

Distribution, activity patterns and diet of *Callithrix penicillata* (Primates: Callithrichidae) in an urban area in central Brazil

Distribuição, padrões de atividade e dieta de *Callithrix penicillata* (Primates: Callithrichidae) em uma área urbana no Brasil central

Distribución, patrones de actividad y dieta de *Callithrix penicillata* (Primates: Callithrichidae) en un área urbana del centro de Brasil

Received: 05/21/2022 | Reviewed: 06/09/2022 | Accept: 06/11/2022 | Published: 06/13/2022

Ana Claudia Bernardes-Dias

ORCID: <https://orcid.org/0000-0002-4635-255X>

Instituto Federal Goiano, Brazil

E-mail: diasanacb@gmail.com

Wellington Hannibal

ORCID: <https://orcid.org/0000-0001-7141-1243>

Universidade Estadual de Goiás, Brazil

E-mail: wellingtonhannibal@gmail.com

Romari Alejandra Martinez

ORCID: <https://orcid.org/0000-0003-0799-6595>

Universidade Estadual de Santa Cruz, Brazil

E-mail: cebus@yahoo.com

Polla Renon Rodrigues Machado

ORCID: <https://orcid.org/0000-0002-6250-7806>

Universidade Federal de Uberlândia, Brazil

E-mail: polla161@outlook.com

Abstract

Urban remnants have been home to large groups of marmosets. However, ecological information about black-tufted marmosets, *Callithrix penicillata* (É. Geoffroy Saint-Hilaire, 1812) on urban areas are scant in the scientific literature. Here, we investigated the distribution, interaction with residents, activity pattern and diet of *C. penicillata* in an urban area in central Brazil. We used direct observation (sightings and scan sampling) and 205 semi-structured interviews to evaluate distribution, interaction and ecological behavior of black-tufted marmosets. *Callithrix penicillata* occurred throughout the urban area of Quirinópolis municipality, occupying mainly the forest remnants and surrounding gallery forests. Supplementary feeding was the interaction most cited by people. However, *C. penicillata* spend most of their time in locomotion (35-40%) and resting (30%), and exudates and supplementary foods represented a large part of their diet. We conclude that *C. penicillata* are well adapted in urban area of central Brazil. However, due interaction with people, we highlighted that these marmoset populations should be part of future municipal public policy concern.

Keywords: Anthropogenic influence; Supplementary food; Urban ecology.

Resumo

Remanescentes urbanos abrigam grandes grupos de saguis. No entanto, as informações ecológicas sobre saguis-de-tufo-preto, *Callithrix penicillata* (É. Geoffroy Saint-Hilaire, 1812) em áreas urbanas são escassas na literatura científica. Aqui, investigamos a distribuição, interação com residentes, padrão de atividade e dieta de *C. penicillata* em uma área urbana no Brasil central. Utilizamos observação direta (avistamentos e amostragem por varredura) e 205 entrevistas semiestruturadas para avaliar a distribuição, interação e comportamento ecológico dos saguis-de-tufo-preto. *Callithrix penicillata* ocorreu em toda a área urbana do município de Quirinópolis, ocupando principalmente os remanescentes florestais e matas de galeria do entorno. A alimentação complementar foi a interação mais citada pelas pessoas. Contudo, *C. penicillata* passa a maior parte do tempo em locomoção (35-40%) e descansando (30%), sendo que exsudatos e alimentos complementares representaram grande parte de sua dieta. Concluímos que *C. penicillata* está bem adaptada na área urbana do Brasil central. Porém, devido à interação com as pessoas, destacamos que essas populações de saguis devem fazer parte das futuras políticas públicas municipais.

Palavras-chave: Influência antropogênica; Alimentação complementar; Ecologia urbana.

Resumen

Los restos urbanos han sido el hogar de grupos de títies. Sin embargo, la información ecológica sobre los títies de pelo negro, *Callithrix penicillata* (É. Geoffroy Saint-Hilaire, 1812) en áreas urbanas es escasa en la literatura científica. Aquí, investigamos la distribución, la interacción con los residentes, el patrón de actividad y la dieta de *C. penicillata*

en un área urbana del centro de Brasil. Usamos observación directa (avistamientos y muestreo de barrido) y 205 entrevistas semiestructuradas para evaluar la distribución, interacción y comportamiento ecológico de los títes de moñudo negro. *Callithrix penicillata* se presentó en toda la zona urbana del municipio de Quirinópolis, ocupando principalmente los remanentes de selva y bosques de galería en los alrededores. La alimentación complementaria fue la interacción más citada por las personas. Sin embargo, *C. penicillata* pasa la mayor parte de su tiempo en locomoción (35-40%) y reposo (30%), con exudados y alimentos complementarios representando gran parte de su dieta. Concluimos que *C. penicillata* está bien adaptada en el área urbana del centro de Brasil. Sin embargo, debido a la interacción con las personas, enfatizamos que estas poblaciones de títes deben ser parte de las futuras políticas públicas municipales.

Palabras clave: Influencia antropogénica; Alimentación complementaria; Ecología urbana.

