THE STRUCTURE OF GREEN URBAN AREAS AS AN INDICATOR OF ENVIRONMENTAL QUALITY AND ITS IMPORTANCE FOR BIRD DIVERSITY IN THE CITY OF CAMPO GRANDE, MATO GROSSO DO SUL

A ESTRUTURA DE ÁREAS VERDES URBANAS COMO INDICADOR DE QUALIDADE AMBIENTAL E SUA IMPORTÂNCIA PARA A DIVERSIDADE DE AVES NA CIDADE DE CAMPO GRANDE, MATO GROSSO DO SUL

Emilia Alibio Oppliger
Fernanda Mussi Fontoura
Ademir Kleber Morbeck de Oliveira
Maria Cecília Barbosa de Toledo
Mauro Henrique Soares da Silva
Neiva Maria Robaldo Guedes

Abstract

Higher biodiversity in urban environments results in lower vulnerability to problems normally encountered in these contexts, such as pollution. Thus conserving natural resources is related to better quality of life for the population. Based on this, the objective was to analyze the vegetation structure in three urban green areas and its importance for maintaining the avifauna in Campo Grande, MS. The elements considered were size, utilization, surroundings, vegetation structure and water bodies to compare richness and frequency of occurrence of bird species. Through a qualitative survey, 107 bird species were recorded in the studied areas. The birds with the highest absolute frequency of occurrence found were Patagioenas picazuro and Ara ararauna. The home ranges of 89% of the birds are not classed as "altered areas", indicating that the city currently has good environmental conditions.

Keywords: Biodiversity. Landscape. Cerrado. Connection of Urban Green Areas. Sustainability.

Resumo

A maior biodiversidade em ambientes urbanos propicia menor vulnerabilidade aos problemas normalmente encontrados nestes contextos, como a poluição, assim, a conservação dos recursos naturais relaciona-se à melhor qualidade de vida da população. A partir disso, objetivou-se analisar a estrutura vegetacional em três áreas verdes urbanas e sua importância para a manutenção da avifauna em Campo Grande, MS. Os elementos considerados foram tamanho, utilização, entorno, estrutura da vegetação e os corpos hídricos para comparar riqueza e frequência de ocorrência das espécies de aves. Através de levantamento qualitativo, foram registradas 107 espécies de aves nas áreas estudadas. As aves encontradas com maior frequência absoluta de ocorrência foram Patagioenas picazuro e Ara ararauna. A área de vida de 89% das aves não se configura como 'áreas alteradas', indicando que a cidade, atualmente, apresenta boas condições ambientais.

Palavras-chave: Biodiversidade. Paisagem. Cerrado. Conexão de Áreas Verdes Urbanas. Sustentabilidade.

https://doi.org/10.11606/issn.2359-5361.paam.2019.162864
Paisag. Ambiente: Ensaios, São Paulo, v. 30, n. 44, e162864, 2019.

1. Introduction

Rapid, unplanned urbanization over the last century has triggered a complex problem involving a range of ecological, sociocultural and economic factors (scarcity and waste of natural resources, urban violence, organized crime, systemic corruption, traffic congestion, unequal income distribution, pollution, poverty, lack of access to drinking water and basic sanitation, among many others).

It is necessary to understand that ecological, socio-cultural and economic systems are interrelated and that changes undergone by nature can have a negative impact. Human activity, such as mining and opening new areas for agriculture, pollute and destroy water resources and cause deforestation and forest fires, as well as significant loss of biomes. Such local impacts contribute to global problems, such as climate change, that leads to glaciers melting and increased average global temperature, showing that interference in nature is the main reason for the degradation, and often irreversible loss, of elements of the ecological system. In seeking self-regulation, the ecological system is not subject to any other system. It is independent and, hierarchically, the most important. It is interesting to note that in areas where the natural environment is almost completely nonexistent, especially in large cities or in locations with poor planning and management, nature manifests this imbalance in the form of storms, runoff, erosion and temperature rise, for example, impacting directly on people's lives.

Humans have suffered the consequences of an urbanization process that is not recognized as part of a larger system. This process significantly impacts biodiversity and ecosystem services on which humans depend. For this reason, it is imperative to invert the current logic, the rhetorical model of sustainability, in which there is no hierarchy and all systems are equally important; and thus recover the value of the landscape. In this context, ecological landscape planning may be the solution to reversing this scenario through balancing natural flows. Considering that the greater the biodiversity of the urban environment, the greater its resistance to tensions and the lower its vulnerability, more effective use of natural resources can be related to improved quality of life for the population (FREITAS, 2017).

Biodiversity is a unique asset and its loss is irreparable. Brazil has the greatest diversity of vascular plants, freshwater fish and mammals on the planet and the third greatest diversity of birds - with 1,919 species (277 endemic) (PIACENTINI et al., 2015). The country has six terrestrial biomes, with two considered diversity hotspots: the Atlantic Forest and the *Cerrado* (BRASIL, 2011).

The Brazilian *Cerrado* is recognized as the richest savanna in the world, with a wide variety of habitats determining a remarkable alternation of species between different phytophysiognomies. Its avifauna totals around 1,044 species - more than half of all Brazilian species (TÁXEUS, 2017). The variety of plant species is one of the determinants of bird diversity in a given environment, whether urban or rural, as they select their habitats according to structural characteristics and, above all, physiognomic aspects of vegetation (SICK, 1997). In recent decades, modification of the natural landscape and the consequent impact on the environment has stimulated the publication of countless studies on avifauna in its different aspects (CASTRO-NAVARRO et al., 2017; MATOS et al., 2018; SANTOS; CADEMARTORI, 2015).

Avifauna can be an indicator of environmental quality in an urban area and studies have shown that its richness is related to the variety of phytophysiognomies and size of the preserved areas (OPPLIGER et al., 2016a; SANTOS; CADEMARTORI, 2010; VALADÃO et al., 2006). Furthermore, birds can be an important tourist attraction (OPPLIGER et al., 2016b).

These areas have different functions and are responsible for different ecosystem services, such as recovering and maintaining comfortable microclimate conditions for the population and minimizing critical atmospheric conditions, such as air pollution (GAUDERETO et al., 2018). These environments can also provide social and economic benefits, such as user satisfaction with locations in green areas (BENAKOUCHE, 1994; XAVIER et al., 2018).

The concept of green areas should consider that such places have requirements such as: urban open space, tree and shrub vegetation (including on public roads), at least 70% of the land free from buildings or waterproof coverings and public access or otherwise. Moreover, they should exercise minimal ecological (increased thermal comfort, control of air and acoustic pollution, interception of rainwater and shelter for fauna), aesthetic (visual and ornamental enhancement of the environment and diversification of the built landscape) and leisure (tourism and recreation) functions (BARGOS; MATIAS, 2011).

Green areas enable natural resources to be preserved and are open spaces for leisure, as long as this does not compromise the balance of already fragile ecosystems throughout the urban context (MAZZEI; COLESANTI; SANTOS, 2007). Quality of life in cities is related to the environmental quality of these spaces; however, planning that is poorly executed, or totally lacking can lead to areas still resisting anthropic pressure to be mischaracterized (AMATO-LOURENÇO et al., 2016).

There are many factors placing what remains of these spaces at risk, such as real estate speculation, disorderly urban growth and irregular land occupation. However, even fragmented, they are an essential environmental resource for maintaining well-being in cities (KUDO et al., 2016).

The municipality of Campo Grande has more than 100,000 hectares of vegetation cover in parks, squares or conservation areas protected by law, inhabited by different species of birds, such as toucans, hawks, owls and herons. It is known as the capital of macaws due to the presence of a large number of these birds, such as blue-and-yellow, and red-and-green macaws, which move between natural areas, palm trees and isolated trees in the urban environment, as food and nesting places can be found there (GUEDES, 2012). It is also known as the Brazilian capital for birdwatching tourism (MAMEDE; BENITES, 2018).

