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Contributions of Urban Woodlands to Bird Diversity and Abundance in The Anatolian Side of Istanbul

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Abstract

Aim of study: The study aimed to assess the impact of urban woodlands on bird species diversity and abundance in the Anatolian side of Istanbul, focusing on species typically absent from urban centers but found within urban environments. The findings are intended to contribute to the development of future conservation and habitat management strategies.

Area of study: The study was conducted in five areas in Üsküdar and Beykoz, including an urban center, three urban woodlands (Fethipaşa, Hidiv, and Beykoz Abrahampaşa) and a natural area in Istanbul's northern region.

Material and methods: Data on bird species and their abundances were collected and tabulated through 900 point counts from April 2022 to March 2023. The data was analyzed using abundance values, species richness and diversity, identifying distribution and evenness through rank abundance distribution and curves. Similarity analysis was performed using the clustering method and species composition was compared using a Venn diagram.

Main results: Seventy-two bird species were identified across the study areas. A decrease in urbanization density enhances bird species richness, diversity and evenness, with the natural area recording the highest values. Urban woodlands harbor species absent from more urbanized locations. Distinctions in species distribution and bird diversity between the areas were revealed.

Research highlights: Urban woodlands are crucial areas for wildlife in metropolises, providing significance from both ecological and sociocultural perspectives. Although they may not match natural areas in species diversity, these woodlands significantly contribute to bird diversity within the urban environments. Further research is needed to explore the unique characteristics of each woodland and their contributions to urban ecosystems.

Keywords: Urban Wildlife, Metropolitan Bird Diversity, Urban Ecology, Bird Ecology, Rank Abundance Curves

İstanbul Anadolu Yakası'nda Kent Korularının Kuş Çeşitliliği ve Bolluğuna Katkıları

Öz

Çalışmanın amacı: Bu çalışmayla İstanbul'un Anadolu Yakası'nda yer alan koru alanlarının katkıları sayesinde, genellikle kent merkezinde rastlanmadığı halde, kent içerisinde de görülebilen kuş türlerinin çeşitlilik ve bolluklarına etkisi ortaya koymaya çalışılmıştır. Bu sayede bölgedeki kuş çeşitliliğinin anlaşılmasına ve doğal yaşam alanlarına yönelik gelecekte yapılacak olan koruma ile yönetim stratejilerinin geliştirilmesine katkı sağlanması amaçlamaktadır.

Çalışma alanı: Araştırma, İstanbul'un Anadolu yakasında, Üsküdar ve Beykoz ilçelerinde; bir kent merkezi, üç kent korusu (Fethipaşa, Hidiv, Beykoz Abrahampaşa) ve İstanbul'un kuzey ormanlarındaki bir doğal alan olmak üzere beş farklı alanda gerçekleştirilmiştir.

Materyal ve yöntem: 2022 Nisan - 2023 Mart arasındaki 12 ay düzenli olarak yapılan toplam 900 nokta sayımı ile kuş türleri ve bollukları elde edilmiştir. Alanlardaki kuş türü zenginlik ve çeşitlilikleri belirlenmiş, bolluk derecesi dağılımı ve eğrileri ile türlerin alanlardaki dağılımı ve düzenlilikleri tespit edilmiş, benzerlik analizi kümeleme metoduyla gösterilmiş ve Venn şemasıyla alanlardaki kuş türleri karşılaştırılmıştır.

Temel sonuçlar: Alanları kullanan 72 kuş türü, alanlardaki bolluk değerleri ve statüleriyle birlikte tablo halinde verilmiştir. Kentleşme yoğunluğunun azalmasının, kuş türü zenginliğini, çeşitliliğini ve düzenliliğini artırdığı belirlenmiş, doğal alanın en yüksek değerlere sahip olduğu kaydedilmiştir. Kent korularının kentleşmiş alanlar içerisinde görülemeyen türleri barındırdığı sonucuna ulaşılmıştır. Türlerin hangi alanlarda ortak olarak bulunduğu ve alanların kuş türü çeşitliği bakımından birbirlerine göre farkları ortaya koyulmuştur.

Araştırma vurguları: Korular, metropollerde yaban hayatı için yüksek öneme sahip, hem ekolojik hem de sosyokültürel açıdan mühim alanlardır. Doğal alanlar kadar çeşitlilik sunmasalar bile kent içerisindeki kuş çeşitliliği ve zenginliğine büyük bir katkı sağlarlar. Her korunun kendi karakteristikleri olduğu, kuş türleri ve çeşitlilik değerlerindeki farklardan anlaşılmaktadır; alanlarda daha fazla araştırma yaparak bu durumun daha belirgin hale getirilebileceği, kent ekosistemine olan katkılarının daha iyi anlaşılacağı görülmüştür.

Anahtar Kelimeler: Kent Yaban Hayatı, Metropol Kuş Çeşitliliği, Kent Ekolojisi, Kuş Ekolojisi, Bolluk Derecesi Eğrileri

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Introduction

Türkiye, located at the intersection of Asia and Europe, boasts a rich avifauna comprising 500 bird species from 76 families belonging to 25 orders, as documented to date. This richness is attributed to the diverse habitats the country possesses and the fact that two of the four major bird migration routes of the Western Palearctic zoogeographical region pass through Türkiye (Küçük et al., 2017; Furtun et al., 2023). Istanbul, Türkiye's most populous metropolis, has around 16 million residents and is home to vital bird areas like northern forests, wetlands, and the Istanbul Strait (Bosphorus), a narrow passage where soaring migrating birds concentrate during migration. This location situates Istanbul as one of the significant bird migration routes in Türkiye. As a result, 397 bird species, constituting approximately 80% of all recorded species in Türkiye, have been observed in Istanbul from the past to the present (İsfendiyaroğlu et al., 2022).

