

Influence of seasonal change and anthropogenic activities on the avifauna composition in a seasonal wetland of India

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Abstract Seasonal wetlands harbour a mosaic of habitats that support a variety of niches for bird species. When seasonal change and anthropogenic activities are coupled with the landscape, the species richness and species composition are presumably influenced by such factors. This study aimed to evaluate avifauna diversity, to investigate feeding guilds, and to determine the impact of seasonality and tourism pressure as anthropogenic disturbance on the avian community of a wetland. Comprehensive surveys were conducted to gather all necessary data, followed by the application of analytical methods to assess the hypotheses formulated in the current research. A total of 61 bird species belonging to 14 orders have been recorded during this year-round study, where Passeriformes was the most dominant order with 27 bird species. The species richness was highest in winter, and five feeding guilds were identified. This study revealed a significant role of seasonality, and tourism pressure on avian species richness of Bortir Bil. The outcomes of the present study could serve as an important baseline to adopt sustainable and bird-friendly management plan for this seasonal wetland.

Keywords: anthropogenic activity, birds, Bortir Bil, seasonal wetland, tourism pressure

Összefoglalás Az évszakos mocsarak mozaikjai különböző élettereket kínálnak a madárfajok számára. Amikor az évszakos változások és az emberi tevékenységek összekapcsolódnak a táj sajátosságaival, a fajgazdagság és a fajösszetétel feltételezhetően ilyen tényezők által befolyásoltak. A tanulmány célja a madárvilág sokféleségének értékelése, a táplálkozási guildek vizsgálata, valamint a szezonális és a turizmus, mint kiemelkedő emberi tevékenység hatásának meghatározása a mocsárterület madárállományára. Összesen 61 madárfajt, amelyek 14 rendbe tartoznak, rögzítettek a vizsgálati időszak során, ahol az énekesmadarak rendje volt a legmeghatározóbb, 27 fajjal. A madárvilág fajgazdagsága télen volt a legmagasabb, és öt táplálkozási guildet azonosítottak. Ez a tanulmány a szezonális és a turizmus, mint antropogén tevékenység jelentős szerepét mutatta ki a Bortir Bil madaraira. A közölt eredmények fontos kiindulópontként szolgálhatnak fenntartható és madárbarát kezelési tervek kidolgozásához ezen évszakos mocsárvidék számára.

Kulcsszavak: antropogén tevékenység, madarak, Bortir Bil, szezonális vizes élőhelyek, turisztikai nyomás

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Introduction

Wetlands serve as a transitional zone between terrestrial and aquatic ecosystems, offering a rich source of biodiversity. They hold diverse utility for various life forms, but for birds, wetlands primarily serve as crucial habitats for breeding, nesting, and feeding purposes (Parchizadeh & Williams 2018). Avian fauna is an important component of different ecosystems and provides varied functional roles including predation, scavenging, pest control, seed dispersal, and nutrient deposition (Şekercioğlu *et al.* 2012). In India, about 60.45% of the terrestrial area is under agricultural cultivation (Yashmita-Ulman & Singh 2021). The agricultural landscape provides resources and habitats for many bird species (Sundar & Subramanya 2010) but hosts lower bird species richness than other habitats (Şekercioğlu *et al.* 2019). These landscapes are a mosaic of different land use and land cover features such as cultivated land, wetland, fallow land, grassland, scattered trees, orchards, or small forest patches (Katuwal *et al.* 2022). Birds often choose to live in a heterogeneous environment, and hence, the heterogeneity, created by landscape features, affects the bird community composition (Redlich *et al.* 2018). Along with other factors, seasonal changes and anthropogenic pressure in an agricultural field can also modify the avian community structure (Şekercioğlu *et al.* 2019).

The low-lying agricultural landscapes which get inundated every year during monsoon can be considered seasonal wetland habitats. These wetlands are beneficial for birds by providing enormous numbers of insects, crustaceans, shrimps, and molluscs as food (Ng'weno 1992, Mukhopadhyay & Mazumdar 2019). Bortir Bil is a seasonal wetland and a popular seasonal tourist spot in the state of West Bengal in India. Fishing is a major local activity along with boating. The tourists mostly visit the area during the monsoon and post-monsoon seasons when the agricultural lands get flooded with rainwater. These activities not only create anthropogenic disturbance to the bird populations but also pollute their habitats. Many birds of wetlands are threatened and declining faster than in other habitats (IUCN 2023a). A decline in avian diversity can cause a dramatic change in the integrity of species interactions and ecosystem functions as birds occupy higher trophic levels in the food chain. Hence, the identification of potential threats or factors that influence the avian community is the primary concern of conservation at present in order to maintain biodiversity.

