

Nest predatory behavior in the Great Kiskadee (Pitangus sulphuratus): an overlooked predator in the Neotropical cities?

Vagner L. Camilotti¹

vagner.camilotti@gmail.com

National Institute for Space Research

Research Article

Keywords: Mesopredator release, Neotropical region, nest predation, Tyrannidae, urban birds, urban ecosystem.

Posted Date: March 11th, 2024

DOI: <https://doi.org/10.21203/rs.3.rs-4014165/v1>

License:  This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Bird's nest predation can have a significant impact on the diversity and structure of bird assemblages in urban ecosystems. Our understanding of this phenomenon in Neotropical cities, however, is still limited. The Great Kiskadee (*Pitangus sulphuratus*), a common species in urban environments, is known to prey on various vertebrate species, yet there is little information on its predation of birds or their nests. Similar to other well-known nest predators in cities worldwide, the Great Kiskadee exhibits behavioral and ecological traits that suggest it may play an important role in nest predation. Nevertheless, its role in this context has yet to be explored. Through a case report of nest predation on the Purple-throated Euphonia (*Euphonia chlorotica*) in an urban setting and a review of its ecological and biological traits, this study explores the potential and possibly overlooked role of the Great Kiskadee as a significant nest predator in Neotropical cities.

Introduction

Nest predation plays a major role in the natural selection of life history traits in birds and is one of the main causes of reproductive failure and species persistence in some environments (Ricklefs, 1969; Martin, 1993; Newton, 1998). In urban ecosystems, studies have shown the impacts of different bird species as nest predators (e.g., Major et al., 1996; Jerzak, 2001; Marzluff et al., 2001; Rodewald and Kearns, 2011). Small birds, for example, can be responsible for 28% of nest predation (Rodewald and Kearns, 2011). Due to its importance, species that play a crucial role as nest predators need to be specifically identified rather than simply presumed (Ibáñez-Álamo et al., 2015).

However, little is known about this phenomenon in the Neotropical cities. The few studies available have shown a high rate of nest predation especially by birds, but with few evidences of predator identity (e.g., López-Flores et al., 2009; Rivera-López and MacGregor-Fors, 2016). In Brazil, the largest country in the Neotropics, only a handful of studies has evaluated nest predation in the urban environment. There is a lack, therefore, in the knowledge of frequency and intensity rates, conditions, and, especially, predator's identity.

My attention to the subject was drawn when I witnessed a Great Kiskadee (*Pitangus sulphuratus*)preying on the nestlings of the Purple-Throated Euphonia (*Euphonia chlorotica*) in an urban park. The Purple-Throated Euphonia nest, a globular-shaped structure, was located approximately 8 m high at the bottom edge of the tree crown of a pink trumpet tree (*Handroanthus heptaphyllus*). It was attached laterally to a descending twig and intertwined with the stems of the mistletoe cactus (*Rhipsalis* sp.). Although the tree was fully covered by leaves, their natural scattered pattern made the nest easily visible in the tree crown, possibly increasing the chances of predation (e.g., Michalski and Norris, 2014). I initially spotted the Great Kiskadee perched on a tree approximately 5 m away from the nest tree. After scanning the area without vocalizing for about 3 min, it flew to a branch ~1 m away from the Purple-Throated Euphonia nest. With a quick flight, the Great Kiskadee snatched one nestling through the nest side entrance. The snatching flight lasted less than 5 s. The Great Kiskadee performed a sally-hover maneuver (Remsen and Robinson,

1990), swiftly flying directly towards the nest from a perch with a brief hover in front of its entrance, then returning to its initial perch with the nestling in its bill. Due to the angle of view, there was doubt whether it hung on to the nest structure or not while hovering to capture the nestling. On the perch, the Great Kiskadee ingested its prey after striking it against the tree branch, a common behavior in birds to kill the prey or separate undesirable parts (Remsen and Robinson, 1990). After consuming the prey, the Great Kiskadee flew out of sight. Both Purple-Throated Euphonias parents were present at the site during the event, agitated and vocalizing, but they did not attack the Great Kiskadee. Subsequent observations of the nest indicated that the Purple-Throated Euphonia adults had abandoned it. Since this species typically lays a clutch of 1-3 eggs (2.1 ± 0.6) (Perrella et al., 2017), it is possible that a single nestling was being reared or the others had been predated earlier.

As the Great Kiskadee stands out as one of the most abundant species – if not the most – in urban areas within its distribution (e.g., Ruzszyk et al., 1987; Cruz and Piratelli, 2011; Sacco et al., 2015), I became intrigued by the potential impact of its nest predation behavior on the structure of urban bird communities. Initially sparked by curiosity, my inquiry delved into gathering information about the species' nest predation behavior, expecting to find any report about its frequency, variations across environments (urban vs. wild ecosystems), influence on bird assemblages, and any potential preferences for specific species. Unfortunately, as I will elaborate on, there is limited knowledge about the Great Kiskadee's predatory behavior on bird nests.

Could that be all? Can we assume that the lack of information means that the nest predation behavior in the Great Kiskadee is insignificant wherever it is found and that it only rarely preys on nests? If so, could changes in environmental conditions alter this relationship? To address these and other questions, here I provide a comprehensive review of existing knowledge on the predation behavior in the species. I go further to explore the similarities between the Great Kiskadee and other recognized nest predators, with a particular focus on the urban environment. I discuss the obtained information in three hypotheses that can explain the lack of information and open potential avenues for further research to deepen our understanding of how this behavior is expressed in the species and its potential impact on structuring bird assemblages.