1. Introduction

The distribution of primates can be influenced by ecological, biogeographical or anthropogenic factors (Bicca-Marques et al., 2011). Marmosets, genus *Callithrix* comprise six arboreal and small weight-size primates' species (230-400 g) endemic of Brazil (Paglia et al., 2012). These species display great ecological and behavioral plasticity, which allow their occurrence and success in areas otherwise hard for primates, such as urban areas (Castro, 2003; Rodrigues & Martinez, 2014). Furthermore, the occupation probability and home range of marmosets in a fragmented landscape or urban area is mostly depending on local factors, like the distribution of gumivorous trees and supplementary food, more than fragment size or landscape composition (Pontes et al., 2007; Da Silva, 2015; Thompson et al., 2013; Sales et al., 2016). So, small forest fragments within cities might harbor large groups of marmosets, due to their association with humans, which ensure their subsistence by introduction of exotic foods (Pontes et al., 2007).

Human food supplementation seems to be vital for urban marmoset populations, and it is seen as positive and beneficial for both, marmosets and people (Leite et al., 2011; Rodrigues & Martinez, 2014). Nevertheless, there has been little attention from the academic community towards several ecological variables of marmosets in urban areas (Leite et al., 2011; Rodrigues & Martinez, 2014; Santos et al., 2014; Santos et al., 2017). Therefore, our research is relevant to propose management strategies compatible with the available spaces within cities, minimize conflicts and accidents for marmosets and humans (Teixeira et al., 2015). In this case, environmental education is an effective measure (Morais et al., 2021), in order to avoid exaggerated population growth, as has happened in several cities of Brazil (Silva et al., 2018b; Aximoff et al., 2020; Pereira et al., 2020). If despite this, the population keeps growing, other measures of population control must to be consider, such as sterilization, which can be logistically complicated and expensive (De Queiroz et al., 2017; Silva et al., 2018a).

In this study, our main questions were: i) Are the populations of *Callithrix penicillata* (É. Geoffroy Saint-Hilaire, 1812) islanded on the remnants of urban forest? ii) What is the perception about these marmosets by the residents? iii) What is the activity pattern and diet of *C. penicillata* marmoset on forest remnants of urban areas? We predicted that *C. penicillata* groups would not be restricted to the forest remnants, using roads, telephone and electrical pole wire networks to establish connections between fragments with different amounts of available resources (Rodrigues & Martinez, 2014). Our expectations were to find the same pattern as other urban or semi-urban groups, with more time spent in locomotion and rest (Santos et al., 2014), and a diet dependent on the floristic composition of the urban remnants, but mainly of the exogenous food resource supplemented by humans as a priority, as it has easy access and continuous availability (Da Silva et al., 2015). Thus, we investigate the distribution of *C. penicillata* and your interaction with residents. Further, we also investigate the activity patterns and diet of *C. penicillata* in the city of Quirinópolis, southern Goiás, Brazil.

2. Methodology

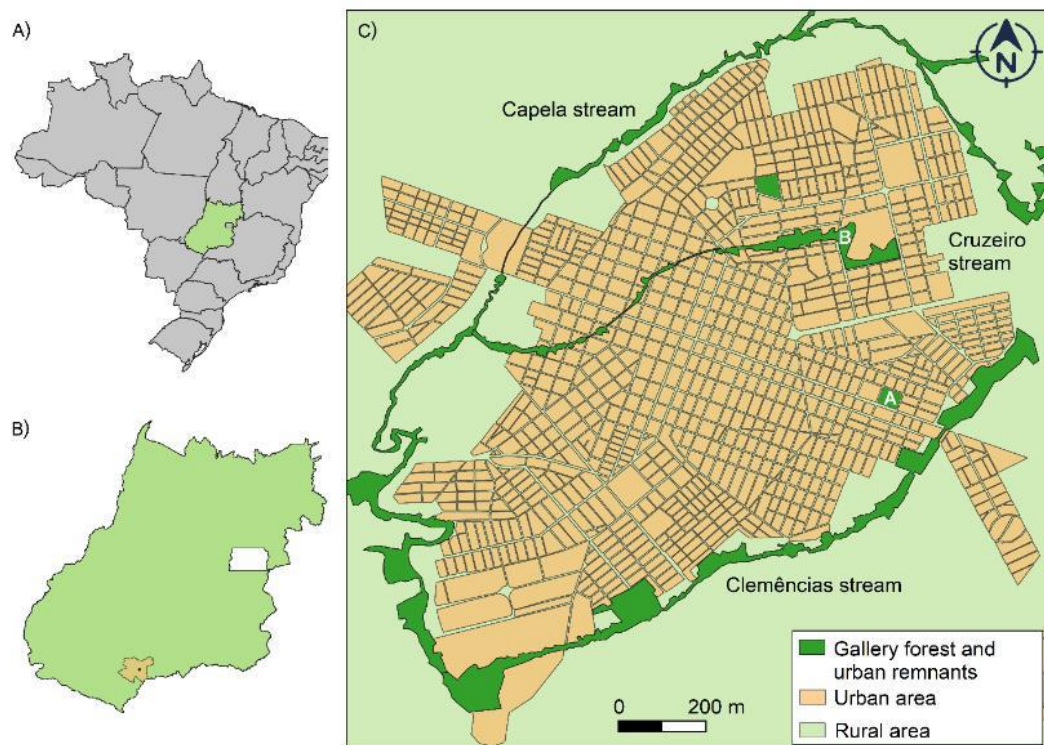
Study area

The study was conducted in the city of Quirinópolis, southern Goiás state in central Brazil. Quirinópolis has 50,060