Earlier studies conducted on wetlands have indicated that avian species richness tends to be higher in the wetlands of semi-urban areas and agricultural lands compared to wetlands of highly urbanized areas (Panda *et al.* 2021). Wetlands experiencing anthropogenic disturbances and agricultural practices exhibit reduced species diversity compared to more natural and less-altered areas (Datta 2011). Despite the rapid urbanization observed worldwide, which has had alarming consequences for various components of biodiversity, seasonal wetlands have received much less attention compared to natural wetlands (Mukhopadhyay & Mazumdar 2019). It is only in the past few decades that bird communities in human-dominated landscapes have garnered attention (Marzluff *et al.* 2001). This increased interest is primarily driven by growing concerns about the detrimental influence of anthropogenic effects on biodiversity and environmental processes (McKinney *et al.* 2011). However, there have been limited studies conducted on avian diversity in seasonal wetlands in India, the

avian diversity of many such areas remains undocumented to date. The first ever scientific documentation on the avifauna of Bortir Bil was made by the authors of this study (Debnath & Pal 2022). An in-depth study of avifauna diversity and the factors affecting it in a seasonal wetland has not been done yet in India. Hence, the present study aimed to assess the diversity and richness of the avifauna in Bortir Bil, to explore the feeding guilds, and to assess whether seasonality, tourism pressure (as an anthropogenic disturbance) had any significant role on the avian community of this wetland.

Material and Methods

Study area

The present study was conducted in the Bortir Bil ($22^{\circ}47' N$ and $88^{\circ}26' E$) of Beraberia village in North 24 Parganas district, West Bengal, India (Figure 1). This landscape consists of marshy lowlands with cultivated fields and most of the lands get flooded during the monsoon (Debnath & Pal 2022). The tropical climate of the study area consists of four seasons: summer (March to May), monsoon (June to August), post-monsoon (September to November), and winter (December to February). Weather varies from sunny to cloudy, and cloudy to rainy during summer and monsoon.

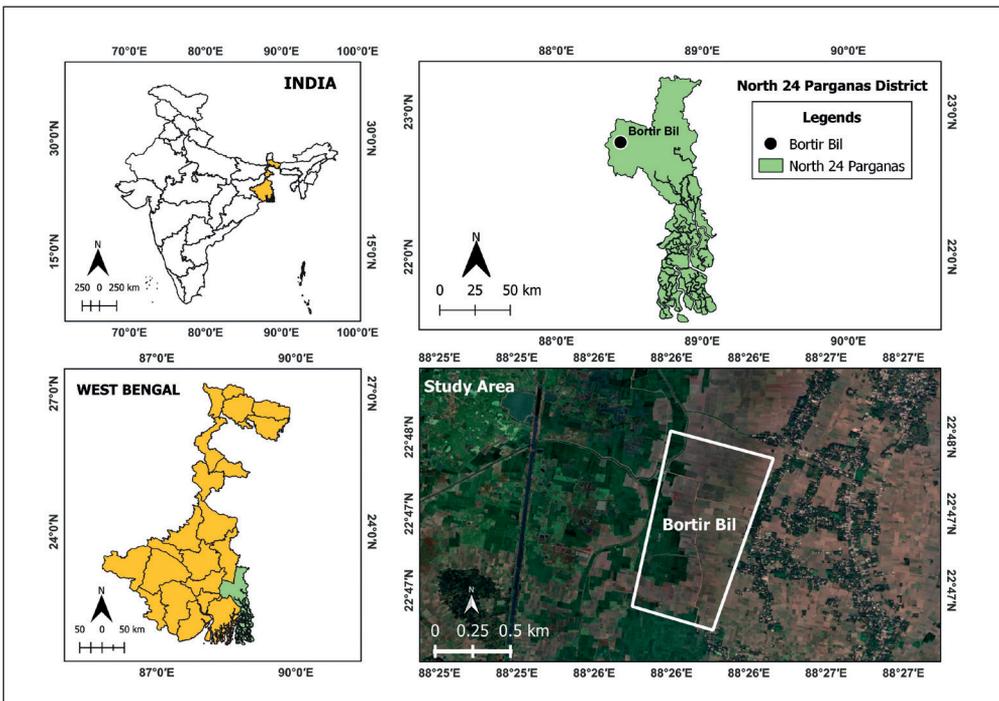


Figure 1. Map of the study area Bortir Bil, West Bengal, India
 1. ábra A kutatási terület térképe: Bortir Bil, Nyugat-Bengál, India

Bird and tourist survey

Surveys were conducted from April 2021 to March 2022 for a year in the agricultural landscapes of the study area. The surveys were carried out at weekly intervals to document both birds and tourists. Field visits were carried out on foot only on the days with suitable weather conditions i.e. in the absence of rain, storm, or strong wind. The point-transect method was used to record the bird species (Sutherland 2006). A total of 10 points were marked on the study area at every 200 m distance to avoid the overlapping of bird countings. Bird species were recorded within a 100 m radius of each of these points in a 360° arc for 20 minutes. To ensure that the same birds would not be counted again, birds were counted at their point of the first detection. In addition, opportunistic observations of birds in the study area were also taken in order to prepare a comprehensive checklist of the avifauna of the study area (Mukhopadhyay & Mazumdar 2017). Birds were counted and recorded either with the unaided eye or using binoculars (Olympus 10×50 S), and photographs were taken, whenever possible, with a digital camera (Nikon COOLPIX P900) for documentation of the avifauna. In some cases, call notes of birds were also used to identify a particular bird along with locating and recording a photograph. The common names of the birds and their respective conservation status and global population trends (GPT: I- increasing, D- declining, S- stable, U- unknown) were assigned from Birds of the World (2024) and the IUCN Red List of species (IUCN 2023b), respectively. The standard method of Khan and Naher (2009) was applied to assign the local status to each recorded bird species based on the percentage of frequency of records: very common (VC) – recorded on 80–100% of field visits, common (C) – recorded on 50–79% of field visits, fairly common (FC) – recorded on 20–49% of field visits and rare (R) – recorded on less than 20% of the field visits. The recorded bird species were categorized into five feeding guilds based on the direct observations of their feeding habits such as – carnivore (CAR): species that feed on vertebrates; frugivore (FRU): species that feed on fruits; granivore (GRA): species that feed on grains or seeds; insectivore (INS): species that feed on insects; omnivore (OMN): species that feed both plant and animal parts (Sundar & Subramanya 2010). The number of tourists was counted following the same method as the bird survey technique mentioned earlier.