Methods

In order to understand the Great Kiskadee's behavioral ecology as a predator, I conducted a comprehensive search across specialized books and online databases (Google Scholar, Scielo, Scopus, Web of Science, and Periódicos Capes – a Brazilian database that congregates different others). My goal was to synthesize the information available on its biology and ecology to create a detailed picture of the species to answer the questions I posed before. Furthermore, I aimed to identify ecological traits that could establish parallels or differences with bird species acknowledged as nest predators, particularly in urban settings. To do that, I employed various combinations of keywords in English, Portuguese, and Spanish: '*Pitangus sulphuratus*', 'Great Kiskadee', 'biology', 'ecology', 'breeding or reproduction', 'predation', 'predatory behavior', 'nest predation', and 'urban'.

Results

The literature review unveiled limited documented cases of the Great Kiskadee as a nest predator. Among the few anecdotal mentions found, Sick (1997:593) reported instances of nest predation by the Great Kiskadee on Bananaquit (*Coereba flaveola*) nests and observed its capture of hummingbirds at artificial feeders. Francisco (2006) also documented the Great Kiskadee preying on the nest of the Double-Collared Seedeater (*Sporophila caerulescens*). In a comprehensive study of the Neotropical region, Menezes and Marini (2017) listed the Great Kiskadee as a nest predator among many others, but there is no specific reference to its prey. Fitzpatrick (1980:49) cited two works conducted in Central America that suggest the Great Kiskadee preys on nestlings.

Interestingly, several studies conducted in natural environments, including those with *in situ* image recording devices, have documented various bird species and mammals preying on bird nests, but the Great Kiskadee (França et al., 2009; Galetti et al., 2009; Cockle et al., 2016). Studies investigating the diet of the Great Kiskadee (nestlings and adults) in urban ecosystems also found no evidence of birds in its diet (e.g., Gorena, 1997; Argel-de-Oliveira et al., 1998; Martins-Oliveira et al., 2012; Pereira and Melo, 2012). On the other hand, the Great Kiskadee has been found preying on a wide range of small vertebrates, including fishes, turtles, snakes, lizards, amphibians, rodents, and bats (Beltzer, 1983; Richard, 1986; Gorena, 1997; Argel-de-Oliveira et al., 1998; Latino and Beltzer, 1999; Carvalho Filho, 2009; Fischer et al., 2010; Munin et al., 2012; Pereira and Melo, 2012; Sazima, 2015).

Discussion

The limited reports on nest predation by the Great Kiskadee confirm, at the very least, the existence of this behavior in the species. Nevertheless, uncertainties persist regarding its frequency of occurrence and other crucial aspects, such as preferences for specific species and the environments where it is more prevalent. Drawing upon the gathered information, I present three hypotheses to address the scarcity of information on nest predation behavior in the Great Kiskadee. These hypotheses not only shed light on the current knowledge gap but also pave the way for future research to delve deeper into this aspect of the species. They are: 1) nest predation is a rare and sporadic behavior, indicated by the low number of documented cases; 2) the behavior is common and frequent, but has been poorly documented 3) its occurrence is influenced by environmental factors that may limit its observation.

Hypothesis 1: Nest predation in the Great Kiskadee occurs sporadically

The initial hypothesis suggests that the scarcity of available records mirrors the rarity of this behavior in the species. As an uncommon phenomenon, the probability of its observation diminishes. Certain aspects of the species' biology could substantiate this hypothesis. Research on the Great Kiskadee's diet reveals a prevalent consumption of invertebrates (van Rossem, 1914; Beltzer, 1983; Argel-de-Oliveira et al., 1998; Latino and Beltzer, 1999; Munin et al., 2012) while others found fruits as the major food source (Gorena, 1997). This dietary preference aligns with the general pattern observed in Neotropical passerines, which

have not specialized in preying on vertebrates (Lopes et al., 2005). In fact, vertebrates constitute a small fraction of their diet, despite this behavior being widely present among the Neotropical passerines with, at least, 11 families with species preying on bird nests (Menezes and Marini, 2017). Frogs and lizards are the most commonly consumed vertebrates by passerines, with only about 18% of the records involving other vertebrate groups (Lopes et al., 2005).

The few studies performed in the urban environment that described the Great Kiskadee's diet did not provide evidence of nestlings in it. While Argel-de-Oliveira et al. (1998) had monitored only one single nest, Pereira and Melo (2012) analyzed the content of 218 regurgitated pellets. In both studies, the only vertebrate found was the Common House Gecko (*Hemidactylus frenatus*). Although analyzing only the diet of the Great Kiskadee's nestlings may not offer a complete understanding of its predatory behavior, a study conducted by Gorena (1997) focusing on adult individuals found that fish constituted the main vertebrate prey (95%), without further description of other taxa. Similarly, Martins-Oliveira et al. (2012) did not provide information on the specific vertebrate taxa preyed upon.

The same lack of evidence regarding the Great Kiskadee preying on nests was observed in studies conducted in wild habitats, monitoring nests of various species (e.g., França et al., 2009; Galetti et al., 2009; Cockle et al., 2016). In these cases, the presence of a more diverse range of prey options, including potential competitors and predators of the Great Kiskadee, or variations in methodological procedures could be speculated as potential causes for the lack of findings. In methodological terms, a possible explanation may lie in the species selected for nest monitoring in those studies. Given that predator-prey relationships can be species-specific or constrained by different factors (Patten and Bolger, 2003), and considering a possible existence of a Great Kiskadee's preference for certain species (nests of small-sized species – I discuss about this later – and in specific strata and locations, i.e., edge or interior), the lack of Great Kiskadee records could be a methodological artifact.

