Journal of Applied and Natural Science
16(4), 1627 - 1638 (2024)
ISSN : 0974-9411 (Print), 2231-5209 (Online)
journals.ansfoundation.org

Research Article

Foraging ecology of wetland birds in heterogeneous habitats: A case study of the Dighal wetlands, Haryana, India

Parul*
Department of Zoology, Kurukshetra University, Kurukshetra-136119 (Haryana) India
Parmesh Kumar
Department of Zoology, Institute of Integrated & Honors Studies, Kurukshetra University, Kurukshetra-136119 (Haryana) India

*Corresponding author. E-mail: parulmaham@gmail.com

Article Info
https://doi.org/10.31018/jans.v16i4.5976
Received: July 23, 2024
Revised: November 21, 2024
Accepted: November 26, 2024

How to Cite
Parul and Kumar, P. (2024). Foraging ecology of wetland birds in heterogeneous habitats: A case study of the Dighal wetlands, Haryana, India. *Journal of Applied and Natural Science*, 16(4), 1627 - 1638. https://doi.org/10.31018/jans.v16i4.5976

Abstract
Understanding the foraging ecology of wetland birds is essential for effective conservation and management strategies. The present study aimed to explore wetland birds' foraging guild structure, habitat characteristics and foraging techniques. The study was conducted at Dighal wetlands, an important bird area (IBA) in the Jhajjar district of Haryana, India, from April 2021 to March 2023. Ninety species of wetland birds, representing 23 families and 12 orders, were identified, with 30 being residents, 4 summer migrants, and 56 winter migrants. Utilizing multivariate techniques, birds were categorized into four foraging guilds (carnivores, herbivores, omnivores, and insectivores) and five distinct habitats (Terrestrial land, Agricultural land, Marshland, Shallow water, Deepwater). Marshland (70) recorded the highest number of species, followed by shallow water (65), agricultural land (45), terrestrial land (43), and the least observed in deep water (31). Carnivores constituted the dominant group (43.3%), followed by omnivores (30%), insectivores (20%), and herbivores (6.7%). Dabbling (18) emerged as the predominant foraging technique, followed by pecking (17), picking (16), probing (14), and others. The Dighal wetland emerged as a crucial resource for diverse bird species, serving as an important wintering ground and food source. This study deepens the present understanding of avian guild structure and offers valuable insights for conservation strategies to safeguard wetland bird populations.

Keywords: Dighal wetland, Feeding guild, Habitat heterogeneity, Trophic structure, Wetland birds

INTRODUCTION

Understanding the intricate relationship between habitat heterogeneity and species richness is fundamental for comprehending spatial ecology. Key ecological processes, profoundly influenced by habitat variability, impact species behaviour, distribution, and community structure (Fahrig and Nuttle, 2005; Stein *et al.,* 2014), with the composition of bird guilds and community features serving as crucial ecological indicators of habitat condition and heterogeneity (Canterbury *et al.,* 2000; Chatterjee *et al.,* 2020). The classification of avian communities into foraging and habitat guilds has proven to be an effective tool in unraveling the structure and dynamics of avian populations within diverse ecosystems (Thiollay, 1995; Clough *et al.,* 2009). Bird species show a spectrum of behaviours related to foraging, movement, and habitat preference, all intricately linked to the availability of resources in their environment (Holmes and Recher, 1986). The preference of birds to live in heterogenous habitat best suits their other behaviour such as perching, nesting, foraging and roosting (Berg, 2002; Veech *et al.,* 2011; Sekercioglu, 2012). The availability of diet and food exploitation methods (Albrecht and Gotelli, 2001; Palmer *et al.,* 2003) in a specific habitat determines avifaunal distributions (Evans and Dugan, 1984) and the structure of the community (Bonilla *et al.*, 2012). Information about utilization of resources (Kattan and Franco, 2004), habitat preferences and evaluation of feeding guilds of wetland bird species are important to analyze their responses towards habitat change and for conservation management strategies (Sekercioglu, 2006).

