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Diversity, Status and Seasonality of Wetland Birds in Rural Ponds of District Kurukshetra, Haryana, India

VIPIN BOORA* AND PARMESH KUMAR
Wildlife Ecology and Animal Behaviour Laboratory, Department of Zoology, Kurukshetra University, Kurukshetra -136119 (Haryana), India
E-mail: vipinboora@kuk.ac.in, parmesh@kuk.ac.in

ABSTRACT
Man-made and perennial ponds occurring in the rural landscape of India support a rich socio-economic and cultural heritage. Surveys were conducted from April 2019 to March 2020 to document diversity, status and seasonality of wetland birds in four man-made and perennial rural ponds of District Kurukshetra, Haryana. Point counts and direct observations were used to record bird species. A total of 70 species of wetland birds belonging to 46 genera, 18 families and 08 orders were identified, of which 38 were winter migrants, 30 were residents and 2 were summer migrants. Charadriiformes was the most dominant order with 6 families and 19 species. Anatidae (n=16) was the most diverse bird family. Carnivore (28 species) recorded to be the most represented foraging guild. Species richness, abundance, diversity and evenness differed significantly ($P < 0.05$) between seasons as well as among ponds. Of the species recorded, five species are classified as Near Threatened and two species as Vulnerable in the IUCN Red List of Threatened Species; one species is listed in Appendix I and two species in Appendix II of CITES, and two species are included in Schedule I of the IWPA, 1972. The region also supported 27 species whose global population trend is decreasing. This reveals that rural wetlands of the study area are the potential habitat for globally threatened bird species and that appropriate conservation measures are needed to protect these species. This study will provide a baseline for future conservation measures and rural pond management programmes.

Key words: Threatened species, Wetlands, Species Richness, Conservation, Anatidae

INTRODUCTION

Wetlands are among the most productive ecosystems of the world and constitute the ecotone between aquatic and terrestrial habitats (Zedler and Kercher 2005). They provide essential ecological and economic services including flood control, carbon sequestration, water supply and purification, food and water source for domestic animals, fish supply, climate change mitigation, pollution abatement, recreational and cultural values, and medicinal plants (Bassi et al. 2014). In addition, wetlands sustain distinct communities of flora and fauna, therefore, often viewed as treasuries of biodiversity within a region or landscape (Manral et al. 2013).

The birds inhabiting and/or found to be ecologically dependent on wetlands directly or indirectly for feeding, breeding, nesting, roosting, overwintering or social interactions are often called wetland birds (Kumar and Gupta 2013). Wetland birds include bird groups commonly known waterfowls, waders, kingfishers, raptors and some passerines (Kumar et al. 2005). The microhabitats of wetland provide rich and quality shelter and food resources for wetland bird populations throughout the year (Kaur et al. 2018). About 25% of Indian bird species depend on wetlands and its surrounding areas for foraging, nesting, resting, and mate finding (Kumar et al. 2005). Hence, the presence or absence of birds reflects ecological conditions of wetlands, and the link between food web and nutrient cycle because most wetland bird species are able to quickly respond to any change in the quality and conditions of their habitat (Rajashekara and Venkatesha 2010, Kumar and Sharma 2018).

Almost half the world's natural wetlands, including those from India, have disappeared in the last century due to imprudent anthropogenic activities including encroachment of wetland habitats, unsustainable harvesting of resources, industrial pollution, poisoning, agricultural runoff, eutrophication, siltation and introduction of invasive plants and weeds (Ali et al. 2013, Bassi et al. 2014, Kumar et al. 2016), while the others are variously affected (Bassi et al. 2014, Woldemariam et al. 2018). Parallelly, man-made wetlands such as ponds, lakes, reservoirs and barrages have increased worldwide, and these provide alternative, often suitable, habitats

for wetland birds (Ali et al. 2013, Kaur et al. 2018, Rai and Vanita 2021).

Man-made, small-sized, perennial, traditional ponds dotted in rural landscape of Haryana support a rich socio-economic and cultural heritage. These village ponds are primarily constructed for harvesting rain water, and bathing and drinking of domestic livestock. They have been traditionally used as an economically efficient way to retain water for irrigation. But these water bodies also function as balancing reservoir to sustain the native biodiversity. The rural ponds along with large marshy and swamp area fed by local village sewage, surrounding uncultivated land and irrigated agricultural fields serve as foraging, roosting, breeding grounds for resident species and stopover or wintering grounds for large congregations of migratory wetland birds (Kumar et al. 2016, Kaur et al. 2018). However**,** the status of bird assemblages in these rural wetlands remains poorly documented.

Only sporadic information is available on the status and diversity of wetland birds in rural ponds of India and particularly in Haryana (Ali et al. 2013, Kaur et al. 2018). Information on species composition and seasonal assemblages of wetland birds in a particular wetland habitat is fundamental to understand the habitat condition and design suitable conservation and management strategies for sustainable biodiversity conservation (Sundar and Kittur 2013). In this context, the present study was conducted to document the diversity, status and seasonality of wetland birds that inhabit rural ponds of Kurukshetra District, Haryana, India.

