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Bird species present in urban parks are more colorful than urban avoiders: A test in the Argentinian Pampas

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ABSTRACT

Bird plumage color has been assessed as a possible trait driving the presence of bird species in urban areas. Although some species can see the ultraviolet (UV) spectrum, the mentioned studies did not take into account UV reflectance when characterizing bird plumage. This study aimed to use a recent database of the colorfulness in passerines that incorporated the UV spectrum to compare bird colorfulness and other traits between urban parks and rural areas in Central-East Argentina. Birds in urban parks were surveyed in 51 parks in 6 cities during breeding and non-breeding seasons. A list of Passeriformes species from parks was created, and a list of urban avoider species was created from the bibliography. Species traits were body mass, clutch size, migratory status, nesting site, diet and habitat breadth, and plumage colorfulness. A total of 85 species were detected in the regional pool, of which 30 species were detected in urban parks. Bird species present in urban parks were more colorful than bird species only present in rural areas. In addition, bird presence in urban parks was positively related to their regional frequency and diet breadth. Moreover, urban presence was related to nesting on trees and buildings, whereas species not present in urban parks nested on the ground. The results obtained showed that bird color is significantly associated with presence of bird species in urban parks.

1. Introduction

According to recent ecological theory, local species assemblages are molded by dispersion from the regional species pool, selection of the local environment, ecological drift, and species evolution or historical factors (Ricklefs and Schluter, 1993; Vellend, 2010, 2016; Keddy and Laughlin, 2021). For example, species that are abundant in the regional pool have more chances to disperse to local assemblages (Ricklefs and Schluter, 1993; Vellend, 2010, 2016). In addition, species that disperse to local assemblages may be selected or filtered by local factors such as abiotic characteristics or biotic interactions (Vellend, 2010, 2016; Keddy and Laughlin, 2021). Local assemblages may be affected by ecological drift due to random demographic or catastrophic events (Vellend, 2016).

In urban areas, several studies have shown that dispersion and selection are strong determinants of local species assemblages. Species inhabiting urban areas have been associated with high regional densities, suggesting a role of dispersal molding local bird assemblages (Croci et al., 2008; Møller, 2014; Dale et al., 2015; Leveau et al., 2022). In addition, urban areas are characterized by a dominance of impervious surfaces, exotic vegetation, human disturbance, pollution, and alteration of resource flows which may constitute a filter to bird species (Chace and Walsh, 2006; Shanahan et al., 2014). Thus, bird species in urban areas are probably selected according to life-history traits related mainly to diet, nesting behavior, and residency status (Croci et al., 2008; Patankar et al., 2021). Generalist diet and nest locations in buildings or trees have been shown to promote bird species in urban areas (Leveau and Leveau, 2005; Bonier et al., 2007; Kark et al., 2007; Leveau, 2013; Palacio, 2020). Moreover, resident species have been favored over migratory species in urban areas (Blair and Johnson, 2008; MacGregor-Fors et al., 2010; Amaya-Espinel and Hostetler, 2019).

Recently, several authors have shown that plumage color may be an important trait in molding urban bird assemblages (Leveau, 2019; Leveau and Ibáñez, 2022; Turak et al., 2022; Hambuckers et al., 2023). Bird species with grey or dark plumage colors have been favored in urban areas, probably due to an enhanced camouflage with grey impervious surfaces (Leveau, 2022), and increased resistance to chemical pollutants (Turak et al., 2022). These studies have considered the visible light spectrum and characterized plumage color based on plates and photos in books (Leveau, 2019; Turak et al., 2022). However, some bird species can also see in the ultraviolet (UV) spectrum (Lind et al., 2014; Olsson et al., 2021). Therefore, it is relevant to consider UV vision

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when analyzing the role of plumage color on the presence of bird species in urban areas.