Hypothesis 2: The behavior is common and frequent, but has been poorly documented

The second hypothesis, in contrast to the first, suggests that the behavior is common in the species but has been insufficiently documented. The broad spectrum of vertebrates preyed upon by the Great Kiskadee allows one to speculate that this behavior can be prevalent. The literature review showed that the Great Kiskadee preys on a broad spectrum of vertebrates, showcasing the species' versatility as a generalist predator, possibly one of the most versatile among passerines (Fitzpatrick, 1980; Sick, 1997). This versatility stems from its medium size (20-25 cm) and its ability to forage on various substrates and strata in both forested and open areas (e.g. tree foliage and branches, on the ground, in the air, above and under the water surface), feeding also on fruits, flowers, seeds, and invertebrates (Fitzpatrick, 1980; Beltzer, 1983; Richard, 1986; Cintra, 1997; Gorena, 1997; Latino and Beltzer, 1999; Gabriel and Pizo, 2005; Fischer et al., 2010; Martins-Oliveira et al., 2012). Its size and prolonged searching capabilities enable it to target larger prey (Schoener, 1971; Fitzpatrick, 1981; Gabriel and Pizo, 2005). These generalist characteristics make the Great Kiskadee a broad-spectrum omnivore, common in both wild and human-modified environments (Ruszczyk et al., 1987; Argel-de-Oliveira, 1995; Cintra, 1997; Sick, 1997) and,

probably as a consequence, widely distributed from the southwestern United States into the central Argentina (Sick, 1997; Brush and Fitzpatrick, 2002).

Moreover, the Great Kiskadee possesses reproductive and abundance characteristics that can heighten its predation potential. With a breeding season lasting up to nine months, this species exhibits high reproductive rates and success within urban ecosystems (Pereira et al., 2009; Santos et al., 2019). It also prefers to nest in anthropic structures distant from forested areas in urban centers, probably to reduce the risk of nest predators (Corrales-Moya and Sandoval, 2021). Despite potential threats from predators, the Great Kiskadee's assertive behavior towards larger birds, coupled with its robust medium size, contributes to effective nest defense (Sick, 1997; Smith, 2006), potentially enhancing its overall reproductive success.

Furthermore, to support this hypothesis, the species biology and ecology resembles other widely recognized birds known for preying on nests, particularly in urban environments. These species can enhance their survival and abundance in urban spaces by limiting the recruitment of potential competitors, potentially exerting additional pressure on other species. For instance, the Pied Currawong (*Strepera graculina*) has been implicated in over 50% of nest predation cases, leading to a decline in species recruitment in urban areas of Australia (Major et al., 1996; Debus, 2006). Similar patterns have been observed for magpies (*Pica pica*) (Jerzak, 2001), Western Scrub-Jay (*Aphelocoma californica*) (Reidy and Thompson III, 2012), and crows (*Corvus* sp.) (Marzluff et al., 2001; Rodewald and Kearns, 2011), recognized as major nest predators in urban habitats, among others. In support of these observations, it has been noted that the foraging versatility of the Great Kiskadee more closely resembles that of the Corvidae family rather than a typical suboscine passerine (Fitzpatrick, 1980). Similar to them, the Great Kiskadee also demonstrates remarkable adaptability to diverse habitats, ranging from natural to highly urbanized environments. Numerous studies conducted in various urban areas across Brazil consistently identify the Great Kiskadee as the most abundant and widespread species (Ruszczuk et al., 1987; Argel-de-Oliveira, 1995; Matarazzo-Neuberger, 1995; Krügel and Anjos, 2000; Scherer et al., 2005; Galetti et al., 2009; Braga et al., 2010; Cruz and Piratelli, 2011; Vasconcelos et al., 2013; Sacco et al., 2015)

The scarcity of records of this behavior, assumed to be common by the hypothesis, may be attributed to the unique characteristics of nest predation. The swift and instantaneous nature of predation poses challenges for observation without the use of video recording devices near the nests (Cox et al., 2012). However, these devices can be expensive and often yield small sample sizes, being mostly used in developed countries (Fischer et al., 2012). As a result, there is a lack of knowledge about the ecology of nest-predators and prey relationships especially in developing countries (Ibáñez-Álamo et al., 2015), which make up the majority of the Great Kiskadee's distribution. For example, Perrella et al. (2017) found a predation rate of 46% in nests of the Purple Euphonia monitored in an urban area, but the predators were not identified. Similarly, Rivera-López and MacGregor-Fors (2016) observed a high rate of nest predation in a Mexican city, but they were unable to accurately identify the predators. Additionally, researchers may be less motivated to publish such occasional events, potentially due to perceived lack of

novelty or previous journal rejections, overlooking the importance of filling knowledge gaps in the phenomenon. However, as emphasized by (Anderson, 2017), naturalistic observations at the organismal level are crucial for a comprehensive ecological understanding and should be encouraged.

Hypothesis 3: The behavior occurrence is influenced by environmental factors that may limit its observation

The third hypothesis can be considered a blend of the two preceding ones. The behavior in natural settings may be assumed as occasional, but it could become frequent in urban environments due to various factors, some of them that may be unique to cities – yet to be understood (Faeth et al., 2005). It is based on propositions suggesting that passerine predation on vertebrates may be influenced by environmental factors, even exhibiting regional patterns across the Neotropics (Poulin et al., 2001; Lopes et al., 2005). Similarly, nest predation rates can vary depending on habitat, nest type, and nest-site characteristics (Martin, 1988, 1993; Thompson and Burhans, 2003; Marini, 2017). Analyzing the urban environment specifically, nest predation is known to vary according to the characteristics of the urban environment (Stracey, 2011). Moreover, the foraging behavior of the Great Kiskadee has been demonstrated to vary in response to urban settings (Martins-Oliveira et al., 2012), influenced by the surrounding environment (Robinson and Holmes, 1982). Additionally, the Great Kiskadee's tendency to forage in tree canopies (Martins-Oliveira et al., 2012) might heighten its likelihood of encountering nests.