Taking into account the impact of urban green areas on environmental quality in cities, our aim was to correlate landscape heterogeneity in three areas of Campo Grande and its importance for maintaining avifauna by evaluating richness and frequency of occurrence of birds.

2. Material and Methods

The municipality of Campo Grande occupies an area of 8,096 km^2 and is located geographically in the central part of the state of Mato Grosso do Sul, close to the watershed of the Paraná and Paraguay Basins, at the geographic coordinates 20°26’34” latitude and 54°38’47”longitude, altitudes varying between 500 and 675 meters. It has an estimated population of 874,210 inhabitants (IBGE, 2017) and is part of the *Cerrado* biome, with phytophysiognomies such as dense woodland, *cerrado sensu stricto*, riparian and gallery forest, savanna with bushes, rocky outcrop, grassland, and *veredas*.

2.1. Areas studied

The study was conducted in three urban green areas: Parque das Nações Indígenas (latitude 20°27’22.10” and longitude 54°34’22.01”), Parque Itanhangá (latitude 20°28’2.49” and longitude 54°36’5.88”) and Itatiaia Lagoon (latitude 20°28’51.37” and longitude 54°34’34.27”) (Figure 1).

These areas are open to the public and located in an urban environment, less than 5 km from the city center and within 3.1 km of each other. The surroundings include residences, access roads, traffic and commercial establishments, characteristic of urbanization, reflecting anthropic interference in the locations (Figure 2).

Parque das Nações Indígenas is located at the eastern end of Avenida Afonso Pena, one of the main roads in the city, bordering the Prosa State Park. It is designed for leisure for residents and visitors, has seven access gates and an approximate area of 112 hectares. Regarding structure, it has internal circulation roads (main, secondary, sector, cycle path and trails), as well as areas for recreational equipment. The Prosa stream crosses it from east to west, and it is home to part of the Revellieu stream, which enters

Figure 1 – Areas studied: (A) Parque das Nações Indígenas, (B) Parque Itanhangá and, (C) Itatiaia Lagoon, Campo Grande, Mato Grosso do Sul.
Source: Author's collection, 2015.

the northeast part of the park and empties into the Prosa, which is dammed to form an artificial lake at the western end.

Parque Itanhangá (Praça Lúdio Martins Coelho Filho) is located between two streets with significant flow of vehicles and has a jogging track and outdoor gym, as well as a children's playground. It has an area of approximately 1.7 hectares and is crossed east to west by the Vendas stream, which has a spring in its central part.

Itatiaia Lagoon is a natural depression of the relief that fills with rainwater, depending solely on precipitation infiltrating throughout its recharge area to maintain its water depth. It is an aquatic ecosystem with zoo- and phytoplankton, insects, fish, molluscs, birds and reptiles, with a depth of up to 1.2 meters and a total area of approximately 9.63 hectares. It is used by the surrounding population for leisure and recreation, with an outdoor gym and sidewalk around the lagoon, used for walking.

2.2. Data collection

Twenty field trips were made between February and May 2015, at irregular intervals, totaling 55 hours of observation, 25 hours in Parque das Nações Indígenas (significantly larger area), 15 hours in Parque Itanhangá and 15 hours at Itatiaia Lagoon. The times varied from 5 to 8 am and from 3 to 6 pm, aiming to register the species qualitatively.

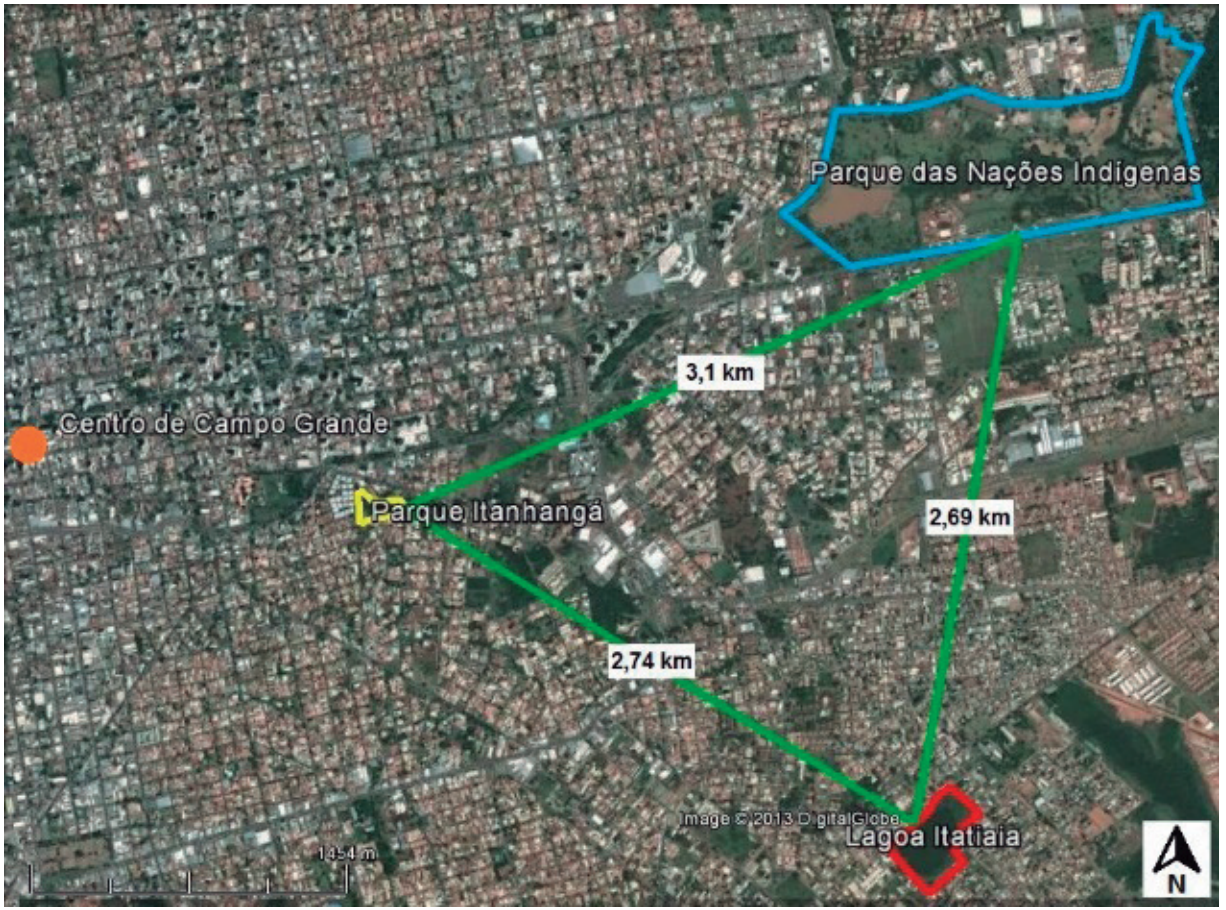

Figure 2 – Location and distances between the studied areas, Campo Grande, Mato Grosso do Sul. Key: Parque das Nações Indígenas (blue), Parque Itanhangá (yellow) and Itatiaia Lagoon (red). Source: Google Earth, 2015.

To register the plant species, the types of environment (aquatic and terrestrial) and composition of green areas were analyzed, identifying species through direct observation and an identification key prepared in accordance with the Angiosperm Philogeny Group III (ANGIOSPERM..., 2009).

To record the birdlife, Bushnell Powerview 10x42 FOV 300FT binoculars and Nikon Coolpix P510 camera were used. The species nomenclature is in accordance with the 2015 Brazilian Ornithological Records Committee (PIACENTINI et al., 2015).

The images of the study areas were obtained using the Google Earth software (free version). In the field, the geographic coordinates were marked using GPS (Garmin 12 XL) and areas were calculated (percentage of total surface and covered by tree vegetation, water depth and aquatic vegetation) using GE Path software (free version).

