Conservation of birds in an urban environment – wild bird fauna at the Osijek Zoo, Croatia

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Abstract

Zoos are our closest, independent, and continuous link to nature. Apart from providing the opportunity to observe captive and exotic wild animals, they also attract various species of wild birds. For that purpose, the main goal of this study was to provide a list of free-living bird species at the Osijek Zoo. During 2021, fieldwork was performed monthly using a point count transect, except during the breeding season when counts were performed twice a month. A total of 61 species were recorded, belonging to 31 families distributed in 15 orders. The most frequently recorded species were Hooded crow, *Corvus cornix* and Great tit, *Parus major*. Five species observed at the Osijek Zoo are listed as endangered species in the Red Book of Birds of Croatia: critically endangered: European roller, *Coracias garrulus*; endangered: Great egret, *Ardea alba* and Western marsh harrier, *Circus aeruginosus*; vulnerable: Little egret, *Egretta garzetta* and Black stork, *Ciconia nigra*. It appears that the Osijek Zoo provides a good foundation for a high diversity of bird fauna, indicating that this is a good quality urban area. The Osijek Zoo should also strive to preserve this abundant avifauna, by educating the public on conservation, and forbidding any potentially disturbing behaviours.

Key words: *Zoo; bird census; biodiversity; urban area bioconservation*

Introduction

Osijek is the largest city in eastern Croatia, and has a long history of ornithology research. Since 1782, 212 bird species have been registered in the city area, and of these, 145 species are still present today (Vidović, 2006). This high bird diversity is due to the proximity of the city to the Kopački Rit Nature Park, Drava River and its diverse habitats. In urban environments, every green area is

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significant for bird survival and diversity, and for generally improving the biodiversity of those areas. Bird monitoring has proven to be an excellent method for determining the biodiversity and importance of particular areas, and for tracking environmental changes. Birds are sensitive to changing habitat conditions and are relatively easy to observe, making them good models for such studies (Ferenc et al., 2014). Landscapes with multiple habitat types provide higher species richness because of the variety of food and nesting resources contained within, along with better shelter from predation (Shih, 2018). Additional food sources provided by humans and the higher temperatures during the winter months in such areas, compared to rural areas, attract rural species to winter in urban landscapes (Atchison and Rodewald, 2006).

Maintaining larger greenspaces with significant structural variety, such as zoos, could be useful in preserving plant and avian diversity (Kheraa et al., 2009). The number of species found in a given area provides information about the ecological significance of their native environment (Raza et al., 2015; Khalid et al., 2016). For this purpose, urban and wild biodiversity conservation is important, not only because of the growing human population in cities, but because this is an innovative strategy to protect biodiversity that is also recommended by many global environmental conventions (Kheraa et al., 2009). In an increasingly urbanised society, zoos give one of the few opportunities for visitors to engage with wildlife and observe animals up close (Ridgway et al., 2005; Bruni et al., 2008). Zoos are designed to allow people, particularly those who are unable to visit wildlife sanctuaries, to witness various species of wild animals. Zoos are humans' closest, most independent, and most consistent link to nature (Conway, 1995; Adetola and Oluleye, 2017). Apart from captive exotic, wild animals, they can also attract various species of wild birds.

The Osijek Zoo is located in the city of Osijek, and it is a great example of greenspace in an urban environment. Osijek Zoo features two artificial lakes and plenty of trees and shrubs, making it a potentially suitable habitat for various bird species. Furthermore, the zoo is positioned on the banks of the Drava River, and is surrounded by a forest that is part of the NATURA 2000 protected area. There are plenty of additional food resources in different animal habitats, and many available shelter sources that could attract numerous bird species. Due to its specific position and proximity to the forest, both forest species and urban bird species can be expected here. There are no published data on the avifauna of this area to date, and therefore, the main goal of this study was to provide a list of free-living bird species at the Osijek Zoo. Such areas that provide food, shelter and nesting resources for birds in cities are very valuable and should be acknowledged and conserved.

