okamura Park (PMO) and Mãe Bonifácia Park (PMB).

Points	Longitude	Latitude	Points	Longitude	Latitude
PMO-1	56°3’52.60” W	15°33’53.41” S	PMB-1	56°6’27.63” W	15°34’53.64” S
PMO-2	56°3’51.59” W	15°33’52.81” S	PMB-2	56°6’25.76” W	15°34’51.83” S
PMO-3	56°3’54.27” W	15°34’10.49” S	PMB-3	56°6’19.20” W	15°34’41.68” S
PMO-4	56°3’50.93” W	15°33’51.24” S	PMB-4	56°6’23.13” W	15°34’46.73” S
PMO-5	56°3’51.54” W	15°33’59.32” S	PMB-5	56°6’14.15” W	15°34’56.51” S
PMO-6	56°3’51.28” W	15°33’54.76” S	PMB-6	56°6’11.69” W	15°34’54.59” S
PMO-7	56°3’51.35” W	15°33’56.79” S	PMB-7	56°6’6.38” W	15°34’40.61” S
PMO-8	56°3’54.09” W	15°33’59.12” S	PMB-8	56°6’14.39” W	15°34’33.63” S
PMO-9	56°3’51.89” W	15°33’51.80” S	PMB-9	56°6’15.45” W	15°34’38.39” S
PMO-10	56°3’55.11” W	15°33’55.87” S	PMB-10	56°6’18.02” W	15°34’38.62” S

Figure 3 – Ovitraps installed in the ten sampling points of the Massairo Okamura Park (PMO) to capture *Aedes aegypti* and *Ae. albopictus*, from February to December 2019. Legend for each figure: see Table 1.

Its vegetation cover is formed by riparian forest and savannah, serving as a shelter for several species of wild fauna, with specimens of mammals (e.g., tamarin, capybara), birds (e.g., bluebird, hummingbird), reptiles (e.g., alligator and lizard) and amphibians (e.g., frog and toad).

The Mãe Bonifácia stream, which is part of the hydrographic network of the Cuiabá River, cuts through Mãe Bonifácia Park from one end to the other (PMB-3 and PMB-5 points are adjacent to the stream), and receives the release of rainwater and sewage from nearby neighborhoods (Secretaria de Estado do Meio Ambiente, 2013). In addition to the stream after which it is named, the park is also crossed by the stream of Caixão, on the east border (PMB-2), forming a large area of flooding in its central region. The vegetation was altered when the physical structures of the park were implemented, such as the administration building (PMB-1), next to the residences on the avenue — second support (PMB-4), behind the toilets (PMB-7). At the point that surrounds the administration building, discards of plastic material and construction material were collected. PMB-6 corresponded to a vegetated area close to the sand trail. The PMB-8 had remains of tree trunks, construction lumber and scrap metal.

Figure 4 – Ovitraps installed in the ten sampling points of Mãe Bonifácia Park (PMB) to capture *Aedes aegypti* and *Ae. albopictus*, from February to December 2019. Legend for each figure: see Table 1.

The record was sent to the administration, but the scraps were just inverted so as not to accumulate water in the metals, and remained there for the entire sampling period. PMB 09 and PMB 10 were located in the region close to the Mãe Bonifácia statue.

The collections were carried out in 8 campaigns for a period of 11 months (February, March, April, May, June, July, November and December), to survey the abundance and spatial and temporal distribution of the two species of Culicidae populations in the two parks. The ovitraps used for capture were installed monthly at a height of 1.5 m, with one trap at each sampling point, and 10 traps for each park (see Table 1). These were idealized by the classic methodology of Fay and Perry (1965) as important tools in surveillance activities, control and ecological dynamics of insect vectors in the environment. Five days after installation, the traps were collected and the material was taken to the Entomology Laboratory of the Federal University of Mato Grosso for analysis. After the eggs spontaneously hatched, the larvae were fed with an extruded float (0.01 g per day), and went through larval stages, followed by the pupal form, after the emergence of adults. Subsequently, the insects were euthanized in a freezer at a temperature of approximately -20°C. Then identified at a specific level, packed in polypropylene tubes, and properly labeled.