inhabitants in an area of 3,780 km² (IBGE, 2019). The city has few green areas and a tree census counted 754 individuals, belonging to 17 Families (37 species), distributed in 10 city squares (Claro et al., 2020). We collected data on the distribution of *Callithrix penicillata* throughout the city and in a gallery forest that surrounds it (Figure 1).

For activity pattern and diet, we monitored marmoset groups in two urban forest fragments: A) Botanical garden of the Universidade Estadual de Goiás (JBUEG), a semideciduous forest remnant (area = 1.8 ha, with dominance of Fabaceae species such as: *Enterolobium contortisiliquium*, *Hymenaea courbaril*, *Platypodium elegans*, *Pterogyne nitens*), and B) Eldorado tennis club, a riparian forest (5.4 ha represented by *Inga laurina*, *Pterodon* sp., *Anadenanthera* sp., *Mimosa caesalpinifolia* [Fabaceae], *Handroanthus impetiginosus* [Bignoniaceae], and introduced species (*Anacardium occidentale* and *Mangifera* sp.) connected to the gallery forest of the Cruzeiro stream (Figure 1). The climate is Tropical with dry winter (Aw in Köppen classification), with wet season (October to March) and dry season (April to September). Rainfall is between 1,600 to 1,900 mm and annual temperature between 19 to 20 °C (Alvares et al., 2013).

Figure 1. A) Map of Brazil highlighting Goiás State, B) Map of the state of Goiás highlighting Quirinópolis Municipality, C) Map of the city of Quirinópolis highlighting the streams, forest remnants.



Source: Authors.

Distribution of marmosets and interaction with residents

To determine the occurrence of *C. penicillata* within the city, we used active search in all available spaces during August 2018, totaling 17 hours of sampling. We considered direct (visualization and vocalizations) and indirect (tree gouged, foraging records, indications of the inhabitants of the areas) observations. Additionally, we applied 205 semi-structured and anonymous interviews to people of both sexes, ages 18 years and over (Appendix 1, modified from Rodrigues & Martinez, 2014) to assess the information of the residents about marmosets. The interviews were authorized by the ethics committee of Universidade Estadual de Goiás (95467117.7.0000.8113). We randomly selected households in 20% of the blocks of each neighborhood, considering only one residence per block. We built the species occurrence map according to the GPS coordinates of the localities recorded by activity search and those mentioned by residents.

Activity pattern and diet

After a habituation period of five weeks, scan sampling (Altmann, 1974) was used to record activity pattern and diet for each adult group member, with 15-minutes intervals between scans. The two group were monitoring between August 2018 to July 2019 and between 07:00 to 17:00 h, however, the group of JBUEG were sampled only one time by month, while de Eldorado tennis club group were monitored three times by month, totaling a sampling effort of 120 and 360 hours, respectively. During the monitoring, we recorded the following behaviors: locomotion (any spatial displacement of the animal), rest (inactive animal, lying or sitting, feeding), social interaction (any interaction with members of the same group), and foraging (movement of the animal's face and limbs, without displacement of the body, orientation to specific positions / locations) (Vilela & Faria, 2004; Vilela, 2007; Pinheiro & Pontes, 2015). Regarding feeding, we recorded the following food items: arthropods, fruits, exudates: scarification and ingestion of gum, and supplementary food items (food provided by humans). We used a 10x50 binoculars to observe the pattern of activity and diet of each individual.

Data analysis

To point the distribution and frequency of records of *C. penicillata* in urban area, we used heatmap plugin in QGIS to create kernel density map based on the frequency of records within each georeferenced locality, thought the program QGIS v. 2.14.3 (QGIS, 2015).

We evaluated the perception (e.g. Have you seen marmosets in the city? [yes OR not]. How often have you seen marmosets? [Every day OR Three times a week OR Once a week]. How much individuals you see? [Alone OR Group: how many?]) by descriptive statistic. We tested the interaction between residents with marmoset through frequency of sighting and food supplementation [yes OR not], using Pearson's Chi-square test.