Materials and methods

The Osijek Zoo and Aquarium is situated near the Drava River (45°34′6″N 18°40′5″E), with a surface area of 11 ha (Fig. 1). It is bounded by the Drava River and the city of Osijek to the south. Northwest of the zoo is a NATURA 2000 area protected under the Birds Directive (Podunavlje and Donje Podravlje, Site code HR1000016), Habitats Directive (Lower Drave, Site code HR2001308). To the northeast is the village Tvrđavica. Habitats in the zoo are mostly deciduous woodland with woody plants and two artificial lakes. Due to occasional flood-

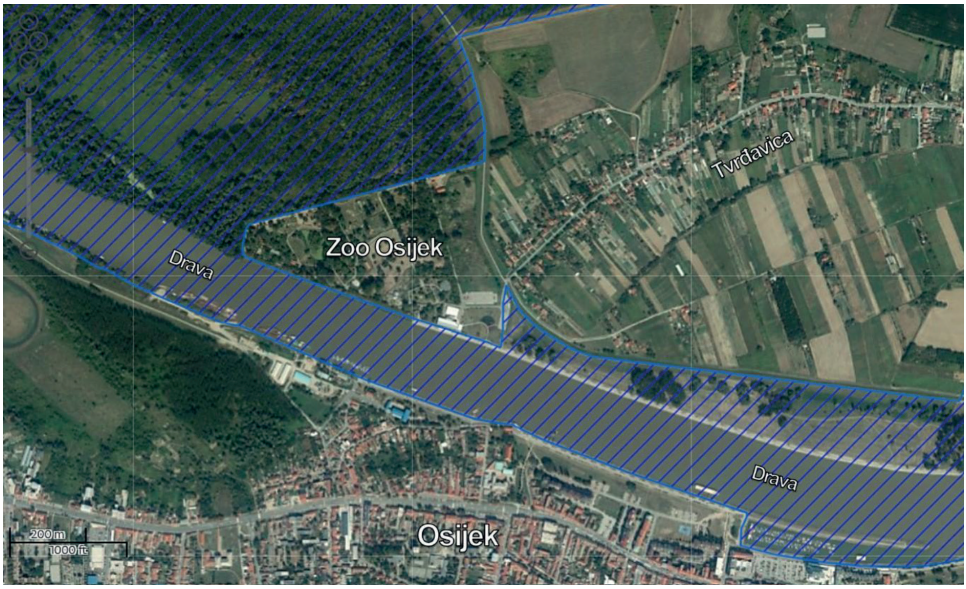

Figure 1. Location of the Osijek Zoo. Blue lines represent the NATURA 2000 site protected under the Birds Directive. (Source: Bioportal)

ing of the Drava River , the most abundance vegetation includes communities of white poplar (*Salix alba*) and Gallium - *Galio-Salicetum albae*, and white poplar (*S. alba*) and black poplar (*Populus nigra*) - *Salici albae-Populetum nigrae*. Open grasslands and pastures are present within the large herbivore enclosures.

The point count method was used according to Blondel et al. (1981) to determine the number of species and number of individuals (Fig. 2). Eight points were placed approximately 150 m set apart to ensure all bird species were detected with a 75 m radius. Counts were performed once a month during 2021, and twice a month during the breeding season. Data collection was performed in the morning between 07:00 and 10:00 a.m. and at each point lasted between 5 and 10 min. Additionally, all bird species flying over the zoo, and in the immediate vicinity of the site (Drava River, flood control dike and the surrounding forests) were recorded.

For every species, its status (breeding (B), wintering (W), passage (P) or rare passage (rP) was determined based on our observations and previous literature (Rožac, 2002; Vidović, 2006).

The frequency for each species (%) was calculated with the following formula:

$$F = \frac{Ns}{N} \times 100$$

F – frequency
Ns – number of visits when species were seen
N – number of visits during the year

Species with frequency values > 90% were recorded at every visit, while species with frequency values < 10% were recorded only once.