In this work, we analyzed the representativeness of the Culicidae species, *Ae. aegypti* and *Ae. albopictus*, and present the results of their distribution and abundance in Massairo Okamura and Mãe Bonifácia state parks, in 2019, as a way of understanding how anthropogenic changes in the landscape, as a destination for garbage, improperly discarded debris interfere with its proliferation in natural wild areas inserted in urban areas. The investigation of the coexistence of these species in the sites where there were captured was also carried out. The abundance estimate for each species was determined by the number of hatched larvae, the number of pupae and adults quantified after emergence. The production and abundance of the totality of individuals/species was made by estimation in the months and sites/sampling points. The quantification of secondary production of *Ae. aegypti* and *Ae. albopictus* was made to identify probable coexistence of the two vector species.

Data on the abundance of larvae, pupae and adults were analyzed between months and sampling sites through the Statistic 7.0 Program using ANOVA — Factor Analysis of Variance. From the number of *Ae. aegypti* (n) and *Ae. albopictus* (n) identified, the factor “months” or “points” was considered as the independent predictor variable, while the abundance factor was the dependent variable. To analyze whether there were differences between pairs of groups, the analysis of variance

(ANOVA) was used. The post hoc (Tukey) test was performed to check which months materially differed from each other ($p < 0.05$), when the ANOVA result was significant, and with the purpose of investigating differences between the means.

Sampling units for months and points/sites were analyzed using spatial and temporal variations of the abundance data. The use of the Spearman Correlation Index (r) was used to identify associations between the values of abundance in each stage of development and the relative humidity of the air (%), and of the species in the sampling sites.

Results

Of the 7,117 larvae quantified from their total production in the collections within 8 months (PMO = 2693; PMB = 4424), 1,462 adults were produced in the laboratory for the two parks (PMO = 467; PMB = 995). By means of factorial ANOVA, the variations in the abundance data of *Aedes* spp. (considering the total of morphospecies as a function of the x axis) were identified temporally (y axis), with significant differences in each developmental stage (larvae, pupae and adults) between the sampling months (Figures 5A and 5B). The greatest variability of larvae was recorded in April and November/2019 in the PMO, corresponding to the rainy season, and in June/2019 in the PMB, during the dry season.

Regarding the sampling points for each park, the abundance results showed significant mean values among individuals for each developmental stage at the sampling points. Specifically, the greatest variability among individuals during the larval stage was identified between points PMO-4, PMO-5, PMO-9 and PMO-10 in Massairo Okamura Park (Figure 6A) and between points PMB-1 and PMB-2, in Mãe Bonifácia Park (Figure 6B).