MATERIAL AND METHODS

Study area

The present study was conducted in four rural ponds located in the villages of Thana, Amin, KhanpurJattan and Niwarsi of Kurukshetra District (29° 52′ N to 30° 12′ N and 76° 26′ E to 77° 04′ E), Haryana (Fig. 1). Situated in the North-Eastern part of the Haryana state, Kurukshetra District has an area of 1530 km^2, accounting for 3.8% of the total area of the state. Saraswati, Markanda and Ghaggar are the main rivers of the region. From agriculture point of view, it is one of the most fertile districts of the state. All the selected ponds are man-made, perennial and primarily rainfed, and water levels varied seasonally depending on the amount of rainfall received. These ponds were surrounded by human habitations and agricultural fields, with local people using them for their domestic and livelihood needs. The surrounding

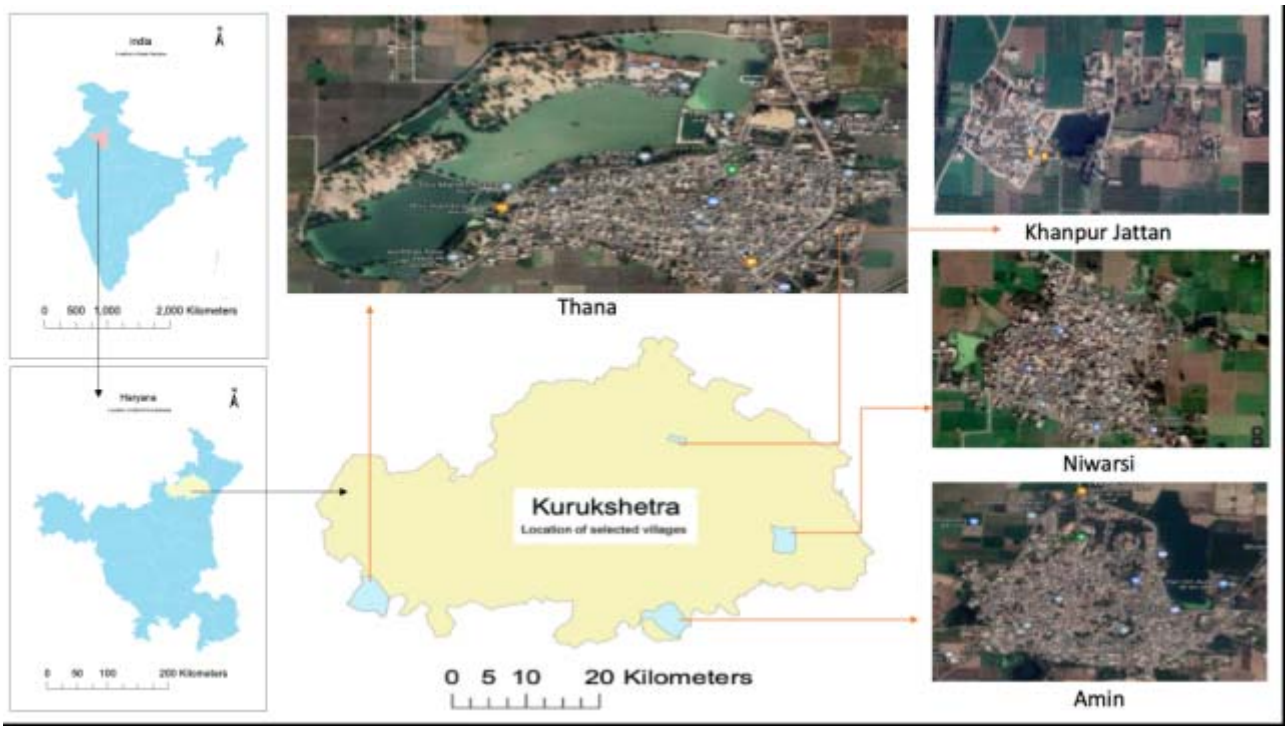

Figure 1. Location of selected rural ponds in District Kurukshetra, Haryana, India

agriculture fields with wheat and paddy as main crops provide extra foraging space and food for certain wetland bird species; islands with their trees provide suitable roosting and nesting sites. Hydrilla (*Hydrilla verticillata*), eel weed (*Vallisneria spiralis*), curly leaf pond weed (*Potamogeton crispus*), slimy green algae (*Spirogyra* spp.), musk grass (*Chara zeylanica*), hornwort (*Ceratophyllum demersum*) are common submerged macrophytes, whereas water hyacinth (Eichhornia *crassipes*), duckweed (*Lemna minor*), smartweed (*Polygonum* sp.) and lotus (*Nelumbo nucifera*) are the free floating macrophytes found in these ponds. The ponds are fringed by emergent macrophytes of which common reed (*Phragmites karka*), cattail narrow-leaved (*Typha angustata*) and nut-sedge (*Cyperus rotundus*) are widespread and abundant. The study area, experiencing sub-tropical climate, has three seasons: rainy (July to September), cool and dry (October-February) and the hot dry (March-June); temperature ranges 3-45º C and annual rainfall averages 582 mm.

Data collection

Bird surveys were conducted at two-week intervals in all the study sites from April 2019 to March 2020, employing the point count method (Bibby et al. 2000). Six to twelve vantage points, at least 250 m apart, were selected at the perimeter of each pond. Each point location was surveyed 24 times during the entire study period. On arrival at a survey point, an initial five-minute settling-down period was used prior to counting the birds, and 10-20 minutes were spent at each vantage point surveying the birds. Birds were recorded directly using a pair of field binoculars (Nikon 8x40), during hours of peak activity 06:00 to 10:00 h and 16:00 to 18:00 h. Birds flying across were not counted. The opportunistic records of birds during the other time of the day were also included to document a comprehensive checklist. Birds were identified using field guides (Ali and Ripley 1987, Grimmett et al. 2011). Praveen et al. (2020d) was followed for the taxonomic position (order and family), common names and scientific names of species observed. Based on their seasonal dispersal pattern in the study area, birds were classified as resident, summer visitor and winter visitor (Grimmett et al. 2011). A local status was assigned to each reported species on the basis of the percentage of frequency of sightings following Mackinnon and Phillipps (1993) as common (CO) - sighted on 80–100% of field visits, fairly common (FC) - sighted on 60–79.9% of field visits, uncommon (UC) - sighted on 20–59.9% of field visits, rare (RA) - sighted on less than 19.9% of field visits. The recorded wetland bird species were classified into four feeding guilds (Carnivore, Insectivore, Omnivore and Herbivore) based on direct observations and available literature (Ali and Ripley 1987).The IWPA (1972), CITES (2012), and IUCN (2021) were used to assess the conservation status and population trends (Increasing ↑, Decreasing ↓, Stable → and Unknown ?) of the documented species. Species richness was calculated as total number of bird species recorded in the study area. The relative diversity (RDi) of bird families was calculated using the formula given by Torre-Cuadros et al. (2007):