The relative dominance for each species was calculated according to Odum and Barrett (1971) with the following formula:

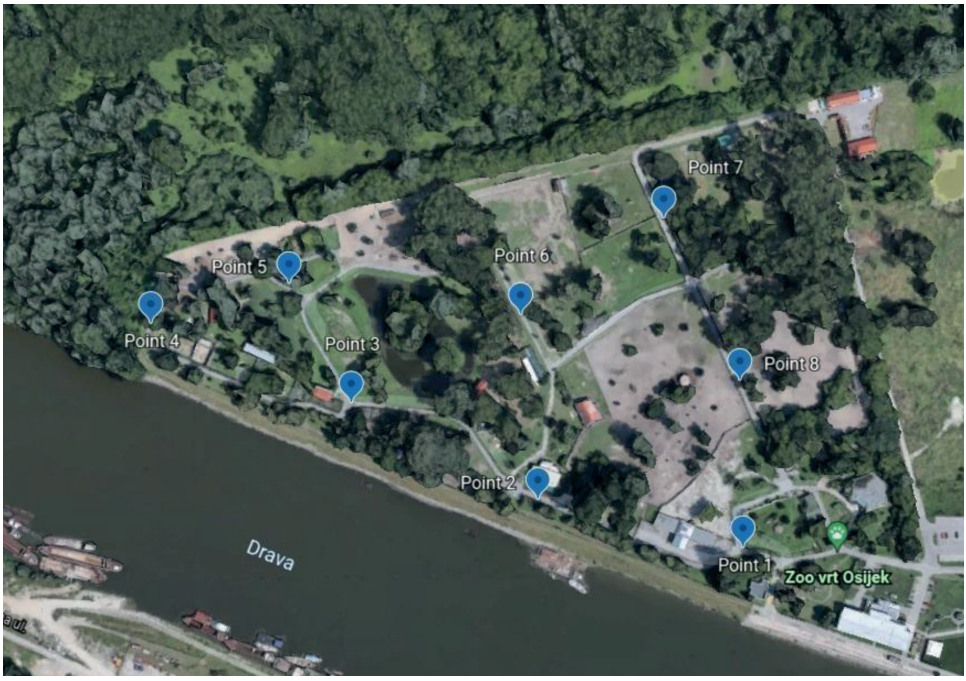

Figure 2. Locations of eight observation points within Osijek Zoo. (Source: Google Earth)

$$D = \frac{Nis}{Ni} \times 100$$

D –dominance of the species
Nis – number of individuals for the species *s*
Ni – number of individuals recorded during the year

Values range are divided into categories: > 10% – Eudominant species; 5-10% – Dominant species; 2-5% – Subdominant species; 1-2% – Recendent species; < 1% – Subrecendent species.

Results and Discussion

This is the first study to provide data on the wild bird fauna of Zoo Osijek. A total of 61 species were recorded, belonging to 31 families distributed in 15 orders (Table 1, Fig. 3). The order *Passeriformes* was the most numerous, comprising 24 families with 28 species. Furthermore, the order *Piciformes*, while only having one family, *Picidae*, consisted of the most recorded (six) species, followed by *Corvidae*, with five observed species. The study area consists of various trees and shrubs, as well as open grassland and pastures providing habitat for a high number of bird species. Most observed species were categorised as breeding species: 22 species breed within the Osijek Zoo, and 23 species breed in the surrounding areas (Table 1). The diverse vegetation structure and community inside the Osijek Zoo and surrounding areas, as part of NATURA 2000 network, provide favourable breeding grounds. Four species were wintering and five were passage birds. Seven species were recorded as rare passage species (Table 1).

Table 1. Overview of the species recorded in the Zoo Osijek, their status and frequency of detection (%).