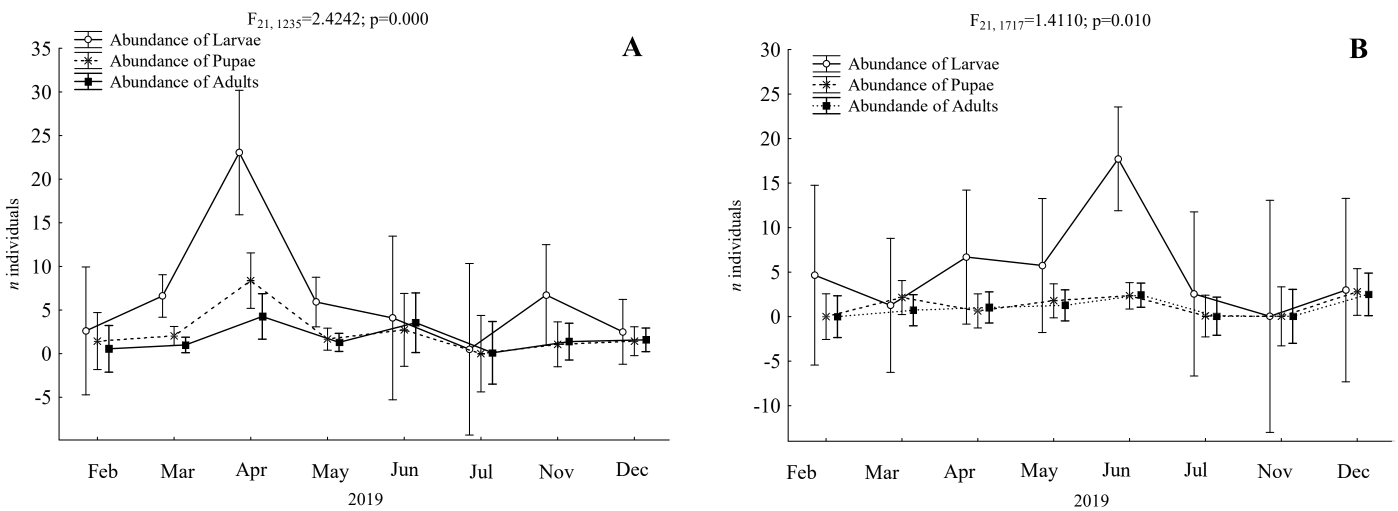


Figure 5 – Mean values of abundance (n) and standard deviation (±) of larvae, pupae and adults of *Aedes* spp. (x axis) recorded in (A) Massairo Okamura and (B) Mãe Bonifácia parks as a function of time (y axis).

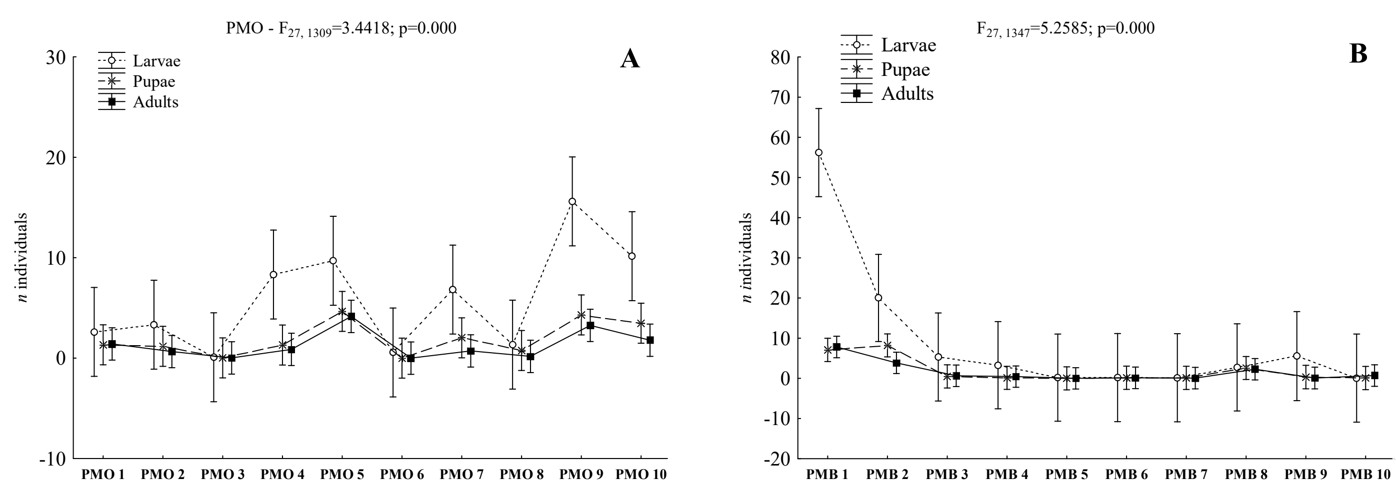


Figure 6 – Mean number of abundance (n) and standard deviation (±) for each stage of development (larvae, pupae and adults) of the two *Aedes* species in the sampling points of (A) Massairo Okamura and (B) Mãe Bonifácia.

Positive correlations ($p < 0.05$) were registered between the values of pupae and adult abundance and relative air humidity ($r = 0.23$; $r = 0.34$, respectively), when considering the entire sample for the two parks.