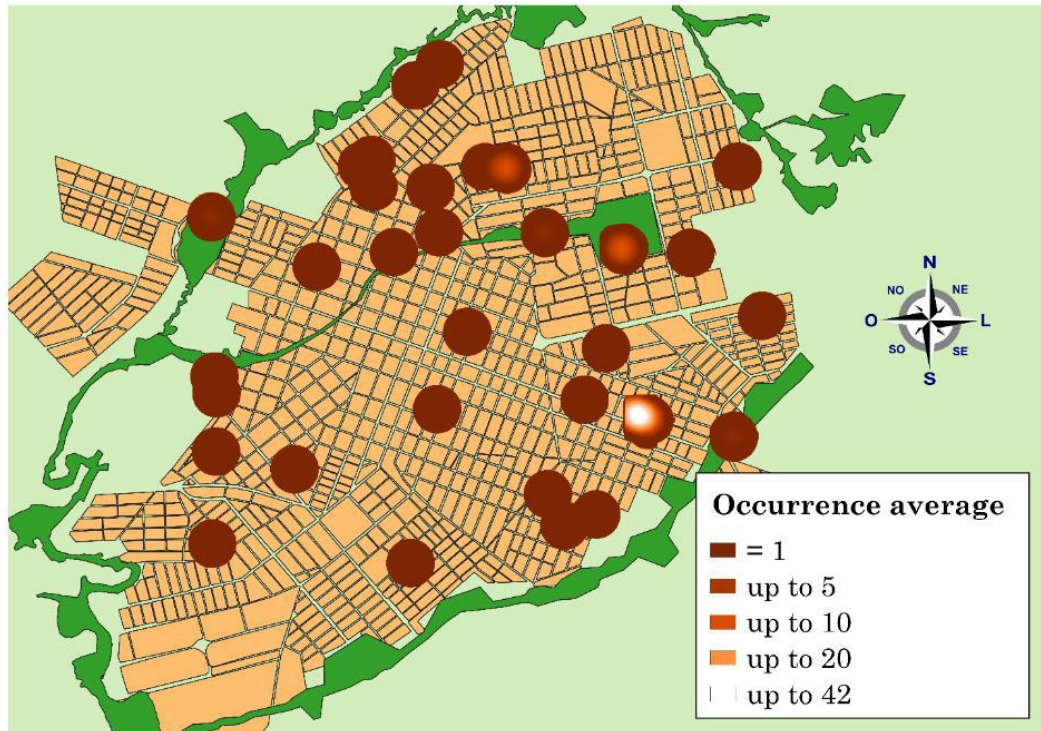
For the activity pattern and diet, first we standardized the difference in the effort applied in each marmoset group (JBUEG and Eldorado) through dividing the number of records of each category by the total records within them and multiplying the result by 100 to return the relative frequency (%). Afterwards, we applied a factorial variance analysis to investigate the effect of activity pattern and diet, and its interaction with marmoset group (explanatory variables) on relative frequency (response variable). We tested all presupposition of the analysis. All analyses were carried in R environment (R Core Team, 2019).

3. Results

Distribution of marmosets and interaction with residents

With a sampling effort of 17 hours and 23 kilometers covered, we recorded six sightings of *C. penicillata* (5.8 individuals \pm 1.17 standard deviation [SD]) in the gallery forests surrounding Quirinópolis, distributed in the Capela stream (n = 6 and 7 individuals), Clemência stream (n = 5 and 4) and Cruzeiro stream (n = 7 and 6). With the interviews, we listed the presence of marmosets in 31 locations throughout the urban area, with a higher frequency of occurrences in the Botanical Garden of the Universidade Estadual de Goiás, a green area of the Rio Preto neighborhood and a forest remnant of the Eldorado tennis club (Figure 2).

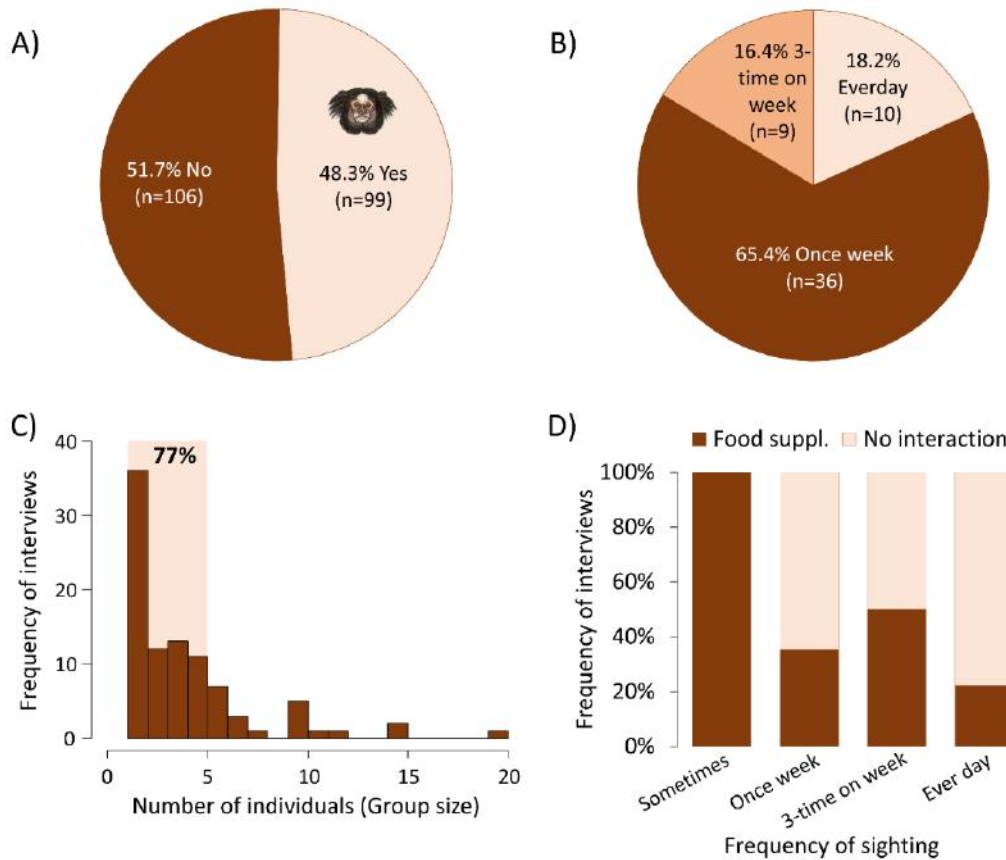
Figure 2. Frequency of occurrence of groups of *Callithrix penicillata* (É. Geoffroy Saint-Hilaire, 1812) in the city of Quirinópolis, south of Goiás, Brazil, through interviews.