Data analysis

Season-wise species richness data were considered to test whether there was any seasonal pattern of the avian assemblage in the study site. The relative diversity (RD_i) of the recorded bird families was calculated by using the formula from La Torre-Cuadros *et al.* (2007). Species similarity between any two seasons was calculated by the Jaccard similarity index based on the species present-absent binary community matrix. Shannon-Wiener's diversity index (H') was used to assess the species diversity of the avian community. Shannon-Wiener's diversity index of avifauna and Jaccard similarity index were estimated using the PAST statistical package (Hammer *et al.* 2001) software.

Shapiro-Wilk test and subsequent histogram revealed that the species richness of avifauna was normally distributed ($W = 0.987$, $df = 48$, $P > 0.05$). We performed the analysis of

variance (ANOVA) using species richness as the dependent variable and seasons as a categorical explanatory variable to find out whether the distribution of species richness across different seasons was statistically different or not. Subsequently, post hoc Tukey's tests were executed where significant differences were noticed. Shapiro-Wilk test and subsequent histogram revealed that the species richness of residents, summer visitors, and winter visitors was non-normally distributed. Hence, we performed the Kruskal-Wallis test in the case of resident, summer, and winter visitors to test whether the seasonal variation had a significant role in their distribution or not. Subsequently, multiple pairwise comparisons using Dunn's procedure were executed where significant differences were noticed. As the avian species richness was normally distributed, the linear regression was performed to test whether the number of tourists had any significant role in shaping the species richness, using species richness as a dependent variable and the number of tourists as an independent variable. Statistical tests were computed using SPSS Version 24.0 (IBM Corp., Armonk, New York) and graphical works were executed using Origin Version 8.0 (OriginLab Corp., Northampton, MA, USA).

Results

Avian diversity and feeding guilds

A total of 9,494 observations of 61 bird species belonging to 14 orders and 31 families were recorded during the study period (Table 1). The study area supported 7.01% of the avian species found in West Bengal. Passeriformes was the dominant order with 27 species (44.26%) and Ardeidae was the most diverse bird family in the study area (7 species, $RD_i = 11.48$) (Table 2). According to the dispersal status of the 61 recorded species, 45 were residents (73.77%), 15 species were winter visitors (24.59%) and only one species was summer visitor (1.64%). Analysis of local status revealed that ten species (16.39%) were very common, seven species (11.48%) were common, 17 species (27.87%) were fairly common and 27 species (44.26%) were rare. Assigning global population trends to the recorded bird species of the study area revealed that 15 species (24.59%) were declining, 10 species (16.39%) were increasing, 21 species (34.43%) were stable, and 15 species (24.59%) were of unknown status. Among the 61 species, two species: Lesser Adjutant (*Leptoptilos*

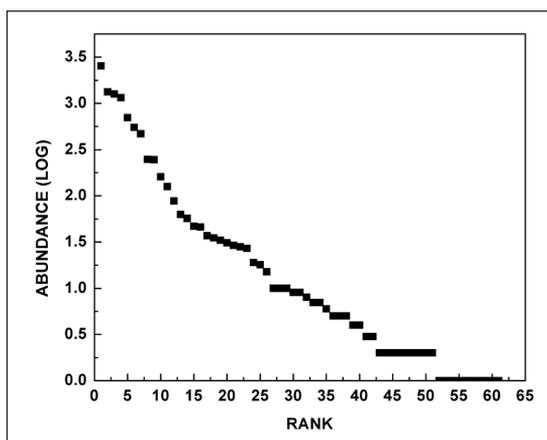


Figure 2. Rank abundance curve of the avifauna in the study area

2. ábra Rang-abundancia görbe a kutatási terület madárfaunája alapján

Table 1. Present status of avian species recorded in the agricultural landscape of Bortir Bil, West Bengal, India [IUCN: International Union for Conservation of Nature and Natural Resources; GPT: Global Population Trend; SM: Summer, M: Monsoon, PM: Post-Monsoon, W: Winter; RE: Residential, SV: Summer Visitor, WV: Winter Visitor; Y: Present or recorded, LC: Least Concern, VU: Vulnerable, NT: Near Threatened; R: Rare, FC: Fairly Common, C: Common, VC: Very Common; I: Increasing, S: Stable, D: Decreasing, U: Unknown; CAR: Carnivore, INS: Insectivore, FRU: Frugivore, GRA: Granivore, OMN: Omnivore]

1. táblázat A Bortir Bil-i mezőgazdasági tájban (Nyugat-Bengál, India) feljegyzett madárfauna jelenlegi helyzete [IUCN: Természetvédelmi Világszövetség; GPT globális állomány trend; SM: nyári; M: monszun; PM: monszun utáni; W: téli; RE: állandó; SV: nyári vendég; WV: téli vendég; VC: közönséges; I: növekvő; S: stabil; D: csökkenő; U: ismeretlen; CAR: ragadozó, INS: rovarevő, FRU: gyümölcssevő, GRA: magedvő, OMN: mindenevő]

