*The Wilson Journal of Ornithology* 134(4):688–694, 2022 DOI: 10.1676/21-00097

# Habitat use by House Sparrow (*Passer domesticus*) in Campo Grande, Brazil

Deivid H.R. Alexandre,[1] Francisco Severo-Neto,[1] Fabio Schunck,[2] Juan C. Guix,[3] and Franco L. Souza[1]*

ABSTRACT—House Sparrow (*Passer domesticus*) populations have been negatively affected in various regions of the world because of the urbanization process, although in Brazil the factors involved are still poorly understood. Through standardized sampling, our study aimed to assess the effects of an urbanization gradient on the abundance of House Sparrows in the city of Campo Grande, in central-western Brazil. We recorded House Sparrow and Saffron Finch (*Sicalis flaveola*) abundance and the percentage of urbanized area (impervious surface) in 61 hexagons of 16 ha each. We surveyed sparrows by using fixed-radius (50 m), 10-min point counts (4 points/hexagon). We recorded 897 House Sparrows and 408 Saffron Finches in all sampled hexagons, with abundance ranging from 0 to 68 House Sparrows/hexagon (~1 individual/ha) and from 0 to 22 Saffron Finches/hexagon (0.42 individual/ha). We found a significant relationship between House Sparrow abundance and the proportion of hexagon impervious surface according to a quadratic equation, as well as more birds in areas that exhibit moderate to high urbanization than in low urbanization. Multilevel Structural Equation Models showed that House Sparrows were negatively (but nonsignificantly) affected by buildings and trees >5 m in height, positively affected by buildings <5 m in height (houses), and Saffron Finch abundance had a positive but nonsignificant effect in House Sparrow distribution. Even for a bird considered common and adapted to urban conditions, cities seem to have barriers for the establishment of House Sparrows. Simple urban architectural considerations, such as the establishment of roof openings or the management of town squares and vacant lots that allow the growth of seed grasses, could help these birds to continue using urban landscapes. *Received 23 September 2021. Accepted 17 September 2022.*

Key words: Saffron Finch, *Sicalis flaveola*, urban birds, urban planning, vacant lots.

**Uso de hábitat por pardais (*Passer domesticus*) em Campo Grande, Brasil**

RESUMO (Portuguese)—As populações de pardais (*Passer domesticus*) têm sido afetadas negativamente em várias regiões do mundo devido ao processo de urbanização, embora no Brasil os fatores ainda sejam mal compreendidos. Por meio de amostragem padronizada, este estudo teve como objetivo verificar os efeitos de um gradiente de urbanização sobre a abundância de pardais na cidade de Campo Grande, na região centro-oeste do Brasil. A abundância de pardais e canários-da-terra (*Sicalis flaveola*) e a porcentagem de área urbanizada (superfície impermeável) foram registradas em 61 hexágonos de 16 ha cada um. As amostragens foram feitas por pontos de escuta por 10 min em 4 pontos/hexágono, considerando-se um raio de 50 m. Registramos 897 pardais e 408 canários-da-terra em todos os hexágonos, com abundância variando de 0–68 pardais/hexágono (~1 indivíduo/ha) e de 0–22 canários-da-terra/hexágono (0.42 indivíduo/ha). Encontramos uma relação significativa entre a abundância de pardais e proporção da superfície impermeável no hexágono de acordo com uma equação quadrática, bem como mais aves em áreas que apresentam níveis de gradiente de urbanização moderado a alto do que em níveis altos. Modelos de Equações Estruturais Multinível mostraram que pardais foram negativamente (mas não significativamente) afetados por edifícios com altura superior a 5 m e árvores e positivamente afetados por edifícios <5 m de altura (casas), enquanto a abundância de canários-da terra teve um efeito positivo não significativo. Mesmo para uma espécie de ave considerada comum e adaptada às condições urbanas, as cidades podem apresentar barreiras ao estabelecimento de pardais. Técnicas arquitetônicas simples como o estabelecimento de fissuras em telhados ou o manejo de praças e terrenos baldios que permitem o crescimento de gramíneas que produzem sementes podem contribuir para que essas aves continuem frequentando as paisagens urbanas.