Source: Authors.

Two hundred and five interviews were performed, with 48% (n = 99 interviewees) stating that they had already seen the marmosets in the city (Figure 3A). Most of them (65%, n = 36) encounter marmosets at least once a week, and 18.2% (n = 10) seeing them every day (Figure 3B). Ninety-three interviewees (45%) had information on group composition: marmosets were mostly sighted in groups of up to five individuals in 77% (n = 72) of interviews (Figure 3C). Based on 63 residents' interaction with marmosets, we found a significant association ($\chi^2 = 17.62$, df = 3, $p < 0.001$) between food supplementation and frequency of sighting. All occasional encounters are related to food supplementation, while 80% of everyday encounters do not imply feeding (Figure 3D).

Figure 3. Frequency of interviewees that answering: A) Having to seen marmoset in the city and B) frequency of these sighting. C) Number of individuals (group size) of *Callithrix penicillata* sighted by 45% of interviewees. D) Association between supply or not supply food and frequency of sighting of *Callithrix penicillata* in the city of Quirinópolis, Goiás, Brazil.

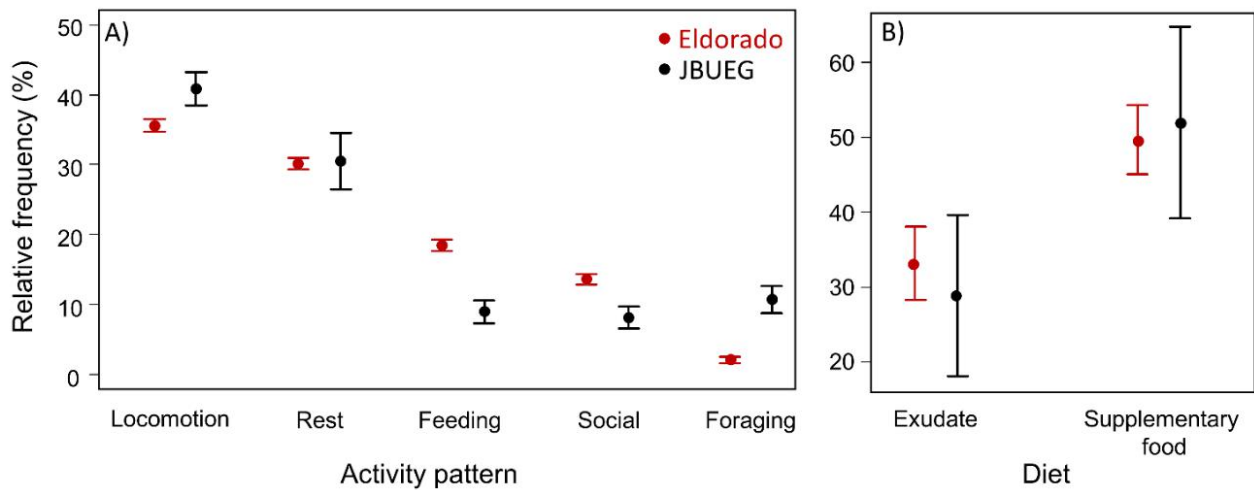


Source: Authors.

Activity pattern and diet

With an effort of 480 hours of observation (120 h in JBUEG and 360 h in Eldorado), we found that both groups spend a significant ($F = 253.4$, $df = 4$, $p < 0.001$) amount of their time in activities related to locomotion (35-40%) and rest (30%), respectively (Figure 4A). However, we found a significative interaction ($F = 14.8$, $df = 4$, $p < 0.001$) between the three last activity patterns, in which feeding and social behavior were displayed more frequently by the group of Eldorado tennis club, while foraging was displayed more frequently by the group of JBUEG (Figure 4A). Exudate and supplementary food represented more than 80% of the diet of both groups, being that consumption of supplemented food was the most frequent feeding behavior for both groups ($F = 7.8$, $df = 1$, $p = 0.006$) (Figure 4B). Most of the exudate consumption by the marmoset groups was from *Anadenanthera* sp. (Fabaceae), and the most frequent exotic food was banana.