RDi = (number of bird species in a family)/(Total number of species) X 100

Jaccard's similarity index (Cj) was used to determine species similarity between any two ponds by formula:

Jaccard's similarity index (Cj) = a / (a + b + c)

where a is number of species common to both the ponds, b is number of the species unique to the first pond and c is the number of the species unique to the second pond.

Shannon–Wiener's diversity and species evenness indices of wetland birds were calculated using PAST version 3.26 software. We pooled the recorded field data corresponding to two seasons, i.e., summer (April–September) and winter (October–March) to test the seasonal variation of wetland bird assemblages in the study area. Two way ANOVA Tukey HSD test were used to analyse difference in the values of diversity and other indices of bird population between seasons and among the four selected rural ponds at 5% level of significance (SPSS).

RESULTS AND DISCUSSION

A total of 70 species of wetland birds belonging to

Table 1. List of wetland birds recorded from rural ponds of District Kurukshetra, Haryana, India.

Sr. No.	Order/Family/Common English name	Scientific name	RS	LS	FG	Conservation status		GPT	Habitat				Time of migration	
						IUCN	IWPA		TA	KJ	AN	NW	Arrival	Departure
	Order: AnseriformesFamily: Anatidae													
1	Lesser Whistling Duck	*Dendrocygna javanica*	S	UC	O	LC	IV	↓	+	+	+	+	May	October
2	Bar-headed Goose	*Anser indicus*	W	UC	H	LC	IV	↓	+		+		November	March
3	Greylag Goose	*Anseranser*	W	RA	H	LC	IV	↑	+		+		December	March
4	Ruddy Shelduck	*Tadorna ferruginea*	W	UC	O	LC	IV	?	+			+	November	March
5	Red-crested Pochard	*Netta rufina*	W	RA	O	LC	IV	?			+		December	February
6	Common Pochard	*Aythya ferina*	W	RA	O	VU	IV	↓	+		+		December	February
7	Ferruginous Duck	*Aythya nyroca*	W	RA	O	NT	IV	↓			+		December	January
8	Tufted Duck	*Aythya fuligula*	W	UC	O	LC	IV	→	+	+			November	March
9	Garganey	*Spatula querquedula*	W	RA	O	LC	IV	↓			+		January	February
10	Northern Shoveler	*Spatula clypeata*	W	UC	O	LC	IV	↓	+	+	+	+	November	March
11	Gadwall	*Mareca strepera*	W	UC	H	LC	IV	↑	+	+	+	+	November	March
12	Eurasian Wigeon	*Mareca penelope*	W	UC	H	LC	IV	↓	+		+		December	March
13	Indian Spot-Billed Duck	*Anas poecilorhyncha*	R	CO	H	LC	IV	↓	+	+	+	+	-	-
14	Northern Pintail	*Anas acuta*	W	UC	H	LC	IV	↓	+	+		+	November	March
15	Common Teal	*Anas crecca*	W	UC	H	LC	IV	?	+	+		+	November	March
16	Comb Duck**	*Sarkidiornis melanotos*	R	FC	O	LC	IV	↓	+		+		-	-
	Order: PhoenicopteriformesFamily: Podicipedidae													
17	Little Grebe	*Tachybaptus ruficollis*	R	FC	C	LC	IV	?	+	+	+	+	-	-
	Order: GruiformesFamily: Rallidae													
18	White-breasted Waterhen	*Amaurornis phoenicurus*	R	CO	O	LC	IV	?	+	+	+	+	-	-
19	Purple Swamphen	*Porphyrio porphyrio*	R	CO	O	LC	IV	?	+	+	+	+	-	-
20	Common Moorhen	*Gallinula chloropus*	R	CO	O	LC	IV	→	+	+	+	+	-	-
21	Common Coot	*Fulica atra*	R	FC	O	NT	IV	↓	+	+	+	+	-	-
	Order: PelecaniformesFamily: Ciconiidae													
22	Painted Stork*	*Mycteria leucocephala*	W	UC	C	NT	IV	↓	+		+		December	February
23	Asian Openbill	*Anastomus oscitans*	W	RA	C	LC	IV	?	+				December	February
	Family: Ardeidae													
24	Black-crowned Night Heron	*Nycticorax nycticorax*	R	RA	C	LC	IV	↓	+		+		-	-
25	Indian Pond Heron	*Ardeola grayii*	R	CO	C	LC	IV	?	+	+	+	+	-	-
26	Cattle Egret	*Bubulcus ibis*	R	CO	C	LC	IV	↑	+	+	+	+	-	-
27	Grey Heron	*Ardea cinerea*	R	FC	C	LC	IV	?	+	+	+	+	-	-
28	Purple Heron	*Ardea purpurea*	R	FC	C	LC	IV	↓	+		+	+	-	-
29	Great Egret	*Ardea alba*	R	FC	C	LC	IV	?	+	+	+	+	-	-