Palavras-chave: aves urbanas, canários-da-terra, planejamento urbano, *Sicalis faveola*, terrenos baldios.

Urbanization is a dynamic process that changes natural ecosystems into places that meet human needs. Urban landscapes are characterized as a heterogeneous environment, where native green areas are associated with artificial habitats that vary in terms of size, shape, and level of human occupation (McDonald et al. 2018). Several studies indicate that bird species richness declines with urbanization, mainly because of the depth of modifications of natural habitats (see Aronson et al. 2014). As a result, remnants of the original landscapes may not exhibit their former heterogeneity and habitat structure, which in turn may affect species, families, or functional groups of local avifaunas (Chace and Walsh 2006, Reis et al.

[1] Universidade Federal de Mato Grosso do Sul, Instituto de Biociências, Campo Grande, MS, Brazil
[2] Comitê Brasileiro de Registros Ornitológicos – CBRO, São Paulo, Brazil
[3] Departament de Biologia Evolutiva, Ecologia i Ciències Ambientals, Facultat de Biologia, Universitat de Barcelona, Spain
* Corresponding author: franco.souza@ufms.br
Associate Editor: Mark E. Deutschlander

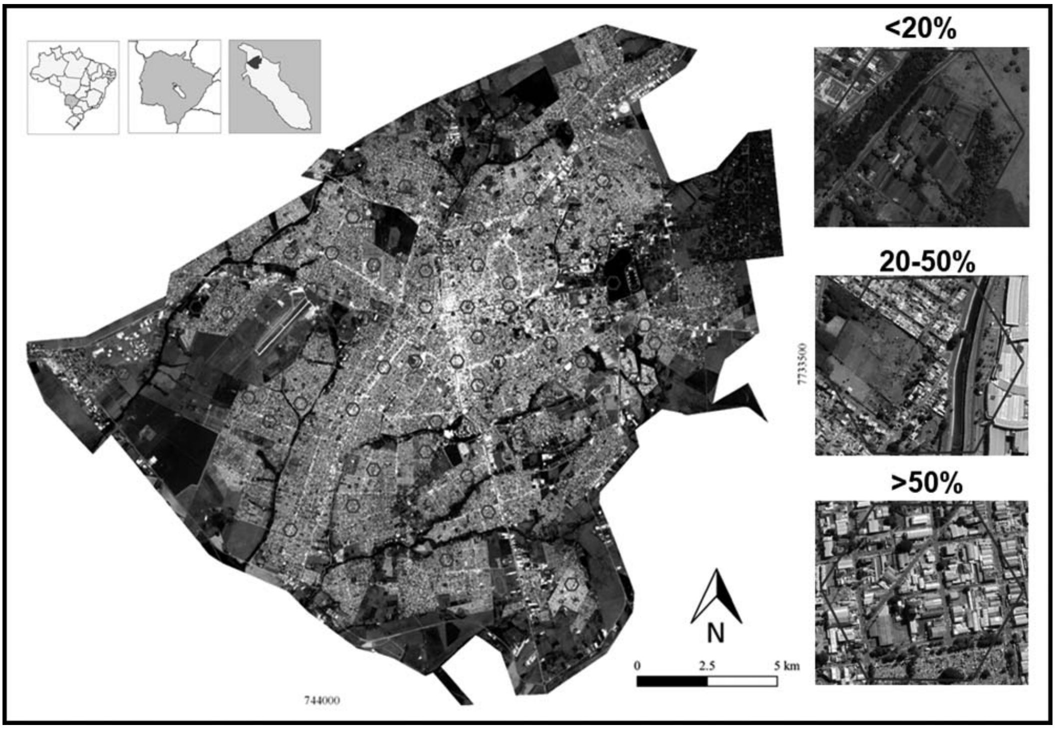


**Figure 1.** Location of the Campo Grande municipality in Mato Grosso do Sul, central-western Brazil. We sampled 61 hexagons within the urban area and estimated House Sparrow abundance relative to 3 levels of urbanization based on the proportion of impervious surface: low (<20%), moderate (20–50%), and high (>50%) (modified from Souza et al. 2019).