A recent study that measured global Passerine plumage colorfulness and took into account the UV spectrum found that bird species were more colorful in the evergreen forests of the tropics (Cooney et al., 2022). These authors suggested that plumage colorfulness may help intra and interspecific communication in closed habitats. Moreover, the authors provided data on the colorfulness of bird species.

This study aims to relate the presence of bird species in urban parks of East-Central Argentina with their plumage colorfulness and other biological traits, taking into account phylogenetic relations between species. I took advantage of available data to compare the colorfulness of bird species and other biological traits between urban parks and rural areas of central Argentina. Due to urban parks in Central Argentina having more tree cover than rural areas (parks = 32.36%, rural areas = 3.63%; Leveau, 2013; Leveau and Leveau, 2016), I expected bird species in urban parks to be more colorful than species present only in rural areas. Moreover, I expected a positive relationship between the regional abundance of bird species and their presence in urban parks, thus suggesting bird species dispersion from rural areas into urban parks. Finally, bird species in urban parks were expected to be diet generalists, residents, and tree nesters.

2. Materials and methods

2.1. Study area

The research was conducted in six cities of Central-East Argentina (Fig. 1). Cities varied in size from 29,629 inhabitants (Miramar) to 860,000 inhabitants (Mar del Plata) (Appendix Table S1; see Leveau, 2022). The landscape surrounding cities was dominated by croplands, cattle grazing, and scattered exotic tree plantations (*Eucalyptus* sp., *Pinus* sp.). The climate is temperate, with cold winters (between 7.5 and 8.5 °C mean monthly values), and warm summers (between 20.30 and 21.50 °C; Servicio Meteorológico Nacional). The mean annual precipitation ranges 901–923.6 mm. Altitude ranges between sea level and 188 m a.s.l.

A total of 51 urban parks were surveyed in the 6 cities. The number of parks surveyed varied between five (Necochea and Miramar) and 15 (Mar del Plata), according to city size (Appendix Table S1). Parks were selected along a gradient of distance to the city center (range = 0–6.83 km, mean = 1.62 km), and also according to area size (range = 0.21–8 ha, mean 2.23 ha). The habitat of urban parks was generally composed of lawns, shrubs, and trees, and dominated by exotic tree species (Appendix Fig. S1).

2.2. Passerine bird surveys in urban parks

A total of 71 fixed point counts were located in the urban parks. Parks of less than 2 Ha had only one point count in the center of the park, whereas larger parks had between two to three point counts separated at least by 200 m. Birds were counted for 5 min and an unlimited radius distance within each park. Bird surveys were made during two visits, one visit during June–July (non-breeding season) and another visit during October–November 2018 (breeding season). Only birds that used the parks by perching or searching for food were counted, whereas birds flying high were ignored.

2.3. Sample coverage of urban passerine bird communities

Data on bird species abundances was used to calculate species accumulation curves with the online software iNEXT (chao.shinyapps.io/iNEXTOnline/). Species accumulation was related to sample coverage, which is defined as the proportion of the total number of individuals that belong to the species detected in the sample (Hsieh et al., 2016). Sample coverage varies between 0 and 1, and the mean value with its 95% confidence interval was obtained through 999 iterations for the bird communities of urban parks.

2.4. Regional passerine species pool

According to the guidelines of Keddy and Laughlin (2021), the regional list of species was obtained through published species regional lists and maps, and personal observations through 22 years of bird-watching in the study area. Cities were nested in political districts, which in turn were nested in Buenos Aires Province (Fig. 1). The six cities belonged to six different districts. Therefore, species lists that had at least one record in the six districts were obtained from Narosky and Di Giacomo (1993). More recent distributional information in Buenos Aires province was obtained from Narosky and Táboas (2021) and maps in López-Lanús (2020) and Pearman and Areta (2020).