Order	Family	Species	Status	Frequency
Suliformes	*Phalacrocoracidae*	*Phalacrocorax carbo* Linnaeus, 1758	P	60.00
Pelecaniformes	*Ardeidae*	*Ardea cinerea* Linnaeus, 1758	P	60.00
		Ardea alba Linnaeus, 1758	rP	6.67
		Egretta garzetta Linnaeus, 1758	rP	20.00
		Nycticorax nycticorax Linnaeus, 1758	P	33.33
Ciconiiformes	*Ciconiidae*	*Ciconia nigra* Linnaeus, 1758	rP	13.33
Anseriformes	*Anatidae*	*Cygnus olor Gmelin*, JF, 1789	B*	13.33
		Anser anser Linnaeus, 1758	rP	6.67
		Anas platyrhynchos Linnaeus, 1758	B*	73.33
Accipitriformes	*Accipitridae*	*Circus aeruginosus* Linnaeus, 1758	rP	6.67
		Accipiter nisus Linnaeus, 1758	B*	26.67
		Buteo buteo Linnaeus, 1758	B*	46.67
Falconiformes	*Falconidae*	*Falco tinnunculus* Linnaeus, 1758	B*	6.67
Galliformes	*Phasianidae*	*Phasianus colchicus* Linnaeus, 1758	B*	6.67
Charadriiformes	*Laridae*	*Chroicocephalus ridibundus* Linnaeus, 1758	P	20.00
Columbiformes	*Columbidae*	*Columba livia* f. *domestica* Gmelin 1789	B*	6.67
		Columba palumbus Linnaeus, 1758	B	93.33
		Streptopelia decaocto Frivaldszky, 1838	B	40.00
Strigiformes	*Strigidae*	*Strix aluco* Linnaeus, 1758	B	13.33
		Asio otus Linnaeus, 1758	B*	6.67
Apodiformes	*Apodidae*	*Apus apus* Linnaeus, 1758	B*	13.33
Coraciiformes	*Alcedinidae*	*Alcedo atthis* Linnaeus, 1758	B*	20.00
	Meropidae	*Merops apiaster* Linnaeus, 1758	rP	6.67
	Coraciidae	*Coracias garrulus* Linnaeus, 1758	rP	6.67
Bucerotiformes	*Upupidae*	*Upupa epops* Linnaeus, 1758	B*	40.00
Piciformes	*Picidae*	*Dryobates minor* Linnaeus, 1758	B*	20.00
		Dendrocoptes medius Linnaeus, 1758	B*	33.33
		Dendrocopos major Linnaeus, 1758	B	93.33
		Dryocopus martius Linnaeus, 1758	B*	6.67
		Picus viridis Linnaeus, 1758	B*	13.33
		Picus canus Gmelin, 1788	B	26.67

Passeriformes	*Hirundinidae*	*Hirundo rustica* Linnaeus, 1758	B	6.67
		Delichon urbicum Linnaeus, 1758	B*	6.67
	Turdidae	*Turdus viscivorus* Linnaeus, 1758	W	26.67
		Turdus merula Linnaeus, 1758	B	40.00
	Muscicapidae	*Luscinia megarhynchos* Brehm, 1831	B*	6.67
		Erithacus rubecula Linnaeus, 1758	W	6.67
		Phoenicurus ochruros Gmelin, S.G., 1774	B	33.33
	Regulidae	*Regulus regulus* Linnaeus, 1758	W	20.00
	Phylloscopidae	*Phylloscopus collybita* Vieillot, 1817	B	13.33
		Phylloscopus sibilatrix Bechstein, 1793	P	6.67
	Sylviidae	*Sylvia atricapilla* Linnaeus, 1758	B	33.33
	Paridae	*Poecile palustris* Linnaeus, 1758	B*	6.67
		Parus major Linnaeus, 1758	B	100.00
		Cyanistes caeruleus Linnaeus, 1758	B	66.67
	Aegithalidae	*Aegithalos caudatus* Linnaeus, 1758	B	53.33
	Sittidae	*Sitta europaea* Linnaeus, 1758	B	86.67
	Certhiidae	*Certhia brachydactyla* Brehm, 1820	B*	13.33
	Oriolidae	*Oriolus oriolus* Linnaeus, 1758	B	13.33
	Corvidae	*Garrulus glandarius* Linnaeus, 1758	B*	73.33
		Coloeus monedula Linnaeus, 1758	B*	6.67
		Corvus frugilegus Linnaeus, 1758	B*	6.67
		Corvus cornix Linnaeus, 1758	B	100.00
		Corvus corax Linnaeus, 1758	B*	46.67
	Sturnidae	*Sturnus vulgaris* Linnaeus, 1758	B	66.67
	Passeridae	*Passer domesticus* Linnaeus, 1758	B	60.00
		Passer montanus Linnaeus, 1758	B	86.67
	Fringillidae	*Fringilla coelebs* Linnaeus, 1758	B	60.00
		Chloris chloris Linnaeus, 1758	B	33.33
		Spinus spinus Linnaeus, 1758	W	6.67
		Carduelis carduelis Linnaeus, 1758	B	40.00

B – species breeding in the Zoo Osijek; B* – species breeding in the vicinity of the Zoo Osijek, W – wintering species; P – passage species; rP – rare passage species.