2012, Estevo et al. 2017, Batáry et al. 2018, Souza et al. 2019).

Paradoxically, these newly created urban spaces are also used as bird habitat (town squares, forest fragments, gardens, and vacant lots) and should be considered as important elements for species conservation and city management policies (Aronson et al. 2017, Lepczyk et al. 2017). In addition to drastic changes in biotic and abiotic characteristics of the original habitats, the urbanization process modifies the permeability of the landscape and creates large areas of impervious surfaces largely devoid of vegetation (Bhakti et al. 2021). Impervious surfaces affect the functional connectivity of populations (Bhakti et al. 2021) and the interaction between intrinsic characteristics of birds, such as their dispersal capacity, and the structure of their surrounding environments such as land cover. Although urbanization may generally represent a threat to biodiversity, cities are also habitat to many species. Some of them have demographic parameters that exceed those of species that inhabit natural environments such as larger populations, faster growth rates, and higher productivity, which reflect different modes, behaviors, and adaptations of these organisms to cities (Spotswood et al. 2021).

Species more tolerant to environmental changes can benefit from these newly created habitats (Lepczyk et al. 2017) and one of the icons of this process is the House Sparrow (*Passer domesticus*). The House Sparrow is considered an exotic species in more than 50 countries (BirdLife International 2021, Callaghan et al. 2021). Although its global population is extremely large (Callaghan et al. 2021), there are numerous reports of local declines taking place in different continents (Sharma and Binner 2020, Berigan et al. 2021, BirdLife International 2021, Mohring et al. 2021). Evidence shows there might be habitat-related differences in population trends. Some studies have shown that urban habitat may affect House Sparrow populations in different ways: positively by providing suitable nesting sites in buildings and negatively by decreasing available feeding sites (Summers-Smith 2003, Chamberlain et al. 2007, Murgui and Macias 2010, Šálek et al. 2015, Skórka et al. 2016, Rodrigues et al. 2018, Jokimäki et al. 2021). The literature also documents that House Sparrow interactions with other putative urban competitors could affect their abundance, suggesting that biotic and abiotic factors alike play a role in House Sparrow presence throughout urban areas (MacGregor-Fors et al. 2010, Skórka et al. 2016, Moudrá et al. 2018).

In South America, House Sparrows have been recorded since the 19th century (Sainz-Borgo et al. 2016). In Brazil, they were introduced for pest control in the state of Rio de Janeiro in the early 20th century (Sick 1959). Currently, the House Sparrow has been recorded in nearly all the Brazilian territory, invariably associated with anthropogenic areas (Lima et al. 2012). However, to date there is no study that addresses the association of House Sparrows with urban characteristics and with other syntopic birds.

The aim of our study was to determine the effects of some components of habitat heterogeneity on the abundance of House Sparrows along an urbanization gradient in a city of central-western Brazil. In our analyses, we also included the Saffron Finch (*Sicalis flaveola*), a seemingly syntopic, small bird with similar feeding and nesting behavior as the House Sparrow. Following Skórka et al. (2016), we hypothesized that Saffron Finch could act as a competitor and affect House Sparrow population dynamics. Specifically, we predicted that House Sparrow abundance will be negatively affected by (1) buildings higher than 5 m (usually represented by commercial, residential, and office buildings, because the architecture of these is made up of taller vertical structures with few or no roofs useful for nesting); (2) tree abundance, because their shade can reduce available feeding habitat for sparrows by reducing the open, sunny areas that allow grass growth; and (3) abundance of Saffron Finches, given the putative competition for feeding and nesting sites. We also predicted that sparrows would (4) be positively affected by an increase in impervious surfaces in highly urbanized areas, and (5) exhibit a positive association with areas dominated by buildings less than 5 m height (mainly houses) because house roofs make better sparrow nesting sites.