Sl.	Family	Common Name	Scientific Name	Seasonal Occurrence				Dispersal Status	IUCN Status	Local Status	GPT	Feeding Guild
				SM	M	PM	W					
Order – Podicipediformes												
1	Podicipedidae	Little Grebe	<i>Tachybaptus ruficollis</i>	-	-	Y	-	RE	LC	R	D	CAR
Order – Columbiformes												
2	Columbidae	Eurasian Collared-Dove	<i>Streptopelia decaocto</i>	Y	-	-	-	RE	LC	R	I	GRA
3	Columbidae	Spotted Dove	<i>Spilopelia chinensis</i>	Y	Y	Y	Y	RE	LC	C	I	GRA
Order – Cuculiformes												
4	Cuculidae	Asian Koel	<i>Eudynamis scolopacea</i>	Y	-	-	Y	RE	LC	R	S	OMN
5	Cuculidae	Greater Coucal	<i>Centropus sinensis</i>	Y	-	Y	Y	RE	LC	FC	S	CAR
6	Cuculidae	Pied Cuckoo	<i>Clamator jacobinus</i>	-	Y	-	-	SV	LC	R	S	INS
7	Cuculidae	Plaintive Cuckoo	<i>Cacomantis merulinus</i>	-	-	-	Y	RE	LC	R	S	INS
Order – Caprimulgiformes												
8	Apodidae	Asian Palm Swift	<i>Cypsiurus balasiensis</i>	Y	Y	Y	Y	RE	LC	VC	S	INS
Order – Charadriiformes												
9	Charadriidae	Little Ringed Plover	<i>Charadrius dubius</i>	-	-	Y	Y	RE	LC	FC	S	INS
10	Charadriidae	Pacific Golden Plover	<i>Pluvialis fulva</i>	Y	-	-	-	WV	LC	R	D	INS
11	Charadriidae	Red-wattled Lapwing	<i>Vanellus indicus</i>	-	Y	-	-	RE	VU	R	U	INS
12	Jacaniidae	Pheasant-tailed Jacana	<i>Hydrophasianus chirurgus</i>	-	-	Y	-	RE	LC	R	D	INS

Sl.	Family	Common Name	Scientific Name	Seasonal Occurrence				Dispersal Status	IUCN Status	Local Status	GPT	Feeding Guild
				SM	M	PM	W					
13	Laridae	Whiskered Tern	<i>Chlidonias hybrida</i>	-	Y	-	-	WV	LC	R	S	CAR
14	Scolopacidae	Wood Sandpiper	<i>Tringa glareola</i>	-	Y	Y	Y	WV	LC	FC	S	INS
Order – Ciconiiformes												
15	Ciconiidae	Asian Openbill	<i>Anastomus oscitans</i>	Y	Y	Y	Y	RE	LC	VC	U	CAR
16	Ciconiidae	Lesser Adjutant	<i>Leptoptilos javanicus</i>	-	Y	-	-	WV	VU	R	D	CAR
17	Ciconiidae	Painted Stork	<i>Mycteria leucocephala</i>	-	Y	-	-	WV	NT	R	D	CAR
Order – Suliformes												
18	Phalacrocoracidae	Little Cormorant	<i>Microcarbo niger</i>	Y	Y	Y	Y	RE	LC	VC	U	CAR
Order – Pelecaniformes												
19	Ardeidae	Eastern Cattle Egret	<i>Bubulcus coromandus</i>	Y	Y	Y	Y	RE	LC	VC	I	CAR
20	Ardeidae	Great Egret	<i>Ardea alba</i>	-	Y	Y	-	RE	LC	R	U	CAR
21	Ardeidae	Gray Heron	<i>Ardea cinerea</i>	-	Y	-	-	RE	LC	R	U	CAR
22	Ardeidae	Indian Pond-Heron	<i>Ardeola grayii</i>	Y	Y	Y	Y	RE	LC	VC	U	CAR
23	Ardeidae	Medium Egret	<i>Ardea intermedia</i>	-	Y	Y	Y	RE	LC	FC	D	CAR
24	Ardeidae	Little Egret	<i>Egretta garzetta</i>	Y	Y	Y	Y	RE	LC	FC	I	CAR
25	Ardeidae	Purple Heron	<i>Ardea purpurea</i>	-	Y	-	-	RE	LC	R	D	CAR
Order – Accipitriformes												
26	Accipitridae	Black Kite	<i>Milvus migrans</i>	-	-	Y	Y	RE	LC	R	S	CAR
Order – Bucerotiformes												
27	Upupidae	Eurasian Hoopoe	<i>Upupa epops</i>	Y	-	-	Y	RE	LC	FC	D	INS
Order – Coraciiformes												
28	Meropidae	Asian Green Bee-eater	<i>Merops orientalis</i>	Y	Y	Y	Y	RE	LC	FC	I	INS
29	Alcedinidae	Common Kingfisher	<i>Alcedo atthis</i>	Y	-	-	Y	RE	LC	FC	U	CAR
30	Alcedinidae	Pied Kingfisher	<i>Ceryle rudis</i>	-	Y	-	-	RE	LC	R	U	CAR