The urban landscape displays a gradient of increasing intensity of use from the periphery to the more urbanized and verticalized central regions, exhibiting a negative correlation with green coverage: as the intensity increases, the green coverage diminishes (Blair, 1996; Lin et al., 2015; McDonald et al., 2023). Such changes have effects on the composition, abundance, and richness of the bird assemblage, increasing the number of exotic species and decreasing overall species richness and diversity (Blair, 1996; de Toledo et al., 2011; Kurucz et al., 2021), leading to a homogenization of bird assemblages (Blair, 2001; McKinney, 2006; Luck and Smallbone, 2011). Moreover, the urban forest environment resembles highly fragmented forests (Soulé, 1991; Marzluff and Ewing, 2001; Chace and Walsh, 2006), where nest predation rates tend to be higher than in less fragmented landscapes (see Hartley and Hunter, 1998). This urban gradient may also influence the types of available prey through trophic cascade effects (e.g., Melo et al., 2016). Invertebrate availability, a key component in the Great Kiskadee diet, tends to be lower in urban environments compared to natural areas (e.g., Zapparoli, 1997; Teglhøj, 2017; Seress et al., 2018), albeit with some divergencies regarding these findings (see Kurucz et al., 2021). Could this potentially lead to an increase in bird nest predation? In fact, studies have shown that the amount of urbanization in the landscape tends to increase nest predation (e.g., Phillips et al., 2005; Reidy and Thompson III, 2012), but the effects are not always straightforward (see discussion in Rodewald et al., 2013; Vincze et al., 2017).

As demonstrated in urban landscapes, the abundance of predators is heterogeneous, resulting in both the relaxation and intensification of nest predation (Major et al., 1996; Gering and Blair, 1999; Rodewald and Kearns, 2011; Rivera-López and MacGregor-Fors, 2016; Vincze et al., 2017). Studies indicate that

opportunistic, medium-sized predators can attain higher densities in urban habitats compared to rural areas, a phenomenon known as mesopredator release (Soulé et al., 1988; Prugh et al., 2009; Fischer et al., 2012). While much attention has been given to mammal mesopredators and exotic species (e.g., domestic and feral cats) in urban environments (e.g., Crooks and Soulé, 1999; Fischer et al., 2012), omnivorous birds can also act as mesopredator species, contributing to increased pressure on other species by typically preying on the young (Fischer et al., 2012), as exemplified by the case I witnessed. Mesopredator bird species typically exhibit a positive response to urbanization (Jerzak, 2001; Fischer et al., 2012). This trend seems to be applicable to the Great Kiskadee as well, as evidenced by its status as one of the most abundant species in the urban and its shared characteristics with notable nest predators, as discussed earlier.

Similar to the second hypothesis, inherent challenges in observing nest predation events and the still limited research in urban ecosystems, particularly in the Neotropical region, could account for the lack of recorded predation events. Given the positive association between the abundance of the Great Kiskadee and urbanization showed before, coupled with the limited examination of the urbanization gradient in urban studies (Fischer et al., 2012), it is not possible to dismiss this possibility.

Potential impact on other bird species

The limited reports on nest predation by the Great Kiskadee (e.g., Sick, 1997; Francisco, 2006), combined with my own observations, indicate a preference for preying on nests of small-sized birds (approximately 9-12 cm). This preference may stem from the convenience of handling smaller nestlings. However, considering its broad spectrum of vertebrate prey, as discussed earlier, it is also plausible that the Great Kiskadee preys on nestlings of varying sizes. Further field observations would provide valuable insights into this aspect.

Nevertheless, what outcomes might we anticipate regarding its impact on urban bird species susceptible to its voracity? If we presume that the low number of reported cases serves as an indicator of the behavior's commonality, the impact could be deemed low and not distinguishable from more preserved environments. Additionally, the conjecture of a low impact aligns with theories currently under examination in the urban ecosystem.

The Prey-switching hypothesis, for instance, posits that the presence of anthropogenic food in the urban environment may diminish predation rates (Stracey, 2011). As a dietary generalist species, the presence of anthropogenic food could influence the species' behavior. However, the extent to which this hypothesis applies to the Great Kiskadee remains uncertain. Conversely, in situations where alternative food sources are scarce, it is unclear whether the Great Kiskadee would redirect its attention to bird nests and under what specific conditions such behavior might occur. The threshold for this potential shift is yet to be determined. These inquiries remain unanswered, necessitating further investigation into the matter.

On the other hand, the Nest Predation Paradox (Stracey, 2011; Fischer et al., 2012) posits that, despite the presence of a high abundance of predators, nest predation rates may vary and could be lower than

initially anticipated. This theory highlights the paradoxical relationship between elevated rates of nest predation and the sustained existence of bird populations. Despite the pronounced threat posed by nest predators, numerous bird species exhibit the ability to uphold stable populations. This paradox implies that birds have evolved diverse strategies, including nest-site selection, camouflage, and mobbing behavior, to mitigate the impact of nest predation events. In this scenario, even if the Great Kiskadee is one of the most abundant species in the urban environment and nest predation behavior were commonplace, its impact would have limited effects on shaping the structure of the urban bird assemblage.

Final Remarks

While the ideas presented here are speculative, they are grounded in a robust theoretical background. They clearly allow to speculate that the Great Kiskadee's role as a nest predator may have been underestimated and overlooked in the urban ecosystem. It is plausible to hypothesize that nest predation in the urban environment is influenced by all the myriad of variables discussed here (the presence/absence of apex predators, the structure of bird assemblages, the urban gradient, the availability of anthropogenic food, and the richness and abundance of arthropods and other small vertebrates as prey) – and probably more (Thompson III, 2007; Reidy and Thompson III, 2012). The interplay of these and other factors highlights the complexity of nest predation dynamics in urban environments. Understanding how these factors interact and contribute to the ecological dynamics of bird assemblages in the urban ecosystem is crucial for assessing the role of the Great Kiskadee – if any – in structuring local bird populations, food webs, and in the overall biotic homogenization of urban biodiversity (Blair, 2001; Faeth et al., 2005; McKinney, 2006; Sacco et al., 2015; Santos et al., 2019). Understanding how urbanization influences the abundance of the Great Kiskadee, for example, and its interactions with other species is necessary to comprehend patterns of nest predation and bird assemblage structure in urban ecosystems. As stressed by Argel-de-Oliveira et al. (1998), it is crucial to further study the biology of the Great Kiskadee in urban settings and compare it to its behavior in less human-impacted environments. This knowledge will inform management strategies aimed at promoting bird diversity in urban landscapes, particularly in light of the challenges posed by climate change in the cities.