## Methods

### Study area

The city of Campo Grande is located in Mato Grosso do Sul, in central-western Brazil (20°28′07″S, –54°37′20″W; Fig. 1). It has ~920,000 inhabitants, a population density of 113 inhabitants/km$^2$, and an urbanization rate of 98% (Planurb 2017). Green areas correspond to 2.4% of the urban landscape, with typical cerrado phytophysiognomies, areas of regeneration, ecotones between cerrado and seasonal semideciduous forests, agriculture, and cattle pastures (Planurb 2017). In the last 30 years, urban expansion has doubled, resulting in a loss of native vegetation of almost 80% (Carelli et al. 2018). The climate is markedly seasonal, with a dry period from April to September and a rainy season between October and March. The mean annual rainfall is 1,500 mm and the temperature ranges between 18 and 30 °C, although extreme periods of cold (1 °C) and hot weather (~43 °C) are common (Ferreira et al. 2017).

### Bird and habitat sampling

Birds were sampled daily in February–March 2016, a period associated with the bird breeding season in the area (FLS, pers. obs.). To ensure a broad spatial coverage and the inclusion of landscape heterogeneity, Campo Grande was subdivided into 2,350 hexagons using ArcGIS 10.1 (ESRI 2012) of 16 ha each and, for each hexagon, we calculated the percentage of urbanized area (impervious surface) with a satellite image (RapidEye, 5 m resolution, 2011). Through an ArcGIS spatial analysis (zonal statistical tool), we generated an urbanization gradient (0–100%) from the periphery (less urbanized) to the city center (highly urbanized).

We verified the frequency of different categories of the city's impervious surface and we selected hexagons that could be accessed (considering logistical and safety issues), resulting in 61 hexagons with a continuous gradient of impervious surface (0–90%; see details in Souza et al. 2019). With this information at hand, we classified the hexagons according to 3 levels of urbanization according to McKinney (2002): low (<20% impervious surface), moderate (20–50%), and high (>50%) (Fig. 1). Within each hexagon, we defined 4 fixed observation points (cardinal points), with a minimum distance of 200 m

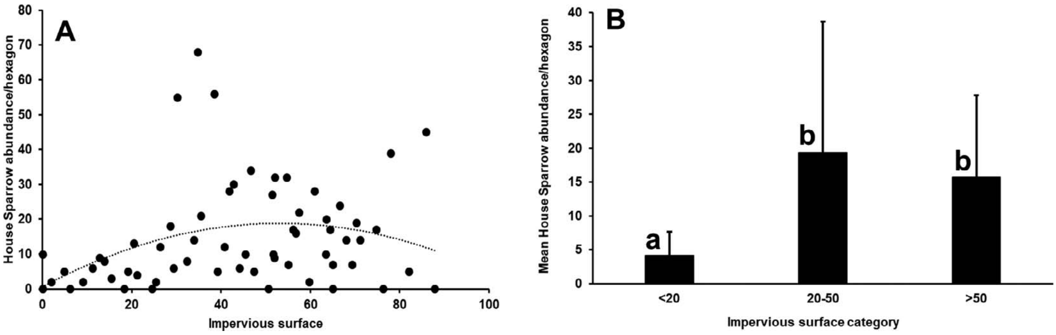


**Figure 2.** House Sparrow abundance according to impervious surface (A) and urbanization gradient (B) in the city of Campo Grande, Mato Grosso do Sul, Brazil. Dashed line in A represents quadratic regression. Vertical lines in B are standard deviations; different letters denote significant statistical differences in ANOVA.

between them, where at least 1 observer remained for 10 min to record both House Sparrows and Saffron Finches within a radius of 50 m, always in the morning (0600–1000 h). The abundance of House Sparrow and Saffron Finch per hexagon (only 1 visit conducted for each survey point) was then defined as the sum of the records from the 4 observation points, that is, the maximum number of individuals detected in each hexagon during our sampling. For each hexagon we also measured the total number of buildings and trees shorter and taller than 5 m around the 4 fixed observation points.

