Urban Biodiversity in Pre- and Post-Social Isolation Times: A Case Study of the Public Squares on the City of Sorocaba, SP, Brazil

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Abstract

The environmental range has long been neglected. Species that play crucial roles for the good functioning of the planet have their activities jeopardized by human ignorance, but the emergence of a zoonotic disease (COVID-19) in December 2019 turned attention to an atypical fact: previously uncommon animals seen in urban environment began to frequent them looking for resources, this is due to the measures of confinement, distance and social isolation adopted in order to contain the spread of the virus. In this work, public squares located in the city of Sorocaba, inlands of São Paulo, were studied, regarding the richness of species, bioindicator groups (birds, butterflies and dragonflies) in three different periods: before the social isolation system coming into effect, during and after it, to analyze whether such measures had an influence on urban biodiversity. The Sorensen and Cluster (Jaccard estimator) analytics methods, Non-metric Multidimensional Scaling (nMDS) and One-Way ANOVA variance analysis showed that, with the reclusion of the citizens, there were no significant difference in species abundance in the sampled locations during the three periods, but the lockdown was marked by the illustrious presence of a rare species butterfly (*Greta oto* [Hewitson 1854]), unregistered in previous surveys carried out in the municipality. It could be concluded that, although the functioning of urban ecosystems is intrinsically linked to human presence, the sudden decrease in the circulation of people and vehicles has had positive consequences for the environment richness inserted in cities.

Introduction

On January 30, 2020, the World Health Organization (WHO) declared the outbreak of a new coronavirus (COVID-19) as an international emergency (Ventura et al. 2020), beginning in the city of Wuhan in China. The COVID-19 pandemic is a public health issue and the beginning of a major global crisis regarding the economic and political spheres (Paulino 2020). Despite the environmental issue being left aside for a long time, the emergence of a zoonotic disease turned the attention to the conservation of wild fauna, being the origin of the pathogen, as the increase in species diversity (resulting in a more biodiverse ecosystem) is proven to reduce the risk of new diseases (Rudolf and Antonovics 2005; Smith 2020).

Although the importance of urban centres for biodiversity is acknowledge and the inverse is also true, they are characterized as degraded and fragmented environments (Beninde et al. 2015). Brazil experienced a process of accelerated urbanization that brought consequences, such as verticalization, also known as the advancement of the urban area over green areas, as well as intensification of vehicles, the increase of waterproofed surfaces and industrial growth (Barros and Virgilio 2003; Leal et al. 2008; Melo et al. 2020). Fauna and flora in large cities have been severely impacted, presenting the reduction of resources made available by green areas, the increase in noise from vehicle traffic and urban expansion, with direct negative effects on several species seen in the city, be it residents or visitors (Corlett et al. 2020).

Considering that transmission by the new coronavirus occurs through interaction between people, the scenario observed as soon as the pathogen is installed is completely different from that experienced in pre-pandemic times (Helm 2020). The implementation of a social isolation system - lockdown of people in order to prevent the spread of the virus - has made the streets emptier and, consequently, encouraged the circulation of wild fauna, with an improvement in environmental conditions (Vilella 2020; Da-Silva and Coelho

2020). Shortly after the declaration of the state of public calamity in Brazil (Presidency of the Republic 2020) it was already possible to notice some changes regarding environmental quality, it's the case in the Baixada Santista-SP commuter belt, where residents declared they could better observe the stars due to the decrease in air pollution (Gatto 2020). Furthermore, illustrious visits of animals adapted to the urban environment, but which are not always exposed (like monkeys) also marked the period of confinement (Da-Silva and Coelho, 2020). On a local scale, the present study aims to analyze the main environmental changes triggered by the quarantine period regarding urban biodiversity of the city of Sorocaba, in the inlands of São Paulo, mainly in the public squares that were previously frequented by residents of the municipality and their inhabitants surroundings.

Material And Methods

Study area

Sorocaba (23 ° 30 '22" S, 47 ° 27 '21" W) is in the interior of the State of São Paulo and is home to more than 600 thousand inhabitants (IBGE 2020), in addition to a considerably rich fauna. The city has more than 1,218 species belonging to several taxonomic groups (Smith et al. 2016), from aquatic macroinvertebrates to medium-sized mammals that predominate peri-urban regions of the city. The municipality is genuinely concerned about biodiversity conservation, since it has established strategic areas for the protection of the city's fauna and flora: there are more than 30 (thirty) open ecological parks, 2 municipal natural parks, 3 ecological stations and countless squares (Smith et al. 2016).