Sr. No.	Order/Family/Common English name	Scientific name	RS	LS	FG	Conservation status		GPT	Habitat				Time of migration	
						IUCN	IWPA		TA	KJ	AN	NW	Arrival	Departure
30	Intermediate Egret	*Ardea intermedia*	R	FC	C	LC	IV	↓	+	+	+		-	-
31	Little Egret	*Egrettagarzetta*	R	UC	C	LC	IV	↑	+	+	+		-	-
	Family: Threskiornithidae													
32	Black-Headed Ibis	*Threskiornis melanocephalus*	W	UC	C	NT	IV	↓	+		+	+	November	March
33	Eurasian Spoonbill	*Platalea leucorodia*	W	UC	C	LC	I	?	+		+		November	March
34	Black Ibis	*Pseudibis papillosa*	W	UC	C	LC	IV	↓	+	+	+	+	October	March
	Family: Phalacrocoracidae													
35	Little Cormorant	*Microcarbo niger*	R	FC	C	LC	IV	?	+	+	+	+	-	-
36	Great Cormorant	*Phalacrocorax carbo*	W	UC	C	LC	IV	↑	+	+	+	+	November	March
	Order: Charadriiformes	**Family: Burhinidae**												
37	Indian Thick-Knee	*Burhinus indicus*	R	FC	O	LC	IV	↓	+				-	-
	Family: Recurvirostridae													
38	Pied Avocet	*Recurviro straavosetta*	W	RA	C	LC	IV	?			+		December	February
39	Black-Winged Stilt	*Himantopus himantopus*	R	CO	C	LC	IV	→	+	+	+	+	-	-
	Family: Charadriidae													
40	Little Ringed Plover	*Charadrius dubius*	W	UC	C	LC	IV	→	+		+		November	March
41	Yellow- wattled Lapwing	*Vanekkus malabaricus*	R	RA	C	LC	IV	→				+	-	-
42	Red-wattled Lapwing	*Vanellus indicus*	R	CO	C	LC	IV	?	+	+	+	+	-	-
43	White-Tailed Lapwing	*Vanellus leucurus*	W	UC	C	LC	IV	↑	+		+	+	October	March
	Family: Jacanidae													
44	Bronze-winged Jacana	*Metopidius indicus*	R	RA	O	LC	IV	?	+				-	-
	Family: Scolopacidae													
45	Black-tailed Godwit	*Limosa limosa*	W	RA	O	NT	IV	↓	+		+		December	February
46	Temminck's Stint	*Calidris temminckii*	W	UC	I	LC	IV	?			+		November	March
47	Little Stint	*Calidris minuta*	W	UC	I	LC	IV	↑			+		November	March
48	Ruff	*Calidris pugnax*	W	UC	O	LC	IV	↓	+		+	+	November	March
49	Common Sandpiper	*Actitis hypoleucos*	W	FC	I	LC	IV	↓	+	+	+	+	August	March
50	Green Sandpiper	*Tringa ochropus*	W	UC	I	LC	IV	↑	+	+		+	September	March
51	Common Greenshank	*Tringa nebularia*	W	RA	C	LC	IV	→			+	+	December	February
52	Common Redshank	*Tringa totanus*	W	UC	C	LC	IV	?	+	+	+	+	November	March
53	Wood Sandpiper	*Tringa glareola*	W	UC	I	LC	IV	→	+		+		October	March
54	Marsh Sandpiper	*Tringa stagnatilis*	W	RA	I	LC	IV	↓	+				September	March
	Family: Laridae													
55	River Tern	*Sterna aurantia*	R	UC	C	VU	IV	↓	+				-	-
	Order: Accipitriformes	**Family: Accipitridae**												
56	Brahminy Kite**	*Haliaster indus*	R	RA	C	LC	I	↓			+		-	-

Sr. No.	Order/Family/Common English name	Scientific name	RS	LS	FG	Conservation status		GPT	Habitat				Time of migration	
						IUCN	IWPA		TA	KJ	AN	NW	Arrival	Departure
Order: CoraciiformesFamily: Meropidae														
57	Blue-Tailed Bee Eater	*Merops philippinus*	S	RA	I	LC	IV	→	+		+		May	August
	Family: Alcedinidae													
58	Common Kingfisher	*Alcedo atthis*	R	RA	C	LC	IV	?	+		+		-	-
59	White-Throated Kingfisher	*Halcyon smyrnensis*	R	CO	C	LC	IV	↑	+	+	+	+	-	-
	Order: PasseriformesFamily: Motacillidae													
60	Rosy Pipit	*Anthus roseatus*	W	UC	I	LC	IV	→	+		+		November	February
61	Yellow Wagtail	*Motacilla flava*	W	FC	I	LC	IV	↓	+	+	+	+	September	March
62	Grey Wagtail	*Motacilla cinerea*	W	UC	I	LC	IV	→	+		+		October	February
63	Citrine Wagtail	*Motacillacitreola*	W	FC	I	LC	IV	↑	+	+	+	+	September	March
64	White-Browed Wagtail	*Motacilla maderaspatensis*	R	CO	I	LC	IV	→	+	+	+	+	-	-
65	White Wagtail	*Motacilla alba*	W	FC	I	LC	IV	→	+	+	+	+	September	March
	Family: Hirundinidae													
66	Streak Throated Swallow	*Petrochelidon fluvicola*	R	UC	I	LC	IV	↑	+		+		-	-
67	Wire-Tailed Swallow	*Hirundo smithii*	R	FC	I	LC	IV	↑	+	+	+	+	-	-
68	Barn Swallow	*Hirundo rustica*	W	UC	I	LC	IV	↓	+			+	September	February
69	Plain Martin	*Riparia paludicola*	R	UC	I	LC	-	↓	+				-	-
70	Pale Martin	*Riparia diluta*	R	UC	I	LC	IV	?	+				-	-

S- Summer migrant, W- Winter migrant, R - Resident, CO- common, FC- fairly common, UC- uncommon, RA- rare, I- Insectivorous, O- Omnivorous, C- Carnivorous, H- Herbivorous, LC- Least Concern, NT- Near Threatened, VU- Vulnerable, * - CITES(Appendix-I), ** - CITES(Appendix-II), → - Stable, ↑ - Increasing, ↓ - Decreasing, ? – Unknown, IUCN- International Union for Conservation of Nature, IWPA- Indian Wildlife (Protection Act), 1972, CITES- The Convention on International Trade in Endangered Species of Wild Fauna and Flora, TA - Thana, KJ- KhanpurJattan, AN- Amin and NW- Niwarsi, GPT - Global population trend, RS - Residential status, LS - Local status, FG - Feeding guild

Table 2. Relative diversity (RDi) of various avian families recorded in the selected rural ponds of District Kurukshetra, Haryana.