The results of the species recorded in the PMO (Figure 7A) showed that *Ae. albopictus* was more abundant in May/2019 (17 ind. ± 6), in the ebb period, while *Ae. aegypti* increased slightly in the flood seasons, in Feb/2019 (8 ind. ± 7) and in Dec/2019. In PMB, there was a synchronous variability of *Ae.aegypti* and *Ae. albopictus* for the period, especially with an increase in Jun/2019 (Figure 7B). Differences were only significant between months, with the highest *Ae. albopictus* (88 ind. ± 76). There was a positive correlation between the abundance values of the two vector species in the PMO ($r = 0.26$; $p < 0.05$) and in the PMB ($r = 0.30$; $p < 0.05$), when considering the data between the points/sites sampling, whose individuals co-occurred in each ovitrap. Through the abundance values of the two species for the two parks together, the two-way ANOVA identified significant differences between the sampling months ($F_{7,337} = 4.196$; $p = 0.000$). Considering the p-value, it was identified that all of them were lower than the adopted significance level (p-value < 0.05) through the Tukey Test ($p < 0.05$), especially for the months of February and May.

Discussion

The abundance of mosquito populations is influenced by the rainfall regime and the presence of garbage potentially involved with population fluctuations in sampling locations and months. The places with the highest production of mosquito eggs were fragments of edges, such as the points of Massairo Okamura Park (PMO 4, PMO 5, PMO 7, PMO 9), probably where there are trails with greater circulation of people. The totality of vectors was more abundant during the months of March and November for this park, in the rainy season. Although *Aedes* spp. occurred in all the months of the research, its reduction was observed during the dry season (Figure 5).

Understanding the factors that contribute to the co-occurrence of vector species is extremely important for the protection of priority areas in conservation units, as well as for their management when it comes to environment and health. Massairo Okamura Park showed a marked presence of *Ae. albopictus*, a species normally associated with stagnant water collections in the dry season. However, *Ae. aegypti*, combined with its potential for arbovirus transmission due to its anthropophilic behavior (Forattini, 2002) and its high levels of abundance, makes this species one of the most important from an epidemiological point of view (Custódio et al., 2019).

The coexistence of *Ae. aegypti* and *Ae. albopictus* in the parks, confirmed by the record in the same ovitraps and positive associations resulting from the Spearman correlation index, highlights its distribution and adaptability to different anthropic environments and its presence throughout the sample period, although reduced in some periods. Rajarethinam et al. (2020) also investigated seasonal fluctuations of *Aedes* in different landscapes for vector management, and found more *Ae. aegypti* in homes and more Ae. albopictus in public areas.

The behavior between the two species was favored in environments with the greatest movement of people, especially near the administration area of Mãe Bonifácia Park (PMB-1 and PMB-2), on the trails with the source of the Barbado stream (PMO-4), forests and trails (PMO-5, PMO-7, PMO-9) in Massairo Okamura Park. Significant changes can occur around urban parks that result in favorable conditions for the *Aedes* mosquito, such as the presence of garbage in the PMB 1 point (Management building). The points with greater abundance are close to the streams in PMO 4 (Starting of the Barbado Stream) and PMB 2 (Bridge/stream near the Administration building). The results are significant in the areas studied, pertinent to the urbanization where the specimens were collected and their geographical location was identified. Hendy et al. (2020) provided evidence for increased arbovirus exchange at forest edges bordering urban environments where humans and urban and wild vectors exist in close contact.

