

UDK 598.293.11:911.375.1(497.521.2)
DOI 10.21857/y7v64t4loy

Original scientific paper
Izvorni znanstveni članak
Received: 22.7.2023.
Accepted: 25.9.2023.

THE BREEDING NUMBERS AND TREE PREFERENCES OF ROOKS *Corvus frugilegus* IN ZAGREB, CROATIA

*Broj gnijezdećih parova i izbor vrsta stabala gačaca
Corvus frugilegus u Zagrebu, Hrvatska*

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ABSTRACT

The Rook is a common breeding species in lowland Croatia where it inhabits agricultural and urban habitats. This study aimed to determine the trend of the Rook population in Zagreb and the preferences of the tree species for nesting. Data used in this analysis was collected from 2017 to 2023 through citizen science. From 2017 until 2023, a total of 20 rookeries were counted and the number of breeding pairs from 2017 has increased by 49.7%. The highest numbers of breeding pairs were observed in 2022 and 2023, with 1172 and 1168 active nests, respectively. Nests were located on 35 different tree species, with the London plane *Platanus x acerifolia* being the most common. Also, a significant proportion of the rookeries' surroundings was covered by grasslands. A total number of 18 instances of nest destruction, tree removal, or the cutting down of main branches was recorded, aiming to reduce the Rook population. These efforts did not impact the overall numbers of breeding pairs significantly.

Keywords: citizen science, corvids, city management, urbanization

INTRODUCTION

The Rook *Corvus frugilegus* is a breeding species of Europe and Asia (CRAMP 1983). In the western and southern parts of its range, it is a resident species, while in eastern and northern Europe, it is migratory. Although there has been data about its nesting since the late 19th century, it was scarce in Croatia until the 1940s. In the middle of the 20th century, it was regularly observed during migration and wintering in Croatia. Nowadays, it is a common breeding species in lowland Croatia, where it inhabits agricultural and urban habitats with high trees needed for its nesting (KRALJ *et al.* 2013). Rooks are a game species in Croatia, with an open hunting season outside the breeding season. The removal or destruction of the nest is prohibited during the breeding season unless one obtains an exemption from the competent ministry.

In Zagreb, the Rook is a resident species. They nest in colonies on trees (rookeries) and feed on open habitats within and around Zagreb. Outside the breeding season, they frequently visit the rubbish dump Prudinec, where 40% to 70% of the Zagreb population forages for food, with even higher numbers in harsher winters (KRALJ & KRNJETA 2015).

The largest rookery in Zagreb was located near the Stjepan Radić student dormitory (SD Stjepan Radić), with over 320 breeding pairs (KRALJ & KRNJETA 2015). Other recorded rookeries were smaller; seven rookeries with a couple of dozens of pairs, and the rest with less than 20 pairs. The number and size of rookeries changed from year to year. One of the reasons for these fluctuations is cutting tree branches from trees where the rookeries are, intending to reduce the number of breeding pairs. However, this type of action often results in breeding pairs dispersing to nearby locations rather than actually reducing their numbers (KRALJ & KRNJETA 2015).

METHODS

The study was conducted in the city of Zagreb, Croatia (45°48'N 15°58'E). Data was collected using citizen science from 2017 to 2023. Volunteers who participated in the monitoring were active members and employees of Birdlife Croatia, Association Biom, as well as biology students of the University of Zagreb. These volunteers were provided with detailed instructions on how to monitor rookeries and were equipped with field equipment as needed. All visited rookeries were counted once during each breeding season and larger rookeries were visited annually. Most of the rookeries were counted by the same individuals throughout the years. Volunteers were instructed to spend at least 15 minutes at each rookery and record the following information: the number of active nests, the tree species (if possible) with rookeries, the number of occupied trees of those species, the number of nests per tree species, any threats to the colony (nest re-

removal, destruction caused by natural events, etc.) or notes, and the GPS coordinates of the rookery. GPS points were taken to track the expansion of the rookeries over the years. Active nests were determined by observing birds incubating in the nest or birds engaged in nest fixing or building. All counts were conducted from the middle of March until the end of April before the trees sprouted their leaves. If the volunteers were unable to determine the tree species, they were instructed to consult the online tree database called the “Greenery Cadastre of the City of Zagreb” (<https://gis.zrinjevac.hr/>).

