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Article

Urban Parks Are Related to Functional and Phylogenetic Filtering of Raptor Assemblages in the Austral Pampas, Argentina

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Simple Summary: Urban parks are hot spots of bird diversity in cities. However, their role as urban filters for raptor species has not been assessed yet. This study aimed to compare the functional and phylogenetic traits of raptor assemblages in urban parks with the regional species pool of raptors in east–central Argentina. Diurnal raptors were surveyed in 51 urban parks in six cities during breeding and nonbreeding seasons. The regional species pool was assessed through raptor surveys and published maps surrounding the cities. The functional and phylogenetic relatedness of urban raptors was higher than expected by chance, suggesting filtering induced by urban parks. Urban raptors were, in general, generalist species with small body sizes. Moreover, species tended to be part of the Falconidae family. Based on the results obtained here and in other published work, a model of raptor assembling in urban parks is proposed. The design of urban parks needs to be more heterogeneous, promoting the occurrence of specialist raptors.

Abstract: Urban parks are hot spots of bird diversity in cities. However, their role as urban filters for raptor species has not been assessed yet. This study aimed to compare the functional and phylogenetic traits of raptor assemblages in urban parks with the regional species pool of raptors in east–central Argentina. Diurnal raptors were surveyed in 51 urban parks in six cities during breeding and nonbreeding seasons. The regional species pool was assessed through raptor surveys and published maps surrounding the cities. The observed functional and phylogenetic relatedness of urban raptors was compared with 999 simulated raptor assemblages from the regional species pool. A total of five species were recorded in urban parks. The Chimango Caracara (*Milvago chimango*) was the numerically dominant species, comprising 95% of the 172 individuals recorded. The regional species pool was composed of 20 diurnal species. The functional and phylogenetic relatedness of urban raptors was higher than expected by chance, suggesting filtering induced by urban parks. Urban raptors were, in general, generalist species with small body sizes. Moreover, species tended to be part of the Falconidae family. Based on the results obtained here and in other published work, a model of raptor assembling in urban parks is proposed. The design of urban parks needs to be more heterogeneous, promoting the occurrence of specialist raptors.

Keywords: birds of prey; diet; green area; Latin America; urbanization

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1. Introduction

Raptors are a fundamental part of bird communities in urban areas due to their role in providing ecosystem services, such as removing livestock carcasses and regulating pest populations [1,2] or providing cultural benefits [3]. However, urban areas may exclude certain raptor species through habitat loss and the fragmentation of rural and natural areas [4–6]. Moreover, threats that include electrocution, collisions with structures and vehicles, poisoning, and diseases also may affect the raptor presence in urban areas [6,7].

Urban areas may constitute a filter for raptor species, allowing for the entry of species with certain biological traits [8,9]. For example, recent large-scale studies found that habitat generalist and small-size species were more frequent in urban areas [10,11], whereas an analysis conducted in the United States found that diet generalists and forest species were more frequent in cities [12]. Moreover, species that nest in trees may be favored by urban areas [12]. In addition, migrant species may be excluded from urban areas due to habitat loss and human disturbance [8,13]. However, an analysis carried out in Argentina revealed that raptor species occurrence in urban areas was not related to their biological traits [14].

Furthermore, the urban filter may be associated with the phylogenetic traits of various animal species, allowing the entering of species that are phylogenetically related [15,16]. Nevertheless, the phylogenetic relatedness pattern of urban raptors showed contrasting results. Leveau et al. [14] found a trend of phylogenetic relatedness among urban raptors, in general, associated with more occurrences of Falconidae species in urban areas. However, Cooper et al. [10] did not find a significant relationship between Accipitridae species relatedness and urban occurrence.

Urban parks are one of the most common green area types in cities and are associated with a high bird species diversity [17]. In general, urban parks are dominated by lawns and some trees and shrubs, and vegetation is managed by pruning and irrigation [18]. Some raptor species may thrive in urban parks, due to their supply of nesting sites in trees and food resources such as passerines and doves [19–21]. However, other raptor species may be excluded from urban parks because of their specialized diet or habitat use. For example, raptor species that nest on the ground may suffer nest predation ([22,23] but see [24]). Although several authors have analyzed the effect of urbanization on raptor communities [4,5,10,25], no studies have analyzed how urban parks filter the phylogenetic and functional traits of raptors.

