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# Avian Diversity and Conservation Value of the Gölköy-Yumrukaya Wetland: A University Campus as a Biodiversity Hotspot on the Urban Fringe

## Gölköy-Yumrukaya Sulak Alanının Kuş Çeşitliliği ve Koruma Değeri: Şehir Sınırlarında Biyoçeşitlilik Sıcak Noktası Olarak Bir Üniversite Kampüsü

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**Abstract:** Urbanization and habitat fragmentation increasingly threaten global avian biodiversity, leading to biotic homogenization and declining community heterogeneity. University campuses, particularly those with wetland ecosystems, are emerging as important refugia for bird species. This study examines avian diversity, dominance patterns, and community structure across the Gölköy-Yumrukaya (GY) wetland and surrounding campus habitats of Bolu Abant İzzet Baysal University, Türkiye. Between 2017 and 2023, systematic field surveys recorded 173 bird species from 45 families. The results underscore the ecological significance of the GY wetland as a complementary habitat, particularly for summer visitor and passage migrant species. Seasonal analyses reveal peak species richness and diversity during the breeding and migration periods, while winter exhibits lower diversity and increased dominance concentration, especially among urban-adaptive species. The study highlights the importance of artificial wetlands in fragmented landscapes, provided they maintain ecological connectivity with natural wetland systems. Additionally, a newly proposed ecological metric, the Heterogeneity Ratio ($H_r$), is introduced, offering a higher-resolution assessment of community structure dynamics compared to traditional diversity indices. Due to its sensitivity to temporal fluctuations in species abundance and evenness, $H_r$ is recommended as a valuable tool for future biodiversity assessments.

**Keywords:** Avian Diversity, Habitat Fragmentation, Artificial Wetlands, Heterogeneity Ratio, Biotic Homogenization

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**Öz:** Küresel ölçekte şehirleşme ve habitat parçalanması, kuş biyoçeşitliliğini tehdit ederek biyotik homojenizasyona ve komünite heterojenliğinde azalmaya neden olmaktadır. Özellikle sulak alan ekosistemine sahip üniversite kampüsleri, kuş türleri için önemli sığınaklar haline gelmektedir. Bu çalışma, Türkiye'deki Bolu Abant İzzet Baysal Üniversitesi kampüsünde ve yakın çevresinde yer alan Gölköy-Yumrukaya (GY) sulak alanının kuş çeşitliliğini, baskın tür desenlerini ve komünite yapısını incelemektedir. 2017-2023 yılları arasında yapılan sistematik arazi çalışmaları sonucunda 45 familyaya ait toplam 173 kuş türü tespit edilmiştir. Sonuçlar, GY sulak alanının özellikle göçmen ve transit göçmen türler için tamamlayıcı bir habitat olarak önemli bir ekolojik role sahip olduğunu göstermektedir. Mevsimsel analizler, tür zenginliğinin ve çeşitliliğinin üreme ve göç dönemlerinde zirve yaptığını, kış aylarında ise çeşitliliğin düştüğünü ve özellikle şehirleşmeye uyum sağlayan türlerin baskın hale geldiğini ortaya koymuştur. Çalışma, yapay sulak alanların doğal sulak alan sistemleriyle ekolojik bağlantılar kurduğunda, parçalanmış peyzajlarda kritik ikincil habitatlar olarak hizmet edebileceğini vurgulamaktadır. Ayrıca, bu araştırmada geleneksel çeşitlilik indislerine kıyasla topluluk yapısındaki değişimleri daha yüksek çözünürlükle değerlendiren Heterojenite Oranı ($H_r$) adlı yeni bir ekolojik metrik önerilmektedir. Tür bolluğu ve eşitliğindeki zamansal dalgalanmalara duyarlılığı nedeniyle $H_r$'nin, gelecekteki biyoçeşitlilik değerlendirmelerinde önemli bir araç olarak kullanılabileceği önerilmektedir.

**Anahtar Kelimeler:** Kuş Çeşitliliği, Habitat Parçalanması, Yapay Sulak Alanlar, Heterojenite Oranı, Biyotik Homojenizasyon

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## INTRODUCTION

Exponential human population growth is recognized as the primary driver of the five major threats to biodiversity: pollution, habitat loss, climate change, invasive species, and overexploitation (Dhyani, 2024; Inbit et al., 2024; Ogidi and Akpan, 2022; Ogwu et al., 2022). This rapid increase is expected to intensify these pressures, particularly affecting bird and mammal species by 2050 (Rodrigues et al., 2021; Simkin et al., 2022). These threats not only reduce species diversity but also impact functional diversity, leading to shifts in ecosystem stability (Stewart et al., 2022). Consequently, protected areas and biodiversity hotspots are gaining increasing importance for conservation. However, urban expansion is encroaching upon these critical areas, exacerbating biodiversity loss (Wang et al., 2023).

Urbanization, driven by human population growth, has profound effects on global biodiversity, with biotic homogenization being one of its most significant consequences (Lepczyk et al., 2017; McKinney, 2006; Reis et al., 2012). As cities expand, university campuses are emerging as potential refuges for biodiversity, offering eco-friendly landscapes that support various species (Guthula et al., 2022; Sanllorente et al., 2023). Initially, most universities were established in rural or forested areas at higher elevations, incorporating extensive green spaces that preserved aspects of the original natural environment (Guthula et al., 2022). From this perspective, university campuses can function as urban/peri-urban biodiversity hotspots, providing habitat continuity within increasingly fragmented landscapes (Guthula et al., 2022; Liu et al., 2017, 2021).

Large university campuses, particularly those containing wetlands and diverse habitat types, serve as essential refuges for bird species (Davros II, 2020; Yadav et al., 2024). Wetland ecosystems within campuses provide key feeding and breeding grounds, particularly for waterbirds. However, many natural wetlands have been modified for purposes such as water reservoirs, artificial ponds, and urban landscaping, leading to habitat degradation and biodiversity loss. Despite these alterations, artificial wetlands can function as secondary habitats, particularly for water-dependent species that prefer shallow aquatic environments (Davros II, 2020; Yadav et al., 2024).

While numerous studies have been conducted on campus bird communities in Türkiye, most have focused primarily on species inventories rather than ecological analyses (Gümüş et al., 2024; Özkan and Keten, 2020; Şahin et al., 2021). In contrast, recent studies have evaluated the ecological functions of university campuses, emphasizing their roles in land management and conservation (Guthula et al., 2022; Liu et al., 2021; Sanllorente et al., 2023; Zhang et al., 2018). Simply cataloging species presence provides limited ecological insight. However, many Turkish university campuses are situated in relatively undisturbed habitats, including forests, wetlands, and lakes, yet their ecological significance remains largely understudied.

One such example is Bolu Abant İzzet Baysal University's Gölköy Campus, which is situated in a forested area and contains Gölköy Pond, an artificial reservoir supplying city water. Adjacent to this, the Yumrukaya wetland further enhances the ecological value of the landscape. Collectively, these interconnected habitats (hereafter referred to as GY) form a critical network of habitat patches within an urbanized landscape. Given its ecological features and proximity to other green spaces, the GY wetland likely serves as a key site for breeding, foraging, and refuge, particularly for water-dependent bird species.

This study aims to assess the temporal variations in species richness, diversity, relative abundance, and dominance of birds within the GY wetland ecosystem. Additionally, this research seeks to:

1. Evaluate the role of university campuses in mitigating urbanization pressures on bird communities.
2. Investigate the ecological function of artificial wetlands as complementary habitats for avifauna.
3. Introduce and test the Heterogeneity Ratio ($H_r$) as a new ecological metric for assessing community structure dynamics.

By addressing these objectives, this study provides a comprehensive evaluation of a university wetland ecosystem, contributing to both regional conservation efforts and global discussions on urban biodiversity management.

## MATERIAL AND METHOD

### *Study Area*

The study was conducted within the Gölköy Campus of Bolu Abant İzzet Baysal University and the adjacent Yumrukaya Wetland (Figure 1). While the study area shows some urban influences (e.g., infrastructure), its dominant characteristics align with peri-urban ecosystems containing agricultural, natural/artificial wetland and forest elements. Located at an elevation of 776 meters above sea level, Gölköy Lake was constructed in the mid-20th century for irrigation, fisheries, and recreational activities. Since 2011, it has also served as a tap water source for Bolu. The lake's surface area fluctuates seasonally between 150 and 180 hectares. It is primarily fed by the Mudurnu Stream, Abant Stream, and groundwater sources. Gölköy Lake is classified as mesotrophic, and pollution in and around the lake originates from recreational activities, poultry farms, and agricultural practices (Çelekli et al., 2007; Külköylüoğlu, 2005; Türker, 2006).


**Figure 1.** Gölköy-Yumrukaya wetland ecosytem.
*Şekil 1. Gölköy-Yumrukaya sulak alan ekosistemi.*

Before 1965, the Yumrukaya wetland was a marshland. However, with the construction of the Gölköy Dam Lake on the Abant Stream, which supplies water to the area, the wetland transformed into a shallow pond with reed beds. The wastewater discharge from Bolu Abant İzzet Baysal University and construction debris have been identified as major pollutants in the wetland. The reservoir water in Yumrukaya exhibits a meso-eutrophic character (Külköylüoğlu, 2005). A concrete channel connects Yumrukaya Wetland and Gölköy Lake, facilitating water transfer from Yumrukaya to Gölköy during spring and summer. Since both wetlands are utilized for irrigation and the municipal water supply, they experience significant seasonal water level fluctuations.

### *Field Survey and Data Collection*

The study commenced in November 2017 and was conducted throughout 2018, with additional surveys focused on the breeding and migration periods in 2019 and 2023 (Table 1). The fieldwork followed both line transect and point count methods, with a total of 48 field surveys carried out from sunrise to sunset. Due to the relatively small size of the study area, fixed observation stations were not established.

Field observations were conducted using 10×42 binoculars and a DSLR camera, with photographs taken during the surveys used for species identification. Additionally, the Collins Bird Guide (Svensson et al., 2010) was utilized for species verification. To facilitate various ecological assessments of the avifauna in the GY wetland ecosystem, individual counts of recorded bird species were systematically documented during field surveys. A minimum of one and a maximum of three observers participated in these surveys, and to minimize repeated counts of the same individuals, the coordinates and timestamps of each observation were rigorously recorded on standardized forms. All daily observations were systematically documented on standardized bird survey forms to ensure data consistency and reliability.

**Table 1.** Monthly and annual distribution of field surveys.
*Çizelge 1. Saha çalışmalarının yıl ve aylara göre dağılımı.*

| | 2017 | 2018 | 2019 | 2023 | Total |
|---|---|---|---|---|---|
| January | | 1 | 1 | 1 | **3** |
| February | | 2 | 2 | | **4** |
| March | | 3 | 3 | | **6** |
| April | | 4 | 3 | 1 | **8** |
| May | | 3 | 2 | 1 | **6** |
| June | | 3 | | 1 | **4** |
| July | | 2 | 1 | | **3** |
| August | | 1 | | 1 | **2** |
| September | | 2 | | | **2** |
| October | | 3 | | | **3** |
| November | 1 | 4 | | | **5** |
| December | | 2 | | | **2** |
| **Total** | **1** | **30** | **12** | **5** | ***48*** |

***Analysis of Avian Diversity and Dominance Patterns***

In this study, the avian community in the area was investigated in terms of species richness, abundance, dominance patterns, and overall diversity. Regarding species conservation status, IUCN Red List categories were presented. Additionally, temporal habitat use patterns of bird species were assessed using BirdLife International's species distribution maps (BirdLife International, 2025).