Sl.	Family	Common Name	Scientific Name	Seasonal Occurrence				Dispersal Status	IUCN Status	Local Status	GPT	Feeding Guild
				SM	M	PM	W					
31	Alcedinidae	Stork-billed Kingfisher	<i>Pelargopsis capensis</i>	-	-	Y	-	RE	LC	R	U	CAR
32	Alcedinidae	White-throated Kingfisher	<i>Halcyon smyrnensis</i>	Y	Y	Y	Y	RE	LC	C	U	CAR
Order – Piciformes												
33	Picidae	Eurasian Wryneck	<i>Jynx torquilla</i>	-	-	-	Y	WV	LC	R	D	INS
Order – Psittaciformes												
34	Psittacidae	Rose-ringed Parakeet	<i>Alexandrinus krameri</i>	Y	-	-	-	RE	LC	R	I	FRU
Order – Passeriformes												
35	Sturnidae	Indian Pied Starling	<i>Gracupica contra</i>	Y	Y	Y	Y	RE	LC	VC	I	OMN
36	Hirundinidae	Barn Swallow	<i>Hirundo rustica</i>	Y	Y	Y	Y	WV	LC	C	U	INS
37	Alaudidae	Bengal Bushlark	<i>Mirafra assamica</i>	Y	Y	-	-	RE	LC	FC	S	OMN
38	Dicruridae	Black Drongo	<i>Dicurus macrocerus</i>	Y	Y	Y	Y	RE	LC	VC	U	INS
39	Oriolidae	Black-hooded Oriole	<i>Oriolus xanthornus</i>	Y	Y	-	-	RE	LC	FC	S	OMN
40	Muscicapidae	Bluethroat	<i>Luscinia svecica</i>	Y	-	-	-	WV	LC	R	S	INS
41	Laniidae	Brown Shrike	<i>Lanius cristatus</i>	Y	-	-	Y	WV	LC	FC	D	CAR
42	Sturnidae	Chestnut-tailed Starling	<i>Sturnia malabarica</i>	Y	-	-	Y	RE	LC	FC	U	OMN
43	Motacillidae	Citrine Wagtail	<i>Motacilla citreola</i>	Y	-	Y	Y	WV	LC	C	I	INS
44	Acrocephalidae	Clamorous Reed Warbler	<i>Acrocephalus stentoreus</i>	Y	-	Y	-	WV	LC	R	S	INS
45	Sturnidae	Common Myna	<i>Acridotheres tristis</i>	Y	Y	Y	Y	RE	LC	VC	I	OMN
46	Cisticolidae	Common Tailorbird	<i>Orthotomus sutorius</i>	Y	-	-	-	RE	LC	R	S	INS
47	Motacillidae	Eastern Yellow Wagtail	<i>Motacilla tschutschensis</i>	Y	Y	Y	Y	WV	LC	VC	D	INS
48	Corvidae	House Crow	<i>Corvus splendens</i>	Y	Y	Y	Y	RE	LC	VC	S	OMN
49	Oriolidae	Indian Golden Oriole	<i>Oriolus kundoo</i>	Y	-	-	-	RE	LC	R	U	OMN
50	Leiotrichidae	Jungle Babbler	<i>Argya striata</i>	Y	-	-	-	RE	LC	R	S	INS

Sl.	Family	Common Name	Scientific Name	Seasonal Occurrence				Dispersal Status	IUCN Status	Local Status	GPT	Feeding Guild
				SM	M	PM	W					
51	Sturnidae	Jungle Myna	<i>Acridotheres fuscus</i>	Y	Y	-	Y	RE	LC	FC	D	OMN
52	Corvidae	Large-billed Crow	<i>Corvus macrorhynchos</i>	Y	Y	-	Y	RE	LC	C	S	OMN
53	Laniidae	Long-tailed Shrike	<i>Lanius schach</i>	-	-	Y	Y	WV	LC	FC	U	CAR
54	Muscicapidae	Oriental Magpie-Robin	<i>Copsychus saularis</i>	Y	-	-	-	RE	LC	R	S	INS
55	Alaudidae	Oriental Skylark	<i>Alauda gulgula</i>	Y	-	-	-	RE	LC	R	D	OMN
56	Cisticolidae	Plain Prinia	<i>Prinia inornate</i>	Y	Y	Y	Y	RE	LC	C	S	INS
57	Pycnonotidae	Red-vented Bulbul	<i>Pycnonotus cafer</i>	Y	Y	-	Y	RE	LC	C	I	OMN
58	Corvidae	Rufous Treepie	<i>Dendrocitta vagabunda</i>	Y	-	Y	Y	RE	LC	FC	D	OMN
59	Estrildidae	Scaly-breasted Munia	<i>Lonchura punctulata</i>	-	Y	Y	-	RE	LC	FC	S	GRA
60	Acrocephalidae	Thick-billed Warbler	<i>Arundinax aedon</i>	-	-	-	Y	WV	LC	R	D	INS
61	Motacillidae	White Wagtail	<i>Motacilla alba</i>	-	-	Y	Y	WV	LC	FC	S	INS

Table 2. Relative diversity (RD_i) of different avian families recorded in the study area
2. táblázat A kutatási területen feljegyzett madárcsaládok relatív diverzitása (RD_i)