In this study, data obtained from the urban parks of six cities in central Argentina are used to analyze whether they constitute an environmental filtering to the raptor species of the regional pool. It is expected that raptor species in urban parks have a generalist diet and habitat use, small size, and nest on trees [10,12,14]. In addition, urban park raptors are expected to be related, and generally composed of Falconidae species.

2. Methods

2.1. Study Area

Surveys of diurnal raptors were conducted in six cities in east–central Argentina (Figure 1). The cities are located in the Austral Pampas, which are dominated by croplands and livestock grazing with scattered tree plantations. The climate is temperate, with cold winters with a monthly mean value between 7.2 and 8.1 °C, and warm summers with a monthly mean value between 20.30 and 21.50 °C (National Meteorological Service, https://www.smn.gob.ar/) (accessed on 18 April 2023).

In each city, between 5 and 15 parks were surveyed, according to park availability (Supplementary Materials, Table S1). Park area size ranged between 0.21 and 8.04 Ha (mean = 2.19; N = 51). Parks were distributed along the urban gradient, from the urban center to the city fringe. Parks in the urban center were surrounded by an impervious cover of >50% and had the highest pedestrian and car traffic surrounding them, whereas parks near the city fringe had a lower impervious cover and pedestrian and car traffic surrounding them. The habitat of urban parks was generally composed of lawns, shrubs, and trees, and was dominated by exotic tree species (Supplementary Materials, Figure S1). The population size of cities ranged between 29,629 and 860,000 inhabitants (Supplementary Materials, Table S1).

Raptor park use was assessed through unlimited radius point counts of 5 min during the first four hours after dawn. I registered individual raptors that were seen or heard, and those which were perching, eating or chasing prey, walking, or fighting with another raptor in the park area. Due to surveys being diurnal, some owl species that usually have diurnal activity, such as the burrowing owl (*Athene cunicularia*) or the short-eared owl (*Asio flammeus*) [26,27], can be detected. The unlimited point count is an accepted survey method for raptors [28–30]. Small parks of less than 2 ha had one point count, whereas larger parks had two or three point counts separated by 200 m. Surveys were carried out during one visit in July 2018 (nonbreeding season) and another visit between October and November 2018 (breeding season).