Avian families	Number of species	RDi value
Anatidae	16	22.85
Scolopacidae	10	14.28
Ardeidae	8	11.42
Motacillidae	6	8.57
Hirudinidae	5	7.14
Rallidae, Charadriidae	4	5.71
Threskiornithidae	3	4.28
Ciconidae, Phalacrocoracidae, Recurvirostridae, Alcedinidae	2	2.85
Podicipedidae, Burhinidae, Jacanidae, Laridae, Accipitridae, Meropidae	1	1.42

46 genera, distributed among 18 families and 8 orders were recorded during the study period (Table 1). Among observed species, 26 (37.14%) were encountered from all the four studied ponds but 44 (62.86%) species were spotted at some specific ponds. Charadriiformes was the most dominant order with 6 families and 19 species, whereas Phoenicopteriformes and Accipitriformes were the least represented order with one family and one species each (Fig. 2**)**. The proportion of species richness of wetland birds by family varied from 1.42-22.8% (Table 2). Anatidae was found to be the most diverse family in the study area (16 species, RDi= 22.8) followed by Scolopacidae (10 species RDi= 14.28), Ardeidae (8 species, RDi= 11.42), while six families, Podicipedidae, Burhinidae, Jacanidae, Laridae, Accipitridae and Meropidae, were poorly represented with a single species in each (RDi=1.42; Table 2). These results are in confirmation with previous records that Anatidae is the common bird family among wetland bird communities in various wetland habitats of northern India (Tak et al. 2010, Kumar and Sharma 2018, Rai et al. 2019, Kaur and Brraich 2021, Singh and Brraich 2022).

According to the residential status, 30 bird species (42.86%) were residents, 38 bird species (54.28%) were winter migrants and 2 bird species (2.86%) were summer migrants (Table 1). These results are consistent with previous findings that winter migratory birds constitute a major component of water bird community in various wetland habitats of northern India (Manral and Khudsar 2013, Jha and Mckinley 2015, Kumar et al. 2016, Rai et al., 2019). Haryana being a part of the Central Asian Flyway serves as a wintering and stopover site for migratory bird species that breed in the Palaearctic region of biogeo-graphic realms. The migratory species (winter visitors and summer visitors) showed a definite species-specific pattern of arrival and departure from the study area (Table1). The winter migratory species start appearing at studied ponds from October, reached a peak in the month of January, then start declining and leave the rural ponds by March, flying back to their breeding grounds. Most of winter migrants were recorded from November to March. Summer migrants started coming to the rural ponds as temperature increases in the months of April-May.

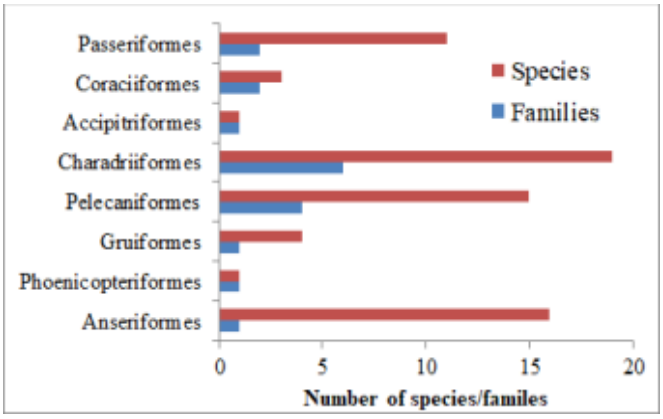

Figure 2. Composition of wetland bird community

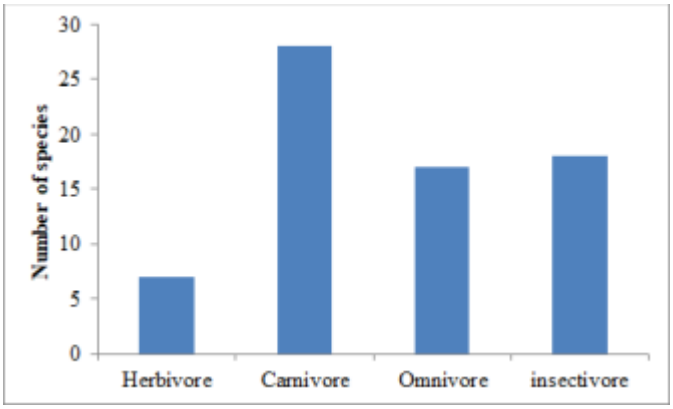

Figure 3. Feeding guilds of wetland bird species recorded from the selected rural ponds

As far as the feeding guilds were concerned, four foraging guilds were found in the study area. Carnivores (28 species) were highly represented, followed by insectivores (18 species), omnivores (17 species) whereas, herbivore (7 species) was the least represented guild (Fig. 3). This implies that the rural wetlands in the study area offer a wide spectrum of food resources catering to the needs of wetland birds belonging to different foraging guilds. The maximum number of carnivorous bird species represents that the rural ponds provide enormous food items in terms of amphibians, crustaceans, fishes, reptiles and other non-insect invertebrates as well as insect species (Jamwal et al. 2017, Kumar and Sharma 2018, Sohil and Sharma 2020, Rai and Vanita 2021).