Urban areas, particularly metropolitan ones, have higher human population densities compared to rural areas. Birds are a highly significant group of urban wildlife, with their diverse species, approachability to humans, and vocalizations. These birds serve as a reminder of wildlife existence, with millions of people experiencing their primary or sole interaction with wildlife through birds in densely populated urban settings (Hedblom & Murgui, 2017). The presence and richness of birds in metropolises increase knowledge about urban wildlife, awareness, and participation in conservation programs (Şekercioğlu, 2002). However, urbanization decreases bird species richness (Clergeau et al., 1998). Urban green spaces positively affect both urban wildlife and the quality of life for urban people, while also contributing to bird species richness and diversity (Öztürk & Özdemir, 2013; Lepczyk et al., 2017; Oğurlu & Suri, 2021).

Woodlands within urban green spaces, referred to as urban woodlands, are forested areas located within or in the vicinity of urban areas. They are enclosed by walls for security measures, maintained for an extended period, and provide recreation for the urban population (Eyüpreisoğlu, 2007). There is no production of any wood material in urban woodlands. Only branches and trees at risk of falling are removed. Other trees remain protected. Therefore, there are always old trees in urban woodlands.

These urban woodlands act as shelters for organisms affected by urbanization and play a crucial role in preserving biodiversity within the city (Sözgen et al., 2020). A study in France analyzed the biological diversity function of urban woodlands, focusing on the responses of birds, small mammals, and insects to urbanization. Results showed that small urban woodlands shelter over half of the species found in forested areas (Croci et al., 2008). Therefore, the ecological and socio-cultural significance of urban woodlands is substantial. Numerous studies have been conducted about their importance in these issues (Luck et al., 2011; Hedblom et al., 2014; Fisher et al., 2021a; 2021b).

This study focuses on the areas within two districts (Üsküdar and Beykoz) of Istanbul, which hosts the highest human population metropolis in Türkiye. The objective of this study is to determine the contribution of urban woodlands to bird species richness, abundance, and diversity by examining an urban center, three different woodland areas within the urban context, and a natural area (forest). By quantifying the diversity and abundance patterns of bird species within the Istanbul metropolis, the study aspires to contribute to future conservation and management plans for urban biotopes.

Materials and Methods

Study Area

The study areas were selected from the Anatolian side of Bosphorus. Bosphorus experiences a transitional climate between the Mediterranean and Black Sea climates. Unlike regions with a typical Mediterranean climate, there is not as severe drought in Istanbul, and drought periods are relatively shorter. Urbanization in Istanbul is predominantly concentrated in the southern part of the city. As one moves north, population density decreases, eventually giving way to forests (Northern Forests) (Figure 1).

Figure 1. Satellite image of the study areas (Google Earth, 2023)

Üsküdar, located south of the Bosphorus, stands as one of the oldest settlements in the heart of Istanbul with a substantial population. Its location in a historically and culturally rich region makes it a residential area encompassing significant tourist attractions such as historical structures, mosques, museums, and various green spaces. The selected urban observation area, Üsküdar Square (41°1'26"N, 29°0'57"E), and its immediate surroundings serve as the district's major transfer, commercial, and tourist hub, thus constituting the most densely populated area. Predominantly covered with impervious surfaces and equipped with stone and concrete structures (squares, mosques, public transportation stops, 4–7-story residential buildings, and 1–7-story commercial buildings), the area is also characterized by landscaped elements. These vegetated areas, including residential gardens, mosque courtyards, wastewater treatment facility gardens, grass-covered medians on streets, and squares resulting from landscape arrangements, contribute to the low percentage of vegetated space within the urban center study area.

The three selected urban woodlands for the study are bordered by urban areas and have been preserved as green spaces for centuries. Within these woodlands, social facilities, as well as sports and recreational areas, are present. The natural vegetation in these areas is characterized by a Mediterranean shrub formation and a mixed forest type with needle-leaf and broadleaf trees. Additionally, non-native species have been introduced to the areas. Common needle-leaf tree genera observed in the three selected woodlands are *Pinus*, *Cedrus*, and *Cupressus*, while broadleaf genera include *Quercus*, *Fraxinus*, *Robinia*, *Tilia*, *Celtis*,

and *Platanus*. The sequence of the selected urban woodlands from the urban center towards the Natural Area is as follows: Fethipaşa Woodland (Üsküdar) (41°1'54"N, 29°1'39"E), Hidiv Woodland (Beykoz) (41°6'17"N, 29°4'34"E), and Beykoz Abrahampaşa Woodland (41°8'0"N, 29°6'5"E).

The Natural Area (41°10'39"N 29°7'33"E) is part of Istanbul's northern forests and falls under the jurisdiction of the Beykoz Forest Directorate. It constitutes a forest area with a mixed stand of deciduous and coniferous trees. The tree species present in the area (in order of abundance) are European Chestnut (*Castanea sativa*), Maritime Pine (*Pinus pinaster*), False Acacia (*Robinia pseudoacacia*), Downy Oak (*Quercus pubescens*), and Silver Lime (*Tilia argentea*). The forest canopy density is categorized as 3 (Considered 0 if less than 10%, 1 if between 11-40%, 2 if between 41-70%, *3 if 71%and above*), and the developmental stages are B and C (Considered A if the the diameter at 1.30m above the ground is less than 7.9cm, *B if between 8-19.9cm, C if between 20-35.9cm,* D if between 36-51.9cm and E if more than 52cm.) (OGM, 2011). The dense and vibrant vegetation in the maquis formation entirely covers the area.