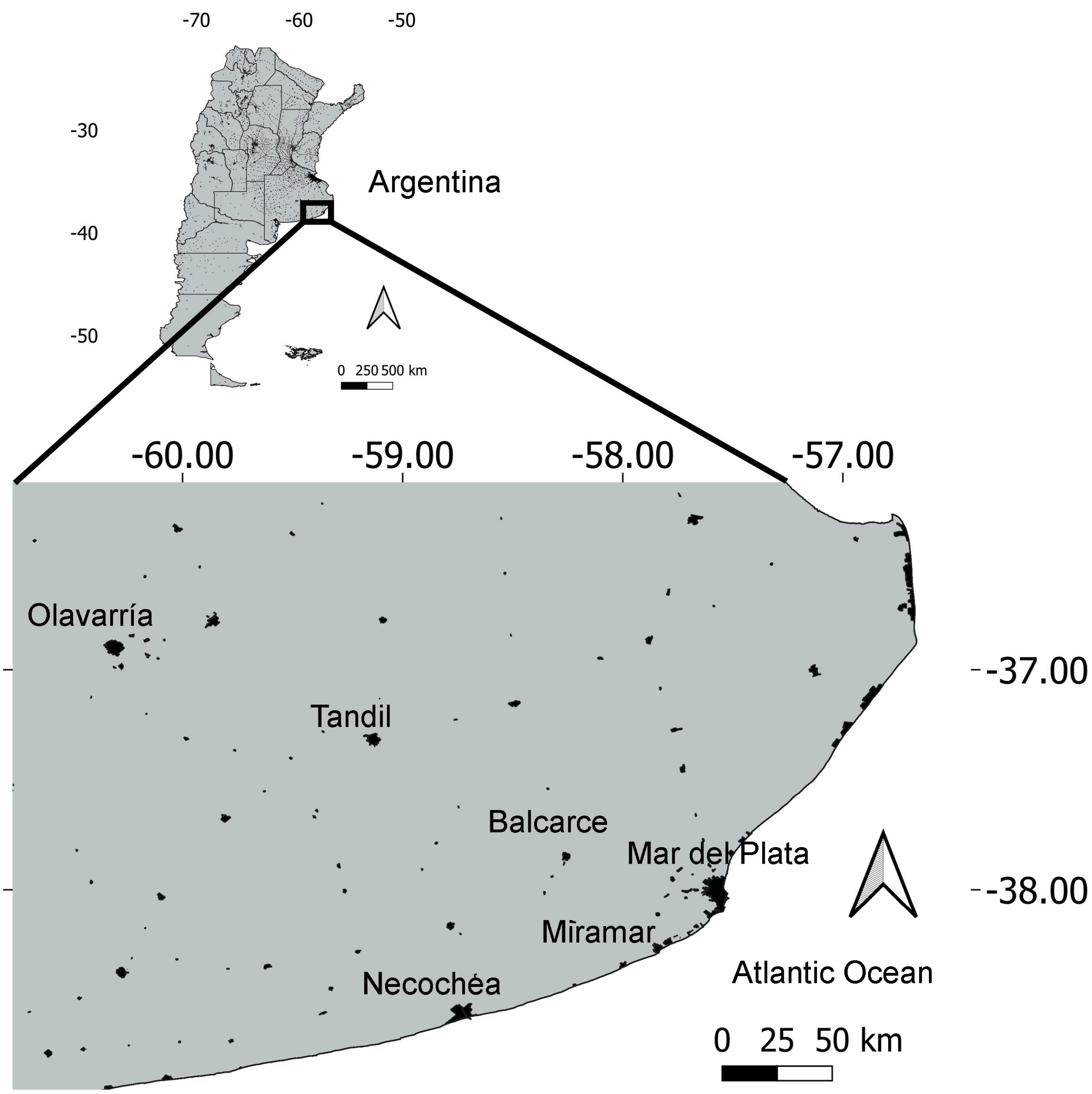

Figure 1. Location of the six cities surveyed in east–central Argentina. The dark color indicates the presence of urban areas.

2.2. Regional Pool of Species

The raptor regional species pool was assessed according to the guidelines of Keddy and Laughlin [31], who proposed to use of local species lists or maps to assess the regional pool of species (see Pärtel et al. [32]). A list of raptor species inhabiting the study area was compiled through a bibliography [33–35]. Resident and migrant species were considered.

2.3. Sample Coverage

The sample coverage of the urban raptor assemblage was assessed using the online software iNEXT (chao.shinyapps.io/iNEXTOnline/) (accessed on 10 September 2022). Sample coverage varies between 0 and 1, and it is the proportion of the total number of individuals detected during the two visits that belongs to the species detected in the sample [36]. A rarefaction curve of species accumulation with species abundance was calculated through 999 iterations. Then, the sample coverage of the assemblage with the 95% confidence intervals (CI) was obtained.

2.4. Raptor Traits

Raptor traits were compiled through a bibliography. Information about the diet, nesting site, habitat, foraging behavior, and migratory status was obtained from the Handbook of the Birds of the World online (accessed on 4 April 2020, see Leveau et al. [14]). The diet, nesting site, and foraging behavior were categorical variables, whereas habitat and migratory status were ordinal variables (Table 1, Leveau et al. [14]). In addition, mean body mass (g) was a continuous variable obtained from Wilman et al. [37].

Table 1. Diurnal raptor species and their functional traits. Habitat: 1 = open, 2 = semi-open, 3 = closed; migration: 1 = resident, 2 = partial migrant, 3 = migrant (see Methods for details). Species are ordered according to taxonomic classification. Species in bold were registered in urban parks.