2.5. Passerine species traits

Species presence/absence from urban parks was related to species traits and their regional abundance. Species traits were body mass, clutch size, migratory status, nesting site, diet and habitat breadth, and plumage colorfulness. Body size and breadth of diet and habitat were obtained from the Elton Traits 1.0 database (Wilman et al., 2014). Body size was the species weight (grams), whereas diet and habitat breadth were calculated using Rao's quadratic entropy B_D with the percentage values of different diet and habitat items (see Leveau and Ibáñez, 2022; de Cáceres et al., 2011, 2016). The B_D index varies between 0 (low niche breadth) to 1 (maximum niche breadth) and was calculated with the

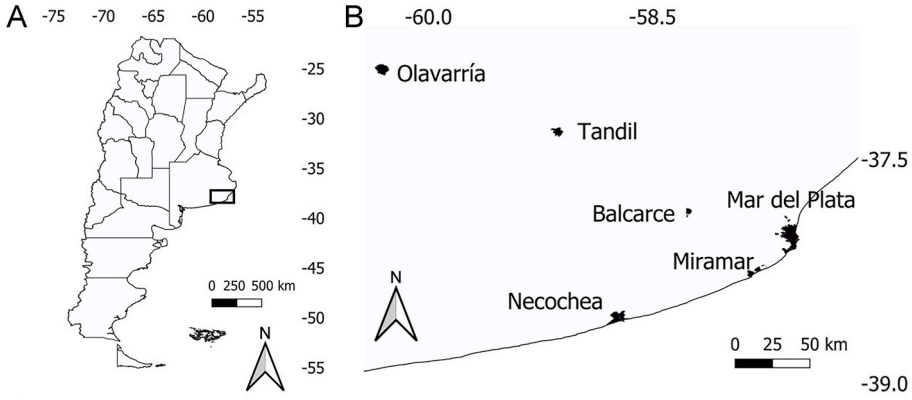


Fig. 1. Location of the region in Argentina (A), and location of the six cities in the region (B).

nichevar function of the indicspecies package. Clutch size and nesting site were obtained from de la Peña (2013). The presence/absence of migratory status was obtained from Narosky and Di Giacomo (1993). Bird plumage colorfulness was obtained from Cooney et al. (2022), which contained information based on calibrated ultraviolet photographs. Colorfulness was the number of 3D spaces (loci) occupied by each species in the tetrahedral color space. Finally, the regional abundance of bird species was obtained from Narosky and Táboas (2021), who developed an index of bird species detectability that ranges from 1 (rare) to 6 (very abundant). Due to some biological traits, such as clutch size, body size, diet, and habitat breadth can vary geographically (Wiens, 1989), the patterns obtained should be taken with caution.

2.6. Statistical analyses

The regional list of passerine bird species was classified into urban, which were recorded in urban parks, and non-urban species, which were not registered in urban parks. Then, the presence/absence of bird species in urban parks was related to the passerine traits: body mass, clutch size, migratory status, nesting site, diet and habitat breadth, plumage colorfulness, and regional abundance. A generalized mixed model with a binomial distribution of errors was used with the glmmTMB function of the glmmTMB package (Brooks et al., 2017) in R (R Core Team, 2019). To control for phylogenetic relatedness of species, bird family was used as a random factor. Continuous predictor variables were scaled with the function scale in R (R Core Team, 2019). Models were obtained by backward elimination of non-significant variables ($p > 0.05$) from the full model using the anova function. The final model was compared with a null model through the Akaike information criterion (AIC), considering strong support for the final model if AIC values are lower than 2 with respect to the null model (Burnham and Anderson, 2004). Final models were plotted using the visreg function of the visreg package (Breheny and Burchett, 2017).

3. Results

A total of 85 Passeriform species were detected in the regional pool, of which 30 species were detected in urban parks. The most frequent species in urban parks were the Rufous Hornero (*Furnarius rufus*), the House Sparrow (*Passer domesticus*), and the Great Kiskadee (*Pitangus sulphuratus*). Bird species sample coverage in urban parks was 0.997 (Confidence interval = 0.995–0.999; Fig. 2), suggesting that sampling of urban parks was nearly complete and few species were not sampled.