Field Method

The point count method was employed for conducting bird surveys in each study area. To reduce errors and avoid bias, all observations were conducted by the same observer. Surveys were conducted from dawn to three hours after, to allow observations when birds were most active in the region. An equal number of points were selected in each area to ensure precision. Silence was maintained at each point, and counts were conducted for equal durations (effort) (Bibby et al., 1992; Oğurlu, 2003). Within each study area, 15 points with a minimum distance of 100 meters apart (Tilghman, 1987; Blair, 1996; Hastedt & Tietze, 2023) were established, totaling 75 points. These points were visited monthly from April 2022 to the end of March 2023, covering all four seasons - from spring to the end of winter - (Ugış et al., 2016), resulting in a total of 900-point counts. After a period of ensuring 2-3 minutes of silence at each point, all individuals of birds (perched or flying low) using the areas were counted for 5 minutes, noting all individuals detected by sight and sound. Birds flying at higher altitudes than trees and buildings in the areas were not included in the counts (Hedblom & Söderström, 2010; Heyman, 2010). Counts were not conducted on days with rain, fog or strong winds (Arslangündoğdu, 2010; Gardner et al., 2019; Issa, 2019; Süel et al., 2021; Mohd-Taib et al., 2022). All areas were located near the Bosphorus; however, to avoid waterbirds influencing bird counts, points were selected at least 100 meters away from the Bosphorus. Points chosen from the urban center, representing different functional areas, aimed to enhance the representation of the area and record the highest number of bird species. In selecting the natural area, attention was paid to choosing a location equidistant from the Bosphorus as the other areas, devoid of human activity and structures, and as far as possible from residential areas to minimize human impact. During the counts, a GPS device was used for locating the points, 8 x 42 and 10 x 50 binoculars, a sound recording device, and a field guidebook (Furtun et al., 2023) were used for bird species identification.

Data Analysis

The bird species and abundances obtained during the counts in the study areas were recorded and compiled into a table. For richness analysis, the Margalef (D_{MG}) index using species numbers and abundance values (Margalef, 1968) was used and for diversity analysis, the Shannon (H') index using relative abundance values (Shannon & Wiener, 1949) was used. It is well-established that Shannon Diversity Index values typically range between 1.5 and 3.5, and rarely exceed 4 (Magurran, 2004).

The distribution of bird species abundances across communities and the evenness of bird species abundances in the areas were elucidated using rank abundance distribution and curves (MacArthur, 1957; Whittaker, 1965). Rank abundance distribution (RAD) is a representation of species count data applicable to all

environments. RADs enable the comparison of samples taken from regionally distinct areas with few or no species in common (Foster & Dunstan, 2010). Rank abundance curves (RAC) are a useful tool for understanding differences in the numbers and abundances of species. Additionally, they are used to demonstrate species richness and evenness. The area under the curve represents the total number of species in the community, and the shape of the curve can provide insights into the diversity and evenness of the community. For example, a curve that is skewed to the right indicates that species at the top are more commonly found than those at the bottom, while a curve that is skewed to the left indicates higher evenness, meaning that the abundances of different species are similar. Overall, the RAC is a useful tool for visualizing the distribution of species abundance within an ecosystem and can provide insights into the structure and dynamics of ecological communities (Magurran, 2004; Da Silva & Matsushita, 2023).

The species shared among the areas and the unique species numbers for each area were illustrated using a Venn diagram (Beskardes, 2020). Inter-area similarity values were analyzed using the Bray-Curtis dissimilarity (B) index (Bray & Curtis, 1957), which formulates the comparison of species and abundances across areas, and clustered using the Ward2[1] hierarchical clustering method. The "1-B" formula was used to obtain similarity values. All analyses were conducted using R (v4.3.1; R Core Team, 2023). Richness, diversity, and similarity analyses were repeated using BİÇEB (Özkan et al., 2020), and the same results were obtained. The Vegan package (Oksanen et al., 2022) was employed for richness, diversity, and similarity analyses in R. BiodiversityR package (Kindt & Coe, 2005) was utilized for Rank Abundance analysis, VennDiagram package (Chen, 2022) and grid package (R Core Team, 2023) for the Venn diagram, and factoextra package (Kassambara & Mundt, 2020) for the Cluster Dendrogram. Line charts were generated using Excel (Microsoft Corporation, 2016).

[1]Murtagh & Legendre (2014) noted that the hierarchical clustering method 'Ward' can be applied to dissimilarity matrices. Ward2 minimizes the clustering criterion by using the distances themselves, while Ward1 uses the squared distances. Therefore, Ward2 is considered more suitable than Ward1.

Results

The bird species recorded in the areas, along with their abundance and the IUCN (2022) (EU) conservation statuses (LC: Least Concern, NT: Near Threatened, VU: Vulnerable) for these species, as well as their Life Status for Istanbul (SM: Summer Migrant, PM: Passage Migrant, WM: Winter Migrant, R: Resident) (İsfendiyaroğlu et al., 2022), systematically arranged according to Gill et al. (2023), are presented in tabular form. Species belonging to each order are highlighted in different colors. The areas are denoted as Urban Area (U), Fethipaşa Woodland. (F), Hidiv Woodland (H), Beykoz Woodland (B), and Natural Area (N) (Table 1).