2.3. Qualitative Survey of Avifauna and calculation of Frequency and Similarity

The study was exploratory, with direct observation of specimens in nature, through ten-minute viewing stops, totaling 33 points (11 points in each area), connected by line transects (walks) (BROWER; ZAR ; ENDE, 1984; CULLEN JR. Et al., 2004). Par-

que das Nações Indígenas was divided into parts, with a path bordering the riparian formation of the Prosa and Revellieu streams. Parque Itanhangá was divided into trails (main and secondary); and Itatiaia Lagoon by its perimeter. Species were grouped into guilds (SICK, 1997), orders (TÁXEUS, 2017) and home range, determined according to Gwynne et al. (2010). The regularity with which each species can be found was calculated using the frequency of occurrence (FO) and to calculate the similarity between the areas, the Jaccard Index (IJ) was used.

a) *Frequency of occurrence* (FO): number of days on which a particular species was observed compared to the total number of observation days (Equation 1):

$$FO = \frac{No \times 100}{Nt} \quad (1)$$

when: No = number of days the species is observed; Nt = total number of observation days

b) *Similarity index or Jaccard index* (IJ): species similarity between the observed sites (Equation 2):

$$IJ = \left(\frac{c}{a+b+c}\right) \times 100 \quad (2)$$

c – number of species in common; a and b - number of species unique to each of the two areas compared.

3. Results and Discussion

3.1. Phytophysionomies

Area A – Parque das Nações Indígenas

It has areas of forest and open vegetation, with tree, shrub and herbaceous species native to the *Cerrado*, as well as fruit trees, ornamental and invasive plants, remnants of the farms that preceded the park. Brachiaria is also present, forming extensive lawns, serving as food for small and medium-sized rodents, such as agoutis and capybaras. In several places, such as on the banks of streams, the vegetation is in the process of regeneration (secondary formation) (Figure 3).

The species found included a large number of ipe trees (*Handroanthus aureus, H. impetiginosus, Tabebuia rosea, T. obtusifolia, T. roseoalba* and *Tabebuia spp*.), used to afforest the place, as well as vines and lianas covering part of the riparian vegetation. This situation indicates secondary succession processes, the result of anthropic action in periods prior to the establishment of the park, through the removal of native vegetation.

The vegetation considered when counting the covered area was riparian (gallery forests) and sparse, of arboreal size. Some 24.3% (27 hectares) of the total area of the park covered by this type of vegetation, with 14 ha of riparian formation bordering the streams and 13 ha of sparse trees.

Area B – Parque Itanhangá (Praça Lúdio Martins Coelho Filho)

The vegetation, for the most part, is composed of species introduced by man, both native and exotic, with well-defined shrub and undergrowth and 75% of its area covered by large trees. The area has been heavily modified, becoming a place without a defined pattern in terms of vegetation, with many fruiting, ornamental and invasive species, and in the spring area, there are plants typical of humid environments, such as ferns (Pteridophytes) and *Monstera* sp., among others.

On the bank of the stream, there are several specimens of a legume species, perhaps native to riparian formations, probably an original remnant of the site. Some individuals, at different points, are in poor condition, indicating their decline and disappearance from the site, within a certain period of time (Figure 4).

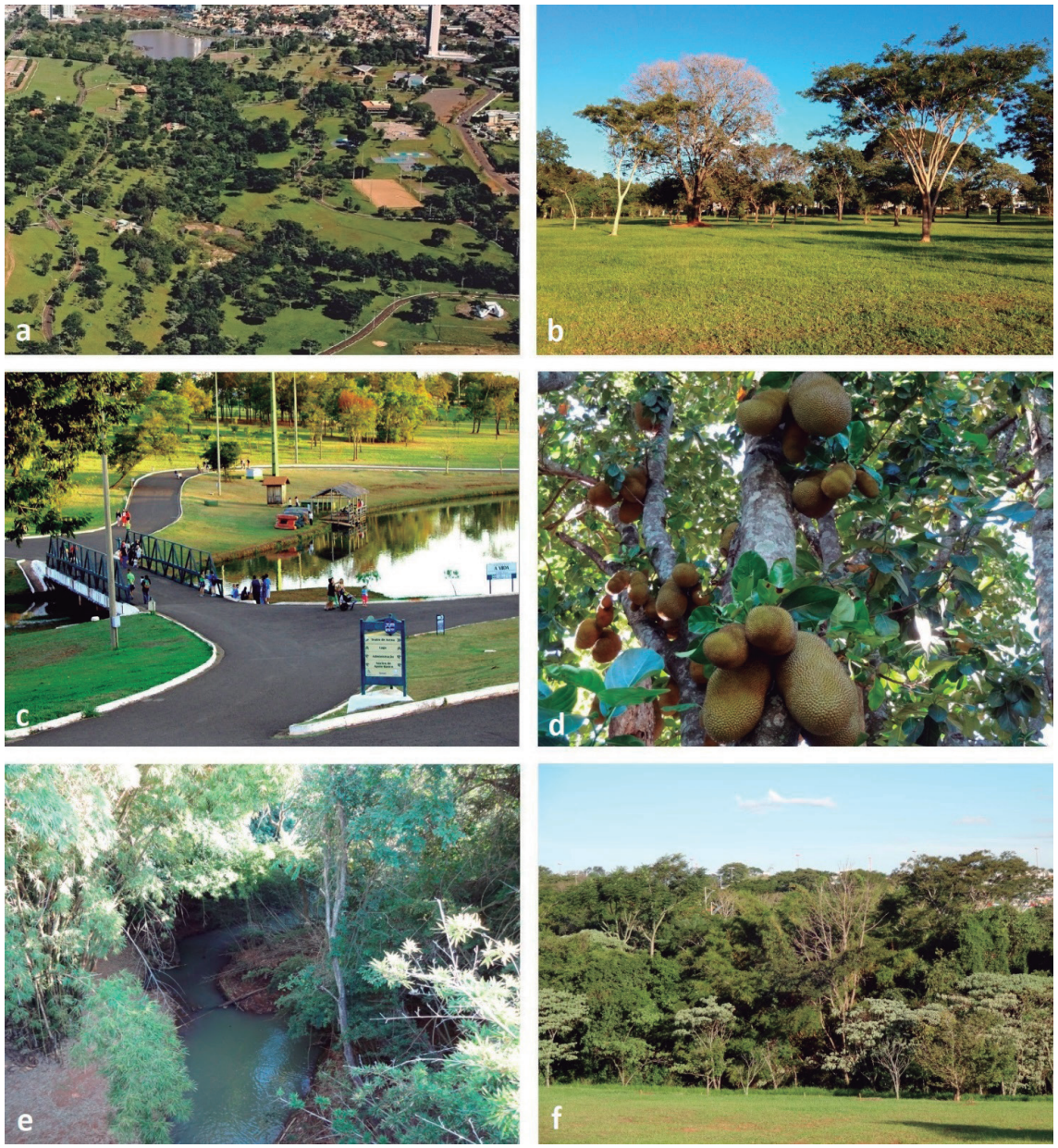

Figure 3 – Parque das Nações Indígenas: (a) overview, (b) sparse vegetation, (c) lake and undergrowth, (d) jackfruit (Artocarpus integrifolia) remnant of the farms which preceded the park, and (e-f) riparian forest.
Source: Author's collection, 2015; except images a and c, taken from Google Images, 2015

Area C – Itatiaia Lagoon

Area covered by sparse aquatic vegetation represents 19.6% of the total, around 1.83 hectares of aquatic vegetation. In the region around the lagoon, native tree vegetation has been almost totally removed, and there are now few species, with the majority of the area covered by grasses (brachiariae) and with isolated, normally exotic trees, such as avocado (*Persea americana* L.), weeping willow (*Salix* sp.) and Royal Ponciana (*Delonix regia* (Bojer ex Hook.) Raf.). In the flooded area, around the waterdepth, humid environment species are found, such as pink morning glory (*Ipomeia carnea* Jacq.), Water lily (*Nymphaea* sp.) and Bahiagrass (*Paspalum notatum* Flüegge) (Figure 5).