Consequently, the assemblage of bird species within a particular guild is influenced by a variety of environmental conditions. Studies on bird feeding guilds help to elucidate the complex ecosystem structure and increase our understanding of the habitats within that ecosystem (Rathod and Padate, 2017). Food availability is crucial for avian survival, growth, and successful

reproduction (Dodge *et al.,* 1990; Ruffino *et al.,* 2014). Raising water levels facilitate substrate penetration and increase invertebrate activity, which increases prey susceptibility to wader predation (Kumar *et al.,* 2021).

Despite the ecological importance of wetland bird species, a knowledge gap exists regarding information on the foraging behaviour and foraging techniques of wetland birds in Haryana, particularly in districts like Jhajjar. Notably, Dighal wetlands in Jhajjar district boast a rich array of wetland habitats, attracting many water birds, especially migratory species, during winters. This study aimed to address the scarcity of data on the status of wetland birds in Dighal wetlands, district Jhajjar, with a specific focus on documenting the foraging behaviour of wetland bird species.

MATERIALS AND METHODS

Study area

The research was conducted in the Dighal wetlands (28° 22'- 28° 49' N & 76° 18'- 76° 59' E), situated in the Beri tehsil of Jhajjar district, Haryana, North India (Fig 1). Spanning approximately 131.5 hectares, the Dighal wetlands encompass a network of variable pond sizes alongside extensive wet fields that have remained inundated for several years due to elevated water table and waterlogging conditions in the Dighal village. Situated on the Central Asian Flyway, these wetlands are important wintering habitats for numerous migratory bird species and are renowned as a popular destination for bird-watching enthusiasts. Recognized as a crucial site for avian conservation and biodiversity, the Dighal Wetlands holds the designation of an Important Bird and Biodiversity Area (IBA) in India, identified with the IBA code IN-HR-06 by the ENVIS Centre on Wildlife and Protected Areas (Rahmani *et al.,* 2016; Parul and Kumar, 2023). Throughout the research duration, eight particular wetland locations were identified within the study area for conducting bird surveys, with each site carefully selected to represent various facets of the wetland ecosystem (Fig 1). The agricultural landscape surrounding Dighal village is characterized by a diverse range of crops, including wheat, rice, maize, sugarcane, and mustard. Additionally, common tree species such as *Eucalyptus*, *Syzygium*, *Acacia*, and *Ziziphus* contribute to the vegetation composition of the area. The study area is experiencing subtropical climate, featuring three distinct seasons: the cool dry season