Figure 4. Relative frequency of activity pattern and diet by marmosets *Callithrix penicillata* in two urban forest remnants in the city of Quirinópolis, Goiás.



Source: Authors.

5. Discussion

Distribution of marmosets and interaction with residents

Callithrix penicillata is distributed throughout the urban area of Quirinópolis, occupying mainly the forest remnants and gallery forests, being spotted at least once a week by city residents. *Callithrix penicillata* is categorized in Least Concern (LC) by the International Union for Conservation of Nature Red List (Bicca-Marques et al., 2018), and has been the marmoset species most studied by the scientific community (Hannibal et al., 2019), with the largest geographical range and introduced in the states of Paraná, Santa Catarina and Rio de Janeiro (Traad et al., 2012). The distribution of marmosets along gallery forests can be explained by resource availability in these areas. At least 26 species of plants in gallery forests are used, mainly for exudate consumption, with highlights to *Callisthene major* Mart. & Zucc., *Tapirira guianensis* Aubl. and *Qualea dichotoma* (Mart.) Warm. (Lacher et al., 1984; Vilela, 2007). Others trees in this area have wood with shorter fibers and thinner cell walls (Sonsin et al., 2012), which can facilitate scarification by marmosets, such as Vochysiaceae family with all seven species reported as exudate sources (Lacher et al., 1984; Vilela, 2007).

We corroborated our initial prediction that marmoset groups are not isolated among urban fragments, and their distribution follows areas of continuous vegetation, seeking the shortest distance between them (Figure 2). Marmosets were also recorded in the city's backyards and orchards (according interviewees), as is reported elsewhere, following their known broad ecological plasticity (Castro, 2003; Rodrigues & Martinez, 2014). Considering the widespread distribution of marmosets in Quirinópolis we expected a greater number of sightings by the interviewees. On the other hand, the people that actually see them around the city, have at least once a week sighting and often of groups of five or more individuals. *Callithrix penicillata* is a common marmoset species in its geographical range, being introduced in other Brazilian states, occurring in semi-urban and urban forest fragments (Traad et al., 2012; Santos et al., 2014).

Food supplementation by residents was the most common interactions reported by interviewees. Leite et al. (2011) reported that marmosets are viewed positively by people. Quirinópolis residents have a compassionate attitude towards marmosets, derived from the idea that, at least the groups at the JBUEG forest, are starving. This has motivated the amateur installations of food trays along the JBUEG fence, where neighbors supplement marmosets' diet with human food or fruits. It is important to underline that people frequently assume that marmosets in urban areas are "starving" and should be fed by the authorities (Leite et al., 2011).

Activity pattern and diet

The activity pattern, with more time spent on locomotion and resting, is in accordance with the behavior adopted by *C. penicillata* in native (Miranda & Faria, 2001) and semi-urban areas (Santos et al., 2014) of Cerrado domain. However, a more time spend in forage for insects instead of locomotion and resting also was found in this domain (Vilela & Faria, 2004). The authors proposed that this difference may be associated with the specific environmental changes of the landscape, such as the increase or decrease in the availability of insects and other resources. This might imply that the activity pattern could also be influenced by the type of environment in which the marmosets are inserted. More research would be needed to answer this question.

Exudates and food supplementation have been one of the main food resources accessed by marmosets; the same was true for the groups present in the JBUEG and in the Eldorado club. Some studies affirm that resources present in natural areas have a regular distribution (Lacher et al., 1984; Silva & Felfili, 2012). However, many urban forest remnants are dominated by one species, which is the case of the *Anadenanthera* sp. present in our study areas. In five forest fragments of Atlantic Forest, the presence of *Anadenanthera peregrina* (L.) Speg. have promoted an excellent source of exudates for marmosets (Francisco et al., 2014).

6. Final Considerations

Our findings point out that Quirinópolis marmosets are well adapted to the urban areas with general behaviors similar to natural environments, but artificial food supplementation can change the normal population dynamics of these small primates. It is important to work with the people living within primate environments, to increase their knowledge on marmoset biology and ecology, seeking to avoid unnecessary food supplementation and close contact. However, we need a better understanding of the mechanisms that affect the distribution, activity patterns and diet of *Callithrix* in anthropic landscapes, as this knowledge is crucial to propose strategies for maintaining natural populations at ecologically consistent levels. Public policy measures need to be foreseen by city authorities, such as mapping of available natural spaces to relocate groups among the city, strategies for avoiding conflicts with humans and other inhabitants of the same spaces. City leaders must contemplate marmosets in their urban planning and design effective measures to avoid exaggerated population growth that could lead to imbalances in urban ecology, forcing undesirable mitigation measures, such as aggressive population control.

Acknowledgments

We thank to colleagues of the Laboratory of Ecology and Biogeography of Mammals for field support, in a special way J. Alencar and W. Parreira. We thank to I. L. Moraes for the identification of botanic species. We are also grateful for scholarship granted by the Programa de Iniciação Científica e Tecnológica (IC&T-UEG) to A.C.B.D.