3.2. Diversity in the three areas

Around 117 plant species were identified, 62 in the park, 50 in the square, and 51 in the lagoon. Considering the size of each area alone and the number of species recorded, the results indicated 3.34; 30.23 and, 24.33 species per hectare, respectively for Parque das Nações Indígenas, Itanhangá and Itatiaia Lagoon.

Compared to other green areas of the city, such as the Matas do Segredo State Park, with 188 species recorded (OLIVEIRA; REZENDE, 2012), the result obtained was significant. The data from the areas surveyed, in plant terms, indicate diversity and availability of resources necessary for feeding and sheltering different groups of birdlife, enabling them to remain and/or facilitating their movement to other areas, in the city or its surroundings.

3.3. Qualitative Survey of avifauna

In the three areas, 107 bird species were recorded, around 10% of those found in the *Cerrado* biome (TÁXEUS, 2017). Of the total, 91 were identified in area A (Parque das Nações Indígenas - 39 exclusively), 39, area B (Itanhangá - 3 exclusively) and 46, area C (Itatiaia Lagoon - 13 exclusively) (Figure 6).

Species registered solely in each of the areas emphasize the particularity of conservation in each location, despite urban interference. No endemic or threatened species were found; however, a solitary sandpiper (*Tringa solitaria*) was recorded. This boreal visitor, which breeds in North America, migrates to South and Central America in the winter. In Brazil, the species is seen rarely, from September to April (GWYNNE et al., 2010) and its sighting in Parque das Nações shows that this area can offer resources to prepare it for the return trip; a corridor for its preservation.

3.4. Orders and families

Passeriform was the most common order, representing more than 39% in all three areas. Species in this group have been identified as specializing in various aspects of occupying the environment, such as foraging and nesting sites, which can be bioindicators of habitat fragmentation (PIRATELLI et al., 2008). However, there is not always a relationship between habitat specialization and sensitivity to forest fragmentation, since habitat-specialist birds also tend to occupy and live in areas converted to agriculture, for example, showing that anthropized spaces are also important for conservation (MARQUES; ANJOS, 2014).

The second most common order, *Psittaciform* (area A 10% and C 13%), feeds preferentially on seeds (nuts) of the fruit, sometimes even disdaining the pulp. They are attracted by palm trees, especially buriti (*Mauritia vinifera* Mart.), acuri (*Scheelea phalerata* (Mart. Ex Spreng.) Burret.) and bocaiuva (*Acrocomia aculeata* (Jacq.) Lodd. Ex Mart.) palms. Even though these palms are often isolated in the urban environment, on public roads, for example, they are sought out by these birds during fruiting and used year after year, demanding orientation skills and considerable journeys (SICK, 1997).

Apodiform was the third most common order, with 15% (area B). These species select habitats with trees with flowers which are close together and which have few leaves (CALVIÑO-CANCELA, 2006), a common type of vegetation in Parque Itanhangá, explaining their presence.

The most representative families were Tyrannidae and Columbidae (common in urban environments) and Psittacidae. No fami-

Figure 4 – Parque Itanhangá: (a-b) entrance gates, (c-d) trail and vegetation, (e) spring and, (f) ornamental plants.
Source: Author's collection, 2015.

Figure 5 –Itatiaia Lagoon: (a) overview, (b-c) sparse vegetation, (d) undergrowth and, (e-f) aquatic.
Source: Author's collection, 2015; except image a, taken from Google Images, 2015.

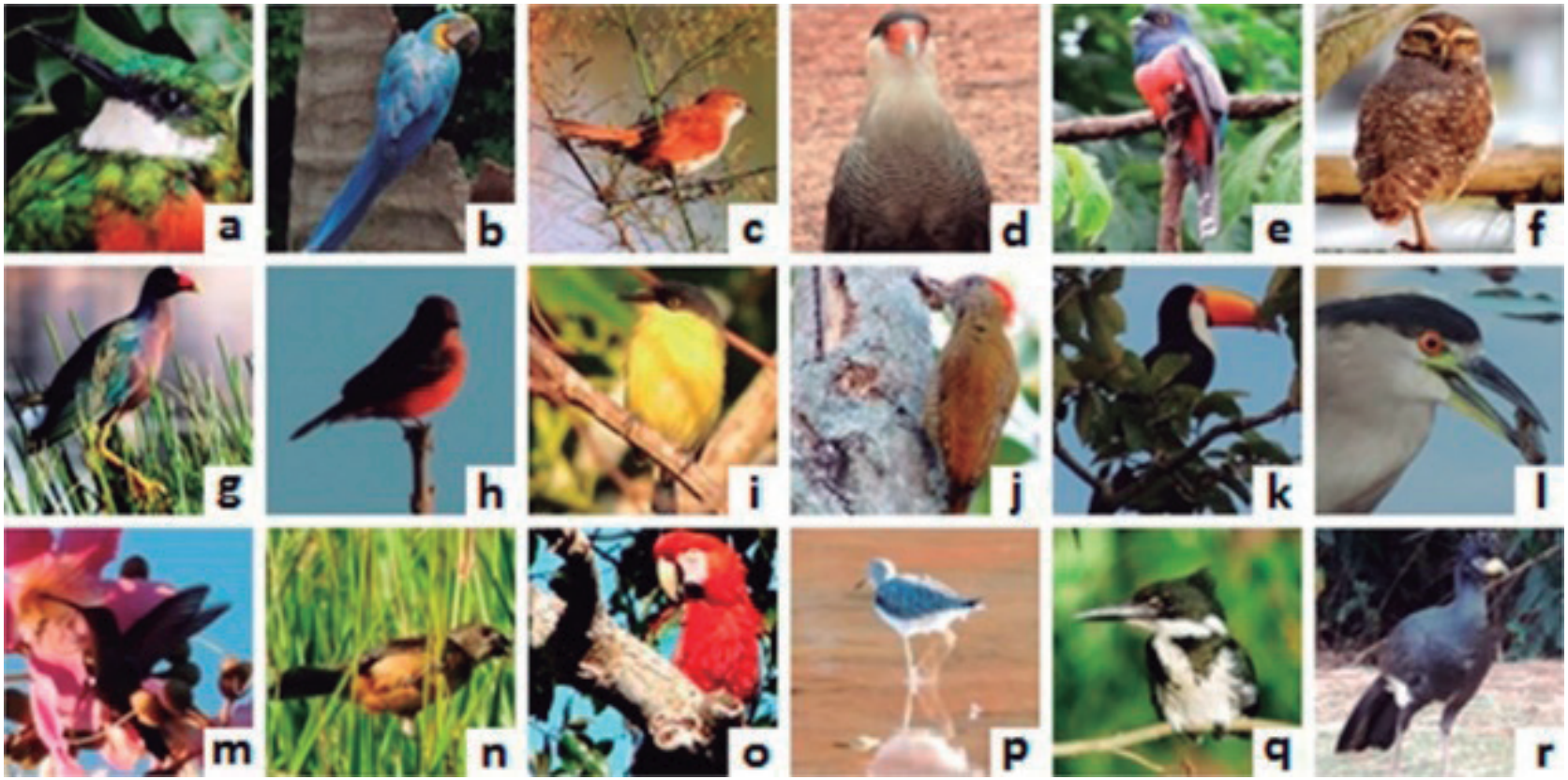

Figure 6 – Some of the bird species found in the three study areas: a) *Galbula ruficauda*, b) *Ara ararauna*, c) *Certhiaxis cinnamomeus*, d) *Caracara plancus*, e) *Trogon curucui*, f) *Athene cunicularia*, g) *Porphyrio martinicus*, h) *Pyrocephalus rubinus*, i) *Todirostrum cinereum*, j) *Veniliornis passerinus*, k) *Ramphastos toco*, l) *Nycticorax nycticorax*, m) *Anthracothorax nigricollis*, n) *Sporophila collaris*, o) *Ara chloropterus*, p) *Tringa solitaria*, q) *Chloroceryle amazona*, r) *Crax fasciolata*.
Source: Oppliger et al., 2016a.

lies were exclusive to area B, while in A, there were Trogonidae, birds which depend on high availability of fruits throughout the year (D'ANGELO NETO et al., 1998), as well as Cracidae (populations of which species have been reduced by hunting) and Scolopacidae (seasonal species). In area C, Aramidae and Jacanidae stand out, characteristic of swamps and aquatic environments.