Table 1. Bird species and 12-month abundance values in the study areas

No	Scientific name	English name	U	F	H	B	N	Total	IUCN	Life Status
1	*Tachymarptis melba* L.	Alpine Swift	29	82	3	0	10	124	LC	SM, PM
2	*Apus apus* L.	Common Swift	3	2	0	0	1	6	NT	SM, PM
3	*Columba livia* J.F. Gmel.	Rock Dove	1097	44	1	26	0	1168	LC	R
4	*Columba palumbus* L.	Common Wood Pigeon	0	0	0	0	37	37	LC	R, PM
5	*Streptopelia turtur* L.	European Turtle Dove	0	0	0	0	4	4	VU	SM, PM
6	*Streptopelia decaocto* Friv.	Eurasian Collared Dove	0	0	0	0	1	1	LC	R
7	*Spilopelia senegalensis* L.	Laughing Dove	377	22	2	1	0	402	LC	R
8	*Larus michahellis* J.F. Naum.	Yellow-legged Gull	653	122	11	0	0	781	LC	R
9	*Ardea cinerea* L.	Grey Heron	0	0	44	0	0	44	LC	R
10	*Pernis apivorus* L.	European Honey Buzzard	0	0	0	0	2	2	LC	PM, SM
11	*Hieraaetus pennatus* J.F. Gmel.	Booted Eagle	0	0	0	1	0	1	LC	PM, SM
12	*Accipiter nisus* L.	Eurasian Sparrowhawk	0	0	0	0	2	2	LC	PM, R
13	*Accipiter gentilis* L.	Eurasian Goshawk	0	0	0	0	1	1	LC	WM, PM
14	*Buteo rufinus* Cretzschmar	Long-legged Buzzard	0	0	0	0	1	1	LC	PM, R
15	*Buteo buteo* L.	Common Buzzard	0	0	0	6	15	21	LC	PM, R, WM
16	*Upupa epops* L.	Eurasian Hoopoe	0	1	0	0	0	1	LC	SM, PM
17	*Merops apiaster* L.	European Bee-eater	0	0	0	0	5	5	LC	PM, SM
18	*Dendrocoptes medius* L.	Middle Spotted Woodpecker	0	0	1	2	0	3	LC	R
19	*Dryobates minor* L.	Lesser Spotted Woodpecker	0	1	8	21	7	37	LC	R
20	*Dendrocopos syriacus* Hemprich & Ehrenb.	Syrian Woodpecker	0	4	0	3	0	7	LC	R
21	*Dendrocopos major* L.	Great Spotted Woodpecker	0	0	0	1	0	1	LC	R
22	*Dendrocopos leucotos* Bechst.	White-backed Woodpecker	0	0	0	0	1	1	LC	R
23	*Picus viridis* L.	European Green Woodpecker	0	0	6	44	0	50	LC	R
24	*Picus canus* J.F.Gmel.	Grey-headed Woodpecker	0	0	0	11	1	12	LC	R
25	*Falco tinnunculus* L.	Common Kestrel	0	0	0	0	1	1	LC	R, PM
26	*Falco subbuteo* L.	Eurasian Hobby	0	0	0	2	0	2	LC	SM, PM
27	*Psittacula eupatria* L.	Alexandrine Parakeet	0	34	79	126	0	239	NT	R
28	*Psittacula krameri* Scop.	Rose-ringed Parakeet	3	38	45	69	0	155	LC	R
29	*Oriolus oriolus* L.	Eurasian Golden Oriole	0	0	0	1	1	2	LC	PM, SM
30	*Garrulus glandarius* L.	Eurasian Jay	0	15	20	44	27	106	LC	R
31	*Pica pica* L.	Eurasian Magpie	2	71	0	2	1	76	LC	R
32	*Coloeus monedula* L.	Western Jackdaw	4	36	159	57	2	258	LC	R
33	*Corvus frugilegus* L.	Rook	0	0	2	0	0	2	VU	WM
34	*Corvus cornix* L.	Hooded Crow	490	584	524	399	6	2003	LC	R
35	*Corvus corax* L.	Common Raven	0	0	3	0	2	5	LC	R, PM
36	*Cyanistes caeruleus* L.	Eurasian Blue Tit	1	60	26	34	13	134	LC	R
37	*Parus major* L.	Great Tit	23	346	199	270	81	919	LC	R
38	*Hirundo rustica* L.	Barn Swallow	0	0	0	2	34	36	LC	SM
39	*Aegithalos caudatus* L.	Long-tailed Tit	0	28	13	15	15	71	LC	R
40	*Phylloscopus sibilatrix* Bechst.	Wood Warbler	0	0	0	0	2	2	LC	PM
41	*Phylloscopus trochilus* L.	Willow Warbler	0	5	4	0	35	44	LC	PM
42	*Phylloscopus collybita* Vieillot	Common Chiffchaff	4	31	8	6	5	54	LC	R, PM, WM
43	*Sylvia atricapilla* L.	Eurasian Blackcap	0	1	5	0	24	30	LC	PM, SM, WM
44	*Sylvia borin* Bodd.	Garden Warbler	0	0	0	0	5	5	LC	PM, SM
45	*Curruca melanocephala* J.F. Gmel.	Sardinian Warbler	0	0	0	2	30	32	LC	R, PM
46	*Regulus ignicapilla* Temminck	Common Firecrest	0	6	6	7	14	33	LC	SM, PM, WM
47	*Regulus regulus* L.	Goldcrest	1	6	10	4	9	30	LC	SM, PM, WM
48	*Troglodytes troglodytes* L.	Eurasian Wren	0	43	98	156	70	367	LC	R
49	*Sitta europaea* L.	Eurasian Nuthatch	0	0	0	1	0	1	LC	R
50	*Certhia familiaris* L.	Eurasian Treecreeper	0	0	2	5	9	16	LC	R
51	*Certhia brachydactyla* C.L. Brehm	Short-toed Treecreeper	0	4	40	92	4	140	LC	R
52	*Sturnus vulgaris* L.	Common Starling	99	31	22	7	0	159	LC	R, WM, PM
53	*Turdus philomelos* C.L. Brehm	Song Thrush	0	1	6	6	0	13	LC	R, PM, WM
54	*Turdus viscivorus* L.	Mistle Thrush	0	0	3	1	1	5	LC	PM, WM
55	*Turdus iliacus* L.	Redwing	0	0	4	0	2	6	LC	WM, PM
56	*Turdus merula* L.	Common Blackbird	0	0	101	91	92	284	LC	R
57	*Muscicapa striata* Pall.	Spotted Flycatcher	0	3	2	0	15	20	LC	PM, SM
58	*Erithacus rubecula* L.	European Robin	2	87	112	91	66	358	LC	R, PM
59	*Luscinia megarhynchos* C.L. Brehm	Common Nightingale	0	0	1	9	25	35	LC	PM, SM
60	*Ficedula parva* Bechst.	Red-breasted Flycatcher	0	4	4	5	8	21	LC	PM
61	*Ficedula albicollis* Temminck	Collared Flycatcher	0	1	0	2	1	4	LC	PM
62	*Phoenicurus ochruros* S.G.Gmel.	Black Redstart	1	0	0	0	0	1	LC	R, PM, WM
63	*Passer domesticus* L.	House Sparrow	565	215	43	90	0	913	LC	R
64	*Prunella modularis* L.	Dunnock	0	0	0	0	1	1	LC	PM, WM

Table 1. (Continued)