### Analyses

We used regression analyses and analysis of variance (ANOVA) with Tukey's pairwise post hoc tests to compare House Sparrow abundance among hexagons with different levels of urbanization (analyses performed with PAST; Hammer et al. 2001). By using multilevel structural equation models (SEM) we estimated the direct and indirect effects of habitat and Saffron Finch on House Sparrow abundance. We performed these analyses using the statistical software JASP 0.16.1.0 (JASP Team 2022).

## Results

We recorded 897 House Sparrows and 408 Saffron Finches in all sampled hexagons, with abundance ranging from 0 to 68 House Sparrows/hexagon (~1 individual/ha; range: 0–4.3) and from 0 to 22 Saffron Finches/hexagon (0.42 individual/ha; range: 0–1.3). We found a significant relationship between House Sparrow abundance and proportion of the impervious surface in the hexagon according to a quadratic equation ($R^2 = 0.10$, $P < 0.05$; Fig. 2A) and detected more birds ($F_{2,58} = 4.56$, $P = 0.01$) in areas that exhibit moderate (20–50%, $n = 21$ hexagons) to high (>50%, $n = 28$) urbanization levels than in low urbanization (<20%, $n = 12$; Fig. 2B).

The SEM met the significant statistical criteria on our expected variables (AIC = 3161.3, $\chi^2 = 4.61$, $P = 0.10$). Buildings have negative impact on vegetation but this was more exacerbated (significant) for small (<5 m height) trees ($R = -0.06$, $P = 0.03$). According to our predictions, House Sparrow was negatively (but not significantly) affected by buildings and >5 m height trees and positively affected by buildings (houses) <5 m height ($R = 0.14$, $P < 0.01$). Contrary to our expectations, Saffron Finch abundance had a positive but nonsignificant effect (Fig. 3).

## Discussion

Our results indicate that House Sparrows occupy areas with high to moderate levels of urbanization (20–50% impervious surfaces). In the city of Campo Grande, these correspond to neighborhoods that have abandoned vacant lots and town squares, which can provide resources in the form of seeds, grains, and even artificial feeders (Souza et al. 2019). Our findings are similar to those found in Spain (Murgui 2009) and India (Nath et al. 2019), in which sparrows avoided highly urbanized areas that did not provide suitable sites for nesting and foraging. In Brazil (in the