Declarations

Acknowledgments

I am deeply thankful to Associação para o Fomento da Arte e Cultura (AFAC) for their invaluable support in establishing the Bird Observatory Project at Vicentina Aranha Park. Initiated in 2014, this social project focuses on providing nature-based experiences through birdwatching activities, promoting eco-literacy, and advancing citizen science.

Funding: The author declare that no funds, grants, or other support were received during the preparation of this manuscript.

Conflicts of interest: The author declares he has no conflict of interest.

References

1. Anderson JGT (2017) Why Ecology needs Natural History. *Am Sci* 105: 290.
<https://doi.org/10.1511/2017.105.5.290>
2. Argel-de-Oliveira MM (1995) Aves e vegetação em um bairro residencial da cidade de São Paulo, São Paulo, Brasil. *Rev Bras Zool* 12: 81-92. <https://doi.org/10.1590/S0101-81751995000100011>
3. Argel-de-Oliveira MM, Curi NA, Passerini T (1998) Alimentação de um filhote de bem-te-vi, *Pitangus sulphuratus* (Linnaeus) (Passeriformes, Tyrannidae), em ambiente urbano. *Rev Bras Zool* 15: 1103-1109. <https://doi.org/10.1590/S0101-81751998000400027>
4. Beltzer AH (1983) Alimentación del "Benteveo" (*Pitangus sulphuratus*) en el Valle Aluvial del Río Paraná Medio. (Passeriformes: Tyrannidae). *Rev Asociación Cien Naturales del Litoral* 14: 47-52. <https://doi.org/10.14409/natura.v1i14.3414>
5. Blair RB (1996) Land use and avian species diversity along an urban gradient. *Ecol Appl* 6: 506-519. <https://doi.org/10.2307/2269387>
6. Blair RB (2001) Creating a homogeneous avifauna. In: Marzluff JM, Bowman R, Donnelly R (eds) *Avian Ecology and Conservation in an Urbanizing World*. Springer Science+Business Media, New York, pp 459-486
7. Braga TV, Zanzini ACdS, Cerboncini RAS, Miguel M, Moura ASd (2010) Avifauna em praças da cidade de Lavras (MG): riqueza, similaridade e influência de variáveis do ambiente urbano. *Rev Bras Ornitol* 18: 26-33
8. Brush T, Fitzpatrick JW (2002) Great Kiskadee (*Pitangus sulphuratus*), version 2.0. In: Poole AF, Gill FB (eds) *The Birds of North America*. Cornell Lab of Ornithology, Ithaca, NY, pp
9. Carvalho Filho FS (2009) Predação pelo bem-te-vi *Pitangus sulphuratus* (Passeriformes, Tyrannidae) no baiacu *Colomesus asellus* (Actinopterygii, Tetraodontidae) e camarão de água doce (Crustacea, Decapoda). *Rev Bras Ornitol* 17: 77-78
10. Chace JF, Walsh JJ (2006) Urban effects on native avifauna: a review. *Landscape Urban Plann* 74: 46-69. <https://doi.org/10.1016/j.landurbplan.2004.08.007>
11. Cintra R (1997) Spatial distribution and foraging tactics of tyrant flycatchers in two habitats in the Brazilian Amazon. *Stud Neotrop Fauna Environ* 32: 17-27. <https://doi.org/10.1076/snfe.32.1.17.13459>
12. Cockle KL, Bodrati A, Lammertink M, Bonaparte EB, Ferreyra C, Sallo FGD (2016) Predators of bird nests in the Atlantic forest of Argentina and Paraguay. *Wilson J Ornithol* 128: 120-131. <https://doi.org/10.1676/wils-128-01-120-131.1>
13. Corrales-Moya J, Sandoval L (2021) Does the forest or the anthropogenic building distance influence Great Kiskadee (*Pitangus sulphuratus*) nesting site selection? *Ornitol Neotrop* 32: 28-33. <https://doi.org/10.58843/ornneo.v32i1.739>