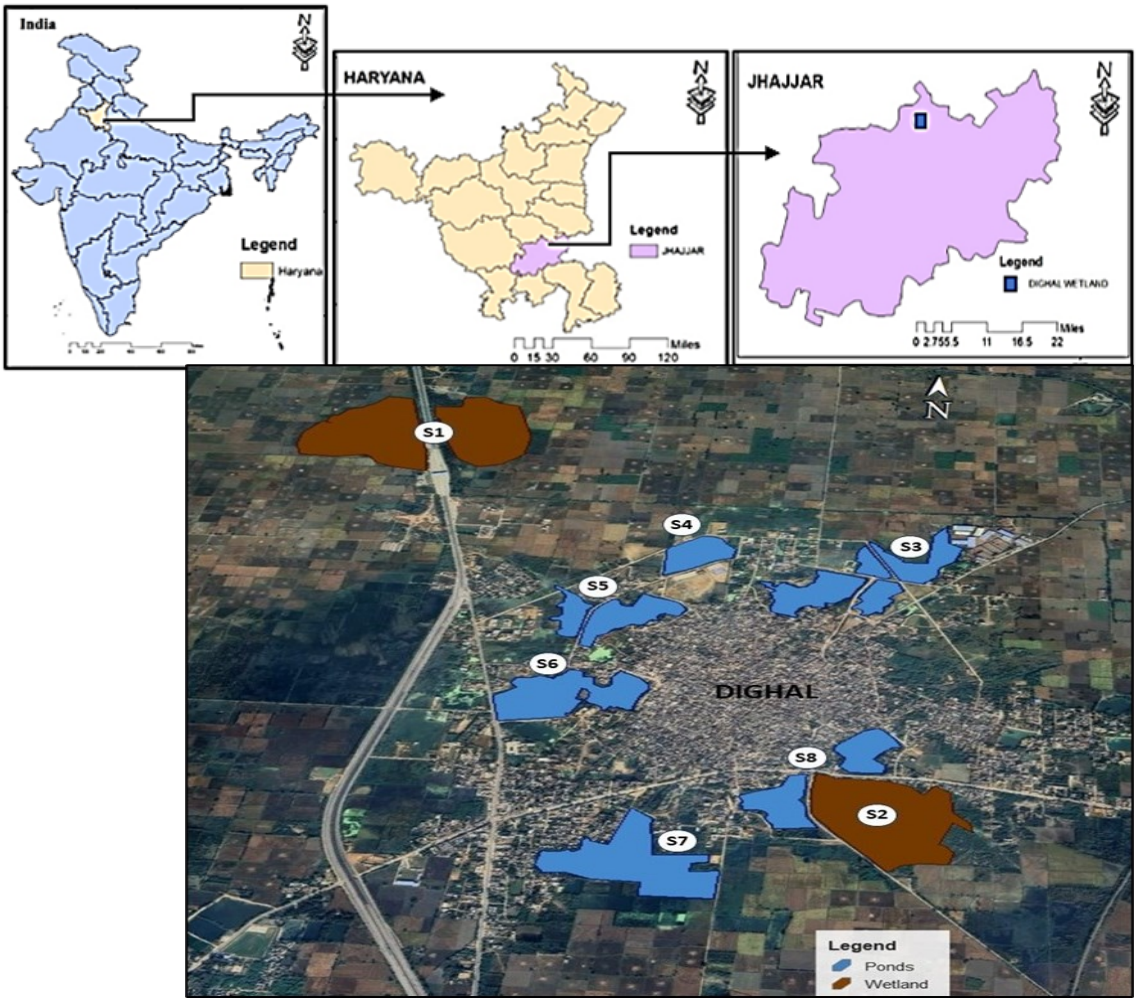

Fig. 1. *Study area showing eight sites (S1-S8) of Dighal wetlands in Jhajjar district, Haryana, India*

(October to February), the hot dry season (March to June), and the rainy season (July to September). Summer temperatures can reach up to 45°C, while winter temperatures may drop to 6°C. The average annual rainfall in the district is recorded at 444 mm.

Methodology

Wetland bird survey was conducted every two weeks from April 2021 to March 2023, employing the point count method (Bibby *et al.,* 2000). Four to six fixed points were strategically positioned along the perimeter at each study site, with a minimum distance of 250 meters between each point. These points were surveyed forty-eight times over the duration of the study period. Upon reaching each designated point, a settling period of five minutes preceded the commencement of bird recording activities. Wetland bird species were observed for 10 minutes at each point, using Nikon 10x50 field binoculars. Observations were conducted during peak avian activity hours, typically between 06:00 to 10:00 in the morning and 16:00 to 18:00. Additionally, opportunistic bird observations were conducted by scanning the periphery of the selected wetlands at other times, contributing to a comprehensive documentation of the avifauna in the area. Birds were identified using field guide Grimmett *et al. (*2016). The taxonomic position (family and order), common names and scientific names of the recorded bird species followed the checklist provided by Praveen and Jayapal (2023).

Feeding guilds and foraging behaviour techniques were categorized based on the combination of direct observations with focal sampling methods and as per the description given by Ali and Ripley (1987). A detailed record of each bird species was maintained, including their food preferences, foraging techniques, and habitat utilization in the study area. Photographs were captured using Nikon D500 DSLR camera mounted with a 2X telephoto lens and 70-200 mm zoom lens. Guild classification was determined based on the food preferences of the observed bird species, categorizing them into Carnivore (feeding primarily on non-insect invertebrates and vertebrates), Omnivore (feeding both on plant parts and other animals), Insectivore (species feeding only on insects) and Herbivore (feeding on plants matter, algae). Moreover, a comprehensive classification of wetland birds into 21 foraging techniques was established through direct observations and a review of existing literature (Cornell Lab of Ornithology, 2023) and is represented in Table 1.

Statistical analysis

A cluster analysis using the Unweighted Paired Group Method with Arithmetic Mean (UPGMA) was conducted with Jaccard's similarity index based on species presence or absence in specific habitats. The analysis was performed using PAST version 3.26 software.