Dendrocolaptidae species are insectivores which occupy large areas. Although they are sensitive to environmental disturbances (SILVA, 1992), they were recorded in areas A and C, indicating that the environment is partially preserved. These sites, although lacking broader vegetation cover, are larger than B in extension (area B has greater vegetation coverage proportional to its total area). The presence of water resources with a lower degree of anthropic interference and aquatic plants can also explain the availability of insects for food. In area B, despite the spring in the central area, flowing into the stream, the entire course of the main water resource is a canal, significantly affecting its surroundings.

The Rallidae, Columbidae, Psittacidae, Trochilidae, Alcedinidae, Ramphastidae, Picidae, Furnariidae, Tyrannidae, Turdidae, Thraupidae, Emberizidae and Fringillidae families were common to all three areas. However, fewer Bucconidae (*Nystalus chacuru* and *Nystalus striatipectus*) and Corvidae (*Cyanocorax cyanomelas* and *Cyanocorax cristatellus*) were found than reasonably occur in the *Cerrado* and in the state of Mato Grosso do Sul (GWYNNE et al., 2010). The absence of this group may be related to the fact that the research was carried out in only one season of the year (between February and May). Thus, the availability of food resources and the reproductive cycle may have affected the presence and/or absence of certain species (PIRATELLI; PEREIRA, 2002).

3.5. Guilds

According to Morante Filho and Silveira (2012), mischaracterizing the environment and de-structuring vegetation enables insectivorous and omnivorous birds to predominate, as they are least affected by anthropic changes, with the disappearance of other guilds, represented by nectarivores and, in particular, frugivores and specialized insectivores. However, the results of this study indicated that frugivorous birds were the most representative (32% on average), demonstrating the environmental quality of the areas studied. Moreover, insectivorous species accounted for about 30%, considering the three areas, also indicating that quality is maintained.

Environments with high levels of environmental degradation tend to have an increasing number of omnivorous birds, while frugivores are more recorded more frequently in the opposite situations (MOTTA-JÚNIOR, 1990), as reported by a study conducted in an urban area, the municipality of Santa Maria, Rio Grande do Sul, where omnivorous species predominated (37%), followed by insectivorous species (18%) (RAMOS; MARIA, 2016). Manica et al. (2010), evaluating species in a 472-hectare fragment of *Cerrado* in São Paulo, found 46.9% were insectivorous birds, demonstrating that even large areas of vegetation under anthropic impact may not be sufficient to maintain diversified trophic guilds.

In addition to the region and its state of conservation, climatic conditions can also have an effect. Regarding the study carried out in the three areas, the data obtained may also relate to the fact that most of the observations took place in the rainy season. The proliferation of insects increases at this time, representing an abundance of food for birds and also affecting the reproductive activity of animals (SICK, 1997). Thus, it could be assumed that, as the areas are anthropized, together with the time of year, the number of insectivorous birds would be greater, which was not found.

Omnivorous birds were recorded in areas A and C and nectarivores in B, all ranked third in relation to eating habits (Figure 7).

Omnivorous species are able to adapt to less favorable conditions, such as lack of food at certain times of the year and/or urban environment conditions (CURCINO et al., 2007). In area B, there were several flowering trees, such as the Brazilian orchid tree (*Bauhinia cheilantha* (Bong.) and silk floss tree (*Ceiba speciosa* (A.St.-Hil.) Ravenna), important sources of food for nectarivores.

Regarding the less commonly found guilds, there were few records of granivorous birds in area B. In A and C, piscivorous and malacophagous were the least representative, which was an unexpected result, s area A (park) has significant water resources and at C, there is a lagoon. It is worth noting that the vegetation surrounding the lagoon is subjected to 'thinning' by brushcutting machines and, during the field trips remnants of fuel used in these machines could be seen by the naked eye in the soaked parts of the land.

Piscivorous/malacophagous birds are considered good environmental indicators as they are sensitive to toxic substances and occupy different positions in the food chain (CUSTER; OSBORN, 1977). Thus, if there is fuel contamination in this area, coming from these machines, the health of these birds may be compromised by cumulative contamination, affecting the diversity of species found from this group. Moreover, the presence of contaminants in the environment can reduce the food supply, limiting the bird species able to survive in the region.

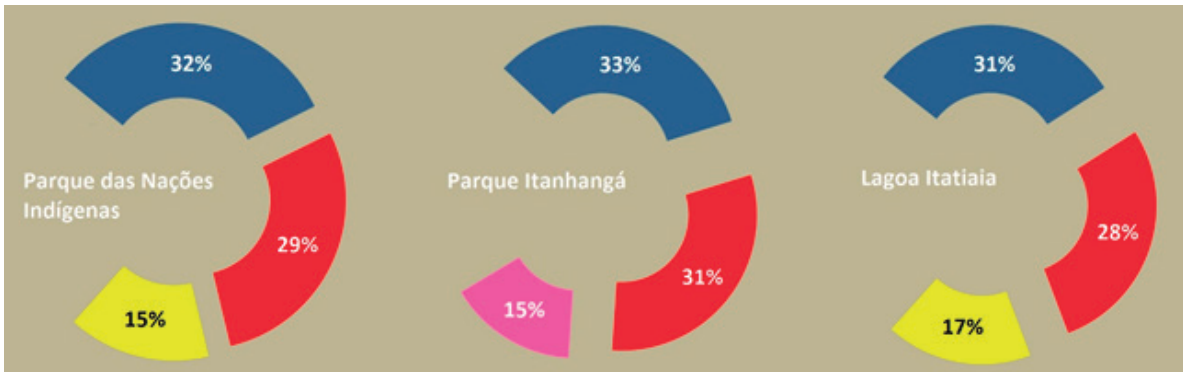

Figure 7 – Comparison between the most representative eating habits of the avifauna of the three urban green areas: frugivore (blue), insectivore (red), omnivore (yellow) and nectarivore (pink).
Source: Prepared by the authors

3.6. Home Range

For around 90% of the species, habitats are in environments not classed as 'altered areas' (Figure 8), an indication of an urban environment with different phytophysiognomies able to shelter not only birds, but also other species of animals.

Vegetation diversity and number of strata defined are directly linked to the diversity and density of birdlife, as well as the size of the fragment and its degree of isolation (DARIO et al., 2002), as birds select their home ranges for structural characteristics and, above all, physiognomic aspects of the vegetation.

3.7. Frequency of occurrence

The species found with the highest absolute frequency were *Patagioenas picazuro* (picazuro pigeon), a species typical of anthropized environments and urbanized areas and *Ara ararauna* (blue-and-yellow macaw), found in floodplains with buriti palm forests and forest edges (ecotone), often seen in the urban environment. The frequency of certain species indicates that the environments studied provide the presence both of birds common to altered areas and of species needing more complex habitats, demonstrating that the environmental quality in these areas remains, allowing different groups of avifauna to maintain themselves.

The birds of prey *Falco sparverius, F. rufigularis, Ictinia plumbea* and *Rupornis magnirostris* were recorded only in area A, and with the lowest frequencies. Food supply for these species, such as reptiles, amphibians and small rodents, may be limited, with the place being used only as a crossing or resting point. The presence of the general public, who use the areas for leisure activities, is a factor that can hinder these species from capturing prey.