English Name	Species	Nest	Diet	Habitat	Mass (g)	Foraging	Migration
Black Vulture	*Coragyps atratus*	rock	scavenger	1	1881.69	flight	1
Osprey	*Pandion haliaetus*	tree	reptile/fish	2	1483.2	flight	3
Black-chested Buzzard-Eagle	*Geranoaetus melanoleucus*	rock	mammals	1	2378.62	perch	1
Variable Hawk	*Geranoaetus polyosoma*	tree	mammals	1	782.61	both	3
White-tailed Hawk	*Elanus leucurus*	tree	mammals	2	346	flight	1
Swallow-tailed Kite	*Elanoides forficatus*	tree	invertebrates	3	416.24	flight	3
Harris's Hawk	*Parabuteo unicinctus*	tree	generalist	2	850.28	perch	1
Snail Kite	*Rostrhamus sociabilis*	ground	invertebrates	1	366.94	flight	2
Roadside Hawk	*Rupornis magnirostris*	tree	generalist	2	269	perch	1
Swainson's Hawk	*Buteo swainsoni*	tree	invertebrates	2	946.61	both	3
Sharp-shinned Hawk	*Accipiter striatus*	tree	birds	3	130.59	both	1
Cinereous Harrier	*Circus cinereus*	ground	birds	1	399.67	flight	2
Long-winged Harrier	*Circus buffoni*	ground	birds	1	507.4	flight	2
Short-eared Owl	*Asio flammeus*	ground	mammals	1	322.61	flight	2
Burrowing Owl	***Athene cunicularia***	**ground**	**generalist**	**1**	**150.61**	**both**	**1**
Chimango Caracara	***Milvago chimango***	**tree**	**generalist**	**2**	**296**	**both**	**1**
Crested Caracara	***Caracara plancus***	**tree**	**generalist**	**2**	**1078.62**	**both**	**1**
Aplomado Falcon	***Falco femoralis***	**tree**	**birds**	**2**	**335.76**	**both**	**1**
American Kestrel	***Falco sparverius***	**tree**	**invertebrates**	**2**	**114.61**	**perch**	**1**
Peregrine Falcon	*Falco peregrinus*	rock	birds	1	759.95	flight	2

2.5. Raptor Phylogeny

A raptor phylogeny was obtained from the BirdTree database (http://www.birdtree.org, accessed on 27 November 2023; [38]; see Leveau et al. [14]). The Ericson backbone phylogeny was used to obtain 1000 phylogenies [39]. Then, the software TreeAnnotator was used to obtain a 50% majority-rule consensus tree [40]. The functions read.nexus and as.phylo of the ape package were used to open the tree in R [41].

2.6. Statistical Analysis

The functional and phylogenetic characteristics of urban raptor assemblages were compared with randomized raptor assemblages of equal species richness obtained from the regional pool. The function mpd.ses of the picante package [42] calculated the standardized effect size (SES) of mean pairwise distances (mpd) in communities, taking into account the differences in species richness with the null model "taxa.labels" using 999 randomizations. Therefore, an SES for functional and phylogenetic distances was obtained. Negative values of SES indicate a higher functional or phylogenetic relatedness than expected by chance, suggesting filtering induced by urban parks. Positive values indicate a higher functional or phylogenetic distinctiveness among species than expected by chance, which may suggest competitive exclusion among species [43]. Functional distances were obtained through the gower dissimilarity among species using the function gowdis of the FD package in R [44,45]. The gower dissimilarity allowed the comparison of categorical, ordinal, and continuous traits among species. Phylogenetic distances among species were obtained through the phylogenetic tree. The significance (P) of the SES value was obtained with the following formula [42]:

$$P = \text{Rank of observed mpd compared to the rank of null communities/number of randomizations} + 1$$

3. Results

A total of 20 diurnal raptor species constituted the regional pool, of which 5 species were registered in urban parks (Table 1). The most common raptor in urban parks was the Chimango Caracara (*Milvago chimango*), comprising 95% of the 172 individuals recorded. Urban park assemblages had a sample coverage of 0.99 (confidence interval = 0.98, 1.00; Figure S2), indicating that the surveys were sufficient to characterize the raptor assemblage.

The mean pairwise functional distance between urban raptors was significantly lower than expected by chance (observed mpd = 0.315; expected mpd = 0.526; SES = −3.351; P = 0.009). Therefore, urban raptors were more functionally similar than randomized raptor assemblages drawn from the regional pool. Most of the urban raptors had a generalist diet and mode of foraging, nested in trees, had an affinity for semi-open habitats, and were resident (Table 1). Moreover, urban raptors had a lower body mass (interspecific mean= 395.12 g; standard deviation = 393.38; N = 5) than nonurban raptors (mean = 789.43; standard deviation = 649.06; N = 15).