The similarity in species composition of wetland bird assemblages determined by Jaccard's similarity index between the four selected ponds is shown in Figure 4. These results revealed that Khanpur Jattan and Niwarsi (0.725) showed maximum species similarity while similarity of Amin with Khanpur

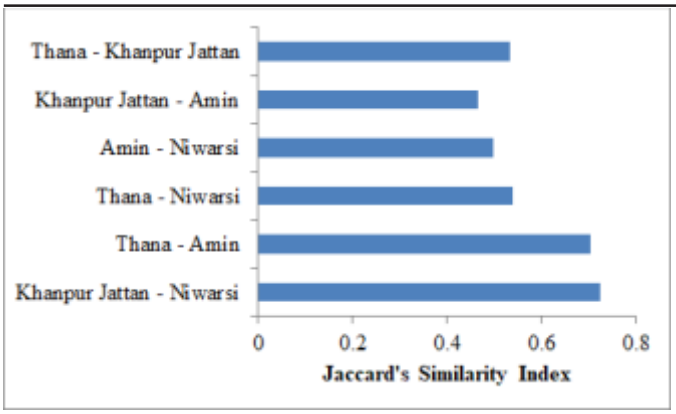

Figure 4. Jaccard's similarity index of selected rural ponds

Jattan was found to be the minimum (0.466). This indicates the contribution of habitat similarity and proximity for local movement of bird communities from disturbed wetland to relatively stable one for feeding, nesting, and other activities. The highest number of bird species was recorded at Thana (61), followed by Amin (56), Niwarsi (37) and lowest number of species was observed at Khanpur Jattan (32) as shown in Table 1. Species richness, abundance, diversity and evenness of wetland birds differed significantly ($P < 0.05$) between seasons as well as among the four ponds (Table 3). This significantly higher species richness, species diversity and abundance of birds registered during the winter season compared to summer season might be due to the inflow of a considerable number of migratory birds in winter which is decreased in the summer (Rajashekara and Venkatesha 2014, Kumar and Sharma 2018). Mean species richness and diversity (35.08 ± 5.03, 3.10 ± 0.12) of wetland birds at Thana pond was found to be significantly higher than that of remaining sites (Tukey's HSD test, all $P < 0.05$). However, species evenness (0.926 ± 0.004) was recorded to be maximum at Amin pond and it was significantly (Tukey's HSD test, all $P < 0.05$) higher than that of the remaining three ponds (Table 3).

The wetland bird species richness and community structure is influenced by the availability of food, roosting and nesting sites, presence of extra foraging grounds, wetland characteristics (size, topographic features, water depth, water quality, vegetation abundance, open-water area), anthropogenic pressure and climatic conditions of the area

Table 3. Seasonal variations in species richness, diversity and evenness of wetland birds in rural ponds of District Kurukshetra, India

Diversity indices	Habitats										ANOVA			
	Thana			Amin			KhanpurJattan			Niwarsi	F-Value		P-Value	
	Summer (mean ±S.E.)	Winter (mean ±S.E.)	Total (mean ±S.E.)	Summer (mean ±S.E.)	Winter (mean ±S.E.)	Total (mean ±S.E.)	Summer (mean ±S.E.)	Winter (mean ±S.E.)	Total (mean ±S.E.)	Summer (mean ±S.E.)	Winter (mean ±S.E.)	Total (mean ±S.E.)	Season	Sites	Season	Sites
Number of birds	444.33 ± 26.15	2192.83 ± 553.58	**1318.58**^{a} **± 373.1**	153.16 ± 19.39	716.33 ± 144.5	**434.75**^{b} **±109.72**	117.33 ± 15.01	543.5 ± 103.07	**330.41**^{bcd} **± 81.19**	173.83 ± 21.72	564.16 ± 86.34	**369.00**^{bc} **± 72.55**	28.168	10.267	0.00*	0.00*
Species richness	19.16 ± 2.16	51 ± 4.20	**35.08**^{a} **± 5.03**	20 ± 1.89	42.5 ± 3.78	**31.25**^{ab} **± 3.94**	15.33 ± 1.56	28.66 ± 1.17	**22.00**^{cd} **± 2.21**	16.83 ± 1.01	32.66 ± 1.64	**24.75**^{bc} **± 2.56**	138.846	10.494	0.00*	0.00*
Diversity	2.50 ± 0.08	3.29 ± 0.07	**2.90**^{b} **± 0.13**	2.73 ± 0.08	3.48 ± 0.07	**3.10**^{a} **± 0.12**	2.02 ± 0.02	1.33 ± 0.09	**1.67**^{d} **± 0.11**	2.37 ± 0.09	2.92 ± 0.04	**2.65**^{c} **± 0.09**	44.093	139.455	0.00*	0.00*
Evenness	0.856 ± 0.01	0.852 ± 0.01	**0.854**^{bc} **± 0.01**	0.918 ± 0.006	0.935 ± 0.004	**0.926**^{a} **± 0.004**	0.797 ± 0.03	0.942 ± 0.006	**0.869**^{b} **± 0.02**	0.8434 ± 0.02	0.8423 ± 0.007	**0.843**^{bcd} **± 0.012**	12.837	11.754	0.01*	0.00*

*-significant differences were found at 5% level of significance. Results in a row followed by different letters indicate significant differences among different agricultural landscapes at 5% level of significance. Results in a row followed by same letters indicate non-significant differences among different agricultural landscapes at P>0.05 (Two-way ANOVA and Tukey's HSD post-hoc test).

(Woldemariam et al. 2018).