An overview of the frequency of the recorded species in Osijek Zoo is shown in Table 1. The most frequently recorded species were Hooded crow (*Corvus cornix*) and Great tit (*Parus major*), both observed during each survey, followed by Wood pigeon (*Columba palumbus*) and Great spotted woodpecker (*Dendrocopos major*).

Two artificial lakes provide suitable foraging grounds for species such as Eurasian kingfisher (*Alcedo atthis*), Grey heron (*Ardea cinerea*) and Mallard (*Anas platyrhynchos*). Tree trunks provide preferable feeding opportunities for various true woodpeckers (*Picidae*), while the canopy, full of Eurasian mistletoe (*Viscum album*), attracts the Mistle thrush (*Turdus viscivorus*). Species such as Feral pigeon (*Columba livia* f. *domestica*), and Eurasian collared dove (*Streptopelia decaocto*) can be seen at Osijek Zoo due to the proximity to Osijek, as these species are known to breed in urban habitats (Rožac, 2002). The European roller (*Coracias garrulus*), a rare passage species, was observed by I. Ribić (*pers. comm*). The Osijek Zoo and the surrounding area along the Drava River are known for high human activity, especially during breeding season.

Figure 3. Several bird species recorded in Osijek Zoo in 2021. Upper left corner: Grey heron (*Ardea cinerea*); upper right corner: Eurasian sparrowhawk (*Accipiter nisus*); lower left corner: Long-tailed tit (*Aegithalos caudatus*); lower right corner: Eurasian hoopoe *(Upupa epops*).

Table 2. Dominance (%) and their category for each species recorded in the Osijek Zoo

Species	Dominance	Category
Corvus cornix	18.71	Eudominant
Sturnus vulgaris	9.95	Dominant
Columba palumbus	8.75	Dominant
Oriolus oriolus	8.55	Dominant
Erithacus rubecula	7.03	Dominant
Passer montanus	6.83	Dominant
Passer domesticus	6.36	Dominant
Garrulus glandarius	2.55	Subdominant
Aegithalos caudatus	2.45	Subdominant
Anas platyrhynchos	2.29	Subdominant
Sitta europaea	2.19	Subdominant
Sylvia atricapilla	1.82	Recendent
Cyanistes caeruleus	1.77	Recendent
Dendrocopos major	1.67	Recendent
Anser anser	1.56	Recendent
Carduelis carduelis	1.51	Recendent
Phalacrocorax carbo	1.30	Recendent
Chroicocephalus ridibundus	1.09	Recendent
Streptopelia decaocto	1.04	Recendent
Chloris chloris	1.04	Recendent
Falco tinnunculus	0.89	Subrecendent
Phoenicurus ochruros	0.89	Subrecendent
Corvus corax	0.78	Subrecendent
Picus canus	0.68	Subrecendent
Turdus merula	0.63	Subrecendent
Buteo buteo	0.57	Subrecendent
Upupa epops	0.57	Subrecendent
Merops apiaster	0.52	Subrecendent
Ardea cinerea	0.52	Subrecendent
Cygnus olor	0.47	Subrecendent
Turdus viscivorus	0.42	Subrecendent
Nycticorax nycticorax	0.42	Subrecendent
Apus apus	0.36	Subrecendent
Spinus spinus	0.31	Subrecendent
Luscinia megarhynchos	0.26	Subrecendent
Accipiter nisus	0.21	Subrecendent