3.8. Similarity Index

The data show greater similarity between the avifauna in areas B and C (square and lagoon), the areas which are smaller in size, with a value of 51.5%. Areas A and B (park and square) showed 28.81% similarity, while areas A and C (park and lagoon) had the lowest index (24.63%), which may be explained by the difference in vegetation, both in terms of density and of phytophysiognomy.

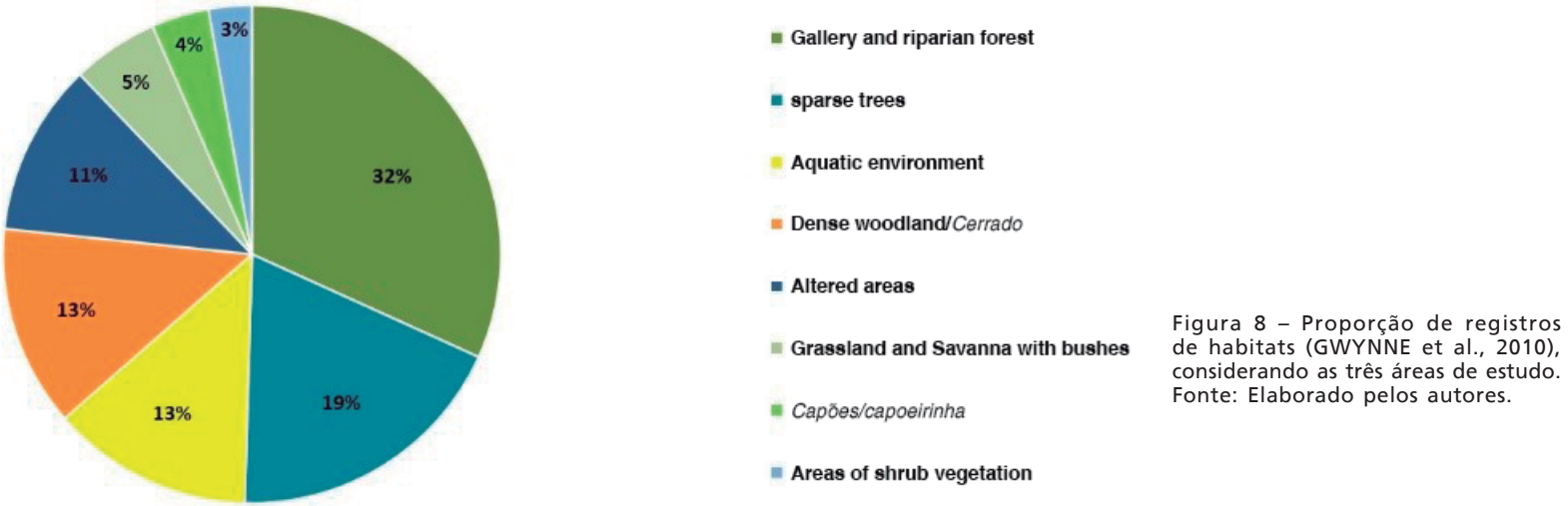

Figura 8 – Proporção de registros de habitats (GWYNNE et al., 2010), considerando as três áreas de estudo. Fonte: Elaborado pelos autores.

3.9. Environmental Quality Indicators

The presence of large macaws (*Ara ararauna* and *Ara chloropterus*) indicates conserved plant and water resources, as their habitat is in dense woodland*, cerrado* and *veredas*. The registration of species from *Cerrado* (*Theristicus caudatus, Colaptes melanochloros* and *Diopsittaca nobilis*) and aquatic environments (*Egretta thula, Megaceryle torquata* and *Porphyrio martinica*), for example, presupposes preserved remnants of such environments on the urban perimeter, an indicator of environmental quality.

On the other hand, in urban environments, *Columbiformes*, for example, adapt to the supply of food and places to shelter and reproduce. In anthropized areas, circumstances are favorable to the proliferation of *Columba livia* and it has few or no natural predators, becoming opportunistic to the conditions offered. *Columbina talpacoti* habitats, on the other hand, are wooded areas with low anthropic interference, ideal for building nests, foraging and caring for offspring (AMÂNCIO et al., 2008).

With a smaller total area, but with a proportionally larger area of vegetation than Parque das Nações Indígenas and Itatiaia Lagoon, Parque Itanhangá had the highest number of bird species per hectare of area covered by vegetation. This shows that, irrespective of size, what can determine the presence and permanence of birds in such places is the quantity and quality of vegetation offering places to rest, nest and provide food and/or shelter. Santos and Cademartori (2010) also compared birdlife in three urban green areas in Porto Alegre, Rio Grande do Sul, concluding that larger green areas and heterogeneous habitats can sustain greater species richness in urbanized environments, as expected.

Connecting urban green areas with preservation areas provides feeding, resting, breeding and nesting sites for various species of birds. Areas adjacent to the locations in this study, within a radius of up to 7 km (including the Lageado Stream Springs Environmental Preservation Area) have denser vegetation and, thus, is one explanation for the diversity of species in the urban environment. Similar studies carried out in urban green areas show that these function as ecological corridors of great importance, as they represent a refuge for local biodiversity (MACIEL; BARBOSA, 2015).

Soares et al. (2012) describe the connection between fragments existing in urban areas as essential for the permanence and maintenance of different species, which can occur with the presence of wooded squares. However, the occurrence of certain exotic species may indicate pressure on green areas, such as the presence of *Rattus*. This situation is reported by Caldara Junior and Leite (2007), in research conducted in the Fonte Grande State Park, located in the urban area of Vitória, Espírito Santo State, in which they demonstrated that most of the non-flying mammal species found are typical of secondary plant formations and closely associated with anthropic activity.

Avifauna susceptibility to changes in the floristic composition of native vegetation results in the disappearance of certain species, which is highlighted by Cruz and Piratelli (2011), in which observations made in the municipality of Sorocaba, São Paulo State, along an urban stretch of the Sorocaba River, registered 65 species. The bird community, in particular, was made up of generalist, resident or likely resident, insectivorous or omnivorous species, the result of historical disturbance of the environment by anthropic action.

Thus, in urban areas, planning and ordering must be in step with the natural environment, valuing, monitoring, conserving and enabling natural resources and environmental quality. The ecological, socio-cultural and economic axes must be interconnected, translating into viable and sustainable actions resulting in effective socioeconomic development committed to conserving natural resources in any and all areas in which they are able manifest themselves.

The diverse presence of avifauna in the urban environment reflects its environmental quality, indicating that, despite the growth of the city, the characteristics allowing groups of animals to survive are preserved. Thus, birds are an indicator that urban planning, taking into account aspects such as existence and maintenance of green areas, becomes an important factor in maintaining quality of life for the population as a whole.

4. Conclusion

The variety in the guilds of bird species found in an urban environment makes it possible to establish the relationship that the number of species will be greater when the variety of plant species available, for both food and shelter, is greater. With this correlation, we can state that, in these areas, there is a balance of natural flows, achieved purposely, through ecological planning of the landscape or resulting from the ecological system's self-regulatory process.

The greater the number of urban areas with diversified tree vegetation, different phytophysiognomy characteristics and availability of resources, the greater the possibilities for maintenance and diversity of avifauna. The connection and diversity of plant species in such areas enables the flow of different species and interaction between different bird populations. The number of unique species can reinforce the particularities of each area being maintained. The birds recorded are indicators of the environmental quality of the urban environment evaluated, which has good environmental conditions for its population, demonstrating the validity of the existence of wooded places, in a process of valuing nature as a whole.

Referências Bibliográficas

AMÂNCIO, Suelen; SOUZA, Valéria Barbosa; MELO, Celine. *Columba livia* e *Pitangus sulphuratus* como indicadoras de qualidade ambiental em área urbana. **Revista Brasileira de Ornitologia**, São Paulo, v. 16, n. 1, p. 32-37, 2008.