Species dominance within a community is determined by calculating the proportion of individuals of a species relative to the total number of observed individuals in the community (Hubálek, 2000). Accordingly, dominance values ($Dom_i$) were calculated for bird species observed in the study area and were presented temporally to identify the most dominant species. In natural communities, species are generally categorized into three abundance classes: approximately 60–65% of species are rare, 25% are of moderate abundance, and only about 10% are common. Additionally, species frequency is classified into five categories based on observation frequency (Aydın, 2021): **81–100%:** "Abundant"; **61–80%:** "Common"; **41–60%:** "Frequent"; **21–40%:** "Occasional"; **1–20%:** "Rare". The frequency analysis of avifauna in the GY wetland ecosystem was categorized according to these five classes and evaluated temporally. To account for seasonal variations in species occurrence, we assessed avian community structure in the GY wetland across four defined periods: winter (December–February), breeding (March–May), summer (June–July), and autumn migration (August–November). Additionally, annual dominance and frequency analyses were conducted for 2018, the only year with continuous data collection throughout the entire year. At this stage, a Whittaker plot (rank-abundance curve) was used to clearly illustrate the seasonal and annual distribution patterns of the community structure. This approach aimed to determine the species abundance distribution profile and provide a comprehensive understanding of how the avian assemblage varies across different periods and throughout the year.

Species richness (S), the most fundamental and commonly used measure of diversity, is influenced by rare species. This effect is primarily due to sampling errors, as rare species often go undetected even in detailed surveys. To estimate the effective (true) species richness, various approaches and non-parametric estimators have been utilized (Aydın, 2021; Krebs, 2014). In this study, the non-parametric estimator 'Chao 1' developed by A. Chao, was used to estimate effective species richness (Chao, 2005; Chao and Chiu, 2012). The Chao 1 approach provides a minimum estimate of species richness and is assessed within the framework of Hill numbers (Krebs, 2014). This estimator predicts the number of undetected species by utilizing singletons and doubletons, as rare species information is predominantly derived from low-frequency observations (Chao, 2005; Chao and Chiu, 2012; Krebs, 2014).

The data obtained from the study area were analyzed using the Shannon diversity index and Hill effective species numbers. The Shannon-Weaver index (H'), one of the most widely used diversity metrics, is based on information theory. It aims to quantify the uncertainty in predicting the species identity of the next observed individual, where greater uncertainty corresponds to higher diversity. This uncertainty is directly proportional to community heterogeneity. As a result, the more uncertain the information content per individual (measured in bits per individual), the greater the diversity (Krebs, 2014).

Hill numbers, proposed by Hill (1973), are widely used due to their simplicity and ease of interpretation (Krebs, 2014). These numbers provide a functional or effective count of species within a sample, avoiding the complex and ecologically ambiguous units (e.g., bits, probability measures) found in other indices. Hill diversity numbers include species richness (S), as well as $N_1$ (the exponential form of Shannon entropy) and $N_2$ (the inverse of Simpson's index), both of which serve as heterogeneity indices. In most cases, calculating $N_1$ and $N_2$ is sufficient to answer questions that heterogeneity indices aim to address (Chao and Jost, 2015; Gotelli and Chao, 2013; Krebs, 2014; Peet, 1974). $N_1$ represents the number of effective typical species in a community, weighted by their relative frequencies or abundances. $N_2$, on the other hand, approximates the number of highly abundant (dominant) species in the community. In a perfectly even community, $N_1$ and $N_2$ are equal to species richness (Gotelli and Chao, 2013).

Our analyses of diversity ($N_1$, $N_2$), heterogeneity ($H'$), and species richness (Chao1) follow established ecological methods (Chao 2005; Krebs 2014), including frequency and dominance calculations for avian community characterization. To estimate species diversity and richness using various ecological indices, the online SpadeR (Species-richness Prediction and Diversity Estimation in R) program, developed by Chao et al. (2016), was used.

Furthermore, despite the existence of various ecological assessment methods, most are either sensitive to common species or rare species, but no single index can evaluate both simultaneously. In this study, for the first time, we assessed the ratio, $H_r=f_1/N_2$ which we named the "heterogeneity ratio," and made inferences about its temporal trends. We believe that applying this newly proposed heterogeneity ratio can be beneficial for diversity profiles.

***Theoretical Framework of the Heterogeneity Ratio***

The proposed heterogeneity ratio, $H_r=f_1/N_2$, quantifies the tension between rarity (singleton species count, $f_1$) and dominance (inverse Simpson index, $N_2$). This metric captures a fundamental ecological trade-off in species abundance distribution functions: as dominance concentration increases (higher $N_2$), singleton representation ($f_1$) declines, reflecting shifts in community evenness.Theoretical bounds and behavior of $H_r$ reveal its ecological interpretation:

- $N_2$ ranges from 1 (single-species dominance) to $S$ (perfect evenness; all species equally abundant).
- $f_1$ spans 0 (no singletons) to $S-1$ (all species except one are singletons).

- ***$H_r$*→0:** Indicates high evenness, approximating a **broken-stick distribution** (A log-normal abundance distribution approaching the "broken stick" model; idealized equilibrium community).
- ***$H_r$*→*S*−1:** Reflects extreme dominance, aligning with a **geometric series** (highly uneven, anthropogenic communities).

Unlike traditional indices (e.g., Shannon *H'*), $H_r$ explicitly links rarity loss to dominance amplification—a critical dimension for assessing anthropogenic impacts.

## RESULTS AND DISCUSSION

### *Avian Assemblage of Gölköy-Yumrukaya Wetland*

During 48 days of fieldwork between 2017-2023 within the study area, a total of 173 bird species from 45 families were recorded, with an overall count of 15452 individuals (Annex 1). The average number of species observed per month was 81, while the average number of individuals recorded per month was 644. However, in 2018, when surveys were conducted year-round, the monthly average species count was 53, and the average individual count was 737.

The GY wetland hosts a relatively rich bird community compared to most university campuses and other wetland avifaunas (Bengil and Uzilday, 2010; Gümüş et al., 2024; Keten et al., 2010; Şahin et al., 2021). The area supports approximately one-third of Türkiye's total bird species richness, likely due to habitat diversity, the proximity of nearby wetlands, and its function as a local stopover, resting, and refueling site for migratory birds—factors known to positively correlate with species richness (Hamza et al., 2024; Karaardıç et al., 2006; Karaardıç and Özkan, 2017; Ünlü et al., 2024).

An analysis of the avifauna based on waterbird families designated by Wetlands International (2012) revealed that 35.84% (14 families, 62 species) of the bird species in the GY wetland are waterbirds or wetland-dependent species, emphasizing the area's importance for waterbird conservation. The most species-rich families recorded were *Anatidae* (ducks, geese, and swans; 15 species), *Accipitridae* (hawks and eagles; 14 species), and *Muscicapidae* (flycatchers; 12 species). The dominance of waterbirds and wetland-dependent raptors in the area is expected, given its wetland ecosystem characteristics. Additionally, the presence of open landscapes (e.g., agricultural fields), forested areas, riparian vegetation, and urbanized structures supports a diverse range of bird species with varying habitat preferences (Rajashekara and Venkatesha, 2017). Further studies on habitat and microhabitat diversity in the area are recommended to explore these patterns in greater detail.

Monthly species richness peaked in April 2018 (77 species) and April 2019 (66 species), while the lowest species counts were recorded in January 2018 (14 species) and January 2019 (13 species) (Figure 2). The high species richness observed in April, coinciding with the breeding season, suggests that the wetland provides high-quality habitat and sufficient ecological niches (Hamza et al., 2024). In contrast, the low species richness recorded in January is likely due to the limited presence of wintering bird species.

Although species richness was generally lower in winter, the highest individual count was recorded in December 2019 (2532 individuals), while the lowest was in January 2018 (100 individuals). Data from the International Mid-Winter Waterbird Census indicate a partial improvement in population trends in Ramsar sites (Wetlands International, 2012, 2018). However, a decline in species richness coupled with an increase in individual counts is frequently observed in Important Bird Areas (IBAs) under urbanization pressure, where population increases tend to be driven by species more adaptable to urban environments (Kirazlı, in press). The combination of low species richness and high individual counts suggests temporal dominance shifts within the bird community (Figure 2). Therefore, evaluating the site alongside dominance analysis data will provide more accurate ecological insights.

When assessing the annual utilization of the GY wetland by bird species, approximately 59% of the recorded species were classified as summer visitors (M) or passage migrants (P), while only 26% were resident (R) and 13% were winter visitors (W). The fact that nearly two-thirds of the observed species are present only during the breeding or migration periods suggests that the campus and wetland ecosystem primarily provide suitable niches for stopover, resting, and energy replenishment (Karaardıç et al., 2006; Karaardıç and Özkan, 2017).

According to the IUCN Red List, three species observed in the study area are classified as Vulnerable (VU): *Aythya ferina*, *Aquila heliaca*, and *Streptopelia turtur*. Additionally, two species are categorized as Near Threatened (NT): *Aegypius monachus* and *Lanius senator*, while the remaining 168 species fall under the Least Concern (LC) category (Annex 1). The Common Pochard (*Aythya ferina*) is a winter visitor to the area, though it has not been observed in large flocks. Breeding populations of Eastern Imperial Eagle (*Aquila heliaca*) and Cinereous Vulture (*Aegypius monachus*) are present in the surrounding region (Arslan and Kirazlı, 2022; Kirazlı, 2019), and individuals have been occasionally recorded in the wetland while foraging, albeit infrequently. The European Turtle Dove (*Streptopelia turtur*) is primarily a summer visitor, observed in low numbers, with no evidence of breeding recorded within the study area. Similarly, the Woodchat Shrike (*Lanius senator*) has been observed rarely, primarily during migration periods. These findings highlight the conservation priority of these species and suggest that the GY wetland plays a complementary habitat role in supporting their populations.