Parus major	0.21	Subrecendent
Regulus regulus	0.21	Subrecendent
Picus viridis	0.21	Subrecendent
Alcedo atthis	0.16	Subrecendent
Certhia brachydactyla	0.16	Subrecendent
Egretta garzetta	0.16	Subrecendent
Dendrocoptes medius	0.16	Subrecendent
Dryocopus martius	0.16	Subrecendent
Strix aluco	0.16	Subrecendent
Ciconia nigra	0.10	Subrecendent
Coloeus monedula	0.10	Subrecendent
Fringilla coelebs	0.10	Subrecendent
Phylloscopus collybita	0.10	Subrecendent
Columba livia f. domestica	0.05	Subrecendent
Coracias garrulus	0.05	Subrecendent
Circus aeruginosus	0.05	Subrecendent
Phasianus colchicus	0.05	Subrecendent
Corvus frugilegus	0.05	Subrecendent
Delichon urbicum	0.05	Subrecendent
Hirundo rustica	0.05	Subrecendent
Phylloscopus sibilatrix	0.05	Subrecendent
Poecile palustris	0.05	Subrecendent
Ardea alba	0.05	Subrecendent
Dryobates minor	0.05	Subrecendent
Asio otus	0.05	Subrecendent

Surprisingly, suitable habitat provides good foraging grounds for Black stork (*Ciconia nigra*). The Black stork prefers old forest for breeding ground and they usually avoid areas with high human activity (Chevallier et al., 2010). However, this record may indicate possible breeding pairs in the forest surrounding the Osijek Zoo, seeing as Black stork has also been spotted in previous years (A. Mikuška, *pers. comm.*).

Tomik (unpublished) recorded 33 species during the breeding season in May 2015. Those data included 28 species that overlap with the results of this study, and five species not observed during our study: White-tailed eagle (*Haliaeetus albicilla*), European stonechat (*Saxicola rubicola*), Red-backed shrike (*Lanius collurio*), Spotted flycatcher (*Muscicapa striata*), and Song thrush (*Turdus philomelos*).

In the present study, five species were recorded at Osijek Zoo that are listed in the Red Book of Birds of Croatia (Tutiš et al., 2013). In the category of critically endangered (CR) species: European roller (*C. garrulus*); endangered (EN): Great egret (*Ardea alba*) and Western marsh

harrier (*Circus aeruginosus*); and vulnerable (VU): Little egret (*Egretta garzetta*) and Black stork (*C. nigra*). Tomik (unpublished) reported one species listed as vulnerable in the Red Book of Birds of Croatia (Tutiš et al., 2013): White-tailed eagle (*H. albicilla*). Moreover, due to the proximity to NATURA 2000 areas, 13 species protected under Annex I of the Birds Directive were detected in this study and by Tomik (unpublished): Common kingfisher (*Alcedo atthis*), Great egret (*Ardea alba*), Black stork (*Ciconia nigra*), Western marsh harrier (*Circus aeruginosus*), European roller (*Coracias garrulus*), Great spotted woodpecker (*Dendrocopos major*), Middle spotted woodpecker (*Dendrocoptes medius*), Black woodpecker (*Dryocopus martius*), Little egret (*E. garzetta*), White-tailed eagle (*H. albicilla*), Red-backed shrike (*L. collurio*), Black-crowned night heron (*Nycticorax nycticorax*), and Grey-headed woodpecker (*Picus canus*).

The dominance of each species is shown in Table 2. According to the dominance categories, most of the species recorded are *Subrecendent*, while only one is Eudominant (Hooded crow, *C. cornix*). In general, high dominance values are influenced by the species diversity. Considering the small surface area of the Osijek Zoo, a high number of species was recorded, subsequently decreasing the number of Eudominant species.