From a qualitative point of view, the public squares of Sorocaba are providers of shelter for urban biodiversity. They are green areas that provide benefits to the good environmental quality of the city - such as thermal and acoustic comfort, combating air pollution and collaboration for soil permeability and fertility (Benini and Martin 2019). For this purpose, these areas are mostly endowed with arboreal vegetation and play aesthetic, social and ecological roles, respectively in the provision of visually more pleasant landscapes, leisure and havens for the resident and visiting fauna of the city.

The public squares studied (Fig. 1) were selected according to their locations and their capacity to shelter species, that is, with a good proportion of tree cover. In the square located in the center of the city (Frei Baraúna) and in its surroundings it is possible to observe a more intense traffic of vehicles and circulation of tourists compared to the others, increasing the availability of food offered by human population and so the concentration of a greater number of species. "Biodiversity" public square is part of the project "Refúgios da Biodiversidade", an initiative proposed by the Secretary of Environment, Parks and Gardens of Sorocaba (SEMA) in 2016 in order to select strategic areas for the development of low-cost actions, such as installation of educational plates, clearing management, planting of native species and others (Smith et al. 2016), being protected by Law No. 12.059 / 19 (Sorocaba 2019) along with 28 other areas. Praça Pio XII is in a peripheral area of the city and is frequented by residents and visitors due to the pleasant landscape and environment provided by the tree richness.

Database

Given that birds have become references for studies aimed at monitoring environmental quality due to their roles as bioindicators in the ecosystem, along with groups of lepidopterans and dragonflies, they were the groups selected for the spatio-temporal analysis of species richness. For this characterization, the sampling was made through periodic visits to the selected public squares in three different periods: pre-quarantine, during and after the confinement period, respectively in the months of September 2019, April and October 2020. The fauna surveys were made through records visual, auditory and photographic in the morning (in the case of birds, between 6 and 10 am) and in the afternoon for the entomofauna (2 pm to 6 pm). Species were identified through consultations with electronic guides, previous local surveys and dichotomous identification keys (Gallo et al. 2002; Ribeiro et al. 2005; Gullan and Cranston 2012; Piratelli et al. 2016; Souza et al. 2016).

Data analysis

Regarding statistical analysis, the data on the presence and absence of species (1 - presence and 0 - absence) were worked on in the three sampled squares (F - Frei Baraúna, B - Biodiversity and P - Pio XII) during the three periods mentioned above. and the similarity between sites in relation to species richness was estimated by the Sørensen index (Sørensen 1948), with similarities greater than 0.5 considered high (Silva Júnior 2001). The evaluated taxa sampled at the three locations was analysed by multivariate method in order to show the tendency of clustering and ordering of the species surveyed, through Cluster analysis (Jaccard estimator) to check the clusters using data on the presence and absence of species, and Non-metric Multidimensional Scaling (nMDS), a method of statistical analysis for two-dimensional and / or three-dimensional data arrangements that represents the association between the samples of a matrix similarity. In this case it was used the Jaccard distance measure, as it measures presence/absence of data. The One-Way ANOVA variance analysis tested the null hypothesis for the univariate data set, showing how similar they are. The results obtained were confirmed through the Test Tuckey. Prior to the completion of the two analyzes, the Shapiro-Wilk test was performed to verify that the data distribution of the three present was within the normal range. All analysis were run using the program Past version 4.03 (<https://past.en.lo4d.com/windows>).

Results

In the qualitative sampling there were registered 25 species of birds belonging to 7 orders and 15 families, 12 species of butterflies distributed in 1 order and 5 families and six species of dragonflies inserted in 1 order and 2 families (Fig. 2), of which, of all these, 20 species of birds, seven of butterflies and two of dragonflies are common to the three sites. The most numerous families in terms of species richness were, respectively, Columbidae (n = 5), Nymphalidae (n = 9) and Libellulidae (n = 5). Most taxa, 20 species of birds, seven of butterflies and two of dragonflies are common to the three sites (Fig. 2). Comparing the periods of pre, during and post-quarantine, it can be seen that the Biodiversity square showed a reduction in the richness of taxa, especially birds. In the Pio XII square there was an increase in wealth with the quarantine, followed by a post-quarantine reduction, the same observed for the Frei Baraúna square, but with a lower value (Fig. 3). It should be emphasized that in the lockdown was registered the rare species *Greta oto* (Hewitson 1854) in Frei Baraúna square, more common in Central America and not previously registered in the municipality of Sorocaba.