The final model explaining the presence of bird species in urban parks included the regional frequency of species, nesting site, diet breadth, and colorfulness (model AIC = 73.3, null model AIC = 114.4; Table 1; Fig. 3). Urban presence was related positively to regional frequency, diet breadth, and plumage colorfulness (Fig. 3). In addition, urban presence was related to nesting on trees and buildings, whereas species not present in urban parks nested on the ground (Fig. 3).

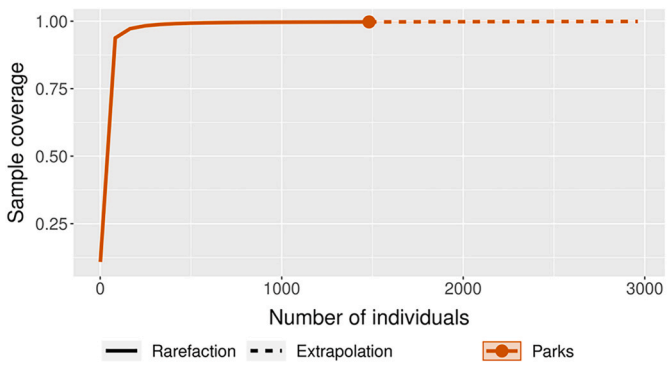


Fig. 2. Sample coverage of bird species in urban parks related to the number of individuals.

Table 1
Generalized mixed final model showing the relationship between bird species presence in urban parks and species traits and regional species frequency.

Variable	Estimate	Std. Error	*z* value	*P*
Intercept	0.523	0.886	0.590	0.555
Regional abundance	1.521	0.439	3.463	<0.001
Nest–Ground	−4.497	1.324	−3.396	<0.001
Nest–Tree	−0.593	0.967	−0.613	0.540
Colorfulness	0.788	0.382	2.061	0.039
Diet Breadth	0.787	0.382	2.058	0.040

Nest site: nesting in buildings is in the intercept.

4. Discussion

The analyses revealed that the presence of bird species in urban parks was related to plumage colorfulness. In addition, other traits such as nesting site and diet were related to bird species presence in parks, suggesting that this type of urban habitat constitutes an environmental filter to the regional species pool. However, due to the presence of bird species in urban parks also being associated with their regional abundance, the dispersion mechanism may be involved in the colonization of urban areas by bird species.

The pattern of bird coloration in urban parks agreed with our hypothesis. Urban parks have more tree cover than rural areas of the Pampas, and wooded environments are expected to have more colorful bird species (Bailey, 1978; Cooney et al., 2022; but see Dalrymple et al., 2015). Therefore, urban parks in the Pampas probably acted as a large-scale experimental manipulation of the landscape, influencing the differential bird species colonization related to their plumage coloration. Colorful birds in the more closed urban parks may enhance their intra and interspecific communication (Cooney et al., 2022). Moreover, urban parks may provide food resources containing carotenoids, which are essential to maintaining colorful plumages (Barreira and Garcia, 2019). Probably, due to the lack of predators in urban areas (Palomino and Carrascal, 2007; Magle et al., 2014), bird species in urban parks may allocate more energy to producing colorful plumages than to avoiding predators (Croci et al., 2008). On the contrary, urban avoiders in rural areas may have more predators and thus invest more energy in avoiding predation.

Other traits influencing the presence of bird species in urban parks were nesting site and diet breadth. Species nesting in buildings and trees were present in urban parks, whereas species nesting on the ground were not present. The tree cover in parks and the buildings surrounding them may favor the nesting substrate availability for birds, whereas nest predation may exclude ground-nesting birds in urban parks (Croci et al., 2008; Jokimäki et al., 2016; Leveau and Ibáñez, 2022). A high diet breadth may favor bird species that exploit a variety of food resources present in urban parks, such as invertebrates, fruits, plant, and human food wastes (Callaghan et al., 2019; Palacio, 2020).