14. Cox WA, Pruett MS, Benson TJ, Chiavacci SJ, Thompson III FR (2012) Development of camera technology for monitoring nests. *Stud Avian Biol-Ser* 43: 185-210
15. Crooks KR, Soulé ME (1999) Mesopredator release and avifaunal extinctions in a fragmented system. *Nature* 400: 563-566. <https://doi.org/10.1038/23028>
16. Cruz BB, Piratelli AJ (2011) Avifauna associada a um trecho urbano do rio Sorocaba, Sudeste do Brasil. *Biota Neotrop* 11: 255-264. <https://doi.org/10.1590/S1676-06032011000400022>.
17. de Toledo MCB, Donatelli RJ, Batista GT (2011) Relation between green spaces and bird community structure in an urban area in Southeast Brazil. *Urban Ecosyst* 15: 111-131. <https://doi.org/10.1007/s11252-011-0195-2>
18. Debus SJS (2006) The role of intense nest predation in the decline of Scarlet Robins and Eastern Yellow Robins in remnant woodland near Armidale, New South Wales. *Pac Conserv Biol* 12: 279-287. <https://doi.org/10.1071/PC060279>
19. Faeth SH, Warren PS, Shochat E, Marussich WA (2005) Trophic dynamics in urban communities. *Bioscience* 55: 399. [https://doi.org/10.1641/0006-3568\(2005\)055\[0399:TDIUC\]2.0.CO;2](https://doi.org/10.1641/0006-3568(2005)055[0399:TDIUC]2.0.CO;2)
20. Fischer E, Munin RL, Longo JM, Fischer W, de Souza PR (2010) Predation on bats by Great Kiskadees. *J Field Ornithol* 81: 17-20. <https://doi.org/10.1111/j.1557-9263.2009.00256.x>
21. Fischer JD, Cleeton SH, Lyons TP, Miller JR (2012) Urbanization and the predation paradox: the role of trophic dynamics in structuring vertebrate communities. *Bioscience* 62: 809-818. <https://doi.org/10.1525/bio.2012.62.9.6>
22. Fitzpatrick JW (1980) Foraging behavior of Neotropical tyrant flycatchers. *Condor* 82: 43-57. <https://doi.org/10.2307/1366784>
23. Fitzpatrick JW (1981) Search strategies of tyrant flycatchers. *Anim Behav* 29: 810-821. [https://doi.org/10.1016/S0003-3472\(81\)80015-2](https://doi.org/10.1016/S0003-3472(81)80015-2)
24. França LF, Sousa NOM, Santos LR, Duca C, Gressler DT, Borges FJA, Lopes LE, Manica LT, Paiva LV, Medeiros RCS, Marini MA (2009) Passeriformes: Nest predators and prey in a Neotropical Savannah in Central Brazil. *Zoologia* 26: 799-802. <https://doi.org/10.1590/S1984-46702009000400028>
25. Francisco MR (2006) Breeding biology of the Double-Collared Seedeater (*Sporophila Caerulescens*). *Wilson J Ornithol* 118: 85-90. [https://doi.org/10.1676/1559-4491\(2006\)118\[0085:BBOTDS\]2.0.CO;2](https://doi.org/10.1676/1559-4491(2006)118[0085:BBOTDS]2.0.CO;2)
26. Gabriel VdA, Pizo MA (2005) Foraging behavior of tyrant flycatchers (Aves, Tyrannidae) in Brazil. *Rev Bras Zool* 22: 1072-1077
27. Galetti M, Bovendorp RS, Fadini RF, Gussoni COA, Rodrigues M, Alvarez AD, Guimarães PR, Jr., Alves K (2009) Hyper abundant mesopredators and bird extinction in an Atlantic forest island. *Zoologia* 26: 288-298. <https://doi.org/10.1590/S1984-46702009000200011>
28. Gering JC, Blair RB (1999) Predation on artificial bird nests along an urban gradient: predatory risk or relaxation in urban environments? *Ecography* 22: 532-541. <https://doi.org/10.1111/j.1600-0587.1999.tb01283.x>

29. Gorená RL (1997) Notes on the feeding habits and prey of adult Great Kiskadees. Bull Texas Ornithol Soc 30: 18-19
30. Hartley MJ, Hunter ML (1998) A meta-analysis of forest cover, edge effects, and artificial nest predation rates. Conserv Biol 12: 465-469. <https://doi.org/10.1111/j.1523-1739.1998.96373.x>
31. Ibáñez-Álamo JD, Magrath RD, Oteyza JC, Chalfoun AD, Haff TM, Schmidt KA, Thomson RL, Martin TE (2015) Nest predation research: recent findings and future perspectives. Journal of Ornithology 156: 247-262. <https://doi.org/10.1007/s10336-015-1207-4>
32. Jerzak L (2001) Synurbanization of the magpie in the Palearctic. In: Marzluff JM, Bowman R, Donnelly R (eds) Avian Ecology and Conservation in an Urbanizing World. Springer Science+Business Media, New York, NY, pp 403-425
33. Krügel MM, Anjos L dos (2000) Bird communities in forest remnants in the city of Maringá, Paraná state, southern Brazil. Ornitol Neotrop 11: 315-330
34. Kurucz K, Purger JJ, Batáry P (2021) Urbanization shapes bird communities and nest survival, but not their food quantity. Global Ecology and Conservation 26: e01475. <https://doi.org/10.1016/j.gecco.2021.e01475>
35. Latino S, Beltzer AH (1999) Ecología trófica del benteveo *Pitangus sulphuratus* (aves: Tyrannidae) en el valle de inundación del río Paraná, Argentina. Orsis 14: 69-78
36. Lin B, Meyers J, Barnett G (2015) Understanding the potential loss and inequities of green space distribution with urban densification. Urban Forestry & Urban Greening 14: 952-958. <https://doi.org/10.1016/j.ufug.2015.09.003>
37. Lopes LE, Fernandes AM, Marini MA (2005) Predation on vertebrates by Neotropical passerine birds. Lundiana 6: 57-66
38. López-Flores V, MacGregor-Fors I, Schondube JE (2009) Artificial nest predation along a Neotropical urban gradient. Landscape Urban Plann 92: 90-95. <https://doi.org/10.1016/j.landurbplan.2009.03.001>
39. Luck GW, Smallbone LT (2011) The impact of urbanization on taxonomic and functional similarity among bird communities. J Biogeogr 38: 894-906. <https://doi.org/10.1111/j.1365-2699.2010.02449.x>
40. Major RE, Gowing G, Kendal CE (1996) Nest predation in Australian urban environments and the role of the pied currawong, *Strepera graculina*. Aust J Ecol 21: 399-409. <https://doi.org/10.1111/j.1442-9993.1996.tb00626.x>
41. Marini MA (2017) Nesting success of birds from Brazilian Atlantic Forest Fragments. Rev Bras Ornitol 25: 77-83
42. Martin TE (1988) On the advantage of being different: nest predation and the coexistence of bird species. Proc Natl Acad Sci USA 85: 2196-2199. <http://dx.doi.org/10.1073/pnas.85.7.2196>
43. Martin TE (1993) Nest predation and nest sites. Bioscience 43: 523-532. <https://doi.org/10.2307/1311947>