Avian families		Number of species	RD _i (%)
Ardeidae		7	11.48
Alcedinidae, Cuculidae, Sturnidae		4	6.56
Charadriidae, Ciconiidae, Corvidae, Motacillidae		3	4.92
Acrocephalidae, Alaudidae, Cisticolidae, Columbidae, Laniidae, Muscicapidae, Oriolidae		2	3.28
Accipitridae, Apodidae, Dicruridae, Estrildidae, Hirundinidae, Jacanidae, Laridae, Leiotrichidae, Meropidae, Phalacrocoracidae, Picidae, Podicipedidae, Psittacidae, Pycnonotidae, Scolopacidae, Upupidae		1	1.64

javanicus), Red-wattled Lapwing (*Vanellus indicus*) were ‘Vulnerable’, one species: Painted Stork (*Mycteria leucocephala*) was ‘Near Threatened’ and the rest were ‘Least Concern’ according to IUCN Red List (Table 1). The rank abundance curve (Figure 2) revealed that Indian Pied Starling (*Gracupica contra*) was the most abundant bird species in the study area followed by Common Myna (*Acridotheres tristis*), Eastern Yellow Wagtail (*Motacilla tschutschensis*), and others. The Shannon-Wiener’s diversity index of the avifauna of the study area was 2.407. Season-wise Shannon-Wiener’s diversity index was highest in winter ($H' = 2.461$), followed by post-monsoon ($H' = 2.307$), summer ($H' = 2.223$), and monsoon ($H' = 2.048$). Five feeding guilds were found in the study area. Among the 61 recorded bird species, insectivores were the most predominant (23 species, 37.70%), followed by carnivores (21 species, 34.43%), omnivores (13 species, 21.31%), granivores (3 species, 4.92%) and frugivores (1 species, 1.64%).

Seasonality on species richness

Among the months, the highest bird species richness (Mean±SD) had been recorded in January (18.75±0.47) (Figure 3). Species richness was highest in winter (18.16±0.76) followed by summer (16.58±0.97), post-monsoon (13.75±0.65), and monsoon (13.08±0.72) (Figure 4A). Jaccard similarity index indicated that species composition was seasonally similar. The highest similarity existed between the winter and post-monsoon (0.60), followed by winter and summer (0.56), whereas the lowest similarity existed between post-monsoon and summer (0.40). ANOVA revealed that the avian species richness was significantly different across the four seasons ($F_{3,44} = 10.942$, $P < 0.05$). A post hoc Tukey test showed that summer and monsoon, summer and post-monsoon, winter and monsoon, and winter and post-monsoon differed significantly at $P < 0.05$ (Figure 4).

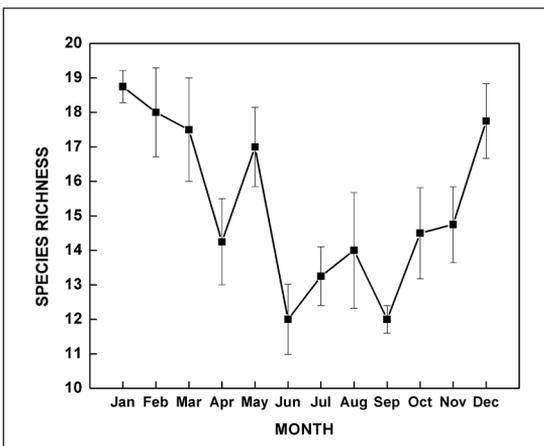


Figure 3. Monthly bird species richness in the study area. Bars denote the standard error of the mean
 3. ábra Madár fajgazdagság havi értékei a vizsgálati területen. A hibásávok az átlag standard hibáját jelölik

The species richness of summer visitors (Kruskal-Wallis test: $K = 6.130$, $df = 3$, $P > 0.05$), showed non-significant variation across the seasons, remaining similar throughout the study period. However, a significant seasonal difference was noticed in the case of residents (Kruskal-Wallis test: $K = 15.502$, $df = 3$, $P < 0.05$) and winter visitors (Kruskal-Wallis test: $K = 20.108$, $df = 3$, $P < 0.05$) (Figure 4). Multiple pairwise post hoc comparisons using Dunn’s procedure revealed that the species richness of residents was highest in summer and differed significantly between summer and monsoon, summer and post-monsoon, winter and monsoon, winter and post-monsoon ($P < 0.05$)