The mean pairwise phylogenetic distance tended to be lower in urban raptors, although the differences did not differ with respect to chance (observed mpd = 99.590; expected mpd = 126.751; SES = −1.308; P = 0.124). Thus, urban raptors tended to be clustered in the phylogeny in comparison with randomized raptor assemblages (Figure 2). In general, urban raptors were members of the Falconidae family, such as the Chimango Caracara, the Aplomado Falcon (*Falco femoralis*), and the American Kestrel (*Falco sparverius*).

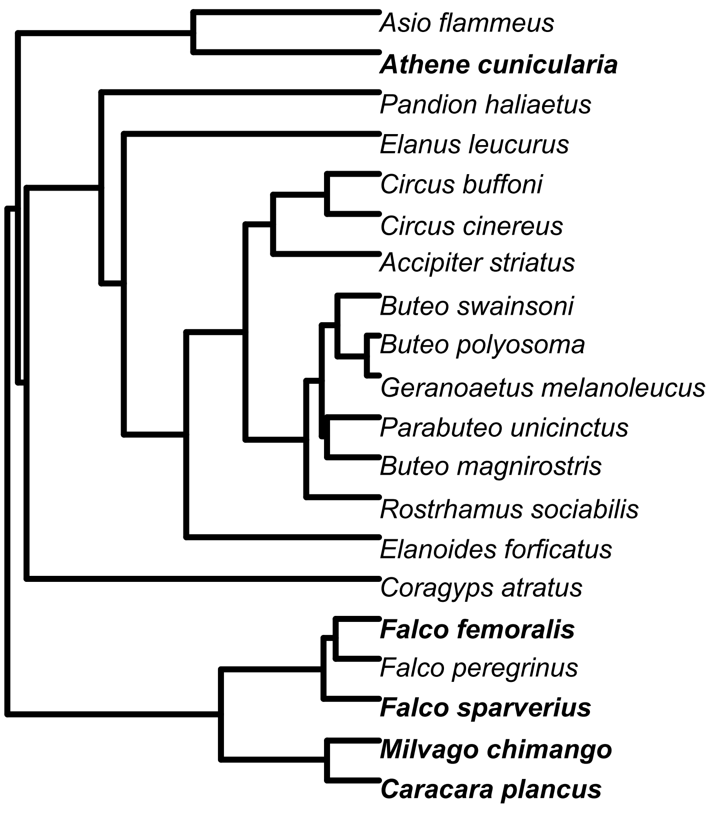

Figure 2. Phylogenetic tree of the regional raptor species pool in east–central Argentina. Species in bold were registered in urban parks.

4. Discussion

The analyses revealed that raptor assemblages of urban parks in the Pampean region of Argentina are functional and phylogenetically filtered. Urban raptors had a generalist diet and mode of foraging, a preference for semi-open habitats, nested in trees, were resident, and had a lower body mass than nonurban raptors. Moreover, urban raptor species tended to be in the same phylogenetic clade, mostly comprising species of the Falconidae family.

In general, urban raptors of the Austral Pampas had a generalist diet and foraging mode. These behaviors may allow raptors to use different resources provided by cities (see also Boal [12]). For example, the Chimango Caracara and the Crested Caracara (*Caracara plancus*) can feed on birds, mammals, and human waste [46,47], three common food items in urban areas. Moreover, the generalist foraging mode allows them to chase prey in different substrates and modes. For example, the author has seen the Crested Caracara chase rock pigeons (*Columba livia*) in flight or on the ground, and also search for food by walking in urban parks of Buenos Aires. In contrast, other raptor species that specialize in small mammals, such as the White-tailed Kite (*Elanus leucurus*) [48], seem to be excluded from urban parks.

Urban raptors also were characterized by their preference for semi-open habitats, composed of a mix of grasslands and scattered trees. This type of habitat is similar to urban parks, which are generally designed with large lawn areas and scattered trees [18]. In general, raptor species not recorded from urban parks were specialist species typical of natural grasslands, such as the Long-winged Harrier (*Circus buffoni*) and the Cinereous Harrier (*Circus cinereus*) [49,50]. These species nest on the ground and hunt by flying at low altitudes on grasslands and harvested wheat fields [51,52]. The pattern obtained in this study contrasts with the findings made by Boal [12] in the United States of America, where urban raptors were associated with forest habitats. The geographical location of cities and human population sizes could be related to the different results between studies [53,54].