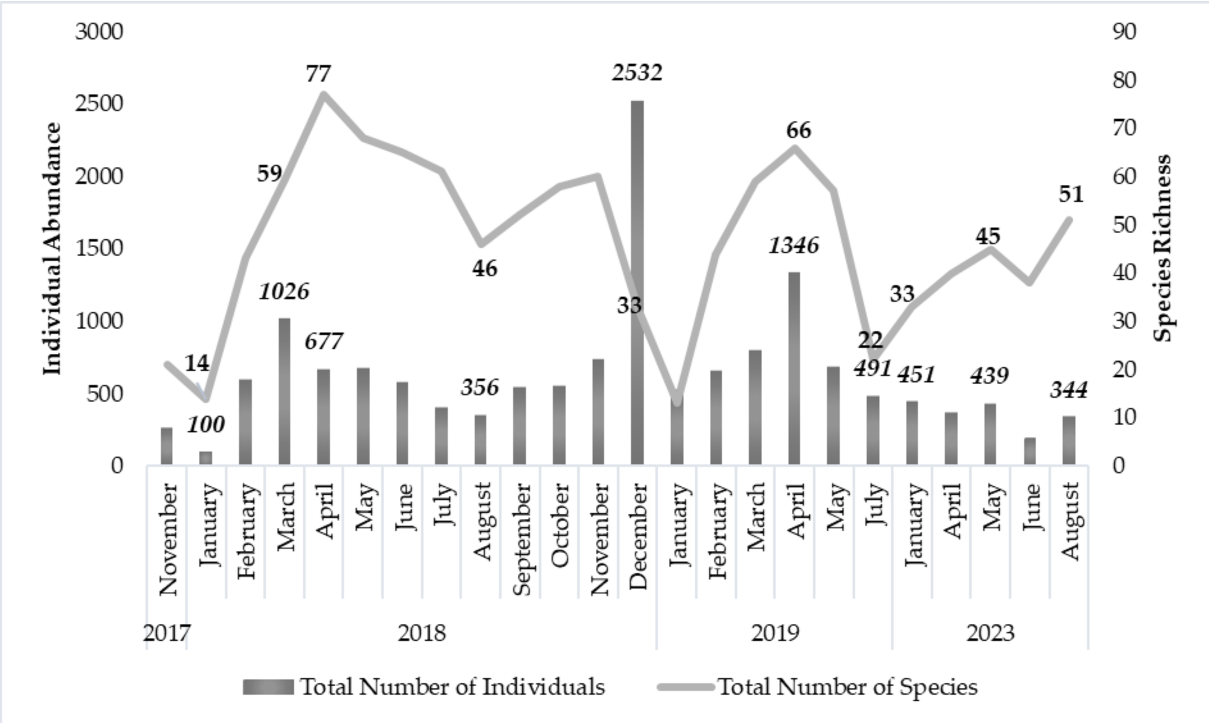


**Figure 2.** Monthly dynamics of species richness and individual abundance.
*Şekil 2. Aylara göre toplam tür ve birey sayılarındaki değişim.*

Increasing urbanization pressure and habitat fragmentation in natural areas (Guthula et al., 2022; Reis et al., 2012), coupled with high interspecies competition in shallow natural wetlands used during migration, may further increase the importance of artificial wetlands for breeding migrants and passage bird species. In this context, non-eutrophic artificial wetland systems, such as reservoirs, could function as temporary protective and complementary buffer zones, serving as small habitat islands connected to primary wetland areas (Davros II, 2020; Guthula et al., 2022). The findings of this study support this perspective.

The application of island biogeography theory to terrestrial systems—where habitats are viewed as islands and the areas connecting them as matrices, including transition corridors—has long been recognized (Matthews, 2021). Recently, increasing attention has been given to the role of small refuge islands, particularly university campuses, in preserving habitats and species while facilitating connectivity between primary habitats (Guthula et al., 2022; Tulloch et al., 2016). Considering that matrix quality influences community structure within habitats—acting as a resource, corridor, or habitat itself (Cook et al., 2002; Kupfer et al., 2006)—the two wetlands in the study area, one artificial and the other natural, along with the campus area connecting them, form a significant wetland ecosystem composed of small habitat patches. The GY wetland habitat islands serve as essential components of the local bird community, reinforcing their ecological importance in maintaining species diversity. Given the potential of campus areas to enhance matrix quality, these small wetland islands are likely to provide ecological connectivity between primary habitats such as Yeniçağa Lake and its peatlands (IBAs), thereby supporting local avian communities. In this context, a critical consideration is the location of artificial wetlands and their connectivity with other natural habitat islands. Future research should examine the connectivity of the GY wetland ecosystem with other natural wetlands from an avian perspective. Additionally, long-term migration monitoring and breeding status assessments of the avifauna would further highlight the area's ecological significance.

***Avian Community Structure: Dominance and Frequency Trends in Gölköy-Yumrukaya Wetland***

In natural ecosystems, communities typically follow a log-normal distribution model (Krebs, 2014). However, in areas experiencing biotic homogenization, community structure tends to shift toward a geometric series distribution (Aydın, 2021). In this context, the data obtained from this study were analyzed both seasonally and annually to assess species abundance distributions and frequency patterns. The primary aim was to determine whether the community structure reflects natural evolutionary and ecological mechanisms or if urbanization pressure has influenced homogenization within the assemblage.

During the winter season, the bird community comprised 71 species, yet it was predominantly dominated by a single species, the Eurasian Coot (*Fulica atra*), accounting for nearly half of the total abundance. Approximately 80% of the community, excluding the European Goldfinch (*Carduelis carduelis*), consisted of waterbirds (Table 2). Wintering species such as the Eurasian Teal (*Anas crecca*), Common Pochard (*Aythya ferina*), and Tufted Duck (*Aythya fuligula*) were observed in relatively low numbers. The Whittaker plot derived from the collected data indicates a log-normal species-abundance distribution within the area (Figure 3). However, the pronounced dominance of a single species suggests an imbalance beyond normal evolutionary and ecological mechanisms. The findings align with the results of the Mid-Winter Waterbird Census conducted across Türkiye (Kirazlı, in press; DKMP, 2023). The presence of individuals belonging to conservation-priority species, such as the Vulnerable Common Pochard, further highlights the role of the GY wetland as a supportive habitat for wintering waterbirds.

**Table 2.** Dominant bird species comprising 80% of the total winter abundance.
*Çizelge 2. Kış döneminde komünitenin %80'ini oluşturan türler.*

| Winter | Abundance | Dominance % | Frequency % |
|---|---|---|---|
| *Fulica atra* | 2449 | 50.13 | 77.78 |
| *Anas platyrhynchos* | 364 | 7.45 | 77.78 |
| *Anas crecca* | 265 | 5.42 | 44.44 |
| *Tachybaptus ruficollis* | 180 | 3.68 | 66.67 |
| *Carduelis carduelis* | 172 | 3.52 | 66.67 |
| *Podiceps cristatus* | 169 | 3.46 | 66.67 |
| *Aythya fuligula* | 167 | 3.42 | 55.56 |
| *Aythya ferina* | 116 | 2.37 | 66.67 |

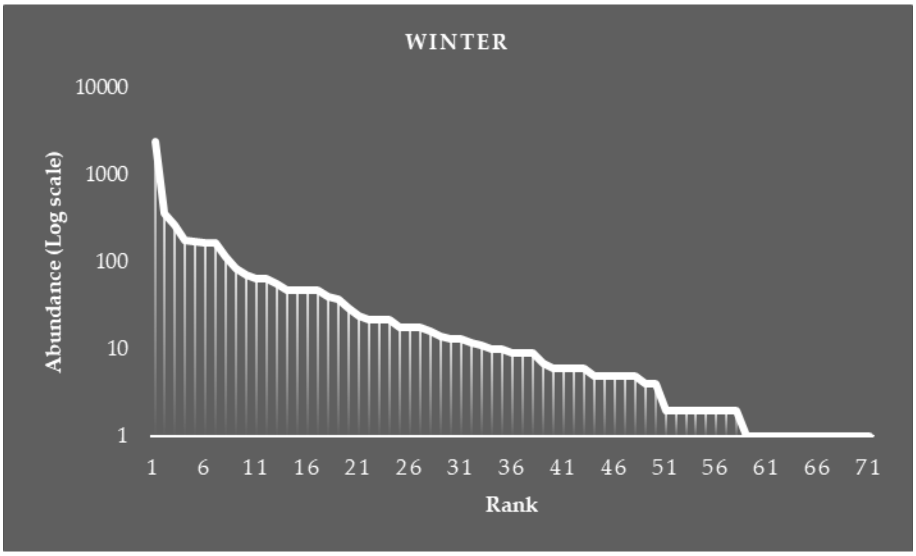


**Figure 3.** Whittaker plot of winter period.
*Şekil 3. Kış dönemi Whittaker grafiği.*

During the breeding season, the avian community comprised 142 species, exhibiting a mosaic dominance structure shaped by the inclusion of adaptive passerine species capable of nesting in urbanized areas, rather than being predominantly composed of waterbirds (Table 3). The Whittaker plot derived from the collected data indicates a log-normal species-abundance distribution within the area (Figure 4), with an increase in the number of widespread species compared to the winter period. This pattern was also observed during the summer (85 species recorded) and migration (113 species recorded) seasons, as well as in the overall 2018 dataset (145 species recorded) (Tables 4–6; Figures 5–7).

Accordingly, the Eurasian Coot (*Fulica atra*) and Mallard (*Anas platyrhynchos*) were the most widespread species in the GY wetland, while urban-adaptive passerines such as the House Sparrow (*Passer domesticus*) and Common Starling (*Sturnus vulgaris*) were among the dominant songbirds. Although campus areas are recognized as refugia for avian communities (Guthula et al., 2022), the urbanization pressure associated with human activity and infrastructure—manifesting as noise, crowding, and construction—may have played a role in shaping the observed community structure (Perillo et al., 2017; Vallejo Jr et al., 2008). These results align with previous studies (Jumilawaty et al., 2024; Vallejo Jr et al., 2008; Yadav et al., 2024), which reported similar dominance structures and species diversity patterns in urban-associated campus areas with aquatic habitats. In this context, 'refugia' refers particularly to the role of the artificial wetland as a temporary shelter for migratory species rather than a stable breeding habitat. Thus, a campus area with an artificial wetland, where a few species dominate but overall species richness remains high, may function as a local biodiversity hotspot. As with other campus areas that include aquatic habitats (Guthula et al., 2022; Yadav et al., 2024), the GY wetland maintained a relatively stable species richness, potentially due to its habitat heterogeneity and size (Sillén and Solbreck, 1977).

Furthermore, seasonal and annual data obtained from frequency analysis (Table 7) reinforce this conclusion, highlighting the role of the GY wetland habitat islands as crucial stopover, foraging, and short-term resting sites. The campus area with aquatic systems acts as a secondary habitat, facilitating movement between primary wetland sites, in line with the concept of habitat patches proposed by other studies (Guthula et al., 2022; Tulloch et al., 2016). These findings highlight the ecological importance of the GY wetland within a sheltered campus environment, emphasizing its crucial role in sustaining avian biodiversity during migration periods.

**Table 3.** Dominant bird species comprising 50% of the total breeding period abundance.
*Çizelge 3. Üreme döneminde komünitenin %50'sini oluşturan türler.*

| Breeding Period | Abundance | Dominance % | Frequence % |
|---|---|---|---|
| *Fulica atra* | 700 | 11.58 | 90.00 |
| *Delichon urbicum* | 692 | 11.44 | 75.00 |
| *Hirundo rustica* | 604 | 9.99 | 75.00 |
| *Passer domesticus* | 354 | 5.85 | 100.00 |
| *Sturnus vulgaris* | 350 | 5.79 | 90.00 |
| *Aythya fuligula* | 272 | 4.50 | 70.00 |

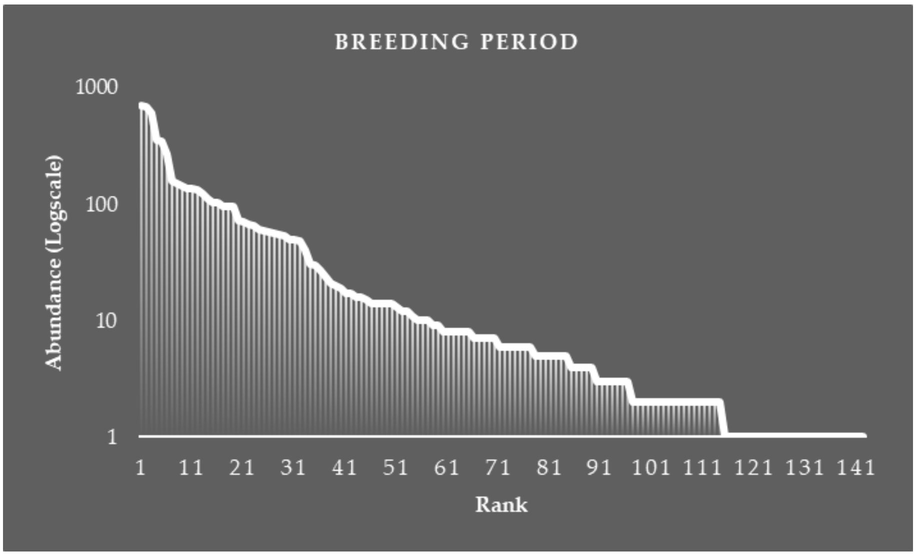


**Figure 4.** *Whittaker plot of breeding period.*
*Şekil 4. Üreme dönemi Whittaker grafiği.*

**Table 4.** Dominant bird species comprising 50% of the total summer abundance.
*Çizelge 4. Yaz döneminde komünitenin %50'sini oluşturan türler.*

| Summer | Abundance | Dominance % | Frequence % |
|---|---|---|---|
| *Fulica atra* | 397 | 23.46 | 100.00 |
| *Sturnus vulgaris* | 146 | 8.63 | 100.00 |
| *Anas platyrhynchos* | 81 | 4.79 | 85.71 |
| *Hirundo rustica* | 77 | 4.55 | 100.00 |
| *Passer domesticus* | 76 | 4.49 | 100.00 |
| *Emberiza calandra* | 74 | 4.37 | 85.71 |