44. Martins-Oliveira L, Leal-Marques R, Nunes CH, Franchin AG, Marçal O, Jr. (2012) Forrageamento de *Pitangus sulphuratus* e de *Tyrannus melancholicus* (Aves: Tyrannidae) em habitats urbanos. *Biosci J* 28: 1038-1850
45. Marzluff JM, Ewing K (2001) Restoration of fragmented landscapes for the conservation of birds: a general framework and specific recommendations for urbanizing landscapes. *Restor Ecol* 9: 280-292. <https://doi.org/10.1046/j.1526-100x.2001.009003280.x>
46. Marzluff JM, McGowan KJ, Donnelly R, Knight RL (2001) Causes and consequences of expanding American Crow populations. In: Marzluff JM, Bowman R, Donnelly R (eds) *Avian Ecology and Conservation in an Urbanizing World*. Springer Science+Business Media, New York, pp 331-364
47. Matarazzo-Neuberger WM (1995) Comunidades de aves de cinco parques e praças da Grande São Paulo, Estado de São Paulo. *Ararajuba* 3: 13-19
48. McDonald RI, Aronson MFJ, Beatley T, Beller E, Bazo M, Grossinger R, Jessup K, Mansur AV, Puppim de Oliveira JA, Panlasigui S, Burg J, Pevzner N, Shanahan D, Stoneburner L, Rudd A, Spotswood E (2023) Denser and greener cities: Green interventions to achieve both urban density and nature. *People and Nature* 5: 84-102. <https://doi.org/10.1002/pan3.10423>
49. McKinney ML (2006) Urbanization as a major cause of biotic homogenization. *Biol Conserv* 127: 247-260. <https://doi.org/10.1016/j.biocon.2005.09.005>
50. Melo MM, Silva CM, Barbosa CS, Morais MC, D'Anuniação PER, Silva VXd, Hasui É (2016) Fragment edge and isolation affect the food web: effects on the strength of interactions among trophic guilds. *Biota Neotrop* 16: e20150088. <https://doi.org/10.1590/1676-0611-BN-2015-0088>
51. Menezes JCT, Marini MA (2017) Predators of bird nests in the Neotropics: a review. *J Field Ornithol* 88: 99-114. <https://doi.org/10.1111/jfo.12203>
52. Michalski F, Norris D (2014) Artificial nest predation rates vary depending on visibility in the eastern Brazilian Amazon. *Acta Amazon* 44: 393-396. <http://dx.doi.org/10.1590/1809-4392201302553>
53. Munin R, Fischer E, Longo J (2012) Foraging of Great Kiskadees (*Pitangus sulphuratus*) and food items offered to nestlings in the Pantanal. *Braz J Biol* 72: 459-462. <https://doi.org/10.1590/S1519-69842012000300007>
54. Newton I (1998) *Population Limitation in Birds*. Academic Press, San Diego, CA, USA
55. Patten MA, Bolger DT (2003) Variation in top-down control of avian reproductive success across a fragmentation gradient. *Oikos* 101: 479-488. <https://doi.org/10.1034/j.1600-0706.2003.12515.x>
56. Pereira ZdP, Melo C (2012) Nestling's pellets of the Great Kiskadee (*Pitangus sulphuratus*) in Brazilian urban environment. *Ornitol Neotrop* 23: 269-276
57. Pereira ZdP, Pereira MP, Arantes CA, Melo C (2009) Monitoramento de ninhos de aves em um parque urbano. *Revista Brasileira de Zoociências* 11: 39-45
58. Perrella DF, Davanço PV, Oliveira LS, Sousa LMS, Francisco MR (2017) Reproductive aspects of the Purple-throated Euphonia, *Euphonia chlorotica* (Aves: Fringillidae) in southeastern Brazil, and first record of the species nesting inside a vespiary. *Zoologia* 34: e19989. <https://doi.org/10.3897/zoologia.34.e19989>.