To analyse the habitats surrounding the rookeries, we used a 1 km buffer around the rookeries and used the ESA WorldCover 10 m raster (ZANAGA *et al.* 2022). All analyses and graphical representations were done in R software, version 4.2.1 (R CORE TEAM 2022), using the statistical package ggplot2 v. 3.4.0 (WICKHAM 2016) and QGIS, version 3.30 (QGIS DEVELOPMENT TEAM 2023).

RESULTS

From 2017 until 2023, a total of 20 rookeries were counted (Table 1), 11 of which were monitored during all six years, and at least five years of data were collected for five rookeries. Additionally, we identified and recorded small rookeries that emerged in various locations around the city. These smaller rookeries were categorized separately as “others”. The rookeries were distributed throughout the city, except for the mountainous region to the north (Figure 1). The highest numbers of breeding pairs were observed in 2022 and 2023, with 1172 and 1168 active nests, respectively. Conversely, the lowest recorded number of pairs occurred in 2017, with a count of 780 nests (Table 1). Despite occasional local declines and rookery disappearances (Table 1), the overall trend of breeding pairs of Rooks in Zagreb is increasing (Figure 2).

Table 1. Number of breeding pairs in different rookeries of Rooks *Corvus frugilegus* in Zagreb, Croatia, from 2017 to 2023.**Tablica 1.** Broj gnijezdećih parova gačca *Corvus frugilegus* u Zagrebu, Hrvatska, od 2017. do 2023. godine

No.	Rookery	2017.	2018.	2019.	2020.	2021.	2022.	2023.
1	Botinec	126	110	93	134	239	135	140
2	Bundek	2	17	17	25	27	23	45
3	Dugave	26	41	10	0	53	95	72
4	Ferenščica	11	21	34	26	34	22	14
5	Folnegovićevo naselje	25	30	9	22	28	10	33
6	Gajnice	-	-	-	6	-	89	77
7	Knežija	-	-	20	28	11	15	9
8	MUP	-	-	-	18	27	33	16
9	Prečko	-	11	18	17	22	-	29
10	Prisavlje	-	-	17	12	8	83	56
11	Ravnice	-	14	16	21	35	39	14
12	Remetinec	54	101	134	92	77	58	61
13	Savski gaj	36	37	39	15	28	14	20
14	Siget	151	188	97	161	122	161	143
15	SD Stjepan Radić	224	196	115	75	105	81	80
16	Studentski grad	-	16	-	24	31	-	29
17	Špansko	-	-	14	4	1	12	41
18	Vrbik	24	26	40	28	23	22	19
19	Vukovarska ulica	-	22	9	12	12	-	-
20	Zaprude	62	108	102	133	135	255	245
	Other	39	0	3	37	31	37	25
	Total	780	938	787	890	1049	1172	1168