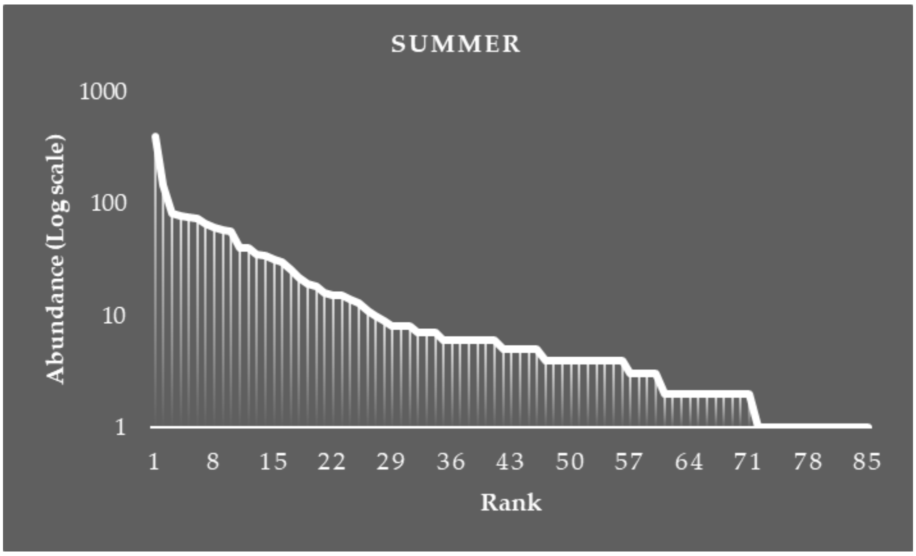


**Figure 5.** Whittaker plot of summer period.
*Şekil 5. Yaz dönemi Whittaker grafiği.*

**Table 5.** Dominant bird species comprising 50% of the total migration period abundance.
*Çizelge 5. Göç döneminde komünitenin %50'sini oluşturan türler.*

| Migration Period | Abundance | Dominance % | Frequence % |
|---|---|---|---|
| *Fulica atra* | 415 | 14.67 | 75.00 |
| *Anas platyrhynchos* | 280 | 9.90 | 83.33 |
| *Carduelis carduelis* | 140 | 4.95 | 75.00 |
| *Passer domesticus* | 131 | 4.63 | 83.33 |
| *Sturnus vulgaris* | 108 | 3.82 | 58.33 |
| *Podiceps cristatus* | 100 | 3.54 | 83.33 |
| *Hirundo rustica* | 88 | 3.11 | 33.33 |
| *Emberiza calandra* | 75 | 2.65 | 75.00 |
| *Corvus corone* | 67 | 2.37 | 83.33 |

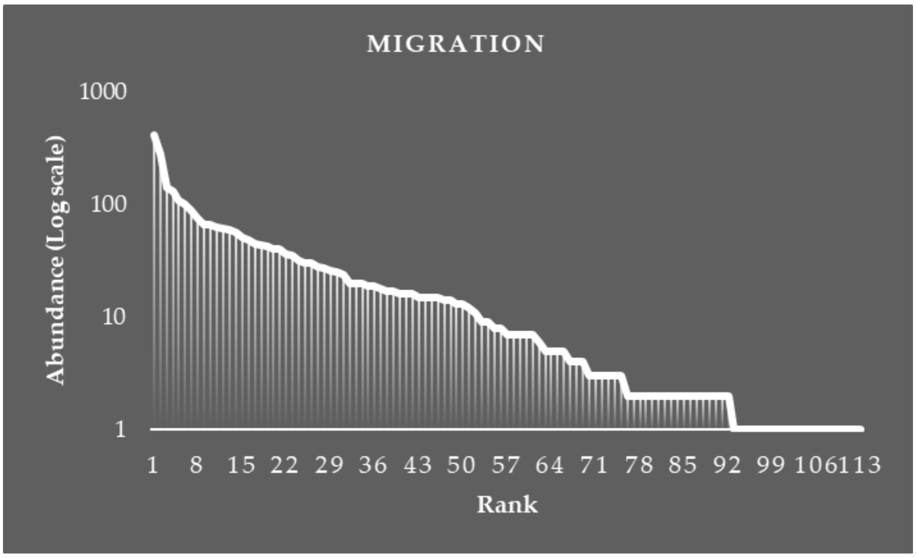


**Figure 6.** Whittaker plot of migration period.
*Şekil 6. Göç dönemi Whittaker grafiği.*

**Table 6.** 2018 GY wetland bird community: species constituting 50% of the total abundance.
*Çizelge 6. 2018 yılı GY sulak alan komünitesinin %50'sini oluşturan türler.*

| 2018 | Abundance | Dominance % | Frequence % |
|---|---|---|---|
| *Fulica atra* | 2350 | 26.58 | 80.00 |
| *Anas platyrhynchos* | 603 | 6.82 | 76.67 |
| *Passer domesticus* | 358 | 4.05 | 90.00 |
| *Sturnus vulgaris* | 323 | 3.65 | 66.67 |
| *Tachybaptus ruficollis* | 252 | 2.85 | 83.33 |
| *Podiceps cristatus* | 251 | 2.84 | 83.33 |
| *Hirundo rustica* | 246 | 2.78 | 53.33 |
| *Delichon urbicum* | 236 | 2.67 | 50.00 |

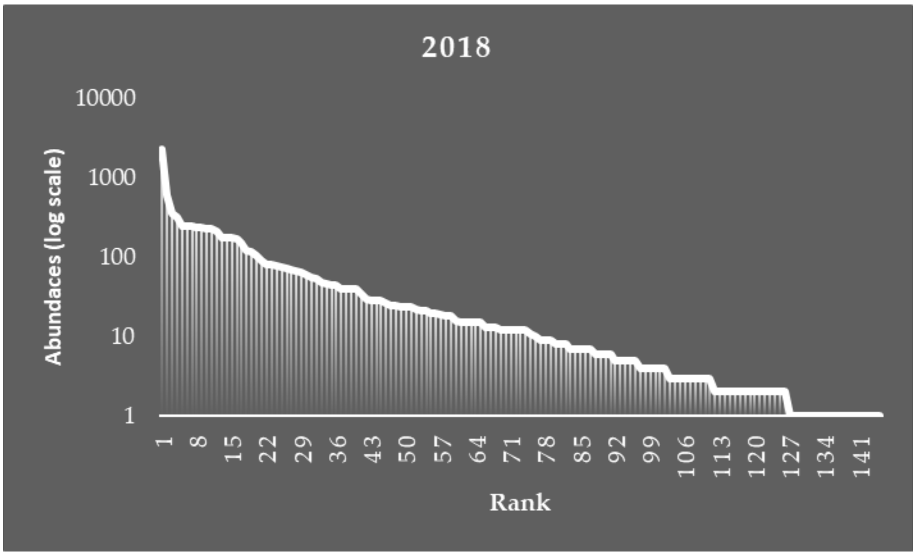


**Figure 7.** Whittaker plot of 2018.
*Şekil 7. 2018 yılı Whittaker grafiği.*

**Table 7.** GY wetland bird community: temporal species frequency profile.
*Çizelge 7. GY sulak alan komünitesinin temporal gözlem sıklığı profili.*

| Period/Frequency | Winter (%) | Breeding (%) | Summer (%) | Migration (%) | 2018 (%) |
|---|---|---|---|---|---|
| *Abundant* | 5.63% | 7.04% | 25.88% | 7.08% | 4.14% |
| *Common* | 16.90% | 9.86% | 12.94% | 8.85% | 6.90% |
| *Frequent* | 8.45% | 6.34% | 21.18% | 15.04% | 11.72% |
| *Occasional* | 30.99% | 14.79% | 8.24% | 22.12% | 20.69% |
| *Rare* | 38.03% | 61.97% | 31.76% | 46.90% | 56.55% |

***Avian Community Structure: Species Richnes and Diversity Trends in Gölköy-Yumrukaya Wetland***

The GY wetland, which hosts approximately one-third of Turkey's avifauna and two-thirds of Bolu's avifauna (243 species) (Nuh'un Gemisi, 2025), exhibits species richness, dominance, and frequency patterns similar to those reported in studies on other campus ecosystems (Guthula et al., 2022; Liu et al., 2021; Rajashekara and Venkatesha, 2017; Sanllorente et al., 2023; Vallejo Jr et al., 2008; Yadav et al., 2024). These findings suggest that the area qualifies as an Important Bird Area (IBA), functioning as a complementary habitat, particularly for migratory bird species. However, the dominance of urban-adaptive species is evident, with a notable inequality in species distribution, particularly during the winter season.

To enhance the ecological resolution of the study area and gain a more comprehensive understanding of community composition, further analyses are needed to examine how relative abundances vary among species. Particularly, assessing heterogeneity dynamics is crucial for understanding the organization of the

GY wetland bird community and predicting future trends. In this context, temporal trends in heterogeneity may offer clearer insights into ecosystem dynamics (Aydın, 2021; Krebs, 2014). The temporal diversity levels and trends were analyzed using effective species richness values (Ef-S, $N_1$, $N_2$), the Shannon diversity index (H'), and a newly proposed ecological index, the "heterogeneity ratio" ($H_r$), which we introduce as a novel metric for assessing heterogeneity due to its ease of interpretation.

Analyses evaluating the presence of rare and sensitive species reveal that effective species richness (Ef-S), as estimated by the Chao 1 model, ranged from a maximum of 187 species in April 2019 to a minimum of 13 species in January 2019. Notably, in 2018, when field surveys were conducted systematically throughout the year, species richness peaked in April (85 species) and reached its lowest level in January (15 species) (Figure 8). These findings indicate a moderate increase in species richness during the breeding season, whereas a pronounced decline is evident in winter, consistent with seasonal trends (Figure 9). The anomaly observed in April and May 2019, when compared to the 2018 and 2023 data, appears to represent a temporary fluctuation rather than a persistent trend.

The annual trend in species richness was evaluated for January, April, and May, revealing a decreasing trend during the breeding season but an increasing trend in winter (Figure 10). Although Rajashekara and Venkatesha (2017) reported an increase in diversity and species richness during winter, the GY wetland showed a relatively low number of wintering visitors in contrast to an increasing trend. Factors such as wetland size, habitat diversity, and proximity to other wetlands may influence species richness and diversity (Hamza et al., 2024). Accordingly, the campus's location, the diversity of habitats it provides, and its proximity to key IBAs are considered major determinants of species richness in the area.