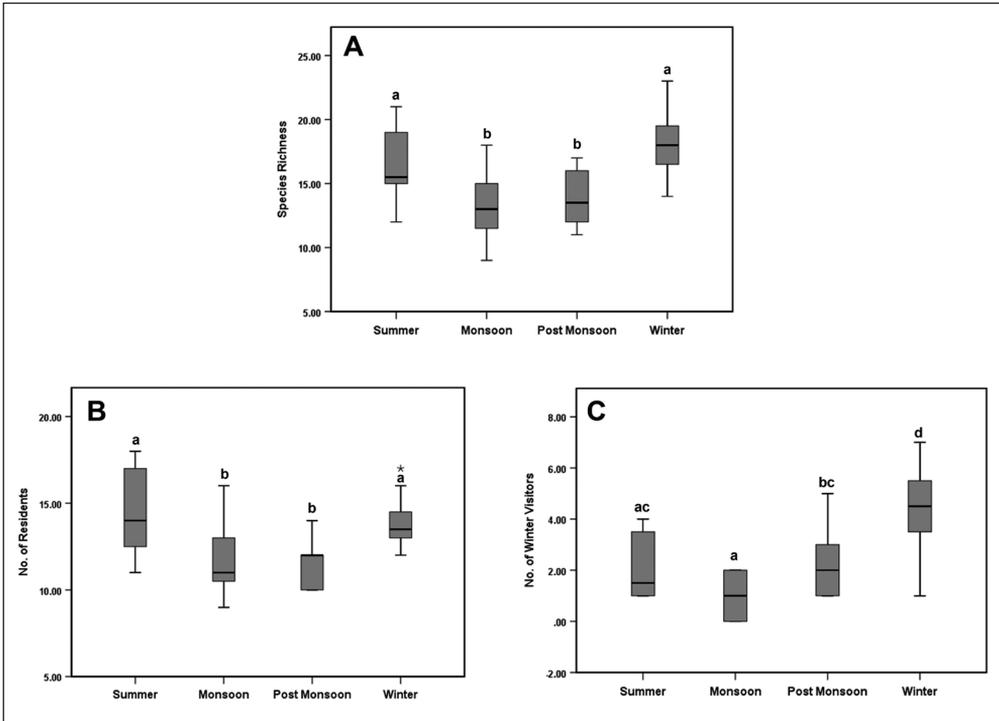


Figure 4. Study of seasonality on species richness. A. Box-plot showing season-wise species richness of avifauna in Bortir Bil; B. Box-plot showing resident (RE) species richness across different seasons; C. Box-plot showing winter visitor (WV) species richness across different seasons. Box-plots with different letters indicate a significant difference in species richness between a pair of seasons as per multiple pairwise comparisons. Bars denote the standard error of the mean.

4. ábra A szezonális hatása a fajgazdagságra. A. Évszakonkénti fajgazdagság a Borti Bil-i madárfauna alapján. B. Az állandó fajok (RE) fajgazdagsága a különböző évszakokban. C. A téli vendég fajok (WV) fajgazdagsága a különböző évszakokban. A dobozdiagramokon a különböző betűvel jelölt csoportok szignifikáns különbséget jelölnek a páronkénti összehasonlítás alapján. A hibásávok az átlag standard hibáját jelölik

(*Figure 4B*). In case of winter visitors, species richness was highest in winter and differed significantly ($P < 0.05$) from all other seasons (*Figure 4C*).

Tourism pressure on species richness

The maximum number of tourists visited the site during monsoon followed by post-monsoon, summer, and winter. The number of tourists explained 36% of the variance in species richness ($R^2 = 0.36$, $F_{1,46} = 25.824$, $P < 0.05$). The number of tourists played a significant role in shaping avian species richness ($B = -0.013$, $t = -5.082$, $P < 0.05$) (*Figure 5*).

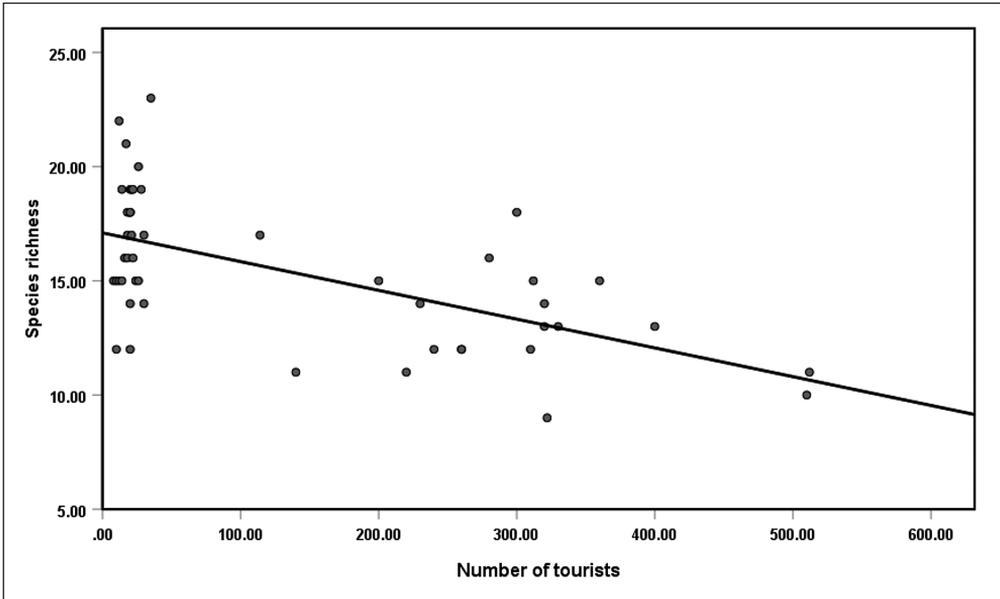


Figure 5. Linear regression plot depicting the effect of tourism pressure on species richness. Regression equation, Species richness = 17.09 – (0.013 × Number of tourists)

5. ábra A turizmus által jelentett terhelés és a fajgazdagság kapcsolatát bemutató lineáris regresszió grafikonja. A regressziós egyenlet. Fajgazdagság = 17.09 – (0.013 × Turisták száma)

Discussion

This year-round study of Bortir Bil found that avian diversity is influenced by seasonal change and anthropogenic activities, also revealing the current conservation status of the avifauna. The bird species richness of Bortir Bil is comparable to many wetlands across India. For instance, Datta (2011) documented 80 and 42 bird species from two wetlands of Jalpaiguri, West Bengal; Kumar and Gupta (2009) found 54 bird species in Kurukshetra, Haryana; Pattnaik *et al.* (2022) documented 77 species at Kirtipur wetland, Odisha; Pawar and Wanjari (2013) reported 34 species at Muchi lake wetland, Maharashtra; Panda *et al.* (2021) documented 68 species at Chilika wetland; Shahbaz *et al.* (2023) documented 73 and 67 species from two wetlands of Patna, respectively. In India, Passeriformes is considered the most dominant order (Praveen *et al.* 2016) which is also consistent with our findings.