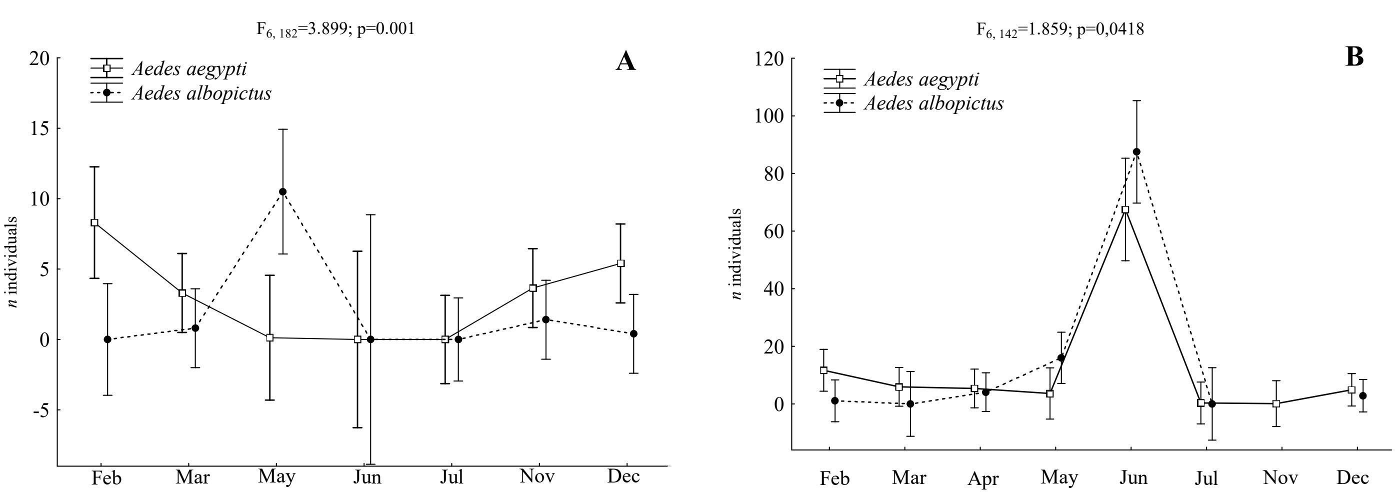


Figure 7 – Abundance (n) and standard deviation (±) of adults of the two vector species recorded in (A) Massairo Okamura and (B) Mãe Bonifácia parks.

The abrupt transformation of natural environments, considered by some authors as "unpredictable", occurs due to natural disasters and catastrophes, or by the implementation of some type of enterprise with great environmental impact (Ferreira Filho et al., 2017). In Massairo Okamura Park, most of the existing watercourses have a characteristic of intermittence, even piped channels that contain small swamps with very little water already at the beginning of the dry season, or are evident by the very dry beds, which can contain eggs of insects in aestivation, and hatched in the rainy season.

Conflicting activities in Mãe Bonifácia Park include the presence of garbage, untreated sewage disposal, de-characterization of the area due to the greater movement of people near the administration site, deforestation of the riparian forest, presence of exotic species, and inadequate use of the space in some stretch.

The existence of a direct relationship between the patterns of land use, topography and vegetation characteristics of each microspace in Mãe Bonifácia Park (Barros et al., 2010) were also recorded by Pinheiro and Mendes (2013). Some contrasting factors noted were the amount of garbage observed in part of the closed forest within the park.

The abundance of *Ae. aegypti* was related to collection points in areas more focused on the urbanized sector, with the greatest movement of people, especially in Mãe Bonifácia Park. At the beginning of our research, we identified discards of non-reusable material at point PMB-8 (with remains of logs and scraps on the ground), in PMB-1 (plastic material, discarded plastic tarpaulins, construction debris), next to the management building. The presence of *Ae. albopictus* was focused on native forest and areas with streams. These offer new breeding sites, and their supply, together with the increase in temperature, accelerates the extrinsic incubation period of the virus in the insect (Arduíno and Ávila, 2015; Lima et al., 2018). Such factors influence their ability to reproduce, which directly interferes with their abundance.

Faced with the anthropic pressure on the researched environments, the presence of these Culicidae species that use these habitats as refuges to maintain their populations is noted. *Ae. aegypti* and *Ae. albopictus* can coexist at the same sampling points and use similar breeding sites, quickly colonizing places where conditions are favorable for their proliferation. The dispersal of these species can be rapid depending on the low availability of habitats for oviposition (Forattini, 2002).