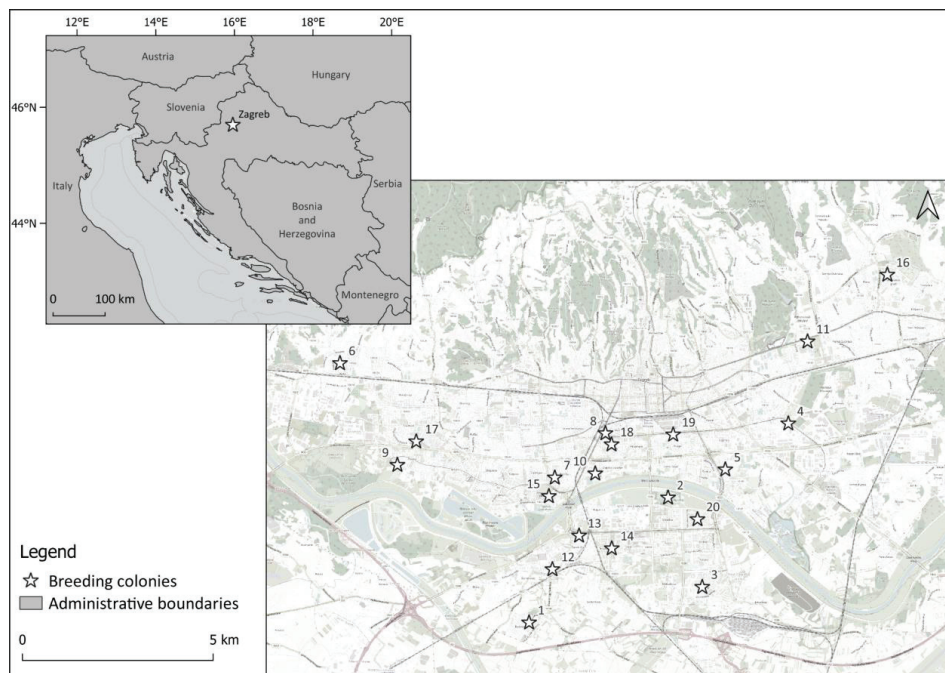


Figure 1. The locations of rookeries of Rooks *Corvus frugilegus* in Zagreb, Croatia. The rookery number on the figure corresponds to the number in Table 1. (No. of rookeries = 20)

Slika 1. Lokacija kolonija gačaca *Corvus frugilegus* u Zagreb, Hrvatska. Broj kolonije označen na slici odgovara broju u Tablici 1. (broj kolonija = 20)

We noted a total of 35 tree species with at least one nest recorded (Table 2). However, not all rookeries were surveyed for all tree species, and the number of nests per tree was not consistently counted throughout the entire period. The London plane *Platanus x acerifolia* was the most frequently encountered tree species across all years. Additionally, numerous trees from the genera *Fraxinus*, *Populus* and *Acer* were recorded (Figure 3). The London plane consistently had the highest number of nests each year (Figure 3). We found one part of the rookery “Remetinec” breeding on a GSM antenna. We collected three years of data for the rookery “Remetinec” which had 10 to 12 nests. We observed that a significant proportion of the buffer area, extending 1 km around the rookeries, was covered by grasslands (Figure 4). Out of the 20 rookeries surveyed, 10 had grassland cover areas ranging from 20% to 30%, 7 had areas between 10% and 20%, while only 3 had less than 10% grassland coverage in the 1 km buffer area around the rookeries.

We recorded a total of 18 instances of nest destruction, tree removal, or the cutting down of main branches. These incidents were documented in the following locations: Siget (2020 and 2023), Knežija (2020 and 2022), Folnegovićevo naselje (2020), SD Stjepan Radić (2020 and 2021), Vrbik (2021), Savski gaj (2021), Gajnice (2022), Ferenščica (2023), and Zapruđe (2023). In some cases, new rookeries appeared in the vicinity, while in other cases, the population experienced a local decrease in numbers.