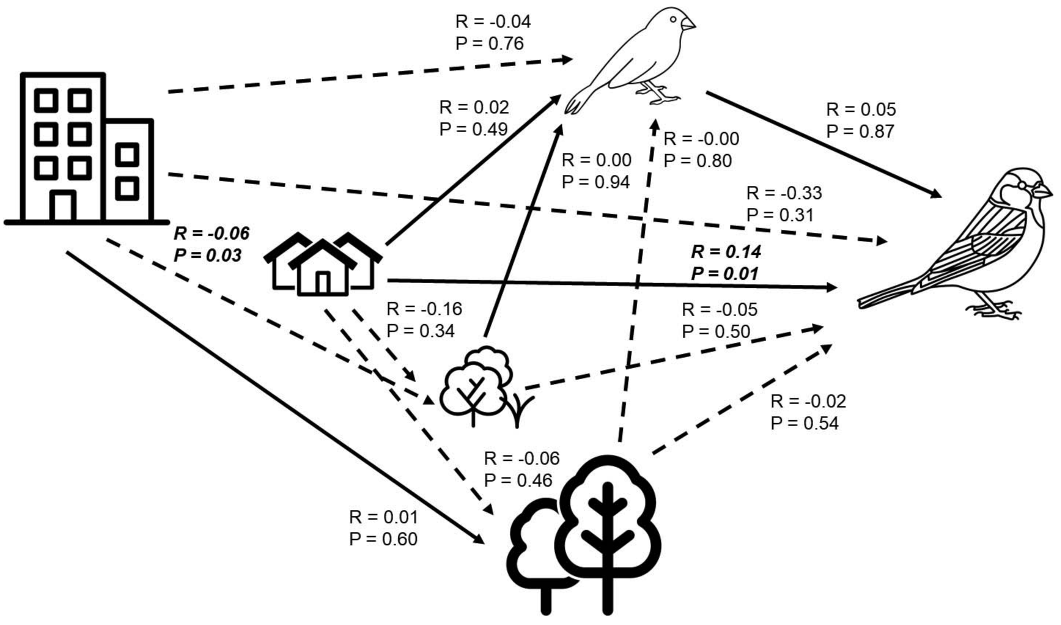


**Figure 3.** Final SEM of direct and indirect effects of habitat structures (buildings, houses, and trees) and Saffron Finches on House Sparrows from Campo Grande, a medium-sized city in central-western Brazil. Arrows represent unidirectional relationships among variables. Solid arrows denote positive and dashed arrows negative relationships. Variables affecting significantly ($P < 0.05$) are identified in bold italic font. Icons from the Noun Project (https://thenounproject.com/).

municipality of Curitiba), Abilhoa and Amorin (2017) also found that House Sparrows were the most persistent species in the low to intermediately urbanized sites and suggested that tolerant urban species appear to benefit from the greater availability of resources that occur in urban areas.

Despite the House Sparrow's seemingly high tolerance to urbanization, the synergy between extrinsic factors (such as architectural practices that limit or block access to nesting spaces in roofs) and intrinsic factors (such as competition with other birds for nesting sites and food) is thought to limit their successful colonization of urban areas (Summers-Smith 2003, Liker et al. 2008, MacGregor-Fors et al. 2010, Sainz-Borgo et al. 2016, Skórka et al. 2016, Moudrá et al. 2018).

Interestingly, Angelier and Brischoux (2019) found that rural nest boxes were occupied more frequently by House Sparrows than urban ones, suggesting that cavity availability is probably a more important constraint in rural areas than in cities. These findings may be viewed as similar to the urban gradient in our study site. In peripheral areas, the more permeable surface (green areas represented by forest patches and vacant lots) reflects few urbanization-associated effects and therefore also make unavailable nesting sites simply because there are fewer houses.

Other factors not considered here may also affect House Sparrow distribution in cities. As an example of these, Balmori (2021) suggested that electromagnetic pollution could be an important source of contamination that would affect House Sparrow abundance in cities in recent years because of its direct impacts on sparrow survival or indirectly by decreasing insect prey during the nesting period. The disappearance of House Sparrows and the introduction of cell phone towers were temporally correlated with this bird's population declines and chronologically matched the growth of mobile telephone networks of recent decades. Although this hypothesis warrants further investigation, this factor is related to socioeconomic variables in Brazil and elsewhere. Socioeconomic status has been linked to House Sparrow abundance in other settlements (Shaw et al. 2008, Moudrá et al. 2018).

Many studies suggest that the reduction of impervious surfaces, increased environmental heterogeneity, and management of green areas are initiatives that can contribute to making the city more biodiversity friendly and provide an opportunity for ecologists to work with decision makers in the management and conservation of cities (Souza et al. 2019). Simple architectural changes such as establishing gaps or openings in roofs and managing town squares and vacant lots to allow the growth of grasses that produce seeds (Šálek et al. 2015) could contribute to the House Sparrow's ability to continue inhabiting urban landscapes.

## Acknowledgments

The authors are grateful to B. Bueno who participated in fieldwork. Two anonymous reviewers and E. Ruelas Inzunza provided important contributions to an early version of the manuscript. FLS thanks CNPq for continuously support his research with a productivity grant (307599/2021-3).

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