In this research, 61 species were observed, accounting for 42% of the total avifauna of Osijek (Vidović, 2006). Compared to other urban bird communities, 100 breeding bird species were recorded in Zagreb, with the most diverse order *Passeriformes* (45 species). However, the most abundant species were those with the widest distribution (Kralj and Krnjeta, 2015). Tome et al. (2013) reported 161 different species in Ljubljana and the surrounding environment, with 104 and 97 species recorded during the spring and winter period, respectively. Several species were present in both seasons, hence the excess of the sum species (Tome et al., 2013). Differences between the observed species can be attributed to the fact that the area of this study is surrounded by many green areas that favour bird life and are a part of the NATURA 2000 network. The study area is also situated near the Drava River, a refuge for many species of waterbirds. The families recorded by Rožac (2002), and not recorded at the zoo are *Podicipedidae, Rallidae,* and *Alaudidae*. The main reasons for their absence are the dietary and habitat preferences of these species. For example, the larks (family Aladaudide) inhabit farmlands, grasslands, savannas, etc. (Campbell and Lack, 1985). Moreover, the *Podicipedidae* family was not recorded due to the unfavourable prey composition at the artificial lakes in the zoo. Grebes prefer lakes rich in fish and aquatic insects (Summers et al., 2011), while the lake at the zoo is inhabited only by Prussian carp (*Carassius gibelio*) and Common carp (*Cyprinus carpio*) (T. Mandić, *pers. comm.*). The *Rallidae* family can be found in a variety of habitats, including freshwater and salt marshes, grasslands, mangroves and tropical forests, and temperate forests (Winkler et al., 2020), all habitats not found in the Osijek Zoo. These species also feed on fish, invertebrates and small vertebrates that cannot be found in large numbers in the lakes at the zoo.

Conclusion

A total of 61 free-living bird species were recorded at the Osijek Zoo. Thanks to its position on the outskirts of the town, its close proximity to the Drava River and its floodplain forests, the Osijek Zoo provides a good foundation for a

rich diversity of bird fauna, indicating an urban area with good quality. The Osijek Zoo should strive to preserve such abundant avifauna by educating the public on conservation, and prohibiting any potentially disturbing behaviours.

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References

1. ADETOLA, B. O. and A. O. OLULEYE (2017): Zoo Visitation and its Implication on Wildlife Conservation Concerns. NJWM. 1, 36-42.
2. ATCHISON, K. A. and RODEWALD, A. D. (2006): The Value of Urban Forests to Wintering Birds. Nat. Areas J. 26, 280-288. 10.1177/146879760100100105
3. BLONDEL, J. (1981): Point counts with unlimited distance. Stud Avian Biol. 6, 414–420.
4. BRUNI, C. M., J. FRASER and P. W. SCHULTZ (2008): The value of zoo experiences for connecting people with nature. Visit. Stud. 11, 139-150. 10.1080/10645570802355489
5. CAMPBELL, B. and E. LACK (1985): A Dictionary of Birds. Vermillion: Buteo Books. South Dakota, USA.
6. CHEVALLIER, D., Y. Le MAHO, F. BAILLON, R. DUPONNOIS, C. DIEULIN, P. BROSSAULT, P. De FRANCLIEU, P. LORGE, A. AUROUET and S. MASSEMIN (2010): Human activity and the drying up of rivers determine abundance and spatial distribution of Black Storks *Ciconia nigra* on their wintering grounds. Bird study 57, 369-380. 10.1080/00063651003678467
7. CONWAY, W. (1995): Wild and Zoo Animal Interactive Management and Habitat Conservation. Biodivers. Conserv. 4, 573-594. 10.1007/BF00222515
8. FERENC, M., O. SEDLÁČEK and R. FUCHS (2014): How to improve urban greenspace for woodland birds: site and local-scale determinants of bird species richness. Urban Ecosyst. 17, 625-640. 10.1007/s11252-013-0328-x
9. KHALID, S., AWAN, M. S., MINHAS, R. A., ASHRAF, N., AHMED, K. B., SHAFI, N. and ABASSI, S. (2017): Distribution and habitat use of avian fauna of Rawalakot city and its surroundings, Azad Jammu and Kashmir, Pakistan. Pak. J. Zool. 49, 2331–2334. 10.17582/journal.pjz/2017.49.6.sc4
10. KHERAA, N., V. MEHTAA and B. C. SABATA (2009): Interrelationship of birds and habitat features in urban green spaces in Delhi, India. Urban For Urban Green. 8, 187-196. 10.1016/j.ufug.2009.05.001
11. KRALJ, J. and D. KRNJETA (2015): Atlas ptica gnjezdarica grada Zagreba. Hrvatska agencija za okoliš i prirodu, Zagreb, pp. 116.
12. ODUM, E. P. and G. W. BARRETT (1971): Fundamentals of ecology. Philadelphia: Saunders, 3, 5.
13. RAZA, H., S. MEHMOOD, B. N. KHAN, F. BIBI and Z. ALI (2015): Avian diversity of Lahore Safari Zoo in winter season Lahore, Pakistan. JAPS 25, 378-381.
14. RIDGWAY, S. C., M. LIVINGSTON and S. E. SMITH (2005): Visitor behavior in zoo exhibits with underwater viewing. Visitor Studies Association. 8, 1-10.
15. ROŽAC, V. (2002): Ornitofauna grada Osijeka i okolice. Diplomski rad. Pedagoški fakultet, Zavod za biologiju, Sveučilište Josipa Jurja Strossmayera u Osijeku.
16. SHIH, W. Y. (2018): Bird diversity of greenspaces in the densely developed city centre of Taipei. Urban ecosyst. 21, 379-393. 10.1007/s11252-017-0720-z
17. SUMMERS, R. W., R. A. MAVOR, S. HOGG and R. HARRIMAN (2011): Lake characteristics and their selection by breeding Slavonian Grebes *Podiceps auritus* in Scotland. Bird Study 58, 349-356. 10.1080/00063657.2011.585630
18. TOME, D., A. VREZEC and D. BORDJAN (2013): Ptice Ljubljane in okolice. Mestna občina, Oddelek za varstvo okolja.
19. TUTIŠ, V., J. KRALJ, D. RADOVIĆ, D. ĆIKOVIĆ and S. BARIŠIĆ (2013): Red Data book of birds in Croatia. Ministry of environmental and nature protection. State Institute for Nature Protection, Zagreb.
20. VIDOVIĆ, S. (2006): Ptice na području grada Osijeka. Muzej Slavonije. str. 95.
21. WINKLER, D. W., S. M. BILLERMAN and I. J. LOVETTE (2020): Rails, Gallinules, and Coots (Rallidae), version 1.0. Birds of the World. Eds.: Billerman, S. M., Keeney, B. K., Rodewald, P. G. and Schulenberg, T. S. E. Cornell Lab of Ornithology, Ithaca, NY, USA. 10.2173/bow.rallid1.01