The Sorensen index (IS) indicated that, in relation to the bird group, squares F and B showed greater similarity (IS = 0.85), while for butterflies P and F they indicated 0.88. For the group of dragonflies, we have 0.75 similarity between B and P (Fig. 6). The organization patterns differ in the pre-quarantine, quarantine and post-quarantine periods, as they were ordered separately in the multi-dimensional space. The ranking produced by nMDS indicated a stress value equal to zero for the three groups. Taking into account that it varies between 0 and 100, the low value shown shows that the fit is perfect and suitable for interpretation (Fig. 4). The groupings found in nMDS confirm those observed in the Cluster analysis. The analysis of the Cluster dendrogram (Jaccard) revealed that for birds there are two interpretable groups, the first formed by the presence / absence of the post-quarantine and pre-quarantine species, with similarity between them; and the second for the presence/absence of species during quarantine. For butterflies there are also two interpretable groups, one for the presence / absence of post-quarantine species and another for species during quarantine and pre-quarantine, these last two showed similarity to each other. Finally, for dragonflies, there are also two interpretable groups, one for the presence/absence of post-quarantine species and the other for species during quarantine and pre-quarantine, the latter two showing similarity to each other (Fig. 5).

Through analysis of variance One-Way ANOVA it was verified for birds (significance level $p < 0.05$; $p = 0.2941$) and for butterflies (significance level $p < 0.05$; $p = 0.1866$), that there are no significant differences for the abundance of species in the points sampled during the three periods, these results were confirmed by the Test Tuckey, reinforcing that there is no significance for the abundance of species in the places sampled during the periods of pre-quarantine, quarantine and post-quarantine. Regarding dragonflies, the Shapiro-Wilk normality test showed that the sample has very similar data, and it is not possible to perform the One-Way ANOVA analysis for this data set.

Discussion

Many studies point to the indirect positive effects triggered by the installation of the social isolation system in relation to the environment, such as the reduction of gases from ordinary industrial activities and noise from heavy vehicle traffic, improvement in water quality, among others (Yunus et al.; Kerimray et al.; Dantas et al. 2020). The present work, on the other hand, is the first evaluative view of the difference in species richness in the municipality in pandemic times. Even though the species registered in pre-social isolation periods are strictly generalist in terms of diet and habitat use and with a great plasticity and capacity to exploit resources in environments altered by anthropic action (Blair 1996), the difference in wealth in three squares during the studied periods corroborate the idea that many animals enjoy the sudden decline in the circulation of people on the streets.

Regarding avifauna, it can be said that many of the species already had urban centers as refuges and places to obtain resources (Rodrigues et al. 2018). On the other hand, in a visit made during the confinement period, a poorly managed mowing was recorded on the site, a fact that may have contributed to the results obtained. The difference in the number of bird species in the period before the cleaning and after this one is relatively large, respectively with 20 and 13, given that about 45% of the species found choose, even partially, to seek refuge and other resources in more forested areas. Three species have medium sensitivity to disturbances (*Patagioenas picazuro* [Naumburg, 1932], *Colaptes campestris* [Vieillot, 1818] and *Brotogeris chiriri* [Vieillot,

1818]), while the others are highly generalist and common in altered cities and environments (Macgregor-Fors and García-Arroyo 2018). Thus, the period of confinement was not marked by the sighting of unusual species in urban centers.

The group of lepidopterans has 7 species, common to the three sites: *Ascia monuste* (Linnaeus 1754) (family Pieridae), *Hermeuptychia hermes* (Fabricius 1775) and *Methona themisto* (Hübner 1818) (Nymphalidae), adapted to urban and altered environments, this the latter belonging to a tribe of butterflies indicating preserved environments (Ithomiinae) and, therefore, considered highly tolerant to environmental disturbances.