AMATO-LOURENÇO, Luís Fernando; MOREIRA, Tiana Carla Lopes; ARANTES, Bruna Lara; SILVA FILHO, Demóstenes Ferreira; MAUAD, Thais. Metrópoles, cobertura vegetal, áreas verdes e saúde. **Estudos Avançados**, São Paulo, v. 30, n. 86, p. 113-130, 2016. DOI: 10.1590/S0103-40142016.00100008.

ANGIOSPERM PHILOGENY GROUP. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. **Botanical Journal of the Linnean Society**, London, v. 161, n. 2, p. 105-121, 2009. DOI: 10.1111/j.1095-8339.2009.00996.x.

BARGOS, Danúbia Caporusso; MATIAS, Lindon Fonseca. Áreas verdes urbanas: um estudo de revisão e proposta conceitual. **REVSBAU**, Piracicaba, n. 6, v. 3, p. 172-188, 2011.

BENAKOUCHE, Rabah. **Avaliação monetária do meio ambiente**. São Paulo: Makron Books, 1994.

BRASIL. Ministério do Meio Ambiente. **Quarto Relatório Nacional para a Convenção sobre a Diversidade Biológica: Brasil**. Brasília, DF: Ministério do Meio Ambiente, 2011.

BROWER, James E.; ZAR, Jerrold H.; ENDE, Carl N. von. **Field and laboratory methods for general ecology**. Dubuque: Wm. C. Brown Publishers, 1984.

CALDARA JUNIOR, Vilacio; LEITE, Yuri Luiz Reis. Uso de habitats por pequenos mamíferos no Parque Estadual da Fonte Grande, Vitória, Espírito Santo, Brasil. **Boletim do Museu de Biologia Mello Leitão**, Santa Teresa, v. 21, p. 57-77, 2007.

CALVIÑO-CANCELA, Maria. Time-activity budgets and behaviour of the Amazilia hummingbird, *Amazilia* (Apodiformes: Trochilidae) in an urban environment. **Biología Tropical**, San José, v. 54, n. 3, p. 873-878, 2006.

CAMPO GRANDE (Município). Secretaria Municipal de Serviços e Obras Públicas. **Relatório de Avaliação Ambiental**. Campo Grande: Sesop, 2007.

CASTRO-NAVARRO, Jaime; SAHAGÚN-SÁNCHEZ, Francisco Javier; REYES-HERNANDEZ, Humberto. Dinámica de fragmentación en la Sierra Madre Oriental y su impacto sobre la distribución potencial de la avifauna. **Madera y Bosques**, Xalapa, v. 23, n. 2, p. 99-117, 2017. DOI: 10.21829/myb.2017.2321429.

CRUZ, Bruna Botti; PIRATELLI, Augusto João. Avifauna associada a um trecho urbano do Rio Sorocaba, Sudeste do Brasil. **Biota Neotropica**, Campinas, v. 11, n. 4, p. 255-264, 2011.

CULLEN JR., Laury; RUDRAN, Rudy; VALLADARES-PADUA, Cláudio. Transectos lineares na estimativa de densidade de mamíferos e aves de médio e grande porte. *In*: CULLEN JR., Laury; RUDRAN, Rudy; VALLADARES-PADUA, Cláudio (org.). **Métodos de estudo em biologia da conservação e manejo da vida silvestre**. Curitiba: Ed. UFPR, 2004. p. 169-179.

CURCINO, Alexandre; SANT'ANA, Carlos Eduardo Ramos; HEMING, Neander Marcel. Comparação de três comunidades de aves na região de Niquelândia, GO. **Revista Brasileira de Ornitologia**, São Paulo, v. 15, n. 4, p. 574-584, 2007.

CUSTER, Thomas W.; OSBORN, Ronald G. **Wading birds as biological indicators: 1975 colony survey**. Washington, DC: U.S. Fish and Wildlife Service, 1977.

D'ANGELO NETO, Santos; VENTURIN, Nelson; OLIVEIRA FILHO, Ary Teixeira; COSTA, Fernando Antônio Frieiro. Avifauna de quatro fisionomias florestais de pequeno tamanho (5-8 ha) no Campus da Ufla. **Revista Brasileira de Biologia**, São Carlos, v. 58, n. 3, p. 463-472, 1998.

DÁRIO, Fábio Rossano; DE VINCENZO, Maria Cristina Veiga; ALMEIDA, Álvaro Fernando. Avifauna em fragmentos de Mata Atlântica. **Ciência Rural**, Santa Maria, v. 32, n. 6, p. 989-996, 2002. DOI: 10.1590/S0103-84782002000600012.

FREITAS, Juliana Maria de Souza. Construindo para a (bio)diversidade: o planejamento ecológico da paisagem urbana. **Paisagem e Ambiente**, São Paulo, n. 40, p. 89-103, 2017. DOI: 10.11606/issn.2359-5361.v0i40p89-103.

GAUDERETO, Guilherme Leite; GALLARDO, Amarilis Lúcia Casteli Figueiredo; FERREIRA, Maurício Lamano; NASCIMENTO, Ana Paula Branco; MANTOVANI, Waldir. Avaliação de serviços ecossistêmicos na gestão de áreas verdes urbanas: promovendo cidades saudáveis e sustentáveis. **Ambiente e Sociedade**, São Paulo, v. 21, p. 1-20, 2018. DOI: 10.1590/1809-4422asoc0120r3vu18l4td.

GUEDES, Neiva Maria Robaldo. Araras da Cidade. *In*.: QUEVEDO, Thiago Lopes. **Araras da cidade**: músicas do mato. Campo Grande: Alvorada, 2012. p. 45-140.

GWYNNE, John A.; RIDGELY, Robert S.; TUDOR, Guy; ARGEL, Martha. **Aves do Brasil**: Pantanal e Cerrado. São Paulo: Horizonte, 2010.

IBGE. Instituto Brasileiro de Geografia e Estatística. **Campo Grande**: panorama (2017). Rio de Janeiro: IBGE, 2019. Available at: https://bit.ly/3cD4G8R. Accessed on: 20 Apr. 2020.

KUDO, Stephany Anry; PEREIRA, Henrique dos Santos; SILVA, Suzy Cristina Pedroza. A proteção jurídica dos fragmentos florestais urbanos: um estudo da paisagem e da legislação ambiental e urbanística da cidade de Manaus. **Desenvolvimento e Meio Ambiente**, Curitiba, v. 38, p. 521-540, 2016.

MACIEL, Tatiane Tagliatti; BARBOSA, Bruno Corrêa. Áreas verdes urbanas: história, conceitos e importância ecológica. **CES Revista**, Juiz de Fora, v. 29, n. 1, p. 30-42, 2015.

MAMEDE, Simone; BENITES, Maristela. Por que Campo Grande é a capital brasileira do turismo de observação de aves e propostas para o fortalecimento da cultura local em relação a esta prática. **Atualidades Ornitológicas**, Ivaiporã, v. 201, p. 8-15, 2018.

MANICA, Lílian; TELLES, Marina; DIAS, Manoel Martins. Bird richness and composition in a Cerrado fragment in the State of São Paulo. **Brazilian Journal of Biology**, São Carlos, v. 70, n. 2, p. 243-254, 2010.

MARQUES, Fernanda Cristina; ANJOS, Luiz. Sensitivity to fragmentation and spatial distribution of birds in forest fragments of northern Paraná. **Biota Neotropica**, Campinas, v. 14, n. 3, p. 1-9, 2014.

MATOS, Veridiana Possati Vieira; MATOS, Tatiana Possati Vieira; CETRA, Maurício; TIMO, Thiago Philipe de Camargo; VALENTE, Roberta Averna. Forest fragmentation and impacts on the bird community. **Revista Árvore**, Viçosa, v. 42, n. 3, p. 1-13, 2018. DOI: 10.1590/1806-90882018000300009

MAZZEI, Katia; COLESANTI, Marlene Terezinha Muno; SANTOS, Douglas Gomes. Áreas verdes urbanas, espaços livres para o lazer. **Sociedade e Natureza**, Uberlândia, v. 19, n. 33, p. 33-43, 2007.