Nesting on trees was another characteristic of raptor species in urban parks. Trees are a fundamental green component of urban parks [18] and constitute the principal nesting substrate for several species such as the Chimango Caracara, Crested Caracara, and Aplomado Falcon [52]. Some species, such as the Chimango Caracara and Crested Caracara, may also nest in anthropogenic substrates [55–57], which may favor their persistence in urban areas.

Urban raptors had a lower body mass than nonurban raptors. This pattern agrees with the results obtained by Cooper et al. [10] and Leveau [25]. Due to large raptors generally having large home ranges [58], they may be precluded by the small size of urban parks relative to the home ranges of these species. Cooper et al. [10] also suggested that a small body size is advantageous for metabolic rates under a scenario of an urban heat island.

A trend of phylogenetic clustering was observed among urban raptors, which generally belonged to the Falconidae family, such as the Chimango Caracara, Aplomado Falcon, and American Kestrel. This result agrees with the pattern found for Argentina by Leveau et al. [14]. Therefore, some traits not measured in this study but associated with the Falconidae family may allow for their use of urban parks. However, Cooper et al. [10] did not find a phylogenetic signal in the urban occurrence of raptors at the global scale. The differences in results may be related to the spatial scale [15,59], because this study focused on urban parks, whereas Cooper et al. [10] compared urban and periurban areas. Moreover, Cooper et al. [10] only included Accipitridae species and excluded Falconidae species, which tended to be more phylogenetically clustered in this study.

The urban raptor assemblage was numerically dominated by the Chimango Caracara, followed by low numbers (<3% of individuals) of the remaining species. The data obtained in the region showed the same pattern. For example, roadside surveys conducted by Travaini et al. ([60], route III) and Leveau and Leveau [34] found that the Chimango Caracara numerically dominated the raptor assemblage, with 89% and 78% of the individuals registered, respectively. Pedrana et al. [49] carried out point count surveys near Mar del Plata city, finding that chimango caracaras comprised 78% of the total individuals registered. Therefore, the results obtained in this study agree with those found by Leveau et al. [14], where the abundance of urban raptor species was related to the raptor species abundance in surrounding cities.

The filtering of the regional raptor assemblage related to urban parks is useful for predicting how these habitats shape raptor assemblages [31,61]. Based on the results obtained and those from previous studies [14], a tentative model of raptor assemblage by urban parks is proposed (Figure 3). Firstly, raptor species are possibly filtered by their functional and phylogenetic traits [10–12,14]. Therefore, raptor species with small body sizes, generalist diets and foraging modes, and semi-open habitats colonize urban parks. Secondly, the relative abundance of the species in urban parks is probably a mirror of their relative abundance in the regional pool. Then, the most common species in nonurban areas, which also has the adequate traits to live in urban areas, is the first to enter the city and has more time to adapt to human presence by reducing its fear of humans [62,63] or nesting in human structures [57,64]. In addition, species may show intraspecific variations in behavior that promote their persistence in urban parks [65]. It is highly unlikely that raptors persisted in the landscape through the urbanization process, because in the study area, urbanization removes native vegetation and replaces it with houses, roads, and exotic vegetation.