Due to its exceptional condition, the appearance of the transparent butterfly species *Greta oto* during the period of seclusion deserves special attention. *G. oto* is considered rare and found in Central and South America, usually thriving in tropical forest environments (Henderson 2002). The Frei Baraúna square, place of registration of the species, is popularly known for its wooded area and has its location close to the city center, consequently presenting a traffic of vehicles and people much more intense compared to the other squares, a fact that can have contributed to the appearance of the mentioned species, given that the circulation of people has decreased drastically during the period of isolation. It is important to note that *G. oto* is not included in previous surveys carried out in the municipality (Barros et al. 2020), a fact that reveals the great relevance of the present study.

The group of dragonflies depends on special conditions to settle in the environment, the presence of swampy environments being an indispensable factor for their creation (Carvalho and Nessimian 1998). Although only the Biodiversidade square presented the 5 species due to the presence of a wetland, the mentioned clearing ended up interfering with the group's appearance during the quarantine.

Under a more general bias, the three locations presented similar results demonstrated by the application of the Sorensen index. The high values of similarity between the locations (0.85, 0.88 and 0.75), being greater than 0.5 considered high according to Gauch (1982), can be explained by the common characteristics of the three areas. Like the Frei Baraúna and Biodiversity squares, which indicated high similarity for the group of birds and butterflies, since both places have a similar and smaller tree richness than that found in Pius XII. In addition, the Biodiversidade square was the place with the greatest species discrepancy due to mowing carried out in an erroneous manner, with irregular pruning and removal of some trees and herbaceous plants - since many species registered in the environment are biondicators of good environmental quality. - corroborating the need for green areas in cities (Frankie et al. 2009; Ernstson et al. 2010). For dragonflies, the similarity index between the Pius XII and Biodiversity squares was already expected due to the lower wealth compared to the two other groups.

Regarding statistical data, the Non-metric Multidimensional Scaling (nMDS) analysis facilitates interpretation and indicates patterns that allow visualizing the distance between objects. In this case, the analysis made it possible to differentiate the groups' wealth over the three periods. The similarities presented by the Sorensen and Jaccard indices were confirmed by nMDS, since the analysis indicated an optimal adjustment between Euclidean distances (McCune and Grace 2002; Borcard et al. 2011). On the other hand, even though the ordering models are efficient and the study tested the appearance of a rare species, the analysis of variance

(ANOVA) shows that there are no significant differences in relation to the abundance of species over the three sampled periods.

Conclusion

The scenario experienced in pandemic periods is something totally atypical for the world: affected economies, failing industries, crowded hospital beds and millions of people imprisoned in their homes in order to prevent the spread of the pathogen - although many do not. During this period, nature took advantage of empty streets and green areas, previously commonly frequented by residents and tourists, to obtain resources such as habitat and food. Although many species have generalist habits - in terms of habitat and diet use - some of them are strictly sensitive to human actions.

The present work concluded that the difference in richness and appearance of species uncommon to urban landscape demonstrates the influence that human presence has on the mechanisms of urban biodiversity. Furthermore, it is extremely relevant for understanding our role as citizens and the importance of the human-nature intersection, where the human being can enjoy the finite resources provided by the species without jeopardizing their processes, since this relationship is mutual, and it must be taken seriously.

Declarations

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Not applicable.

Conflict of interest

The authors declare that they have no conflict of interest.

Data availability

Due to the sensitive nature of the species locations, the datasets from the current study are not publicly available but are available from the corresponding author on reasonable request.

Code availability

Not applicable.

Author contributions

WSS conceived the research idea, performed all statistical analyses and helped with statistical advice and corrections; JFC designed the methodology, collected field data, led the writing and editing of the manuscript;

FLS was responsible for the maps design. The final version of the manuscript was read and approved by all authors.

Ethics approval

Not applicable.

Consent to participate

Not applicable.

Consent for publication

Not applicable.

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Figures

Figure 1

Public squares of Sorocaba, chosen for this research. Credits: Silva (2020).

Figure 2

Taxonomic groups represented by families of birds, butterflies and dragonflies in the three locations. Organized by Silva (2020).

a)

b)

c)

Figure 3

Richness of species of birds, butterflies and dragonflies in each square during three periods: a) Biodiversidade square, b) Pius XII square and c) Frei Baraúna square.

Figure 4

Diagram of the ordering of the nMDS analysis based on the presence/absence matrix for the occurrence of species in the squares sampled during the pre-quarantine, quarantine and post-quarantine periods.

Figure 5

Cluster dendrogram, Jaccard estimator. A) Cophen. corr.: 0.9895; B) Cophen. corr.: 0.9853; C) Cophen. corr.: 0.9042.