From the observations it is evident that species richness and diversity of wetland birds varied among studied rural ponds within the geographical area considered in the present study. The highest species richness, abundance and diversity recorded at rural pond of Thana village may be related to its bigger size, habitat heterogeneity and low anthropogenic pressure. The mosaic of habitats at Thana in the form of mudflats, marshy area, islands, large number of trees at banks and surrounding irrigated crop fields provided multiple and variety of the alternative food resources, and opportunities for micro-habitat segregation for the wetland birds (Murillo-Pacheco et al. 2018). Moreover, there is low anthropogenic pressure at Thana because the pond is being considered sacred by local people. Absence of netting or wires over the pond and poaching also contributed to highest species richness at this wetland. In contrast, Niwarsi and Khanpur Jattan being located in close proximity to human habitations are exposed to more anthropogenic pressure and as a result bird activities (foraging, nesting, roosting, hiding and breeding) are affected at these wetlands. Local people used to dump domestic waste in these ponds. Moreover, presence of wires and nets over the ponds prevented the birds from catching the fishes. Birds like egrets and herons were often observed with their wings stuck and hanging to the wires present over the ponds.

The rural ponds in the study area support several species of global conservation priorities. Of the 70 species recorded, two species (Common Pochard *Aythya ferina* and River Tern *Sterna aurantia*) are classified as Vulnerable and five species (Ferruginous Duck *Aythya nyroca*, Common Coot *Fulica atra*, Painted Stork *Mycteria leucocephala*, Black-headed Ibis *Threskiornis melanocephalus* and Black-tailed Godwit *Limosa limosa*) as Near Threatened in the IUCN Red List (2021). All the remaining wetland bird species (n=63) are placed in the Least Concern category in the IUCN Red List of Threatened Species (Table 1). Additionally, Painted Stork (*M. leucocephala)* is listed in Appendix I, and Comb Duck (*Sarkidiornis melanotos*) and Brahminy Kite (*Haliastur indus*) are listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Two species (Eurasian Spoonbill *Platalea leucorodia* and

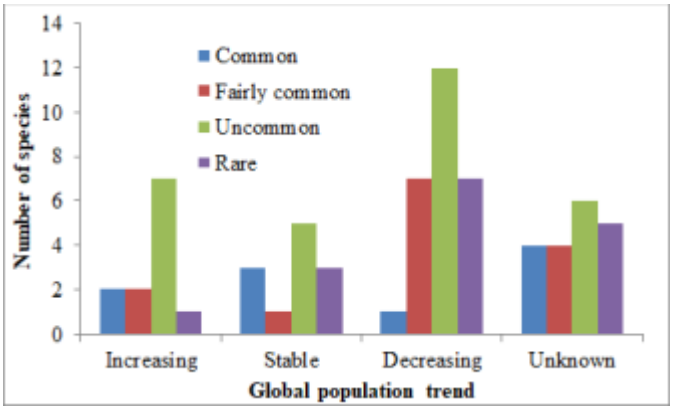

Figure 5. Relationship between global population trend and local abundance status of wetland bird species recorded from the rural ponds

Brahminy Kite *H. indus*) are included in Schedule I of the Indian Wildlife (Protection Act), 1972 (Table 1). With regard to the global population trend, the studied wetlands supported 12 globally stable bird species (17.14%), 27 globally decreasing species (38.58%), 12 globally increasing species (17.14%) and 19 species (27.14%) whose global population trend was unknown (Fig.5). Assessment of local abundance status revealed that 10 species were common, 14 species were fairly common, 30 species were uncommon and 16 species were rare in the study area. The relationship between global population trend and local status of reported species revealed that out of 27 globally decreasing species, one species (Indian Spot-Billed Duck) was still common in the study area.

CONCLUSIONS

The present study suggests that the selected man-made rural ponds support a rich diversity of wetland birds including resident and migratory species as well as species on global conservation priorities. Our findings on wetland birds can be used as a baseline for further research on conservation and management of existing bird species in rural ponds. Long-term monitoring of bird species should be continued in the study area, focusing on seasonal abundance, habitat use, nesting and breeding ecology, to supplement holistic approach of conservation and management strategies for sustenance of ecosystem services derived from wetland birds. Awareness among local people with combined efforts of

researchers, conservators, stake holders and government agencies can support sustainability of avifaunal diversity in rural wetlands.

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Authors' contributions: VB performed the field surveys, analysed the data and prepared rough draft of the manuscript. PK conceived and designed the study as well as wrote the final draft of the manuscript. Both authors read and approved the final manuscript.

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REFERENCES

Ali, A.S.M., Kumar, S.R. and Arun, P.R. 2013. Waterbird assemblage in rural ponds of Samakhiali region, Kutch District, Gujarat, India. Bird Populations, 12, 12-18.

Ali, S. and Ripley, S.D. 1987. Handbook of the birds of India and Pakistan together with those of Bangladesh, Nepal, Bhutan and Sri Lanka. Oxford University Press, Delhi, India. 737 pages.

Bassi, N., Kumar, M. D., Sharma, A. and Pardha Saradhi, P. 2014. Status of wetlands in India: a review of extent, ecosystem benefits, threats and management strategies. Journal of Hydrology: Regional Studies, 2, 1–19.

Bibby, C.J., Burgess, N.D., Hill, D.A. and Mustoe, S.H. 2000. Bird Census Techniques. Academic Press, London.

CITES. 2012. Convention on International Trade in Endangered Species of Wild Fauna & Flora. CITES, Geneva, Switzerland. http://www.cites.org.

Grimmett, R., Inskipp, C. and Inskipp, T. 2011. Birds of the Indian Subcon*tinent*. Oxford University Press, London. 528 pages.

IUCN. 2021. The IUCN Red List of Threatened Species. Version 2021-1. http://www.iucnredlist.org.