The record of *Ae. aegypti* is associated with the degree of degradation to modified environments (Almeida et al., 2020). Understanding the patterns of its distribution contributes to the knowledge of the scenario in conservation units, with the search for better strategies for its control, in addition to allowing a moment of discussion in the context of global public health relevant to its vector allocation to various viruses. The transmission of arboviruses serves as evidence of the importance of these two species for public health (Parker et al., 2019), and their control is a major challenge to determine which habitats should be prioritized for the development of more effective strategies (Wilke et al., 2020; David et al., 2021). For the sake of prevention, it is necessary to define vector-specific risk areas, and relative population abundance to achieve maximum effect with minimum input of resources through intensive control (Hwang et al., 2020). Due to the expansion of *Aedes* morphospecies as vectors globally over the past two decades, investigations are urgently needed to update wild species records (Guarido et al., 2021). Recognition of the complexity of urban ecology must take place through a systematic strategy that addresses this physical complexity, which is essential to better control *Aedes* spp. (Alonso and McCormick, 2018).

The maintenance and expansion of the green islands inserted in the urban area is necessary to improve the quality of life of the population in Cuiabá and to preserve the biodiversity of species, including those of native mosquitoes that do not transmit viruses. Inserted in a natural ecosystem, a given mosquito population remains controlled by various selective pressures. Once its environment has changed, the population may disappear or benefit from the new conditions to which it is constrained, and become more abundant in the absence of limiting factors (e.g., predators and competition), starting to act as a nuisance factor for the human population, or even becoming competent for the transmission of pathogens.

The changes caused by man in the natural environment form an ecosystem that is considered artificial, due to its unpredictable nature in relation to the biosphere. It is understood that, depending on the complexity peculiar to each park, the number of niches and habitats they offer, as well as the adaptability of populations, varied. The increase in populations of mosquito vectors with the epidemics of dengue and yellow fever, among other factors, encourage the search for integrated measures for their control.

Faced with these challenges and the serious situation in relation to arboviruses outlined by the expansion of these viruses in Brazil, and especially in the state of Mato Grosso, it is essential to adopt specific strategies, with greater investments in adequate methods. These provide sustainability to the actions established by surveillance networks, in addition to giving rise to the analysis of their effectiveness.

Due to the results presented, the urban Conservation Units show vulnerabilities in relation to the presence and proliferation of Culicidae vectors. As seen in the Management Plan (Secretaria de Estado do Meio Ambiente, 2013), the factors include the impacts of the urbanization process, smaller dimensions, human pressure, exotic species, contamination of water sources, among others. Even internationally recognized as an area of great biodiversity and under increasing threat, the change in the vegetation cover causes consequent reductions in native species, changing the value of natural resources and the quality of human life (Ferreira Filho et al., 2017). Urbanization processes in the study areas seem to play an important role in the dynamics of abundance triggered by changes made by man in the environment, resulting in a population structure that previously shows a pattern of great epidemiological importance (Wilk-da-Silva et al., 2018).

To the detriment of anthropogenic pressure on park environments, culicids use these habitats for the maintenance and refuge of their populations. It is recommended that these environments be under constant epidemiological surveillance, since the *Aedes aegypti* collected are important in public health as vectors of pathogens to the human population.

Conclusion

The relevance of the Massairo Okamura and Mãe Bonifácia State Parks, from the social point of view, is indisputable. Urban natural areas dedicated to leisure are essential to intensify social interaction and improve the population's quality of life. At the same time, it is important to understand that its existence depends on the capacity for environmental conservation and recovery, generating a minimum context of environmental preservation against the characteristic pressures of the urban area, which only a conservation unit can guarantee, preventing the constant fragmentation and redefinition of its perimeter. In this way, it can prove to be an interesting instrument of sustainable management, with vector control, to reconcile recreation, health, the sustainable use of parks, their conservation and human activities at the sites. This fact shows the need to establish monitoring networks to control the vector through environmental management strategies or mechanism, which are the most frequently used by the municipalities.

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