MORANTE FILHO, José Carlos; SILVEIRA, Rosicleire Veríssimo. Composição e estrutura trófica da comunidade de aves de uma área antropizada no oeste do estado de São Paulo. **Atualidades Ornitológicas**, Ivaiporã, v. 169, p. 33-40, 2012.

MOTTA JÚNIOR, José Carlos. Estrutura trófica e composição das avifaunas de três habitats terrestres na região central do estado de São Paulo. **Revista Ararajuba**, Ivaiporã, v. 1, p. 65-71, 1990.

OLIVEIRA, Ademir Kleber Morbeck; REZENDE, Ubirazilda Maria. Composição florística do Parque Estadual Matas do Segredo, localizado na área urbana do município de Campo Grande, Mato Grosso do Sul. **Revista da Sociedade Brasileira de Arborização Urbana**, Piracicaba, v. 7, n. 3, p. 57-74, 2012.

OPPLIGER, Emilia Alibio; FONTOURA, Fernanda Mussi; OLIVEIRA, Ademir Kleber Morbeck; TOLEDO, Maria Cecília Barbosa; SILVA, Mauro Henrique Soares; GUEDES, Neiva Maria Robaldo. Estudo da avifauna de três áreas verdes urbanas com diferentes características de paisagem e potencial turístico em Campo Grande, Mato Grosso do Sul. **Atualidades Ornitológicas**, Ivaiporã, v. 192, p. 33-40, 2016a.

OPPLIGER, Emilia Alibio; FONTOURA, Fernanda Mussi; OLIVEIRA, Ademir Kleber Morbeck; TOLEDO, Maria Cecília Barbosa; SILVA, Mauro Henrique Soares; GUEDES, Neiva Maria Robaldo. O potencial turístico para a observação da avifauna em três áreas verdes na cidade de Campo Grande, MS. **Revista Brasileira de Pesquisa em Turismo**, São Paulo, v. 10, n. 2, p. 274-292, 2016b. DOI: 10.7784/rbtur.v10i2.789.

PIACENTINI, Vítor de Queiroz *et al*. Lista comentada das aves do Brasil pelo Comitê Brasileiro de Registros Ornitológicos. **Revista Brasileira de Ornitologia**, Rio Grande, v. 23, n. 2, p. 91-298, 2015.

PIRATELLI, Augusto; PEREIRA, Márcia Regina. Dieta de aves na região leste de Mato Grosso do Sul, Brasil. **Ararajuba**, São Paulo, v. 10, n. 2, p. 131-139, 2002.

PIRATELLI, Augusto *et al.* Searching for bioindicators of forest fragmentation: passerine birds in the Atlantic forest of southeastern Brazil. **Brazilian Journal of Biology**, São Carlos, v. 68, n. 2, p. 259-268, 2008.

RAMOS, Lisiane Acosta; MARIA, Luciane. Contribuição ao estudo da avifauna urbana do município de Santa Maria, RS. **Atualidades Ornitológicas**, Ivaiporã, v. 193, p. 57-64, 2016.

SANTOS, Marcelo Fischer Barcellos; CADEMARTORI, Cristina Vargas. Estudo comparativo da avifauna em áreas verdes urbanas da região metropolitana de Porto Alegre, sul do Brasil. **Biotemas**, Florianópolis, v. 23, n. 1, p. 181-195, 2010. DOI: 10.5007/2175-7925.2010v23n1p181.

SANTOS, Marcelo Fischer Barcellos; CADEMARTORI, Cristina Vargas. Composição e abundância da avifauna em quatro fitofisionomias de área rural pertencente ao domínio da Mata Atlântica no sul do Brasil. **Ciência Florestal**, Santa Maria, v. 25, n. 2, p. 351-361, 2015. DOI: 10.5902/1980509818453.

SICK, Helmut. **Ornitologia brasileira**. Rio de Janeiro: Nova Fronteira, 1997.

SILVA, Wesley Rodrigues. As aves da Serra do Japi. *In*: MORELLATO, Leonor Patrícia Cerdeira. (org.). **História natural da serra do Japi**. Campinas: Ed. Unicamp, 1992. p. 238-263.

SOARES, Glória Ramos; OLIVEIRA, Andréa Aparecida Paiva; SILVA, André Roberto Melo. Borboletas (Lepidoptera: Papilionoidea e Hesperioidea) de um parque urbano em Belo Horizonte, Minas Gerais, Brasil. **Biota Neotropica**, Campinas, v. 12, n. 4, p. 209-217, 2012.

TÁXEUS. **Lista de espécies (2017)**. [*S. l.*]: Táxeus, 2017. Available at: http://www.taxeus.com.br/listabioma/cerrado/aves. Accessed on: 20 Apr. 2020.

VALADÃO, Rafael Martins; FRANCHIN, Alexandre Gabriel; MARÇAL JÚNIOR, Oswaldo. A avifauna do Parque Municipal Victório Siquierolli, zona urbana de Uberlândia, MG. **Biotemas**, Florianópolis, v. 19, n. 1, p. 81-91, 2006.

XAVIER, Fernanda Berguerand; FELIPE, Juliana; ARANA, Alba Regina Azevedo. O parque verde urbano: características do uso através de observação sistemática. **Revista Brasileira de Gestão Urbana**, Curitiba, v. 10, n. 1, p. 82-95, 2018. DOI: 10.1590/2175-3369.010.supl1.ao05.

Acknowledgements

Thanks to the Coordination for the Improvement of Higher Education Personnel (Capes), the Support Program for the Post-Graduation of Private Education Institutions (Prosup) and Universidade Anhanguera-Uniderp, for the scholarships granted and equipment made available. Thanks to the National Research Council (CNPq), for the Research Productivity scholarship.

Emilia Alibio Oppliger
Universidade Anhanguera (Uniderp), Pós-Graduação em Meio Ambiente e Desenvolvimento Regional.
Avenida Alexandre Herculano, 1400, Campo Grande, MS, Brazil, CEP: 79037-280.
Orcid: https://orcid.org/0000-0002-8970-4025
emiliaoppliger@hotmail.com

Fernanda Mussi Fontoura
Instituto Arara Azul.
Rua Klaus Stuhrk, 106, Campo Grande, MS, Brazil, CEP: 79051-660.
Orcid: https://orcid.org/0000-0001-5342-5131
font.fm@gmail.com

Ademir Kleber Morbeck de Oliveira
Universidade Anhanguera (Uniderp), Pós-Graduação em Meio Ambiente e Desenvolvimento Regional.
Avenida Alexandre Herculano, 1400, Campo Grande, MS, Brazil, CEP: 79037-280.
Orcid: https://orcid.org/0000-0001-9373-9573
akmorbeckoliveira@gmail.com

Maria Cecília Barbosa de Toledo
Universidade de Taubaté, Departamento de Biologia, Laboratório de Ecologia.
Avenida Tiradentes, 500, Taubaté, SP, Brazil, CEP: 12030-180.
Orcid: https://orcid.org/0000-0002-2082-5558
cecilia@unitau.br

Mauro Henrique Soares da Silva
Universidade Federal do Mato Grosso do Sul, Programa de Pós-Graduação de Mestrado em Geografia.
Avenida Capitão Olinto Mancini, 1662, Três Lagoas, MS, Brazil, CEP: 79600-080.
Orcid: https://orcid.org/0000-0001-7710-3153
mauro.soares@ufms.br

Neiva Maria Robaldo Guedes
Instituto Arara Azul e Universidade Anhanguera-Uniderp, Pós-Graduação em Meio Ambiente e Desenvolvimento Regional.
Rua Klaus Stuhrk, 106, Campo Grande, MS, Brazil, CEP: 79051-660.
Orcid: https://orcid.org/0000-0002-2887-133X
guedesneiva@gmail.com

Editor's Note
Submission date: 03/10/2019
Approval date: 20/01/2020
Translation: RMO Empresarial