IWPA. 1972. https://www.wiienvis.nic.in/Database/ScheduleSpeciesDatabase_7969.aspx

Jamwal, P.S., Chandan, P., Rattan, R., Anand, A., Kannan, P.M. and Parsons, M.H. 2017. Survey of avifauna of the Gharana wetland reserve: implications for conservation in a semi-arid agricultural setting on the Indo-Pakistan border. BMC Zoology, 2, 7. https://doi.org/10.1186/s40850- 017-0016-z

Jha, K.K., and Mckinley, C.R. 2015. Composition and dynamics of migratory and resident avian population in wintering wetlands from northern India. Notulae Scientia Biologicae, 7(1), 1-15.

Kaur, R. and Brraich, O.S. 2021. Abundance and diversity of threatened birds in Nangal Wetland, Punjab, India. Journal of Threatened Taxa, 13(12), 19733-19742.

Kaur, S., Kler, T.K. and Javed, M. 2018. Abundance and diversity of water bird assemblages in relation to village ponds in Punjab. Journal of Entomology and Zoology Studies, 6(1), 1375-1380.

Kumar, A., Sati, J.P., Tak, P.C. and Alfred, J.R.B. 2005. Handbook on Indian Wetland Birds and their Conservation. Zoological Survey of India, Kolkata.

Kumar, P. and Gupta, S.K. 2013. Status of wetland birds of Chhilchhila Wildlife Sanctuary, Haryana, India. Journal of Threatened Taxa, 5(5), 3969–3976.

Kumar, P., Rai, D. and Gupta, S.K. 2016. Wetland bird assemblage in rural ponds of Kurukshetra, India. Waterbirds, 39(1), 86-98.

Kumar, P. and Sharma, A. 2018. Wetland birds assemblages in man-made sacred ponds of Kurukshetra, India. Proceedings of the Zoological Society, 72(1), 61-73.

MacKinnon, J. and Phillipps, K. 1993. A field guide to the birds of Borneo, Sumatra, Java and Bali, the Greater Sunda Islands. Oxford University Press, London. 692 pages.

Manral, U. and Khudsar, F.A. 2013. Assessment of wetland water quality and avian diversity of a human-modified floodplain wetland on River Yamuna. Notulae Scientia Biologicae, 5(1), 25-33.

Manral, U., Raha, A., Solanki, R., Hussain, S.A., Babu, M.M., Mohan, D., Veeraswami, G.G., Sivakumar, K. and Talukdar, G. 2013. Plant species of Okhla bird sanctuary: A wetland of Upper Gangetic Plains, India. Check List, 9(2), 263–274.

Murillo Pacheco, J., López Iborra, G.M., Escobar, F., Bonilla Rojas, W.F. and Verdú, J.R. 2018. The value of small, natural and man made wetlands for bird diversity in the east Colombian Piedmont. Aquatic Conservation: Marine and Freshwater Ecosystems, 28(1), 87-97.

Praveen J., Jayapal, R., Inskipp, T., Warakagoda, D., Thompson, P.M., Anderson, R.C. and Pittie, A. 2020d. Checklist of the birds of the Indian Subcontinent (v4.1). http://www.indianbirds.in/indian-subcontinent/.

Rai, D., Gulia, R., Chopra, G. and Kumar, P. 2019. Avifaunal community composition and current status in Basai Wetlands: an Important Bird Area in Haryana, India. Indian Forester, 145(10), 971-985.

Rai, D. and Vanita 2021. Community composition and status of avifaunal diversity in and around Ottu reservoir of Sirsa, Haryana, India. Journal of Applied and Natural Science, 13(2), 593 - 606. https://doi.org/10.31018/jans.v13i2.2666

Rajashekara, S. and Venkatesha, M.G. 2010. The diversity and abundance of waterbirds in lakes of Bangalore city, Karnataka, India. Biosystematica, 4(2), 63–73.

Rajashekara, S. and Venkatesha, M.G. 2014. Eco-spatial and

temporal variation in waterbirds composition and their relationship with habitat characteristics of Urban Lakes of Bengaluru city, India. International Journal of Advanced Research, 2(7), 60-80.

Singh, J. and Brraich, O.S. 2022. Seasonal composition of avian communities in different habitats of Harike Wetland, a Ramsar site in Punjab, India. Journal of Threatened Taxa, 14(2), 20550-20565.

Sohil, A., and Sharma, N. 2020. Bird diversity and distribution in mosaic landscapes around Jammu, Jammu & Kashmir. Acta Ecologica Sinica, 40(4), 323-338.

Sundar, K.S.G. and Kittur, S. 2013. Can wetlands maintained for human use also help conserve biodiversity? Landscape-scale patterns of bird use of wetlands in an agricultural landscape in north India. Biological Conservation, 168, 49–56.

Tak, P.C., Sati, J.P. and Rizvi, A.N. 2010. Status of waterbirds at Hathnikund Barrage wetland, Yamunanagar District, Haryana, India. Journal of Threatened Taxa, 2(4), 841-844.

Torre-Cuadros, M.D.L.A., Herrando-Pérez, S. and Young, K.R. 2007. Diversity and structural patterns for tropical montane and premontane forests of central Peru, with an assessment of the use of higher-taxon surrogacy. Biodiversity and Conservation, 16(10), 2965–2988.

Woldemariam, W., Mekonnen, T., Morrison, K. and Aticho, A. 2018. Assessment of wetland flora and avifauna species diversity in Kafa Zone, Southwestern Ethiopia. Journal of Asia-Pacific Biodiversity, 11(4), 494-502.

Zedler, J.B. and Kercher, S. 2005. Wetland resources: status, trends, ecosystem services, and restorability. Annual Review of Environment and Resources, 30, 39-74.

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