Seasonal analysis results indicate that the highest species richness occurs during the breeding season (Figure 9), which aligns with findings from studies on the avifauna of Yeniçağa Wetland (Kirazlı and Gözütok, 2017). Although detailed breeding data for the GY wetland avifauna are currently lacking, future studies are necessary to address this gap. However, current findings support the hypothesis that the wetland serves as a complementary and supporting habitat for the regional avifauna, particularly in connection with Yeniçağa IBA. The GY wetland functions as a stopover corridor for migratory species (e.g., Aythya ferina) en route to regional IBAs (e.g., Yeniçağa Wetland), providing temporary refueling habitats in a fragmented landscape.

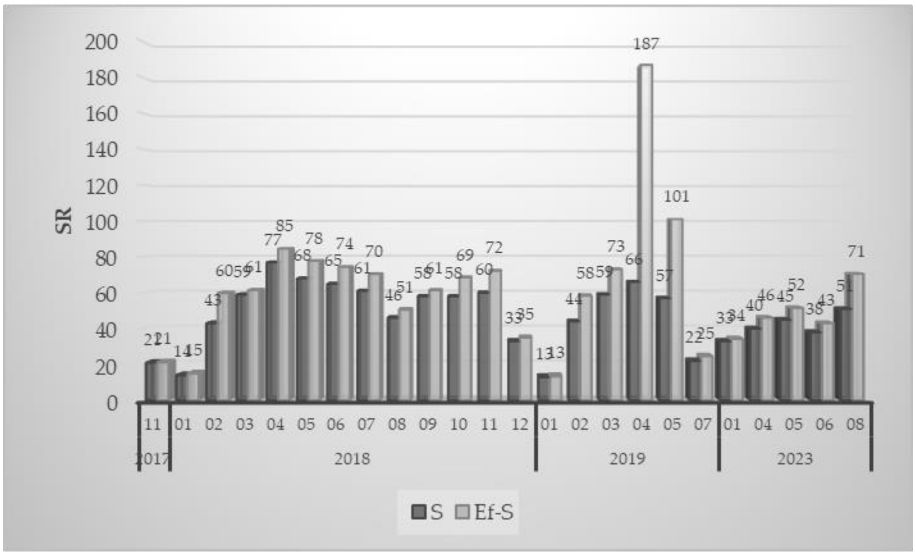


**Figure 8.** Monthly variation in species richness at GY wetland.
*Şekil 8. GY sulak alanı için aylık tür zenginliği profili.*

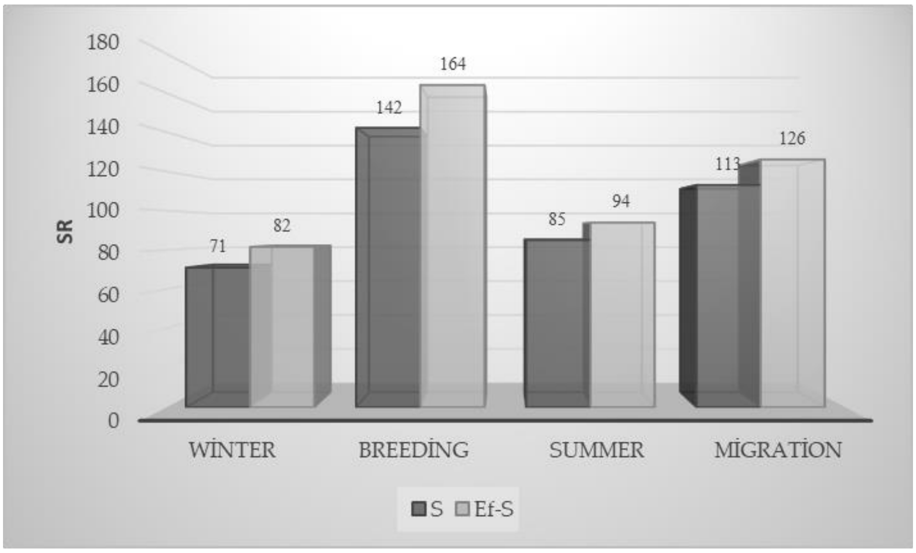


**Figure 9.** Seasonal trends in species richness at GY wetland.
*Şekil 9. GY sulak alanı için dönemlere göre tür zenginliği profili.*

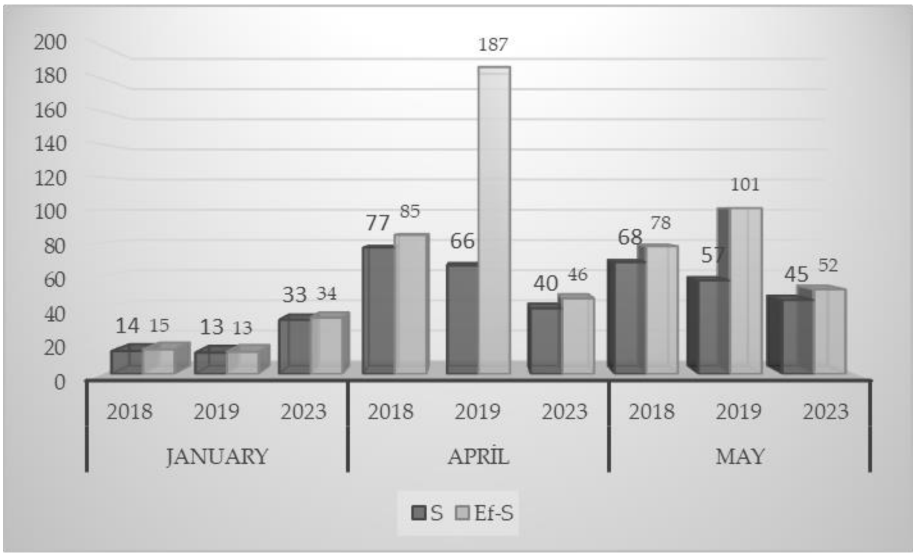


**Figure 10.** Annual trends in species richness at GY wetland.
*Şekil 10. GY sulak alanı için yıllara göre tür zenginliği profili.*

An analysis of the $N_1$, $N_2$, H′, and $H_r$ index values reveals that avian diversity was highest in April (April 2018: $N_1 = 41$, $N_2 = 27$, H′ = 3.66), while seasonally, the greatest diversity was observed during the migration period ($N_1 = 42$, $N_2 = 22$, H′ = 3.71, $H_r = 0.98$). In contrast, the lowest diversity was recorded in January (January 2019: $N_1 = 3$, $N_2 = 2$, H′ = 1.12), with the winter season exhibiting the lowest overall diversity ($N_1 = 10$, $N_2 = 4$, H′ = 2.30, $H_r = 3.47$) (Figures 11–15).

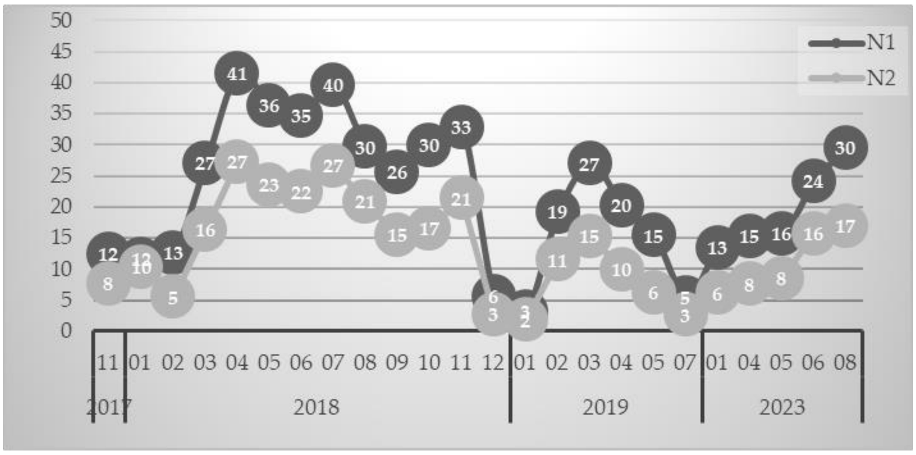


**Figure 11.** Monthly variation in $N_1$ and $N_2$ diversity ındices at GY wetland.
*Şekil 11. GY sulak alanı için aylık $N_1$ ve $N_2$ indis profili.*

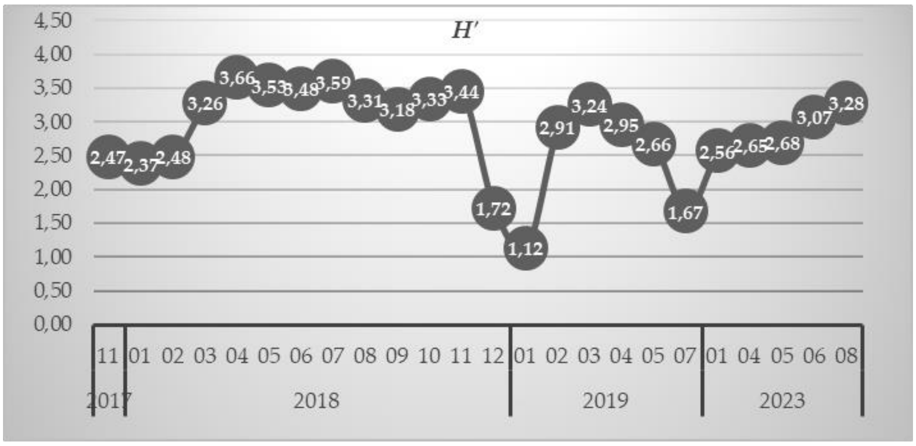


**Figure 12.** Monthly variation in Shannon diversity ındices at GY wetland.
*Şekil 12. GY sulak alanı için aylık Shannon çeşitlilik indis profili.*

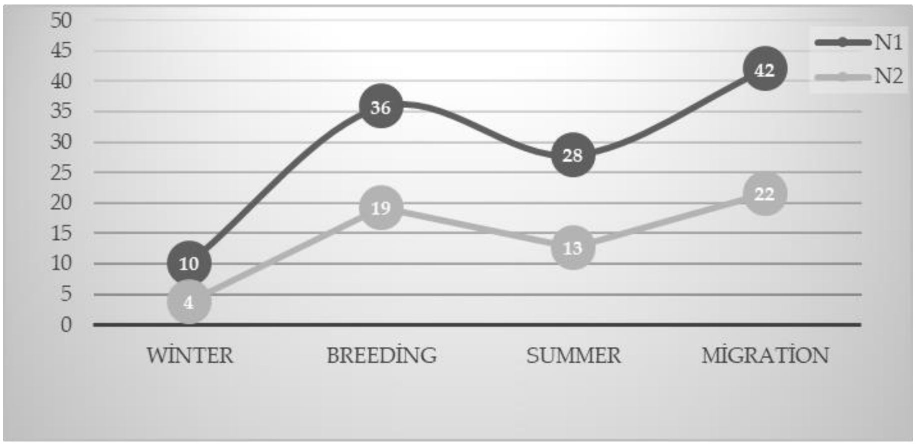


**Figure 13.** Seasonal trends in $N_1$ and $N_2$ diversity indices at GY wetland.
*Şekil 13. GY sulak alanı için dönemlere göre $N_1$ ve $N_2$ indis profili.*