RESULTS AND DISCUSSION

A total of 90 wetland bird species distributed across 12 orders, 23 families, and 62 genera were identified in the study area. These species were systematically studied to understand their feeding guilds and foraging techniques within the selected wetlands. Among the documented species, the order Charadriiformes exhibited the highest species richness (24 species), followed by Anseriformes (19 species) and Pelecaniformes (12 species) (Table 2). Within the wetland bird community, the Anatidae family emerged as the most abundant, with 19 species accounting for 21.1% of the total species richness observed. The Scolopacidae family was identified as the second most diverse, comprising 13 species, while the Ardeidae family ranked third in diversity. However, 8 bird families, including Phoenicopteridae, Podicipedidae, Anhingidae, Jacanidae, Burhinidae, Accipitridae, Pandionidae, and Meropidae, were poorly represented, each registering only one species in the study area.

Dominance of the order Charadriiformes in species richness underscores the importance of this group within wetland ecosystems, likely due to their adaptation to various aquatic habitats and foraging strategies. These findings align with previous studies conducted in various Indian wetland habitats such as Khaparwas bird sanctuary, Haryana (Gupta *et al*., 2012); Basai wetlands Gurugram district, Haryana (Rai *et al.,* 2017); Komaranahalli Lake, Karnataka (Harisha and Hosettii, 2018); Purbasthali oxbow lake, West Bengal (Mandal *et al*., 2021). The prevalence of the Anatidae family as the most abundant group further highlights their significance in wetland bird communities, representing a considerable portion of the total species richness observed, which is consistent with broader trends recorded in different wetlands across India such as Asan wetland, Uttarakhand (Malik and Joshi, 2013); wetland on river Yamuna (Manral and Khudsar, 2013); Gharana wetland (Reserve), Jammu (Sharma and Saini, 2014); wintering wetlands from Uttar Pradesh (Jha and McKinley, 2015); man-made sacred ponds of Kurukshetra (Kumar and Sharma, 2018); unprotected wetlands of Ayodhya district, Uttar Pradesh (Yashmita-Ulman and Singh, 2022).

Based on habitat preferences, wetland bird species were classified into five habitat guilds, with marshland recording the highest species richness (70), followed by shallow water (65), agricultural land (45), terrestrial land (43), and deep water (31). The cluster analysis using Unweighted Paired Group Method with Arithmetic Mean (UPGMA) revealed the highest similarity between marshland and shallow water habitats, whereas deep water habitats demonstrated the greatest dissimilarity compared to agricultural land (Fig 2).

The classification of wetland bird species into habitat

Table 1. Description of foraging techniques observed in wetland birds in the study area

S.No.	Foraging techniques	Description
1.	Grazing (G)	Feeding on grasses, sedges or their seeds in fields or meadows.
2.	Striking (S)	Bird uses its beak and neck to swiftly hit its target after making a stalking motion.
3.	Upending (U)	When a bird uses the 'tipping' or upending technique, its tail and legs remain above the water's surface while it is partially immersed in a vertical position.
4.	Catching (C)	Catching/ Hawking involves catching of flying insects in the air.
5.	Filtering (F)	The bill was retained on the water's surface plane to filter the water for food particles, submerging only the mandible.
6.	Dabbing (Da)	Dabbling or 'tipping up' involves dipping of bill and head under water for foraging.
7.	Picking (Pi)	When the birds collected any food, it was visible on top of the muddy substratum.
8.	Pecking (Pe)	The bird penetrates its beak into the mud strata by less than one-quarter of bill length and pulls it out repeatedly.
9.	Probing (Pr)	The bird lowers its beak into the mud and browse through the mud strata. At times, it withdraws the beak a little and probes at an adjacent location.
10.	Scything (Sc)	This technique involves foraging in shallow water, scything their bills from side to side cutting through vegetation or water to capture prey.
11.	Stabbing (St)	Fishes are sometimes caught by being stabbed with one or both mandibles with a rapid jerk or force.
12.	Skimming (Sk)	Flying low over water to pick food items using beak.
13.	Diving (Di)	When the swimming bird dives into the water, the observer cannot see it.
14.	Plunge Diving (PD)	Diving head first into water from overhead flight or perch in order to catch fish.
15.	Foot Plunging (FP)	A nearly vertical plunge dive with wings half- folded and feet thrown in water just before diving.
16.	Foot Trembling (FT)	Also known as foot stirring is rapid shaking of one leg at a time to disturb prey into range.
17.	Standing Still (SS)	Standing still or stalking involves visually inspection of immediate surrounding in the mud strata.
18.	Tactile Technique (TT)	The bird walks forward in shallow water holding its partially open bill under the water.
19.	Surface Feeding (SF)	It involves skimming along the surface of the water with the neck stretched out and the bill parallel to the water.
20.	Sweeping Bill (SB)	Lateral or sidewise sweep of the bill to find the food.
21.	Walking Slow (WS)	The bird walks very slowly and cautiously without disturbing water and attacks the opportunistic prey nearby.