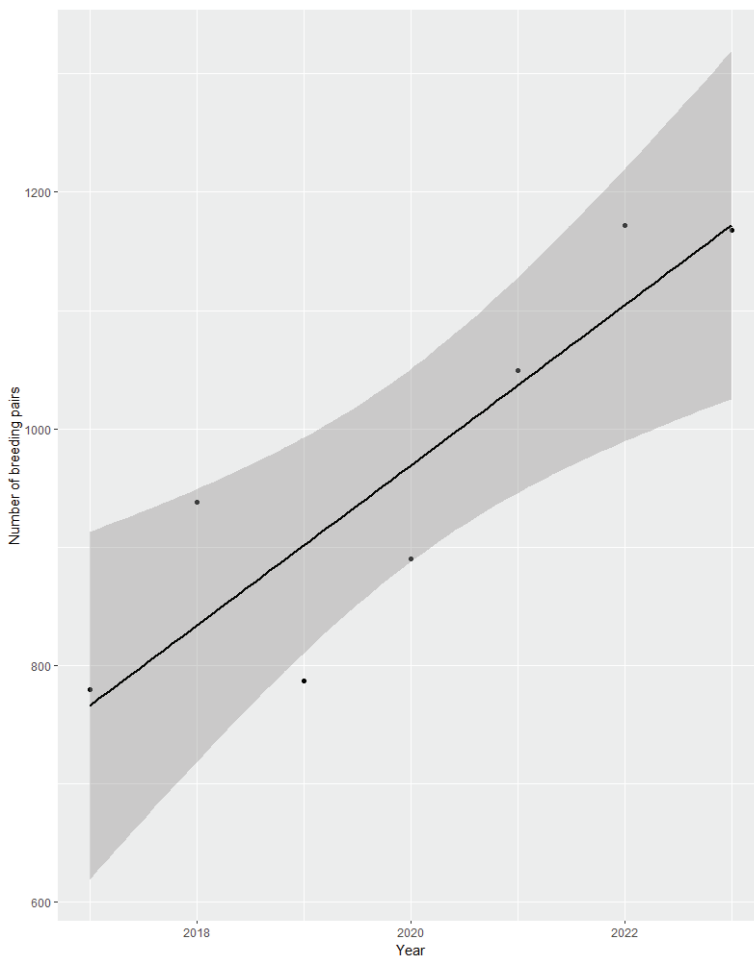


Figure 2. The trend of the number of breeding pairs of Rooks *Corvus frugilegus* in Zagreb, Croatia, from 2017 until 2023.

Slika 2. Trend brojnosti gnijezdećih parova gačaca *Corvus frugilegus* u Zagrebu, Hrvatska, od 2017. do 2023. godine.