No	Scientific name	English name	U	F	H	B	N	Total	IUCN	Life Status
65	*Motacilla cinerea* Tunstall	Grey Wagtail	0	1	0	0	0	1	LC	WM, PM, R
66	*Fringilla coelebs* L.	Eurasian Chaffinch	1	76	72	115	312	576	LC	R
67	*Fringilla montifringilla* L.	Brambling	0	0	0	0	2	2	LC	WM, PM
68	*Coccothraustes coccothraustes* L.	Hawfinch	0	1	1	1	3	6	LC	R, PM
69	*Carpodacus erythrinus* Pall.	Common Rosefinch	0	0	0	0	1	1	LC	PM, SM
70	*Chloris chloris* L.	European Greenfinch	0	0	0	0	29	29	LC	R
71	*Serinus serinus* L.	European Serin	0	0	1	0	0	1	LC	R, WM
72	*Spinus spinus* L.	Eurasian Siskin	0	0	0	0	2	2	LC	WM, PM

U: Urban Area, F: Fethipaşa W., H: Hidiv W., B: Beykoz W., N: Natural Area, LC: Least Concern, NT: Near Threatened, VU: Vulnerable, SM: Summer Migrant, PM: Passage Migrant, WM: Winter Migrant, R: Resident

In Beykoz Woodland, both the species richness and abundance in the order Piciformes were recorded higher than those in the natural area. As one approaches the urban center, a decrease in both the species richness and abundance of Piciformes is observed (Table 1).

The number of species recorded in the study areas listed in Table 1, along with the abundance values obtained by summing the population numbers of these species, are depicted in Figure 2 as a line graph. As seen, while the number of species increases from the urban center to the natural area, the abundance values decrease. This trend is attributed to the decrease in generalist bird species due to reduced urbanization. Indeed, urbanization decreases gradually from south to north across the entire Anatolian side of Istanbul.

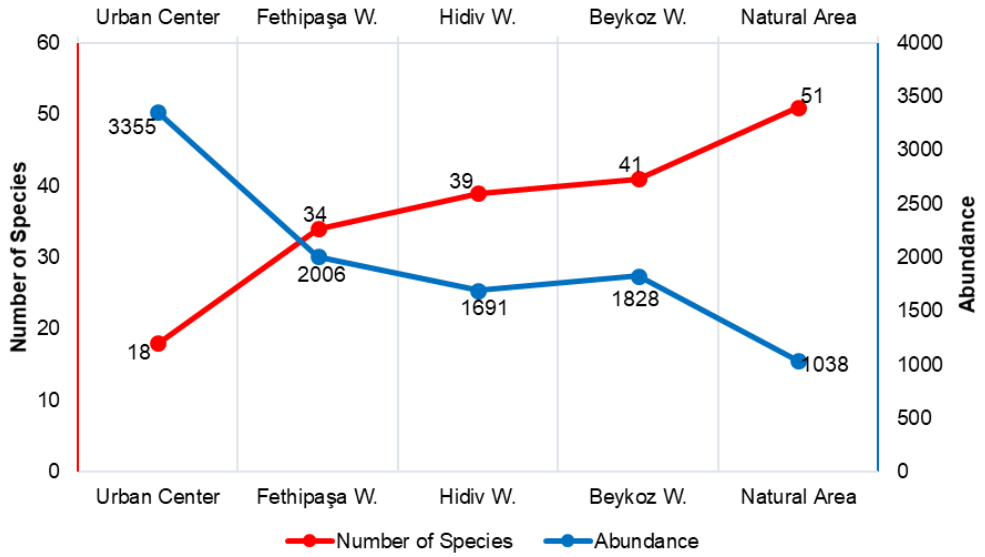

Figure 2. Comparison of species numbers and abundance values in the study areas

The Margalef Richness (D_{MG}) and Shannon Diversity (H') values of the study areas, along with the distances of each to the natural area (obtained from the Google Earth application) are shown in Figure 3. As the areas approach the natural habitat, both species richness and diversity increase.

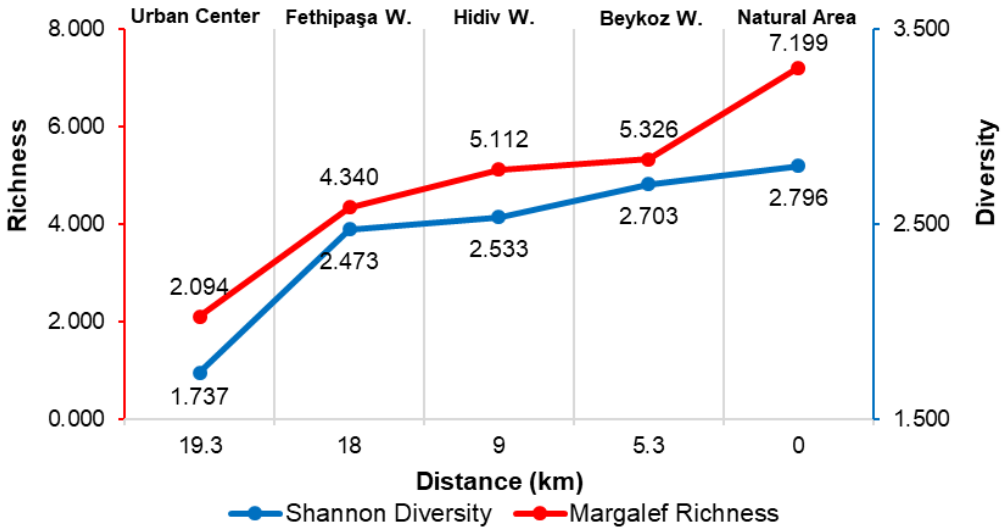

Figure 3. Distances of the areas to the natural area along with richness and diversity values

The rank abundance distribution, curves, and equations of the areas are provided in Figure 4. The evenness of the areas is understood from the equations of the curves. When examining the slope values in the equations, it is evident that the natural area, with the shallowest slope value (closest to 0), has the highest evenness, while the urban woodlands exhibit intermediate values (i.e., -0.820 to -0.881), and the urban center, with the steepest slope, has the lowest evenness (Figure 4).