guilds revealed marshland as the preferred habitat, consistent with previous studies highlighting the importance of marshes for avian biodiversity especially for wading birds (Kumar and Sharma, 2019; Yashmita-Ulman and Singh, 2022). The clustering analysis further elucidated the similarities and dissimilarities between different habitat types, providing valuable information for habitat management and conservation efforts. Most species of the Anatidae family used both shallow water and deep water as their feeding habitat, consistent with the earlier study in urban perennial wetlands of West Bengal by Mukherjee and Roy (2021).

The wetland bird species documented in the study were classified into four distinct foraging guilds based on their primary dietary preferences. Among these guilds, carnivores emerged as the most prevalent, comprising 39 species, followed by omnivores (27 species), insectivores (18 species), and herbivores (6 species) (Fig. 3). Analysis revealed that marshland was identified as the most preferred habitat for carnivore wetland birds. In contrast, herbivores exhibited the least preference for agricultural land, while omnivores predominantly occupied terrestrial land. Additionally, insectivores and carnivores showed higher frequencies in deep water habitats compared to other guilds.

These findings align with previous records, highlighting carnivorous as the most represented feeding guild in freshwater wetlands such as Keshopur wetland of Punjab (Jangral and Vashishat, 2023); man-made sacred ponds of Kurukshetra, Haryana (Kumar and Sharma, 2018); unprotected wetlands of Ayodhya district, Uttar Pradesh (Yashmita-Ulman and Singh, 2022); river Ganges in district Rae Bareli, Uttar Pradesh (Mishra et al., 2016) and Mandothi wetlands, Haryana (Rai and Yadav, 2023). This finding suggests the importance of diverse prey availability in the form of amphibians, crustaceans, fishes, reptiles, and other non-insect invertebrates played a crucial role in shaping the distribution

Table 2. Wetland bird species documented from Dighal wetlands of Jhajjar district, Haryana, India, along with their taxonomic position, foraging guild, foraging technique, residential status, habitat and migratory schedule