The species richness of the avifauna was lowest during the monsoon as compared to the other three seasons. This may be due to some birds like storks, and egrets dispersing in search of nesting sites with the advent of monsoon (Urfi 1996). This trend has been observed by Mukhopadhyay and Mazumdar (2019) during their study in the suburban area of the lower Gangetic plains. However, during the monsoon, these low-level agricultural fields get flooded by rainwater and hence act as a seasonal wetland. This provides sufficient food supply to the resident birds, as well as attracts migratory birds in winter. Many of the bird species like Eastern Cattle Egret (*Bubulcus coromandus*), Asian Openbill (*Anastomus oscitans*), Whiskered Tern (*Chlidonias hybrida*), and kingfishers were found during

the monsoon, and post-monsoon because of the availability of abundant food. Common water hyacinth was the most abundant and invasive floating macrophyte species found at Bortir Bil during the monsoon and post-monsoon. Many wetlands support large breeding populations of the Pheasant-tailed Jacana (*Hydrophasianus chirurgus*) which thrive on floating vegetation (Mukhopadhyay & Mazumdar 2019). In this context, Pheasant-tailed Jacanas were also found during the monsoon on the floating vegetation of water hyacinths at Bortir Bil. During monsoon, ground birds like Common Myna, and Indian Pied Starling were also found on the floating vegetation and the floating jute logs, which provide food resources like insects, and gastropods for the birds. In Bortir Bil, aquatic insects act as one of the major food resources for the birds during the monsoon and post-monsoon. Additionally, crustaceans, molluscs, fishes were also available during this time. With decreasing water levels in winter and summer, this seasonal wetland was much favoured by carnivorous bird species like Asian Openbill, Eastern Cattle Egret, Great Egret (*Ardea alba*), Indian Pond Heron (*Ardeola grayii*), and many more. In the study area, the major feeding guild was insectivores followed by carnivores and omnivores, while granivores and frugivores were less common. More than 75% (46 species) of the avian species documented during this study were resident. The wetlands attract and serve as a wintering ground for migratory birds (migratory ducks) every year. Our study reported that the species richness of winter visitors (14 species, 22.95%) exhibited significant variations between different seasons in Bortir Bil. This is due to their appearance only during the winter season. Mukhopadhyay and Mazumdar (2017) also reported in their study that significant seasonal differences were noticed for winter visitors.

The studied seasonal wetland is a frequented tourist spot during monsoon, post-monsoon, and winter seasons along with associated disturbances such as the use of loudspeakers, music systems, and horns of vehicles. A primary threat to waterbirds of Bortir Bil includes hunting, which poses a direct challenge to their conservation efforts, along with the potential for poisoning and causing physical harm to eggs and chicks. Additionally, solid waste originating from tourists and nearby villages had been indiscriminately disposed of within the wetland, resulting in contamination of the waters of Bortir Bil. Ferrarini *et al.* (2021) reported that tourism pressure not only disturbs the avian community, especially birds during their breeding season but also destroys their nesting habitat, nests, and eggs, and sometimes increases the mortality of the chicks (Bukaciński *et al.* 2020). The wetlands of South Asia are facing extensive anthropogenic pressure, which can greatly influence the structure of the bird community (BirdLife International 2023). Changes in vegetation composition due to adverse effects of anthropogenic disturbances, climate change, and natural calamities can affect the quality and quantity of habitats for birds in terms of resources and shelter, which can further affect their diversity, abundance and distribution (Chen *et al.* 2011, Şekercioğlu *et al.* 2012). IUCN Red List of Endangered Birds has already recognized 1,445 threatened species globally, 94 species of which are from India (IUCN 2023a). Although Passeriformes is the dominant order of most of the avifauna studies of India, this order has the highest number of threatened species worldwide. These findings emphasize the immediate importance of the study of different environmental factors that control the community structure of avian fauna across different potential seasonal wetlands of India. As more footfalls of tourists are

expected at Bortir Bil in the upcoming years, more research in this direction is required to evaluate the effect of anthropogenic disturbances and other biotic, abiotic factors on the avian community structure.

Conclusion

Anthropogenic threats pose significant challenges to seasonal wetlands. Therefore, it is crucial to maintain the ecological stability and resource availability of these wetland habitats to preserve the overall diversity of bird species in the area. This research provides a valuable foundation for assessing the impact of seasonality and tourism on avifauna, allowing future surveys to compare species richness in Bortir Bil. It is recommended to establish regular and long-term monitoring of avifauna, focusing on abundance, feeding and breeding ecology, and resource utilization patterns. Such monitoring efforts will contribute to the development of a sustainable and bird-friendly management plan for this study area. Involving local communities in monitoring efforts can help garner public support for habitat protection and the conservation of avifauna in this seasonal wetland.

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