59. Phillips J, Nol E, Burke D, Dunford W (2005) Impacts of housing developments on Wood Thrush nesting success in hardwood forest fragments. *Condor* 107: 97-106.
<https://doi.org/10.1093/condor/107.1.97>
60. Poulin B, Lefebvre G, Ibañez R, Jaramillo C, Hernández C, Stanley Rand A (2001) Avian predation upon lizards and frogs in a neotropical forest understory. *J Trop Ecol* 17: 21-40.
<https://doi.org/10.1017/S026646740100102X>
61. Prugh LR, Stoner CJ, Epps CW, Bean WT, Ripple WJ, Laliberte AS, Brashares JS (2009) The rise of the mesopredator. *Bioscience* 59: 779-791. <https://doi.org/10.1525/bio.2009.59.9.9>
62. Reidy JL, Thompson III FR (2012) Predatory identity can explain nest predation patterns. *Stud Avian Biol-Ser* 43: 135-148
63. Remsen JV, Jr. , Robinson SK (1990) A classification scheme for foraging behavior of birds in terrestrial habitats. *Stud Avian Biol-Ser* 13: 144-160
64. Richard E (1986) Predación del Benteveo sobre peces y tortugas. *Nuestras Aves* 4: 3-4
65. Ricklefs RE (1969) An analysis of nesting mortality in birds. *Smithson Contrib Zool* 9: 1-48.
<https://doi.org/10.5479/si.00810282.9>
66. Rivera-López A, MacGregor-Fors I (2016) Urban predation: a case study assessing artificial nest survival in a neotropical city. *Urban Ecosyst* 19: 649-655. <https://doi.org/10.1007/s11252-015-0523-z>
67. Robinson SK, Holmes RT (1982) Foraging behavior of forest birds: The relationships among search tactics, diet, and habitat structure. *Ecology* 63: 1918-1931. <https://doi.org/10.2307/1940130>
68. Rodewald AD, Kearns LJ (2011) Shifts in dominant nest predators along a rural-to-urban landscape gradient. *Condor* 113: 899-906. <https://doi.org/10.1525/cond.2011.100132>
69. Rodewald AD, Kearns LJ, Shustack DP (2013) Consequences of urbanizing landscapes to reproductive performance of birds in remnant forests. *Biol Conserv* 160: 32-39.
<https://doi.org/10.1016/j.biocon.2012.12.034>
70. Ruzszczyk A, Rodrigues JJS, Roberts TMT, Bendati MMA, del Pino RS, Marques JCV, Melo MTQ (1987) Distribution patterns of eight bird species in the urbanization gradient of Porto Alegre, Brazil. *Ciência e Cultura* 39: 14-19
71. Sacco AG, Rui AM, Bergmann FB, Müller SC, Hartz SM (2015) Perda de diversidade taxonômica e funcional de aves em área urbana no sul do Brasil. *Iheringia, Ser Zool* 105: 276-287.
<http://dx.doi.org/10.1590/1678-476620151053276287>
72. Santos GS, Ribeiro IC, Centoducatte LDA, Mendes SL (2019) Reprodução da avifauna e o processo de homogeneização em área verde planejada no sudeste da Mata Atlântica, Brasil. *Neotrop Biol Conserv* 14: 83-98. <https://doi.org/10.3897/neotropical.14.e34838>
73. Sazima I (2015) Tropical House Gecko (*Hemidactylus mabouia*) shelter raided by a single tyrannid bird (*Pitangus sulphuratus*) in an urban park. *Herpetol Notes* 8: 433-435
74. Scherer A, Scherer SB, Bugoni L, Mohr LV, Efe MA, Hartz SM (2005) Estrutura trófica da avifauna em oito parques da cidade de Porto Alegre, Rio Grande do Sul, Brasil. *Ornithologia* 1: 25-32

75. Schoener TW (1971) Theory of Feeding Strategies. *Annu Rev Ecol Syst* 2: 369-404.
<https://doi.org/10.1146/annurev.es.02.110171.002101>
76. Seress G, Hammer T, Bokony V, Vincze E, Preiszner B, Pipoly I, Sinkovics C, Evans KL, Liker A (2018) Impact of urbanization on abundance and phenology of caterpillars and consequences for breeding in an insectivorous bird. *Ecol Appl* 28: 1143-1156. <https://doi.org/10.1002/eap.1730>
77. Sick H (1997) *Ornitologia Brasileira*. Nova Fronteira, Rio de Janeiro, Brasil
78. Smith PK (2006) Interspecific aggression in nesting Great Kiskadees *Pitangus sulphuratus* in Paraguay. *Boletín SAO* 16: 67-70
79. Soulé ME (1991) Land use planning and wildlife maintenance: guidelines for conserving wildlife in an urban landscape. *Journal of the American Planning Association* 57: 313-323.
<https://doi.org/10.1080/01944369108975502>
80. Soulé ME, Bolger DT, Alberts AC, Wrights J, Sorice M, Hill S (1988) Reconstructed dynamics of rapid extinctions of chaparral-requiring birds in urban habitat islands. *Conserv Biol* 2: 75-92.
<https://doi.org/10.1111/j.1523-1739.1988.tb00337.x>
81. Stracey CM (2011) Resolving the urban nest predator paradox: the role of alternative foods for nest predators. *Biol Conserv* 144: 1545-1552. <https://doi.org/10.1016/j.biocon.2011.01.022>
82. Teglhøj PG (2017) A comparative study of insect abundance and reproductive success of barn swallows *Hirundo rustica* in two urban habitats. *J Avian Biol* 48: 846-853.
<https://doi.org/10.1111/jav.01086>
83. Thompson FR, III, Burhans DE (2003) Predation of songbird nests differs by predator and between field and forest habitats. *J Wildl Manage* 67: 408-416. <https://doi.org/10.2307/3802781>
84. Thompson III FR (2007) Factors affecting nest predation on forest songbirds in North America. *Ibis* 149: 98-109. <https://doi.org/10.1111/j.1474-919X.2007.00697.x>
85. van Rossem A (1914) Notes on the Derby Flycatcher. *Condor* 16: 11-13.
<https://doi.org/10.2307/1362189>
86. Vasconcelos MF, Dutra EC, Mazzoni LG, Pedroso LF, Perillo A, Valério FA, Guerra T, Petrocchi D, Morais R, Santos LPS, Garzon B, Dias JEM, Santos JE, Morais AS, Guimarães LSL, Garcia FIA, Almeida TO, Benfica CERT, Peixoto HJC, Ribeiro BP (2013) Long-term avifaunal survey in an urban ecosystem from southeastern Brazil, with comments on range extensions, new and disappearing species. *Pap Avuls Zool* 53: 327-344. <https://doi.org/10.1590/S0031-10492013002500001>
87. Vincze E, Seress G, Lagisz M, Nakagawa S, Dingemanse NJ, Sprau P (2017) Does urbanization affect predation of bird nests? A meta-analysis. *Front Ecol Evol* 5: Article 29.
<https://doi.org/10.3389/fevo.2017.00029>
88. Zapparoli M (1997) Urban development and insect biodiversity of the Rome area, Italy. *Landscape Urban Plann* 38: 77-86. [https://doi.org/10.1016/S0169-2046\(97\)00020-0](https://doi.org/10.1016/S0169-2046(97)00020-0)