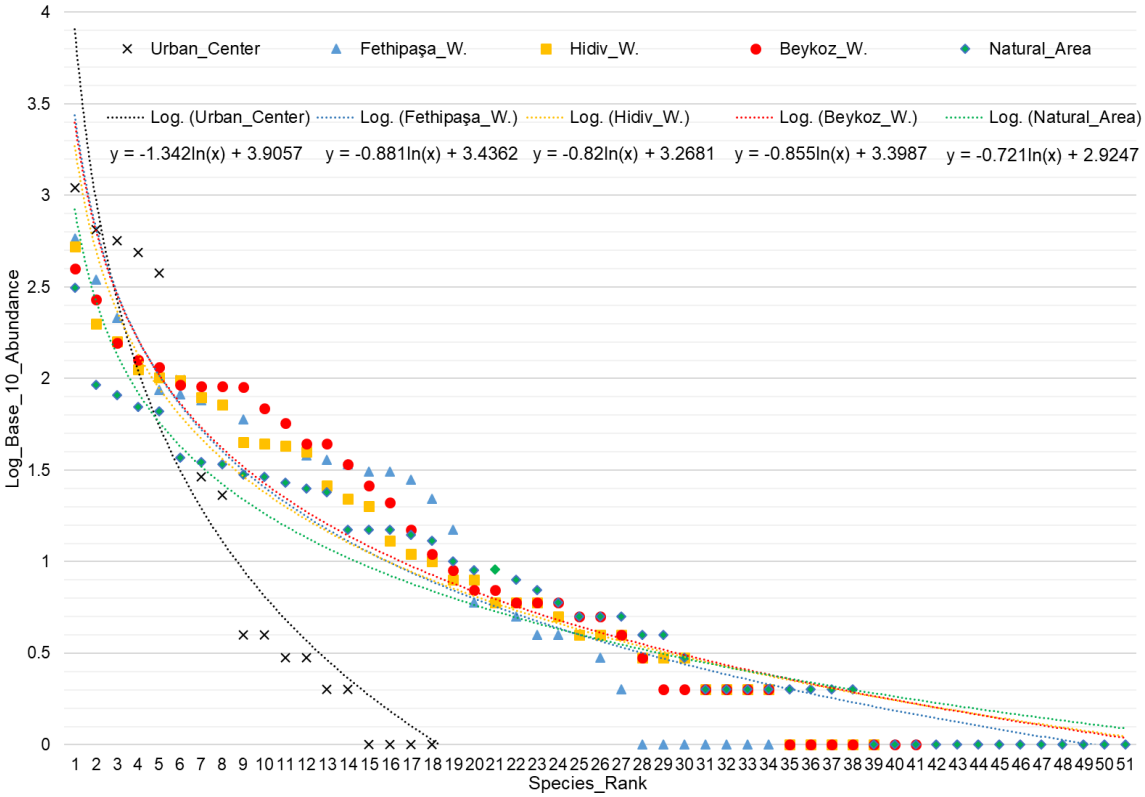

Figure 4. Rank abundance distribution and curves

The distribution of species numbers in the areas is depicted using a Venn diagram. According to the Venn diagram, encompassing the 72 recorded species in the study, a total of 8 common species (Western Jackdaw, Hooded Crow, Eurasian Blue Tit, Great Tit, Common Chiffchaff, Goldcrest, European Robin, Eurasian Chaffinch) were observed across all areas. Additionally, 23 species were commonly recorded in the three urban woodlands, including Rock Dove, Laughing Dove, Lesser Spotted Woodpecker, Alexandrine Parakeet, Rose-ringed Parakeet, Eurasian Jay, Western Jackdaw, Hooded Crow, Eurasian Blue Tit, Great Tit, Long-tailed Tit, Common Chiffchaff, Common Firecrest, Goldcrest, Eurasian Wren, Short-toed Treecreeper, Common Starling, Song Thrush, European Robin, Red-breasted Flycatcher, House Sparrow, Eurasian Chaffinch, and Hawfinch. The 8 species (Lesser Spotted Woodpecker, Eurasian Jay, Long-tailed Tit, Common Firecrest, Eurasian Wren, Short-toed Treecreeper, Red-breasted Flycatcher, Hawfinch) recorded in both urban woodlands and the natural area were not observed in the urban center. Likewise, the 5 species (Rock Dove, Laughing Dove, Rose-ringed Parakeet, Common Starling, and House Sparrow) recorded in both the urban woodlands and the urban center were not recorded in the natural area.

Two species were recorded in all three urban woodlands but were absent from the urban center and the natural area (Alexandrine Parakeet and Song Thrush). In the urban center, 1 species was recorded exclusively (Black Redstart). Fethipaşa Woodland had 2 species recorded exclusively (Eurasian Hoopoe and Grey Wagtail). Hidiv Woodland had 3 species recorded exclusively (Grey Heron, Rook, and European Serin). Beykoz Woodland had 4 species recorded exclusively (Booted Eagle, Great Spotted Woodpecker, Eurasian Hobby, and Eurasian Nuthatch). In the natural area, 17 species were recorded exclusively (Common Wood Pigeon, European Turtle Dove, Eurasian Collared Dove, European Honey Buzzard, Eurasian Sparrowhawk, Eurasian Goshawk, Long-legged Buzzard, European Bee-eater, White-backed Woodpecker, Common Kestrel, Wood Warbler, Garden Warbler, Dunnock, Brambling, Common Rosefinch, European Greenfinch, and Eurasian Siskin).

Commonly shared species between the natural area and only Beykoz Woodland included 5 species (Common Buzzard, Grey-headed Woodpecker, Eurasian Golden Oriole, Barn Swallow, and Sardinian Warbler). Only 2 species were shared between the natural area and only Hidiv Woodland (Common Raven and Redwing). There were no shared bird species recorded between the natural area and only Fethipaşa Woodland, as well as between the natural area and the urban center. However, if we consider Fethipaşa Woodland and the urban center together, there was one shared species with the natural area (Common Swift) (Figure 5).