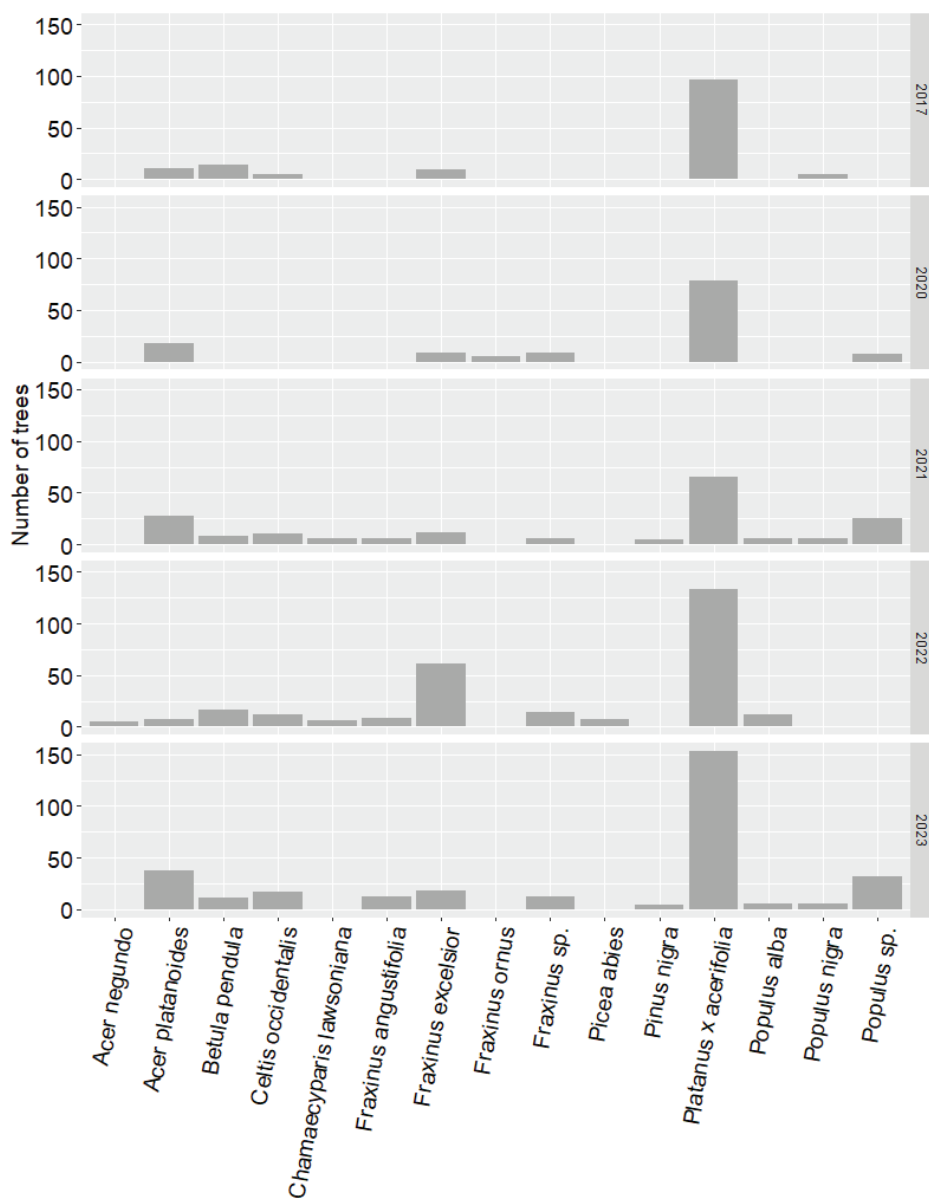


Figure 3. Number of trees occupied by Rooks *Corvus frugilegus* by tree species in Zagreb, Croatia, from 2017 until 2023. Tree species observed more than five times are shown.

Slika 3. Broj stabala okupirana gačcima *Corvus frugilegus* po vrsti stabala u Zagrebu, Hrvatska, od 2017. do 2023 godine. Prikazane su vrste stabla zabilježene više od 5 puta.