References

- Altmann, J. (1974). Observational study of behavior: sampling methods. *Behaviour*, 49, 227-267.
- Alvares, C. A., Stape, J. L., Sentelhas, P. C., De Moraes Gonçalves, J. L. & Sparovek G. (2013). Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift*, 22 (6), 711-728.
- Aximoff, I., Zaluar, M. T., Pissinatti, A., Bastos, P. A., Moraes, T. A., Rosa, C. A., Oliveira, L. C., Teixeira, D. S. & Vale, M. M. (2020). Anomalous pigmentation in invasive and native marmosets, *Callithrix jacchus*, *Callithrix penicillata* (Primates, Callitrichidae), and their hybrids in Brazil. *Folia Primatologica*, 91 (2), 149-158.
- Bicca-Marques, J. C., Silva, V. M. & Gomes, D.F. (2011). *Ordem Primates*. In: Reis, N. R., Peracchi, A. L., Pedro, W. A. & Lima, I. P. *Mamíferos do Brasil* (2° ed.). Ed. Nelio R. dos Reis, 101 p.
- Bicca-Marques, J., Jerusalinsky, L., Mittermeier, R.A., Pereira, D., Ruiz-Miranda, C., Rímoli, J., Valença-Montenegro, M. & Do Valle, R. R. (2018). *Callithrix penicillata*. <https://www.iucnredlist.org/species/41519/17935797>.