S. No.	Common name	Scientific/ Zoological name	FG	FT	Residential status	Habitat				
						TL	AL	ML	SW	DW
		Order: ANSERIFORMES Family: Anatidae								
1	"Lesser whistling Duck"	*Dendrocygna javanica* (Horsfield, 1821)	O	Da	SM		+	+	+	
2	"Bar Headed Goose"	*Anser indicus* (Latham, 1790)	H	G/Da	WM	+		+	+	+
3	"Greater White-fronted Goose"	*Anser albifrons* (Scopoli, 1769)	H	G/Da	WM				+	+
4	"Graylag Goose"	*Anser anser* (Linnaeus, 1758)	H	G/Da	WM	+		+	+	
5	"Common Shelduck"	*Tadorna tadorna* (Linnaeus, 1758)	O	Da	WM				+	+
6	"Ruddy Shelduck"	*Tadorna ferruginea* (Pallas, 1764)	O	SF/U	WM			+	+	+
7	"Red crested Pochard"	*Netta rufina* (Pallas, 1773)	O	Di/U	WM				+	+
8	"Common Pochard"	*Aythya farina* (Linnaeus, 1758)	O	Di/U	WM				+	+
9	"Ferruginous Duck"	*Aythya nyroca* (Güldenstädt, 1770)	O	SF/U/Da	WM			+	+	
10	"Tufted Duck"	*Aythya fuligula* (Linnaeus, 1758)	O	Di	WM				+	+
11	"Garganey"	*Spatula querquedula* (Linnaeus, 1758)	O	Pi/Da	WM			+	+	+
12	"Northern Shoveler"	*Spatula clypeata* (Linnaeus, 1758)	O	Da/U	WM			+	+	+
13	"Gadwall"	*Mareca strepera* (Linnaeus, 1758)	O	Da/U	WM			+	+	+
14	"Eurasian Wigeon"	*Mareca Penelope* (Linnaeus, 1758)	H	G/Da	WM	+		+	+	+
15	"Indian Spot-billed Duck"	*Anas poecilorhyncha* J.R. Forster, 1781	H	Da/U	R	+	+	+	+	+
16	"Northern Pintail"	*Anas acuta* Linnaeus, 1758	H	Da/U	WM		+	+	+	+
17	"Common Teal"	*Anas crecca* Linnaeus, 1758	O	Da/U	WM			+	+	+
18	"Knob-billed Duck"	*Sarkidiornis melanotos* (Pennant, 1769)	O	G/SF	R	+	+	+	+	+
19	"Mallard"	*Anas platyrhynchos* Linnaeus, 1758	O	G/Da/U	WM					+
		Order: PHOENICOPTERIFORMES Family: Phoenicopteridae								
20	"Greater Flamingo"	*Phoenicopterus roseus* Pallas, 1811	O	F/Da	WM			+	+	
		Order: PODICIPEDIFORMES Family: Podicipedidae								
21	"Little Grebe"	*Tachybaptus ruficollis* (Pallas, 1764)	C	Di/Pi	R				+	+
		Order: GRUIFORMES Family: Rallidae								
22	"White-breasted Water-hen"	*Amaurornis phoenicurus* (Pennant, 1769)	O	Pe	R	+	+	+	+	
23	"Grey-headed Swamphen"	*Porphyrio poliocephalus* (Latham, 1801)	O	Pi/Pe	R		+	+	+	
24	"Common Moorhen"	*Gallinula chloropus* (Linnaeus, 1758)	O	Da/Pe	R			+	+	+
25	"Eurasian Coot"	*Fulica atra* Linnaeus, 1758	O	U/Di	WM				+	+
26	"Baillon's Crake"	*Zapornia pusilla* (Pallas, 1776)	O	Pr	WM			+		

Contd.....