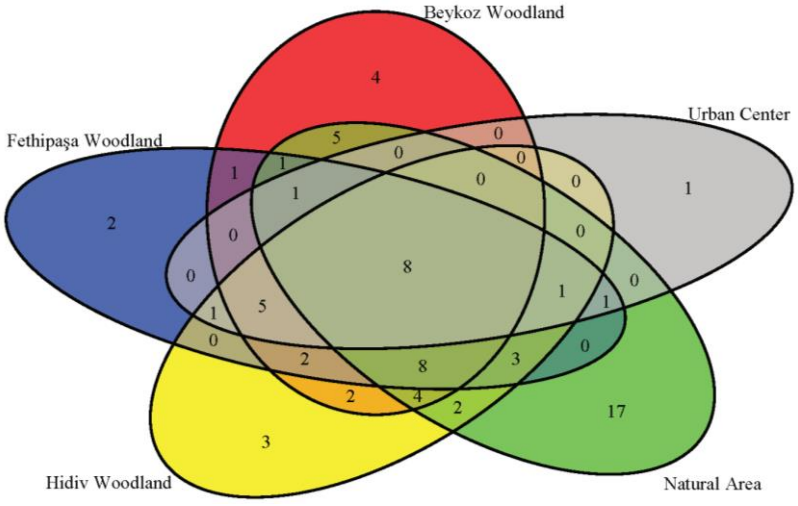

Figure 5. Venn diagram of bird species numbers in the areas

The Bray-Curtis dissimilarity table was clustered using the Ward2 hierarchical clustering method. The highest dissimilarity was found between the urban center and the natural area, with the urban woodland having the least similarity to the natural area being Fethipaşa, followed by Hidiv, and Beykoz woodlands, respectively (Table 2, Figure 6).

Table 2. Bray-Curtis similarity (1-B) matrix of the areas

Areas	Urban Center	Fethipaşa W.	Hidiv W.	Beykoz W.
Fethipaşa W.	37%	100%	65%	63%
Hidiv W.	24%	65%	100%	75%
Beykoz W.	22%	63%	75%	100%
Natural Area	2%	24%	36%	38%

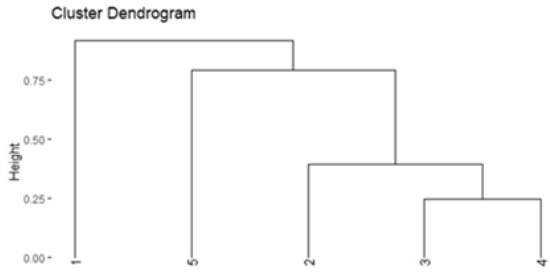

Figure 6. Dissimilarity cluster analysis of the areas (1: Urban center, 2: Fethipaşa Woodland, 3: Hidiv Woodland, 4: Beykoz Woodland, 5: Natural area)

Similarity values percentage to the urban area decreased as the distance from the urban area increased and to the natural area increased as the distance from the natural area decreased (Table 2).

The bird species that most increased the similarity between the urban center and urban woodlands were first Hooded Crow, followed by House Sparrow. The species contributing most to the similarity between the natural area and urban woodlands were, in order of abundance, Eurasian Chaffinch, Eurasian Wren, Great Tit, European Robin, Eurasian Jay, Long-tailed Tit, and Eurasian Blue Tit (Table 1).

Discussion

Despite careful consideration of bird counting techniques during the surveys, some individuals, such as those remaining silent or quietly passing behind the observer, may have been missed. Because of this, the results obtained from the counts are always lower than the actual numbers (Bibby, 1992; Oğurlu, 2003).

The findings obtained during the research indicate that the urban woodlands significantly contribute to the richness and diversity of bird species across the metropolitan area of Istanbul. According to the results, the urban center has the lowest bird species richness and diversity, while the natural area exhibits the highest bird diversity and richness. The lower diversity and richness of bird species in the urban center compared to the urban woodlands and the natural area indicate the negative impact of urbanization and human activities on natural habitats. The similarity of the diversity values of the urban woodlands to the diversity value of the natural area, being closer than the urban center's diversity value, is attributed to the urban woodlands retaining some natural habitat characteristics and environmental factors despite being within the urban environment. This suggests that urban woodlands play a crucial role as habitats for birds within the urban environment, as they provide opportunities for feeding, shelter, nesting, and resting during migration, contributing to the protection of birds from negative factors in urban centers such as noise, air pollution, and human activities (Marzluff et al., 2001).

The bird species composition among urban woodlands varies depending on factors such as the vegetation structure, degree of human pressure, and location of woodland areas (Marzluff et al., 2001). Since the data for this study were obtained only from counts during dawn hours, the number of people in urban woodlands was at its lowest during the observation hours. However, human-induced (anthropogenic) effects such as structures in the area, impervious surface applications, clearance of the understory, and litter left by area users varied in different amounts in each urban woodland. In addition, according to a study in China, natural influences were considered more significant than anthropogenic effects on bird diversity in urban parks (Liu et al., 2019).

Patterns of richness, diversity, and similarity among study areas were influenced by the distance of the study area to the

northern forests of Istanbul. The observed increase in richness, diversity, and similarity values (relative to the natural area) in urban woodlands as one moves north can be explained by the proximity of Istanbul's northern forests, leading to more suitable habitats for various bird species as they become closer, coupled with a reduction in urbanization. Accordingly, as one moves away from the urban center, there is an increase in both the richness and diversity of bird species. Among the urban woodlands, Beykoz Woodland, located where the continuous forest habitat from the northern forests directly contacts the urban, exhibits the highest species richness and diversity, while Fethipaşa Woodland, being both closer to the urban center and farthest from large forested areas, has the lowest species diversity (Figure 3). Similarly, Beykoz Woodland has the highest number of shared species with the natural area (Figure 5). This situation, when considered from the perspective of bird species, supports the notion that increasing urbanization and habitat loss contribute to a decrease in richness and diversity (Blair, 1996; Clergeau et al., 1998).

The highest overall bird abundance being in the urban center and the decrease in abundance towards the natural area are explained by the high adaptation of bird species categorized as generalists to urbanization. Generalist bird species are not highly specialized in their habitat or food requirements, allowing them to exploit a variety of resources and environments. They are species with broad tolerances to various environmental, physiological, and ecological conditions prevalent in urban ecosystems, enabling them to succeed. As a result, compared to species with specific habitat and food requirements, they are typically more common and widespread in the urban environment (Callaghan et al., 2019; Keten et al., 2020; Thompson et al., 2022).