- Castro, C. S. S. (2003). Tamanho da área de vida e padrão de uso do espaço em grupos de saguís, *Callithrix jacchus* (Linnaeus) (Primates, Callitrichidae). *Revista Brasileira de Zoologia*, 20(1), 91–96.
- Claro, H. W. P., Rossi, R. F. & Hannibal, W. (2020) Bird communities in urban habitat: the importance of vegetation in city squares. *Revista Sapiência: Sociedade, Saberes e Práticas Educacionais*, 9 (3), 201-207.
- Da Silva, L. G., Ribeiro, M. C., Hasui, É., Da Costa, C. A. & Da Cunha, R. G. T. (2015). Patch size, functional isolation, visibility and matrix permeability influences neotropical primate occurrence within highly fragmented landscapes. *PLoS ONE*, 10 (2), 1-20.
- De Queiroz, F. F., Kristosch, G. C., Soffiati, F. L., Luz, M. J., Oliveira, A. L. A., Borges, T. R. J., Miranda, C. R. R. & Silveira, L. S. (2017). Sterilization of hybrid marmoset (*Callithrix* sp.) females: an evaluation of two surgical methods. *Journal of Zoo and Wildlife Medicine*, 48 (4), 1095-1101.
- Francisco, T. M., Couto, D. R., Zanuncio, J. C., Serrã, J. E., De Silva, I. O. & Boere, V. (2014). Vegetable exudates as food for *Callithrix* spp. (Callitrichidae): Exploratory patterns. *PLoS ONE*, 9 (11), e112321.
- Hannibal, W., Renon, P., Figueiredo, V. V., Oliveira, R. F., Moreno, A. E. & Martinez, R. A. (2019). Trends and biases in scientific literature about marmosets, genus *Callithrix* (Primates, Callitrichidae): biodiversity and conservation perspectives. *Neotropical Biology and Conservation*, 14 (4), 529-538.
- IBGE (Instituto Brasileiro de Geografia e Estatística) (2019). Quirinópolis census. <http://ibge.gov.br>.
- Lacher, T. E., Fonseca, G. A. B., Alves, C. & Magalhaes-Castro, B. (1984). Parasitism of tree by marmosets in a central Brazilian gallery forest. *Biotropica*, 16 (3), 202-209.
- Leite, G. C., Duarte, M. H. L. & Young, R. J. (2011). Human-marmoset interactions in a city park. *Applied Animal Behaviour Science*, 132 (3-4), 187-192.
- Miranda, G. H. B. & de Faria, D. S. (2001). Ecological aspects of black-pinellated marmoset (*Callithrix penicillata*) in the cerrado and dense cerrado of the Brazilian central plateau. *Brazilian Journal of Biology*, 61, 397-404.
- de Moraes, I. L., Rizzo, C. D., Brandelero, S. M., & Hannibal, W. (2021). Eficácia de placas educativas no descarte de resíduos sólidos urbanos e à não alimentação do sagui-de-trufo-preto (*Callithrix penicillata*). *Research, Society and Development*, 10(13), e300101321463-e300101321463.
- Paglia A. P., Fonseca, G. A. B., Rylands, A. B., Herrmann, G., Aguiar, L. M. S., Chiarello, A. G., Leite, Y. L. R., Costa, L.P., Siciliano, S., Kierulff, M. C. M., Mendes, S. L., Tavares, V. C., Mittermeier, R. A. & Patton, J. L. (2012). Lista anotada dos mamíferos do Brasil. *Occasional papers in conservation biology. Conservação Internacional*.
- Pereira, A. A. B. G., Dias, B., Castro, S.I., Landi, M. F. A., Melo, C. B., Wilson, T. M. & Castro, M. B. (2020). Electrocutions in free-living black-tufted marmosets (*Callithrix penicillata*) in anthropogenic environments in the Federal District and surrounding areas, Brazil. *Primates*, 61(2), 321-329.
- Pinheiro, H. L. N. & Pontes, A. R. M. (2015). Home range, diet, and activity patterns of common marmosets (*Callithrix jacchus*) in very small and isolated fragments of the Atlantic forest of northeastern Brazil. *International Journal of Ecology*, 2015, 1-13.
- Pontes, A. R. M., Normande, I. C., Fernandes, A. C. A., Ribeiro, P. F. R. & Soares, M. L. (2007). Fragmentation causes rarity in common marmosets in the Atlantic forest of northeastern Brazil. *Biodiversity and Conservation*, 16 (4), 1175-1182.
- QGIS Development Team (2015). QGIS Geographical Information System (Open Source). <http://qgis.osgeo.org/>.
- R Core Team (2019) R: A Language and Environment for Statistical Computing. <http://www.R-project.org/>.
- Rodrigues, N. N. & Martinez, R. A. (2014). Wildlife in our backyard: interactions between Wild's marmoset *Callithrix kuhlii* (Primates: Callitrichidae) and residents of Ilhéus, Bahia, Brazil. *Wildlife Biology*, 20 (2), 91-96.
- Sales, L. P., Hayward, M. W. & Passamani, M. (2016). Local vs landscape drivers of primate occupancy in a Brazilian fragmented region. *Mammal Research*, 61 (1), 73-82.
- Santos, M. N., Duarte, M. H. L. & Young, R. J. (2014). Behavioural and ecological aspects of black tufted-ear marmosets, *Callithrix penicillata* (Geoffroy, 1812) (Primates: Callitrichidae) in a semi-urban environment. *Revista de Etologia*, 13 (1), 37-46.
- Santos, S. G., Duarte, M. H. L., Sousa-Lima, R. S. & Young, R. J. (2017). Comparing contact calling between black tufted-ear marmosets (*Callithrix penicillata*) in a noisy urban environment and in a quiet forest: noise effects on contact calls in black tufted-ear marmosets. *International Journal of Primatology*, 38 (6), 1130-1137.
- Silva, D. F., Silva, E. B. & Terra, A. P. (2018a). Population control of invasive wild species through tubal ligation and vasectomy in primates *Callithrix penicillata*: case report. *Veterinária e Zootecnia*, 25 (1), 99-104.
- Silva, F. F. R., Malukiewicz, J., Silva, L. C., Carvalho, R. S., Ruiz-Miranda, C. R., Coelho, F. A. S., Figueira, M. P., Boere, V. & Silva, I. O. (2018b). A survey of wild and introduced marmosets (*Callithrix*: Callitrichidae) in the southern and eastern portions of the state of Minas Gerais, Brazil. *Primate Conservation*, 32, 1-18.
- Silva, J. S. & Felfili, J. M. (2012). Floristic composition of a conservation area in the federal district of Brazil. *Revista Brasileira de Botânica*, 35 (4), 385-395.
- Sonsin, J. O., Gasson, P. E., Barros, C. F. & Marcati, C. R. (2012). A comparison of the wood anatomy of 11 species from two cerrado habitats (cerrado s.s. and adjacent gallery forest). *Botanical Journal of the Linnean Society*, 170 (2), 257-276.
- Teixeira, B., Hirsch, A., Goulart, V. D. L. R., Passos, L., Teixeira, C. P., James, P. & Young, R. (2015). Good neighbours: distribution of black-tufted marmoset (*Callithrix penicillata*) in an urban environment. *Wildlife Research*, 42 (7), 579-589.

Thompson, C. L., Robl, N. J., Melo, L. C. O., Valença-Montenegro, M. M., Valle, Y. B. M., de Oliveira, M. A. B. & Vinyard, C. J. (2013). Spatial Distribution and Exploitation of Trees Gouged by Common Marmosets (*Callithrix jacchus*). *International Journal of Primatology*, 34 (1), 65-85.

Traad, R. M., Leite, J. C. M., Werckerlin, P. & Trindade, S. (2012). Introdução das espécies exóticas *Callithrix penicillata* (Geoffroy, 1812) e *Callithrix jacchus* (Linnaeus, 1758) em ambiente urbanos (Primates: Callitrichidae). *Revista de Meio Ambiente e Sustentabilidade*, 2 (1), 9-23.

Vilela, S. L. & Faria, D. S. (2004). Seasonality of the activity pattern of *Callithrix penicillata* (Primates, Callitrichidae) in the cerrado (scrub savanna vegetation). *Brazilian Journal of Biology*, 64 (2), 363-370.

Vilela, S. L. (2007). Simpatia e dieta de *Callithrix penicillata* (Hershkovitz) (Callitrichidae) e *Cebus libidinosus* (Spix) (Cebidae) em matas de galeria do Distrito Federal, Brasil. *Revista Brasileira de Zoologia*, 24 (3), 601-607.