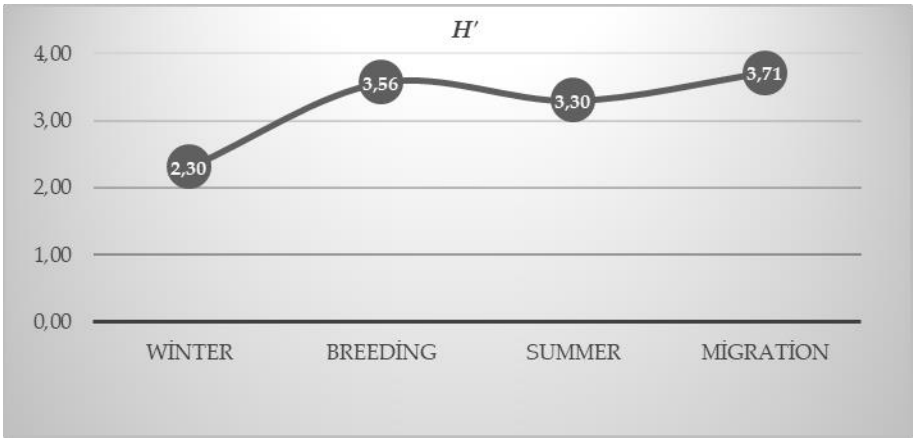


**Figure 14**. Seasonal trends in Shannon diversity ındices at GY wetland.
*Şekil 14. GY sulak alanı için dönemlere göre Shannon çeşitlilik indis profili.*

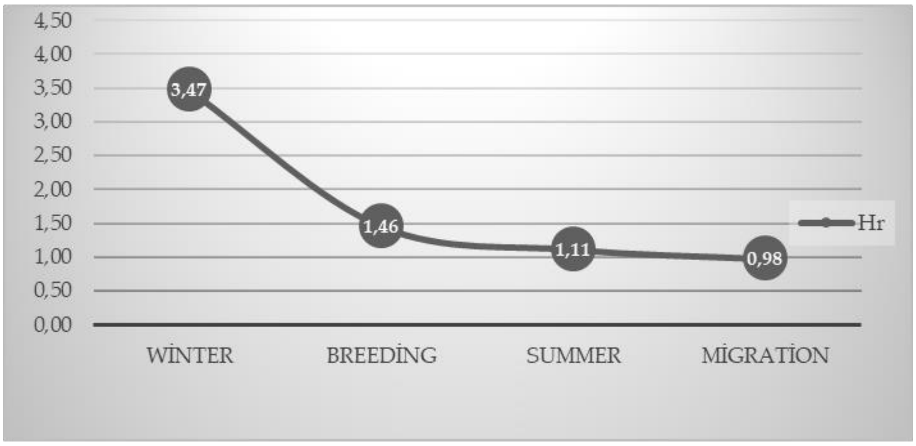


**Figure 15**. Seasonal trends in heterogeneity ratio ındices at GY wetland.
*Şekil 15. GY sulak alanı için dönemlere göre heterojenite oranı çeşitlilik indis profili.*

Additionally, a comparison of January, April, and May across different years suggests a slight decline in community heterogeneity over time, accompanied by an increase in dominance and inequality (Figures 16–18).

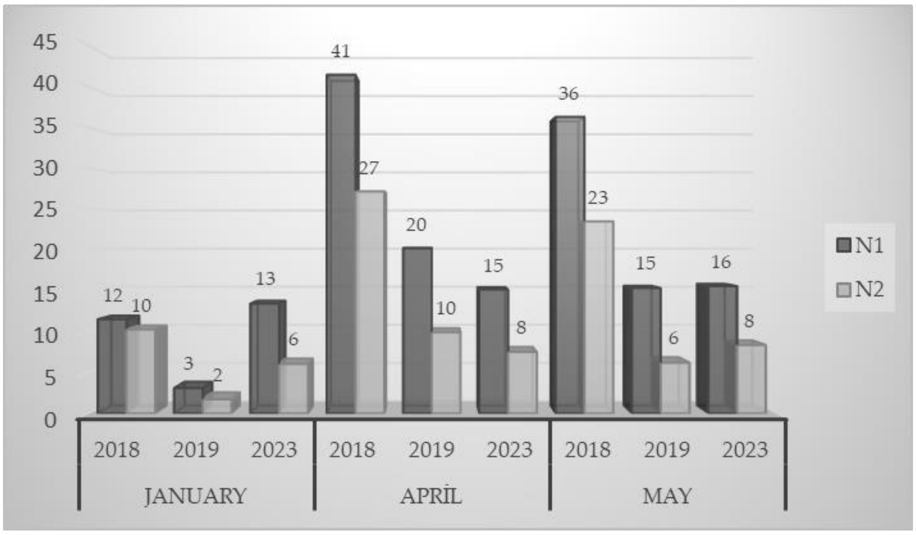


**Figure 16.** Annual trends in $N_1$ and $N_2$ diversity ındices at GY wetland.
*Şekil 16. GY sulak alanı için yıllara göre $N_1$ ve $N_2$ indis profili.*

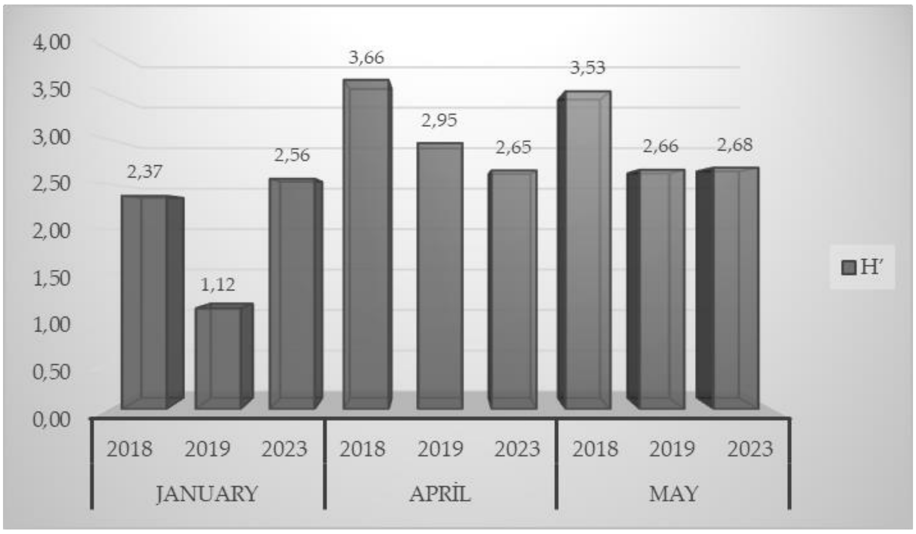


**Figure 17.** Annual trends in Shannon diversity ındices at GY wetland.
*Şekil 17. GY sulak alanı için yıllara göre Shannon çeşitlilik indis profili.*

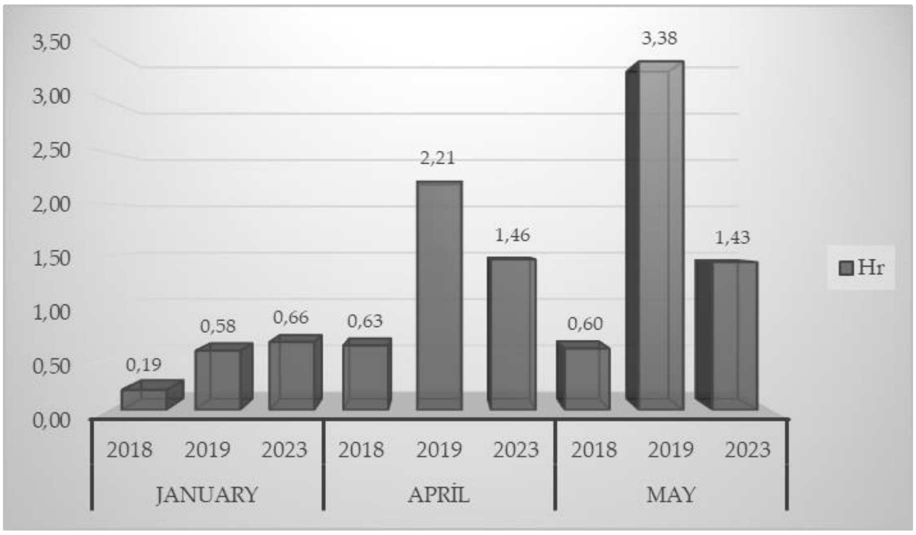


**Figure 18.** Annual trends in heterogeneity ratio ındices at GY wetland.
*Şekil 18. GY sulak alanı için yıllara göre heterojenite oranı çeşitlilik indis profili.*

As observed in the Yeniçağa IBAs (Kirazlı and Gözütok, 2017) and other natural wetlands in Türkiye (Bengil and Uzilday, 2010; Keten et al., 2010), species richness and diversity were notably higher during the breeding season, particularly in April, and the migration period, whereas both metrics were lower in winter, especially in January. This pattern is largely driven by the presence of breding migrants and passage migrant species, alongside increased avian activity during these periods. Notably, the habitat islands within the study area support exceptionally high species richness and diversity, underscoring their ecological significance.

Furthermore, the findings indicate that the GY wetland harbors greater taxonomic diversity than many other campus areas and wetlands across Türkiye. For example, comparative studies report 42 bird species at Düzce University (Özkan and Keten, 2020), 93 at Hacettepe University Beytepe Campus (Şahin et al., 2021), and 63 at Harran University (Gümüş et al., 2024). Notably, METU (ODTÜ) campus—one of Türkiye's most biodiverse urban green spaces—supports 231 species (Oruç and Kırlangıç, 2014), though its larger size (4,500 ha vs. GY's 255 ha) and mature forest habitats differ markedly from our study area's peri-urban wetland complex.

Among protected wetlands, the Kocaeli-Yuvacık Dam Basin (near an IBA) hosts 130 species (Keten et al., 2010), while the Küçük Menderes Delta sustains 120 species (Bengil and Uzilday, 2010). The GY wetland's richness (173 species) surpasses these sites and aligns with recognized IBAs like Gediz Delta (113 breeding species; Arslan et al., 2023) in community structure. While formal IBA designation requires meeting quantitative thresholds (e.g., ≥1% of a biogeographic population; BirdLife International, 2023), GY's provisional compliance with Criteria A4 (species richness) and B1a (regular presence of threatened species) underscores its conservation value. These results justify its recognition as a local biodiversity hotspot, though long-term monitoring is recommended to confirm IBA eligibility.

Studies on university campus avifauna in China have identified a positive correlation between bird species richness, phylogenetic and functional diversity, elevation range, and mean annual precipitation (Zhang et al., 2018). Similarly, research on Spanish university campuses found taxonomic diversity differences between campuses and randomly selected sites, though no significant variations in phylogenetic or functional diversity were detected (Sanllorente et al., 2023). While no studies have yet explored phylogenetic or functional diversity within the GY wetland, nor the environmental and climatic factors shaping its avian community, such research is essential for future ecological assessments. Nevertheless, the current findings highlight the considerable ecological value of the GY wetland in terms of avian diversity.

Urbanization-driven biotic homogenization has been widely documented in campus avifauna, particularly in developing countries (Liu et al., 2021; Vallejo Jr et al., 2008). A similar trend is evident in the GY wetland, where community heterogeneity has shown a gradual decline alongside increasing dominance and imbalance. Given this, it is essential to investigate not only the impacts of urbanization but also other potential threats to the bird community. University and local authorities should incorporate bird diversity into site management strategies, such as preserving green spaces adjacent to faculty buildings, creating rooftop and pocket gardens in high-traffic areas, and planting native fruit-bearing trees suited to the local flora. Recent studies emphasize the importance of small habitat patches in maintaining regional biodiversity by linking them with primary diversity areas (Guthula et al., 2022; Liu et al., 2017; Tulloch et al., 2016). In this context, the habitat islands within the GY wetland hold significant conservation value and should be managed accordingly.