The association between the regional abundance of bird species and their presence in urban parks highlights the role of dispersal in shaping urban bird communities. Therefore, the most abundant species in the region have more chances of entering cities, colonizing, and adapting to the new environmental conditions (Møller, 2009, 2014; Sol et al., 2013). The gradual adaptation to the urban environment may also include loss of fear humans, the capacity of feeding innovations, and other cognitive abilities to cope with novel environments (Møller, 2009, 2014; Sol et al., 2013; Morelli et al., 2023).

5. Conclusions

The results obtained showed that bird color is significantly associated with the presence of bird species in urban parks. Bird species in urban parks were more colorful than bird species excluded from cities of

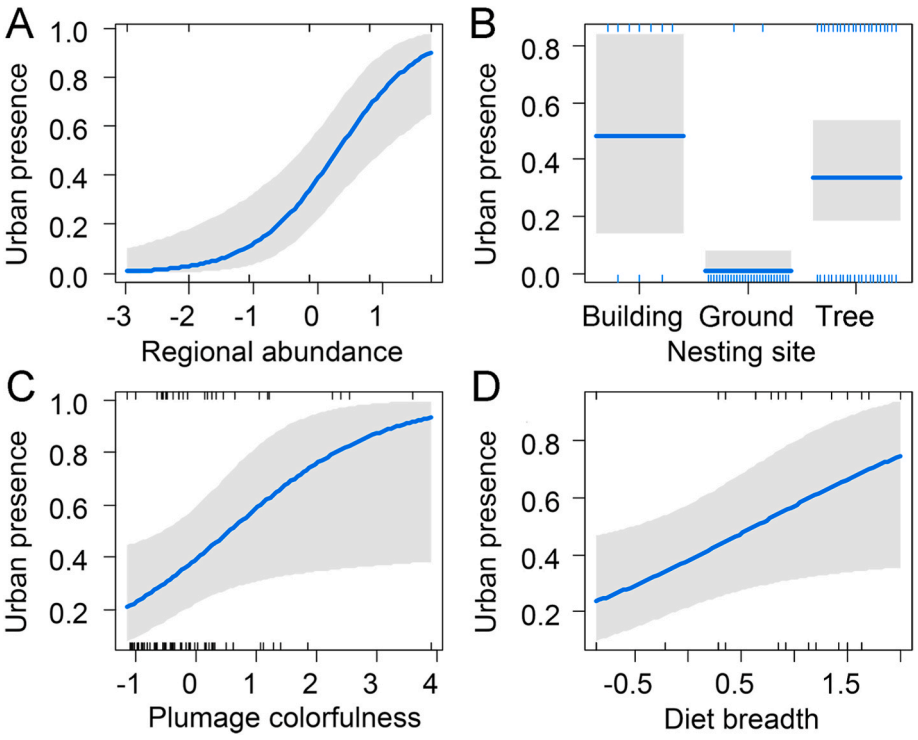


Fig. 3. Probability of occurrence of bird species in urban parks (urban presence) in association with species regional frequency and species traits. Blue lines indicate the fitted model and grey areas indicate 95% confidence intervals. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

the Pampean region. Due to urban parks having more tree cover than rural areas of Pampas (Leveau, 2013), the results obtained support recent findings made at global scales where the most colorful birds are in the tropical forests compared to open areas. Thus, the difference in bird colorfulness between urban parks and non-urban areas may change with the biome. For example, urban parks located in tropical forested biomes may have lower bird colorfulness than forested non-urban areas. Therefore, studies in different biomes are necessary to get more insights into the urbanization impacts on bird colors.

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CRediT authorship contribution statement

Lucas M. Leveau: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Lucas Leveau reports financial support was provided by Agencia Nacional de Promoción de la Investigación, el Desarrollo Tecnológico y la Innovación.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.avrs.2024.100161.

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