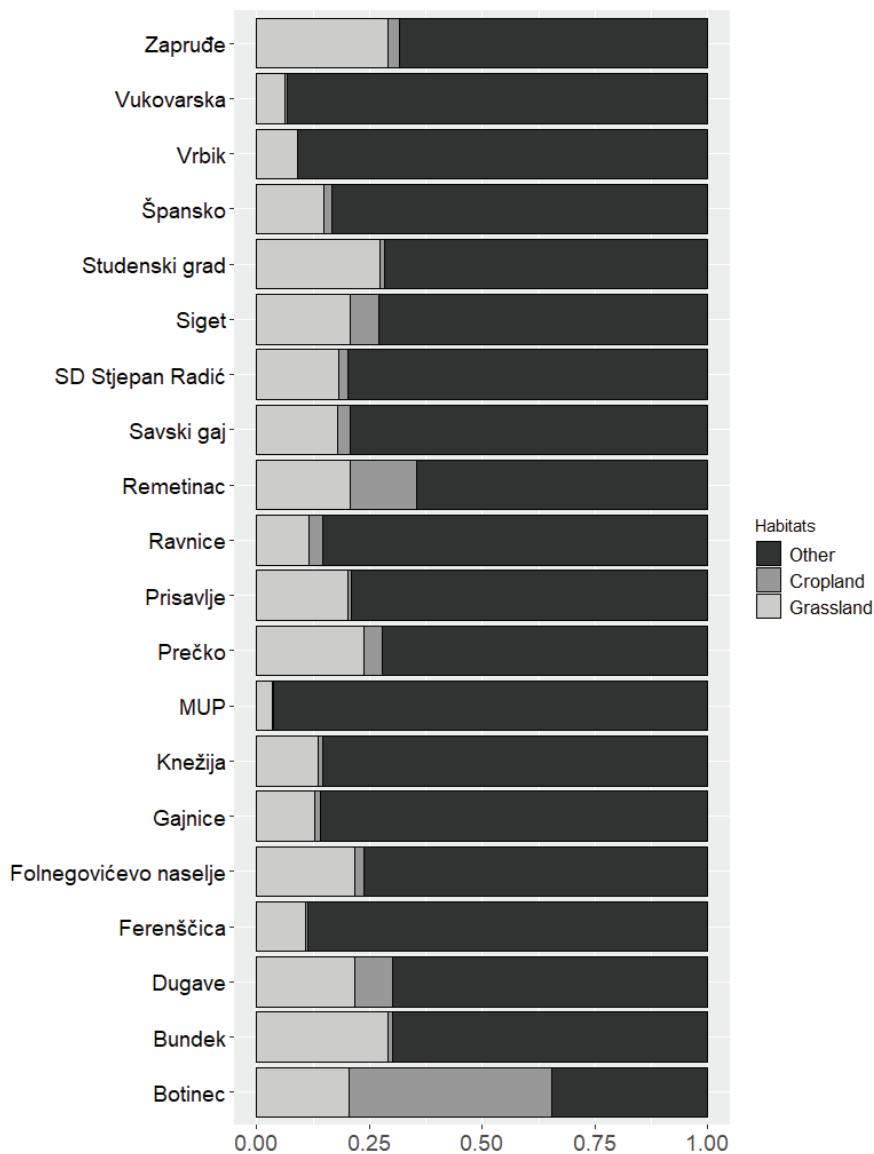


Figure 4. Percentage of grassland, cropland and other (built-up, tree cover, permanent water bodies and bare / sparse vegetation) habitats surrounding the studied rookeries of Rooks *Corvus frugilegus*

Slika 4. Postotak travnjaka, usjeva i ostalih površina (izgrađeno područje, stabla, trajne vodene površine i gola ili rijetka vegetacija) u okolici istraživanih kolonija gačaca *Corvus frugilegus*

DISCUSSION

The number of breeding Rooks pairs in Zagreb, Croatia increased by 49.7% between 2017 and 2023. The larger rookeries observed at the beginning of the study have generally maintained stable or had fluctuating pair numbers. The notable growth in overall numbers is primarily attributed to rookeries such as Bundek, Gajnice, Prisavlje, and Zaprude, which experienced a sudden surge. However, the largest rookery, SD Stjepan Radić, witnessed a sharp decline of 66.5% within three years before stabilizing. This sudden decrease can likely be attributed to branch removal in 2020 and 2021, possibly even earlier, along with persecution in the area. The data from 2014 with an estimated 730 – 780 breeding pairs (KRALJ & KRNJETA 2015) and 2006 with an estimated 1174 pairs (VLAHOVIĆ *et al.* 2010), together with our results, suggests that the long-term trend of the species is stable but exhibits fluctuations in some years. One possible reason for this variation could be the decline of the largest colonies, such as SD Stjepan Radić (KRALJ & KRNJETA 2015) and Brezovica (VLAHOVIĆ *et al.* 2010).

Previous studies (WAITE 1984, GRIFFIN & THOMAS 2000, MASON & MACDONALD 2004, KASPRZYKOWSKI 2007) have highlighted the significance of grasslands as important foraging habitats and how it could relate to the size of rookeries. In our observations, we found that the rookeries MUP, Vukovarska ulica and Vrbik had less than 10% grassland coverage within the 1 km buffer. Conversely, all rookeries with over 100 nests had more than 20% grassland coverage, with Bundek and Zaprude leading the way at 29% of the area covered by grasslands within the 1 km buffer. This type of permanent grassland could serve as a highly dependable food source (MASON & MACDONALD 2004). This is because young Rooks rely almost entirely on soil-dwelling invertebrates for sustenance during their initial two weeks of life (LOCKIE 1955). Apart from grasslands, Rooks seem to prefer London planes and trees from the genera *Acer*, *Fraxinus*, and *Populus*. Together, these trees accounted for 77% to 90% of all the counted trees, with London planes representing the majority at 33% to 61%. In future research, to confirm the preference for certain trees, it would be necessary to analyse all the tree species surrounding rookeries. This analysis should determine whether Rooks exhibit a preference for particular trees or if they simply utilize suitable trees. Additionally, the research should ascertain whether the most frequently recorded utilised tree species are more abundant in the area and, thus are more likely to host rookeries. Besides grasslands, Rooks have been recorded in large flocks foraging on the rubbish dump Prudinec (KRALJ & KRNJETA 2015). The rubbish dump is located 1.5 km from the rookeries Zaprude and Bundek. The rubbish dump serves as a dependable food source (KASPRZYKOWSKI 2003), which could be one of the reasons for the observed increase in the number of Rooks in that area. Another