***Heterogeneity Ratio: A Novel Metric for Assessing Ecological Diversity***

Traditional avian diversity studies in Turkish wetlands have primarily focused on species richness, often failing to capture key community dynamics (Aydın, 2021). However, species richness alone does not provide sufficient ecological resolution, particularly in the context of biotic homogenization driven by urbanization (Ferenc et al., 2014). To address this limitation, we introduce the heterogeneity ratio ($H_r$), a novel metric that quantifies the relationship between rare species (singletons) and dominant species (inverse Simpson index, $N_2$). This approach offers a more nuanced understanding of avian diversity by integrating both dominance and rarity, two critical components of community structure.

Applied to the Gölköy-Yumrukaya wetland, $H_r$ revealed: (1) pronounced winter dominance by urban-adapted species ($H_r$ = 3.47; 4 dominant species vs. 82 estimated species), (2) near-equilibrium during the breeding season ($H_r \approx 1$), reflecting balanced abundance distributions, and (3) superior sensitivity to short-term fluctuations compared to traditional diversity indices. Notably, winter communities exhibited high dominance concentrations, particularly of species well-adapted to anthropogenic environments, such as the Common Coot (*Fulica atra*) and Mallard (*Anas platyrhynchos*). Meanwhile, the breeding season was characterized by a more balanced species abundance distribution, suggesting a temporally dynamic avian community.

$H_r$'s unitless value is scaled to species counts, enabling intuitive interpretation of community structure while maintaining statistical rigor. Unlike conventional indices that rely on abstract mathematical units (e.g., Shannon entropy in bits), $H_r$ provides direct ecological meaning, making it highly applicable for long-term biodiversity monitoring. Given its ability to detect both seasonal and short-term diversity fluctuations, $H_r$ emerges as a promising tool for assessing community health under urbanization pressures.

While $H_r$ effectively captures community heterogeneity in our research, its theoretical behavior in artificial communities remains unexplored. Future research should investigate whether $H_r$ exhibits the expected mathematical properties in simulated ecological datasets and whether it aligns with patterns observed in empirical studies. Validating $H_r$ in controlled artificial communities could provide deeper insights into its potential applications and limitations, further refining its role in biodiversity assessment and conservation planning. Additionally, future applications could assess $H_r$'s utility in detecting early signals of biotic homogenization across varying degrees of anthropogenic influence.

## CONCLUSION

The Gölköy-Yumrukaya Wetland, located within and around the Bolu Abant İzzet Baysal University campus, serves as a local biodiversity hotspot, with 173 recorded bird species. Beyond being a protected green space under urbanization pressure, this wetland demonstrates significant ecological value and should be considered for designation as an Important Bird Area (IBA). However, the observed decline in community heterogeneity, consistent with global trends in biotic homogenization, underscores the need for long-term monitoring and detailed reproductive data collection.

This study highlights the role of artificial wetlands as secondary habitats, particularly when ecologically connected to natural wetlands. The conservation of small habitat patches is crucial for maintaining primary bird communities, and further research should explore the connectivity between the GY wetland and nearby IBAs. Additionally, matrix quality in fragmented landscapes must be managed to prevent biodiversity loss due to edge effects and the spread of urban-adaptive or invasive species.

The newly introduced Heterogeneity Ratio ($H_r$ ) demonstrated strong potential for capturing community structure dynamics with higher resolution than traditional diversity indices. Future studies should further validate $H_r$'s applicability and compare its measurement accuracy with other ecological metrics. Given its ability to detect temporal fluctuations in species abundance and evenness, $H_r$ is recommended as a valuable tool for future biodiversity assessments.

## CONFLICT OF INTEREST

The authors declare no conflicts of interest related to the content of this article.

## DECLARATION OF AUTHOR CONTRIBUTION

All authors contributed to every step of the study. The fieldwork was conducted collaboratively by the author team, while the analyses were carried out by Cihangir Kirazlı. The initial draft of the manuscript was written by Cihangir Kirazlı and was finalized with contributions from the other authors.

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**Annex 1.** GY Wetland avifauna

*Ek 1. GY sulak alanı avifauması*

| *Family* | *Species* | January | February | March | April | May | June | July | August | September | October | November | December | IUCN | Status (local) | Status (Regional) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Podicipedidae*** | *Tachybaptus ruficollis* | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | LC | R | RW |
| | *Podiceps cristatus* | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | LC | R | RW |
| | *Podiceps nigricollis* | | ■ | ■ | | | | | | | | ■ | | LC | P | W |
| ***Phalacrocoracidae*** | *Phalacrocorax carbo* | ■ | ■ | ■ | ■ | | | ■ | ■ | | | ■ | ■ | LC | RW | WR |
| | *Microcarbo pygmaeus* | | | | ■ | | | | | | | | | LC | P | WR |
| ***Ardeidae*** | *Ardeola ralloides* | | | | ■ | ■ | | | | | | | | LC | M | M |
| | *Egretta garzetta* | | | | ■ | ■ | | | | | ■ | ■ | | LC | M | M |
| | *Ardea alba* | ■ | | ■ | ■ | ■ | | | | | ■ | ■ | ■ | LC | W | W |
| | *Ardea cinerea* | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | LC | R | R |
| | *Ardea purpurea* | | | ■ | ■ | ■ | ■ | | | | | | | LC | M | M |
| ***Ciconiidae*** | *Ciconia nigra* | | | | ■ | ■ | ■ | ■ | ■ | ■ | | | | LC | M | M |
| | *Ciconia ciconia* | | | | | ■ | ■ | | | | | | | LC | M | M |
| ***Threskiornithidae*** | *Platalea leucorodia* | | | | | | ■ | | | | | | | LC | P | P |
| | *Plegadis falcinellus* | | | | ■ | ■ | | ■ | | | | | | LC | PM | PM |
| ***Anatidae*** | *Anser anser* | ■ | | | | | | | | | | | | LC | WV | MW |
| | *Cygnus olor* | | | | | ■ | | | | | | | | LC | P | RP |
| | *Cygnus cygnus* | ■ | | | | | | | | | | | | LC | W | WP |
| | *Cygnus columbianus* | ■ | | | | | | | | | | | | LC | W | PW |
| | *Tadorna tadorna* | | | | ■ | | | | | | | | | LC | P | PW |
| | *Tadorna ferruginea* | | | | | | | ■ | | | | | | LC | R | RM |
| | *Anas acuta* | | | | ■ | | | | | | | | | LC | P | PW |
| | *Anas crecca* | ■ | ■ | ■ | | | | | | | ■ | ■ | ■ | LC | W | W |
| | *Mareca penelope* | | ■ | ■ | ■ | | | | | | | ■ | | LC | PW | PW |
| | *Mareca strepera* | | | ■ | ■ | | | | | | | | | LC | P | RW |
| | *Anas platyrhynchos* | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | LC | R | R |
| | *Spatula querquedula* | | ■ | ■ | ■ | ■ | | | | | | | | LC | MP | PM |
| | *Netta rufina* | | ■ | | | | | | | | | | ■ | LC | W | RW |
| | *Aythya ferina* | ■ | ■ | ■ | ■ | | ■ | | | | ■ | ■ | ■ | VU | WP | WR |

| *Family* | *Species* | January | February | March | April | May | June | July | August | September | October | November | December | IUCN | Status (local) | Status (Regional) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Aythya fuligula* | | ■ | ■ | ■ | ■ | | | | | ■ | | ■ | LC | WP | WP |
| ***Pelecanidae*** | *Pelecanus onocrotalus* | | | | | | ■ | | | | | | | LC | P | PM |
| ***Accipitridae*** | *Aegypius monachus* | | | | | | ■ | | | | | | | NT | R | R |
| | *Aquila chrysaetos* | | | | ■ | | | | | | | | | LC | R | R |
| | *Aquila heliaca* | | ■ | ■ | | | | | | | ■ | | | VU | R | RW |
| | *Haliaeetus albicilla* | | | ■ | | | | ■ | | | | | | LC | WR | PWR |
| | *Clanga pomarina* | | | | | ■ | | | | | | | | LC | MP | MP |
| | *Hieraaetus pennatus* | | | | | | | | ■ | | | | | LC | P | MP |
| | *Circaetus gallicus* | | | | ■ | ■ | | | ■ | ■ | ■ | | | LC | M | M |
| | *Milvus migrans* | | | | | ■ | | | | | | | | LC | PM | MP |
| | *Buteo buteo* | ■ | ■ | ■ | ■ | | ■ | | | ■ | ■ | ■ | ■ | LC | RW | RW |
| | *Buteo rufinus* | ■ | ■ | ■ | ■ | | ■ | ■ | ■ | | | | | LC | R | R |
| | *Pernis apivorus* | | | | | ■ | | | ■ | | | | | LC | PM | MP |
| | *Accipiter gentilis* | | | | | ■ | | ■ | | ■ | | | | LC | R | R |
| | *Accipiter brevipes* | | | | | ■ | | | ■ | | | | | LC | P | MP |
| | *Accipiter nisus* | ■ | | ■ | | | | | | ■ | ■ | ■ | | LC | WR | RW |
| ***Falconidae*** | *Falco tinnunculus* | | | ■ | | ■ | | | | | | | | LC | R | R |
| | *Falco subbuteo* | | | | | ■ | | | | ■ | | | | LC | PM | M |
| | *Falco peregrinus* | | | | | ■ | | | | | | | | LC | P | RW |
| ***Rallidae*** | *Gallinula chloropus* | | | | | ■ | | | | | | ■ | | LC | R | R |
| | *Fulica atra* | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | LC | R | R |
| ***Burhinidae*** | *Burhinus oedicnemus* | | | | ■ | | | | | | | | | LC | P | PM |
| ***Charadriidae*** | *Charadrius dubius* | | | | ■ | ■ | ■ | | | | | | | LC | MP | M |
| | *Charadrius alexandrinus* | | | | | | | | ■ | | | | | LC | P | PM |
| ***Scolopacidae*** | *Gallinago gallinago* | ■ | ■ | ■ | ■ | | | | | ■ | ■ | ■ | | LC | WP | W |
| | *Calidris pugnax* | | | | ■ | ■ | | | | | | | | LC | P | PW |
| | *Calidris minuta* | | | | ■ | | | | | | | | | LC | P | WP |
| | *Calidris temminckii* | | | | ■ | ■ | | | | | | | | LC | P | P |