Očuvanje ptica u urbanom okruženju – fauna divljih ptica u Zoološkom vrtu Osijek, Hrvatska

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Zoološki su vrtovi najbliža, neovisna i stalna veza čovjeka s prirodom. Osim što pružaju priliku za interakciju i promatranje egzotičnih i/ili divljih životinja, privlače i mnogo vrsta divljih ptica. Glavni je cilj ovoga istraživanja popis slobodnoživućih vrsta ptica u Zoološkom vrtu Osijek. Tijekom 2021. godine metodom transekta u točki, ptice su osim u sezoni gniježđenja, kada su se brojenja obavljala dva puta mjesečno, promatrane jednom mjesečno. Promatranjem je zabilježeno ukupno 61 vrsta ptica koje pripadaju u 31 porodicu i 15 redova. Najčešće su zabilježene vrste: siva vrana, *Corvus cornix* i velika sjenica, *Parus major*. Pet vrsta opažanih u Zoološkom vrtu Osijek uvrštene su kao ugrožene vrste u Crvenu knjigu ptica Hrvatske: zlatovrana, *Coracias garrulus* – kritično ugrožena, velika bijela čaplja, *Ardea alba* – ugrožena, eja močvarica, *Circus aeruginosus* – ugrožena, mala bijela čaplja, *Egretta garzetta* – osjetljiva, crna roda, *Ciconia nigra* – osjetljiva. Zoološki vrt Osijek dobar je temelj za bogatu raznolikost ornitofaune što ukazuje da je urbano područje Osijeka kvalitetno. Zoološki vrt Osijek trebao bi ulagati u očuvanje bogate faune divljih ptica i educirati građanstvo o biološkoj raznolikosti svoga zavičaja.

Ključne riječi: *Zoo, cenzus ptica, bioraznolikost, urbano područje, očuvanje okoliša*