reason could be the absence of predators in the city, such as the Eurasian Eagle Owl *Bubo bubo*, which does not breed within the city, and the Northern Goshawk *Accipiter gentilis*, estimated to have only two pairs (KRALJ & KRNJETA 2015).

The increase in the number of Rooks in the city has led to heightened persecution. We have observed instances of branch removal aimed at reducing or eliminating the Rook population. However, these efforts to remove Rooks did not impact the overall numbers significantly. Instead, they caused the rookery to disperse throughout the area, or the Rooks attempted to build their nests later in the season once the leaves sprouted when they were not so visible. In the Netherlands, due to the disturbance of large rookeries, small satellite rookeries formed in the surrounding areas (SCHOPPERS 2004). In Zagreb, Rooks are persecuted because of issues with defecation and noise at their roost and breeding sites (Šoštarić, *pers. comm.*). In addition, they have also been associated with the spread of bacteria (BOUTTEFROY *et al.* 1997, PEREC-MATYSIAK *et al.* 2017). The urban areas offer abundant foraging and breeding habitats that positively influence the Rook population, and Rooks are increasingly feeding on the short-mown grass of garden lawns, parks, playing fields and recreation grounds associated with built-up areas (HELDBJERG *et al.* 2023). To solve the conflict between rookeries and local residents, instead of focusing on branch and tree removal to decrease their numbers, actions should be taken to reduce the availability of food sources. Possibly, this could be achieved by reducing and fragmenting the uniform habitats by planting more densely packed trees, scrubs and bushes, reducing the availability of short grazed or mowed grassland during summer (HELDBJERG *et al.* 2023) by delaying the mowing after the chick-rearing period or minimizing the food supply at the rubbish dump. To gain insights into future population trends of Rooks in Zagreb, it is necessary to continuously monitor the birds' behaviour, nesting success, movement patterns, and survival. Furthermore, research should be expanded to investigate how various variables affect Rooks' nesting success and breeding site choices. These variables may include the extent of built-up areas, the availability of water sources, and alternative food sources besides grasslands, such as croplands and rubbish dumps.

Acknowledgements

We would like to thank all the people that helped during the monitoring and Iva Šoštarić for guidance and her devoted contribution during the monitoring.

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SAŽETAK

Gačac je česta gnjezdarica u nizinskoj Hrvatskoj gdje nastanjuje poljoprivredna i urbana područja. Cilj ovog rada bio je odrediti trend populacije gačaca u gradu Zagrebu te vrste stabla na kojima se gnijezde. Podaci korišteni u analizi prikupljeni su od 2017. do 2023. godine metodom građanske znanosti. Volonteri su u istraživanom razdoblju posjećivali kolonije pri čemu su bilježili broj gnjezdećih parova, vrste stabla na kojima se gnijezda nalaze te ostale važne napomene. U razdoblju od 2017. do 2023. na području grada Zagreba zabilježeno je 20 kolonija te se broj gnjezdećih parova ukupno povećao za 49,7 %. Najveći ukupan broj gnjezdećih parova zabilježen je 2022. i 2023. godine s 1172 i 1168 gnjezdećih parova. Gnijezda su se nalazila na 35 različitih vrsta stabla, a najčešće na platani *Platanus x acerifolia*. U okolini kolonija zabilježen je velik udio travnjačkih površina koje su značajne za prehranu gačaca. Zabilježeno je 18 pokušaja uklanjanja gnijezda ili rezanja grana sa stabla na kojima se nalaze kolonije s ciljem smanjenja broja gačaca. Ti pokušaji nisu imali velik utjecaj na promjenu broja gačaca na području grada Zagrebu.