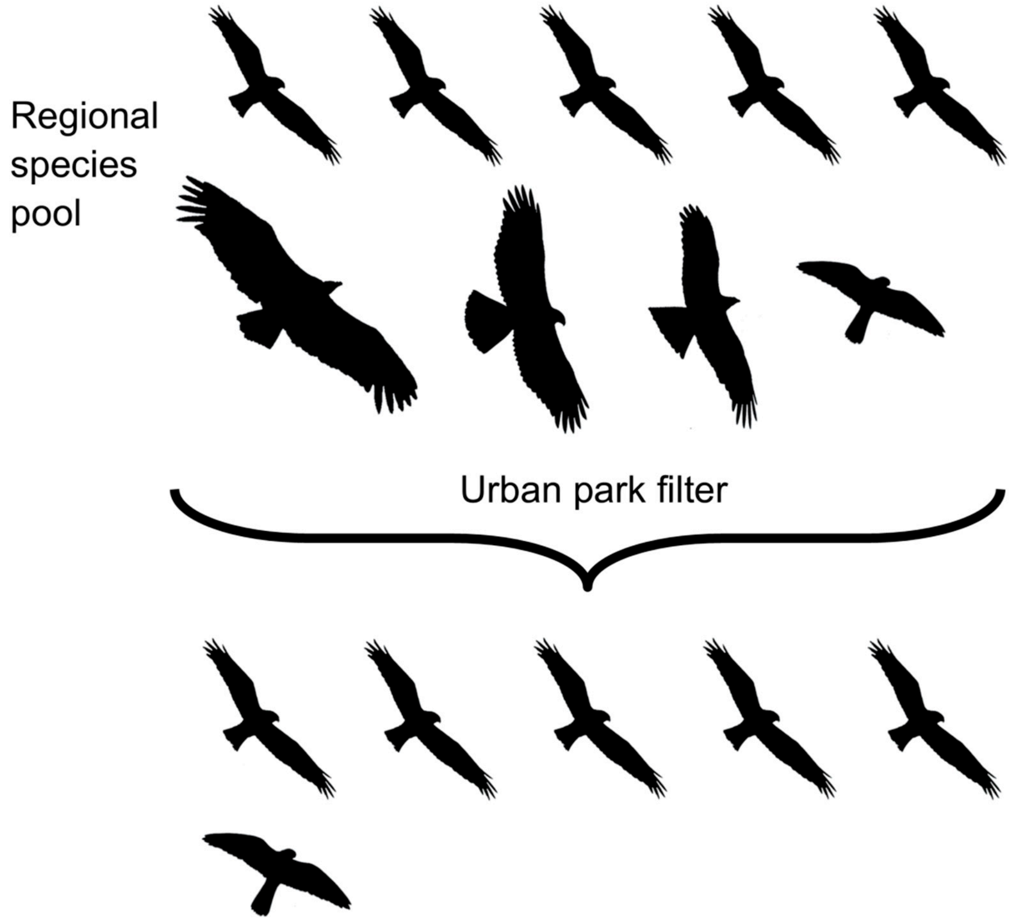

Figure 3. Schematic representation of urban park filtering on raptor species of the regional pool. Urban parks induce functional and phylogenetic filtering of species, generally promoting the presence of small generalist raptors. The relative abundance of species in urban parks is a mirror of their abundance in the regional pool. Raptor silhouettes taken from birdinginspain.com (accessed on 10 September 2022).

5. Conclusions

The results obtained showed that urban parks filtered the raptor assemblages of central Argentina. Nesting in trees, a generalist diet, and a semi-open habitat affinity were the main traits associated with raptor assemblages in urban parks. Moreover, raptors of urban parks were phylogenetically clustered, suggesting that species of Falconidae are more prompt to inhabit urban parks due to their preexisting traits conserved in their phylogeny [16]. The patterns found suggest that urban parks need to be more heterogeneous, allowing the persistence of raptors with other traits. For example, parks with a dominance of herbaceous vegetation could favor the presence of raptors typical of open areas. Alternatively, the existence of other types of green areas such as vacant lands may promote the persistence of raptor species excluded from urban parks [66].

6. Limitations of the Study

Raptor surveys in this study were carried out through fixed points during the morning. This technique is commonly used in raptor studies [29,49]. Other survey techniques, such as transect counts or territory mapping, can be used to characterize urban raptor assemblages [28]. For example, Zilio et al. [67] found that point counts were more efficient than transect counts in characterizing raptor assemblages in Brazilian grasslands. Thus, future studies should analyze which raptor survey method is more appropriate in urban areas.

Although the sampling effort seemed to be enough to record most of the raptor species inhabiting the urban parks, more sampling effort would be desirable to get a more comprehensive picture of the urban raptor community. Moreover, the number of cities surveyed may not be representative of the region. Further studies including more cities in the region and globally are necessary to validate or invalidate the conclusions from our analysis.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/birds5010003/s1, Figure S1: Pictures of urban parks of the six cities in central Argentina; Figure S2: Sample coverage in relation to the individuals registered. Shaded areas indicate 95% confidence intervals. Table S1: Description of cities surveyed.

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