| *Family* | *Species* | January | February | March | April | May | June | July | August | September | October | November | December | IUCN | Status (local) | Status (Regional) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Tringa ochropus* | | | | | | ■ | | ■ | | | | | LC | P | WP |
| | *Tringa nebularia* | | | | ■ | | | | ■ | | | | | LC | P | P |
| | *Tringa glareola* | | | | | ■ | | | | | | | | LC | P | P |
| | *Actitis hypoleucos* | | | | | | | ■ | ■ | | | | | LC | PM | PM |
| ***Laridae*** | *Hydrocoloeus minutus* | | | | | ■ | | | | | | | | LC | P | P |
| | *Larus ridibundus* | | | | | | | ■ | | | ■ | | | LC | RP | RW |
| | *Larus michahellis* | | | ■ | | | | | | | | ■ | | LC | P | WR |
| | *Sterna hirundo* | | | ■ | ■ | | | | | | ■ | | | LC | P | MP |
| ***Columbidae*** | *Columba livia* | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | LC | R | R |
| | *Columba palumbus* | | | | | | ■ | | | | | | | LC | S | MR |
| | *Streptopelia turtur* | | | | | | ■ | ■ | ■ | | ■ | | | VU | SP | M |
| | *Columba oenas* | | | ■ | ■ | ■ | ■ | | | | | | | LC | MR | R |
| | *Spilopelia senegalensis* | ■ | | | | | | | | | | ■ | | LC | W | R |
| | *Streptopelia decaocto* | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | ■ | | LC | R | R |
| ***Cuculidae*** | *Cuculus canorus* | | | | | | ■ | | | | | ■ | | LC | PS | M |
| ***Caprimulgidae*** | *Caprimulgus europaeus* | | | | ■ | | | | | | | | | LC | P | M |
| ***Apodidae*** | *Apus apus* | | | | ■ | ■ | ■ | ■ | ■ | ■ | | | | LC | M | M |
| | *Tachymarptis melba* | | | | ■ | ■ | ■ | ■ | ■ | ■ | | | | LC | M | M |
| | *Apus pallidus* | | | | ■ | | | | | | ■ | | | LC | P | MP |
| ***Alcedinidae*** | *Alcedo atthis* | | | | ■ | | | | | | | ■ | | LC | PM | RM |
| ***Meropidae*** | *Merops apiaster* | | | | | ■ | | | | ■ | | | | LC | PM | M |
| ***Coraciidae*** | *Coracias garrulus* | | | | | ■ | | | | | | | | LC | PM | M |
| ***Upupidae*** | *Upupa epops* | | | ■ | ■ | ■ | ■ | ■ | ■ | | | ■ | | LC | M | M |
| ***Picidae*** | *Picus viridis* | | ■ | ■ | ■ | | | ■ | ■ | ■ | | ■ | ■ | LC | R | R |
| | *Picus canus* | | | | | | | | | ■ | | ■ | | LC | P | R |
| | *Dendrocopos major* | | ■ | ■ | ■ | ■ | ■ | | | | ■ | ■ | | LC | R | R |
| | *Dendrocopos syriacus* | ■ | ■ | ■ | ■ | ■ | | | | | ■ | ■ | ■ | LC | R | R |
| | *Dryobates minor* | | | ■ | | | ■ | | | | ■ | | | LC | R | R |

| *Family* | *Species* | January | February | March | April | May | June | July | August | September | October | November | December | IUCN | Status (local) | Status (Regional) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Leiopicus medius* | | | | | | | | | | | | | LC | R | R |
| | *Jynx torquilla* | | | | | | | | | | | | | LC | MP | M |
| ***Alaudidae*** | *Galerida cristata* | | | | | | | | | | | | | LC | R | R |
| | *Lullula arborea* | | | | | | | | | | | | | LC | MR | MR |
| | *Alauda arvensis* | | | | | | | | | | | | | LC | MR | R |
| ***Hirundinidae*** | *Hirundo rustica* | | | | | | | | | | | | | LC | M | M |
| | *Cecropis daurica* | | | | | | | | | | | | | LC | PM | MP |
| | *Delichon urbicum* | | | | | | | | | | | | | LC | M | M |
| | *Riparia riparia* | | | | | | | | | | | | | LC | PM | M |
| ***Motacillidae*** | *Anthus campestris* | | | | | | | | | | | | | LC | P | MP |
| | *Anthus pratensis* | | | | | | | | | | | | | LC | P | WP |
| | *Anthus spinoletta* | | | | | | | | | | | | | LC | P | WM |
| | *Anthus trivialis* | | | | | | | | | | | | | LC | PM | PM |
| | *Anthus cervinus* | | | | | | | | | | | | | LC | P | PW |
| | *Motacilla flava* | | | | | | | | | | | | | LC | M | M |
| | *Motacilla cinerea* | | | | | | | | | | | | | LC | PW | RW |
| | *Motacilla alba* | | | | | | | | | | | | | LC | RM | R |
| | *Motacilla citreola* | | | | | | | | | | | | | LC | P | PM |
| ***Troglodytidae*** | *Troglodytes troglodytes* | | | | | | | | | | | | | LC | R | R |
| ***Turdidae*** | *Turdus merula* | | | | | | | | | | | | | LC | R | R |
| | *Turdus pilaris* | | | | | | | | | | | | | LC | W | W |
| | *Turdus philomelos* | | | | | | | | | | | | | LC | R | R |
| | *Turdus viscivorus* | | | | | | | | | | | | | LC | R | RW |
| ***Acrocephalidae*** | *Acrocephalus arundinaceus* | | | | | | | | | | | | | LC | MP | MP |
| | *Acrocephalus scirpaceus* | | | | | | | | | | | | | LC | M | MP |
| | *Acrocephalus palustris* | | | | | | | | | | | | | LC | P | PM |
| | *Acrocephalus schoenobaenus* | | | | | | | | | | | | | LC | P | MP |
| | *Iduna pallida* | | | | | | | | | | | | | LC | P | M |

| *Family* | *Species* | January | February | March | April | May | June | July | August | September | October | November | December | IUCN | Status (local) | Status (Regional) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Scotocercidae*** | *Cettia cetti* | | | | ■ | ■ | ■ | ■ | ■ | | | | | LC | M | M |
| ***Sylviidae*** | *Curruca nisoria* | | | | | ■ | ■ | ■ | | | | ■ | | LC | MP | M |
| | *Curruca curruca* | | | | | | | | ■ | | | | | LC | P | MP |
| | *Sylvia atricapilla* | | | | ■ | | | ■ | | | | | | LC | PS | MP |
| | *Curruca communis* | | | | ■ | ■ | | ■ | ■ | | ■ | | | LC | M | MP |
| ***Phylloscopidae*** | *Phylloscopus collybita* | | ■ | ■ | ■ | | ■ | | ■ | | ■ | ■ | | LC | MP | MP |
| | *Phylloscopus trochilus* | | | | | | | | | ■ | | | | LC | P | P |
| ***Regulidae*** | *Regulus regulus* | | ■ | ■ | ■ | | | | | | | | | LC | WP | RW |
| | *Regulus ignicapilla* | ■ | | ■ | ■ | | | | | | | | | LC | WP | WR |
| ***Muscicapidae*** | *Muscicapa striata* | | | | | ■ | ■ | ■ | ■ | ■ | | | | LC | M | MP |
| | *Ficedula parva* | | | | ■ | | | | | ■ | ■ | ■ | | LC | P | PM |
| | *Ficedula albicollis* | | | | ■ | | | | | | | | | LC | P | P |
| | *Ficedula hypoleuca* | | | | ■ | | | | | | | | | LC | P | P |
| | *Erithacus rubecula* | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | LC | R | RW |
| | *Luscinia megarhynchos* | | | | ■ | ■ | ■ | ■ | ■ | | | | | LC | M | M |
| | *Phoenicurus ochruros* | | | ■ | ■ | ■ | ■ | ■ | | ■ | ■ | | ■ | LC | MP | MP |
| | *Phoenicurus phoenicurus* | | | | ■ | ■ | | | | | ■ | | | LC | P | PM |
| | *Saxicola rubetra* | | | ■ | ■ | ■ | | | | | | | | LC | PM | PM |
| | *Saxicola torquatus* | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | LC | M | MP |
| | *Oenanthe isabellina* | | | | ■ | | | | | | | | | LC | P | M |
| | *Oenanthe oenanthe* | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | ■ | | LC | M | M |
| ***Aegithalidae*** | *Aegithalos caudatus* | ■ | ■ | ■ | | | | | | ■ | | | | LC | WR | R |
| ***Paridae*** | *Periparus ater* | | ■ | ■ | ■ | ■ | | | ■ | | ■ | ■ | | LC | R | R |
| | *Cyanistes caeruleus* | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | ■ | ■ | | LC | R | R |
| | *Parus major* | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | LC | R | R |
| | *Poecile palustris* | | ■ | | | | ■ | ■ | ■ | | ■ | ■ | | LC | R | R |
| ***Sittidae*** | *Sitta europaea* | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | ■ | | LC | R | R |
| | *Sitta krueperi* | ■ | | | | | | | | | | | | LC | WR | R |

| *Family* | *Species* | January | February | March | April | May | June | July | August | September | October | November | December | IUCN | Status (local) | Status (Regional) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Certhiidae*** | *Certhia brachydactyla* | | | ■ | ■ | ■ | | | | | | | ■ | LC | R | R |
| | *Certhia familiaris* | | ■ | | ■ | | | | | | | | | LC | RW | R |
| ***Laniidae*** | *Lanius collurio* | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | LC | M | M |
| | *Lanius minor* | | | | | ■ | | | | | | | | LC | P | M |
| | *Lanius excubitor* | ■ | ■ | | | | | | | | ■ | | | LC | W | W |
| | *Lanius senator* | | | | | ■ | ■ | | ■ | ■ | | | | NT | M | MP |
| | *Lanius nubicus* | | | | | ■ | | | | | | | | LC | P | PM |
| ***Oriolidae*** | *Oriolus oriolus* | | | | | ■ | ■ | ■ | ■ | | ■ | ■ | | LC | MP | M |
| ***Corvidae*** | *Garrulus glandarius* | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | ■ | ■ | ■ | ■ | LC | R | R |
| | *Pica pica* | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | LC | R | R |
| | *Corvus frugilegus* | | ■ | | | | | | | | ■ | ■ | | LC | W | WR |
| | *Corvus corone* | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | LC | R | R |
| | *Corvus corax* | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | LC | R | R |
| | *Corvus monedula* | ■ | ■ | ■ | | ■ | | ■ | ■ | | | ■ | | LC | R | R |
| ***Sturnidae*** | *Sturnus vulgaris* | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | LC | R | R |
| | *Pastor roseus* | | | | | ■ | | | | | | ■ | | LC | P | PM |
| ***Passeridae*** | *Passer domesticus* | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | LC | R | R |
| | *Passer montanus* | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | ■ | ■ | | LC | R | R |
| | *Passer hispaniolensis* | | | | ■ | ■ | | ■ | | | | | | LC | M | M |
| ***Fringillidae*** | *Fringilla coelebs* | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | LC | R | R |
| | *Fringilla montifringilla* | | ■ | | | | | | | ■ | | ■ | ■ | LC | W | W |
| | *Serinus serinus* | | | ■ | | ■ | ■ | ■ | ■ | | | ■ | | LC | RM | RW |
| | *Chloris chloris* | | | ■ | ■ | ■ | ■ | ■ | ■ | | ■ | ■ | | LC | RM | R |
| | *Carduelis carduelis* | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | LC | R | R |
| | *Spinus spinus* | ■ | | | | | | | | | | | | LC | W | WR |
| | *Linaria cannabina* | | | ■ | ■ | ■ | | | | ■ | ■ | | | LC | MP | RM |
| | *Carpodacus erythrinus* | | | | | ■ | ■ | ■ | | | | | | LC | SM | M |
| | *Pyrrhula pyrrhula* | | ■ | | | | | | | | | | | LC | W | RW |

| *Family* | *Species* | January | February | March | April | May | June | July | August | September | October | November | December | IUCN | Status (local) | Status (Regional) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Coccothraustes coccothraustes* | | | ■ | | | | | | | | ■ | ■ | LC | W | RW |
| ***Emberizidae*** | *Emberiza cirlus* | | | ■ | ■ | | | ■ | | ■ | | | | LC | R | R |
| | *Emberiza hortulana* | | | | ■ | ■ | ■ | ■ | ■ | | | | | LC | M | M |
| | *Emberiza melanocephala* | | | | | ■ | ■ | ■ | ■ | | ■ | ■ | | LC | MP | M |
| | *Emberiza calandra* | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | LC | R | R |