In the urban center, Rock Dove, in the urban woodlands, Hooded Crow, and in the natural area, Eurasian Chaffinch species were the dominant species. Dominance by one or a few individual species negatively affects the evenness in each community. The steep slope observed in the rank abundance distribution and curves in the urban center, in terms of the numerical distribution of bird species, indicates low evenness, attributed to a few species having high abundance. This contrasts with the more balanced and equitable distribution of abundances (greater evenness) observed in urban woodlands and the natural area compared to the urban center (Figure 4). This condition suggests that urban woodlands, by providing different habitat types and microhabitats for bird species, relative to the urban center, meet the ecological niches required by forest birds due to similar habitats in urban woodlands and the natural area (Magurran, 2004; Avolio et al., 2019).

According to the similarity analysis, the bird community in the urban center resembles the natural area by only a mere 2%. This clearly highlights the distinction between the urban center and the northern forests. While bird communities in urban woodlands are 63-75% similar to each other, they are 22-37% similar to the urban center and 24-38% similar to the natural area. Urban woodlands offer birds similar habitat features and microhabitat diversity. However, due to the unique characteristics of individual urban woodlands, they are found to be dissimilar to each other by 25-37%. In addition, despite having forest habitats, urban woodlands resemble the natural area only up to 38%, suggesting that the natural area has a distinct bird species composition (Table 2). The higher proportion of dense understory and lack of impervious surface in the natural area is thought to be influential in this result (Heyman, 2010).

Conclusion

As one approaches the northern forests and urbanization decreases, the richness and diversity of bird species in urban woodlands increase, and bird communities are more evenly distributed. The natural area, consisting of deciduous and coniferous species, provides suitable habitats for different bird species throughout the year. The extensive coverage of dense shrubs is also essential for birds seeking shelter. The absence of human activity and structures in the natural area eliminates human pressure on birds. Despite the high species diversity in

the natural area due to these factors, the lack of mature trees in the D and E age classes in the area (OGM, 2011) has a negative impact on certain bird species, particularly woodpecker species (Akdemir, 2023).

The three woodlands studied among the urban woodlands in Istanbul are characterized by their centuries-old existence as green spaces. These urban woodlands, due to their long history, harbor a higher proportion of mature and dead trees than the northern forests, creating microhabitats that provide a suitable environment for particular wildlife species. The presence of mature trees, especially, accounts for the increased occurrence of woodpecker species in these urban woodlands. Therefore, the urban woodlands contribute to wildlife support, enabling wildlife to enter urban areas. This is best exemplified by Fethipaşa Woodland. In Fethipaşa Woodland, located on the outskirts of the urban center, all species observed in the urban center, except for one species (Black Redstart), were recorded. Additionally, 17 species (Eurasian Hoopoe, Lesser Spotted Woodpecker, Syrian Woodpecker, Alexandrine Parakeet, Eurasian Jay, Long-tailed Tit, Willow Warbler, Eurasian Blackcap, Common Firecrest, Eurasian Wren, Short-toed Treecreeper, Song Thrush, Spotted Flycatcher, Red-breasted Flycatcher, Collared Flycatcher, Grey Wagtail and Hawfinch) were recorded in the woodland that were not observed in the urban center. On the other hand, Rook (*Corvus frugilegus*), recorded within the scope of the study, holds a Vulnerable (VU) conservation status, and was observed only in Hidiv Grove. This situation serves as an indicator that urban woodlands, despite being surrounded by the urban environment, provide habitat for species that need protection. However, despite having a forest habitat, urban woodlands, primarily due to their smaller areas and being surrounded by urbanized areas, are affected by habitat fragmentation. Subsequently, human impacts, including efforts to make the areas suitable for recreational use (such as asphalt roads, facility buildings, pruning, and clearance of understory), and the use of fossil-fuel vehicles in the area, result in lower bird species richness and diversity compared to natural areas.

The diversity and abundance of bird species are crucial tools for collecting scientific data about habitats and understanding changes in ecosystems. Increasing diversity of bird species in metropolitan areas leads to a greater number of people acquiring knowledge about wildlife and developing awareness. This situation brings about opportunities to conserve suitable habitats for birds or expand existing areas. Efforts to preserve biodiversity in the face of urban growth should focus on preserving as much remnant natural habitat as possible. This can be achieved through the use of ecological principles such as preserving remnant natural habitat and restoring modified habitats to promote native species conservation. Additionally, managing the large amount of residential vegetation in ways that promote native plants and animals could also make a significant contribution to conservation. Urban planners should find ways to preserve biodiversity as cities expand outward and subsequently modify natural habitat. (McKinney, 2002).

In this study, the bird species richness, diversity, and evenness of three urban woodlands on the Anatolian side of Istanbul were compared with the urban center and a natural area, through conducted counts and analyses. Naturally, the generalizability of the results is limited as the study is confined to only five areas. Therefore, the continuation of periodic observations in these areas in the coming years and even further studies in additional areas could provide a more comprehensive understanding of bird species abundance and diversity.

In conclusion, urban woodlands, while not reaching the same level as natural habitats in terms of bird species diversity and richness, are nevertheless significant habitats in this regard. They provide opportunities for feeding, sheltering, and breeding for a variety of species, distinct from the generalist bird species, and even offer resting opportunities for migratory birds during migration, thereby contributing to the diversity of bird species within urbanized areas. Conservation efforts should be directed toward sustaining the viability of these areas.

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Ethics Committee Approval

N/A

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Author Contributions

Conceptualization: Z.A., Ö.T.S., İ.O.; Investigation: Ö.T.S.; Material and Methodology: Ö.T.S., Z.A., İ.O.; Supervision: Z.A., İ.O.; Visualization: Ö.T.S., Z.A.; Writing-Original Draft: Ö.T.S.; Writing-review & Editing: İ.O., Z.A., Ö.T.S.; Other: All authors have read and agreed to the published version of manuscript.

Conflict of Interest

The authors have no conflicts of interest to declare.

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