Table 2. Contd……

		Family: Gruidae								
27	"Sarus Crane"	*Antigone Antigone* (Linnaeus, 1758)	O	Pe/Pi	R		+	+		
28	"Demoiselle Crane"	*Grus virgo* (Linnaeus, 1758)	O	Pe/Pi	WM			+	+	
		Order: CICONIIFORMES								
		Family: Ciconiidae								
29	"Painted Stork"	*Mycteria leucocephala* (Pennant, 1769)	C	TT	R	+	+	+	+	
30	"Asian Openbill"	*Anastomus oscitans* (Boddaert, 1783)	C	TT	R		+	+	+	
31	"Woolly-necked Stork"	*Ciconia episcopus* (Boddaert, 1783)	C	Pr	R	+	+	+		
		Order: PELECANIFORMES								
		Family: Ardeidae								
32	"Black-crowned Night Heron"	*Nycticorax nycticorax* (Linnaeus, 1758)	C	S	R	+		+		
33	"Indian Pond Heron"	*Ardeola grayii* (Sykes, 1832)	C	S	R	+	+	+	+	
34	"Cattle Egret"	*Bubulcus ibis* (Linnaeus, 1758)	C	Pi/C	R	+	+	+		
35	"Grey Heron"	*Ardea cinerea* Linnaeus, 1758	C	SS/WS	R		+	+	+	
36	"Purple Heron"	*Ardea purpurea* Linnaeus, 1766	C	SS/WS	R		+	+	+	
37	"Great Egret"	*Ardea alba* Linnaeus, 1758	C	SS/FT	R	+	+	+	+	
38	"Intermediate Egret"	*Ardea intermedia* Wagler, 1829	C	SS/WS	R	+	+	+	+	
39	"Little Egret"	*Egretta garzetta* (Linnaeus, 1766)	C	FT/WS	R	+	+	+	+	
		Family: Threskiornithidae								
40	"Black-headed Ibis"	*Threskiornis melanocephalus* (Latham, 1790)	C	Pr	R		+	+	+	
41	"Red Napped Ibis"	*Pseudibis papillosa* (Temminck, 1824)	C	Pr	R	+	+	+		
42	"Glossy Ibis"	*Plegadis falcinellus* (Linnaeus, 1766)	C	Pr	WM		+	+	+	
43	"Eurasian Spoonbill"	*Platalea leucorodia* Linnaeus, 1758	C	SB	WM			+	+	
		Order: SULIFORMES								
		Family: Phalacrocoracidae								
44	"Little Cormorant"	*Microcarbo niger* (Vieillot, 1817)	C	Di	R	+	+	+	+	+
45	"Great Cormorant"	*Phalacrocorax carbo* (Linnaeus, 1758)	C	Di	WM			+	+	+
46	"Indian Cormorant"	*Phalacrocorax fuscicollis* Stephens, 1826	C	Di	R	+		+	+	+
		Family: Anhingidae								
47	"Oriental Darter"	*Anhinga melanogaster* Pennant, 1769	C	Di, St	WM	+			+	+
		Order: CHARADRIIFORMES								
		Family: Burhinidae								
48	"Indian Thick-knee"	*Burhinus indicus* (Salvadori, 1865)	O	Pe/Pr	WM	+				
		Family: Recurvirostridae								
49	"Pied Avocet"	*Recurvirostra avosetta* Linnaeus, 1758	C	Pi/Sc	WM			+	+	
50	"Black-winged Stilt"	*Himantopus Himantopus* (Linnaeus, 1758)	C	Pi/Sc	R	+	+	+	+	

Contd…..

Table 2. Contd……

		Family: Charadriidae								
51	“Little-ringed Plover”	*Charadrius dubius* Scopoli, 1786	C	FT	R	+		+		
52	“Red-wattled Lapwing”	*Vanellus indicus* (Boddaert, 1783)	C	Pi	R	+	+	+		
53	“White-tailed Lapwing”	*Vanellus leucurus* (M.H.C. Lichtenstein, 1823)	C	FT/Pr	WM	+	+	+		
54	“Yellow-wattled Lapwing”	*Vanellus malabaricus* (Boddaert, 1783)	C	Pi	R	+				
		Family: Scolopacidae								
55	“Black-tailed Godwit”	*Limosa limosa* (Linnaeus, 1758)	O	Pi/Pr/FT	WM		+	+	+	
56	“Marsh Sandpiper”	*Tringa stagnatilis* (Bechstein, 1803)	I	Pe	WM			+	+	
57	“Green Sandpiper”	*Tringa ochropus* Linnaeus, 1758	I	Pe	WM		+	+		
58	“Spotted Redshank”	*Tringa erythropus* (Pallas, 1764)	C	Pe/Da	WM			+	+	
59	“Little Stint”	*Calidris minuta* (Leisler, 1812)	I	Pe	WM			+	+	
60	“Eurasian Curlew”	*Numenius arquata* (Linnaeus, 1758)	O	Pe/Pr	WM		+	+	+	
61	“Ruff”	*Calidris pugnax* (Linnaeus, 1758)	O	Pi/Pr	WM		+	+		
62	“Temminck's Stint”	*Calidris temminckii* (Leisler, 1812)	I	Pe/Pr	WM			+		
63	“Common Snipe”	*Gallinago gallinago* (Linnaeus, 1758)	C	Pr	WM			+		
64	“Common Sandpiper”	*Actitis hypoleucos* (Linnaeus, 1758)	I	Pe	WM		+	+	+	
65	“Common Greenshank”	*Tringa nebularia* (Gunnerus, 1767)	C	Pe/Pr	WM			+	+	
66	“Common Redshank”	*Tringa tetanus* (Linnaeus, 1758)	C	Pe/Da	WM		+	+	+	
67	“Wood Sandpiper”	*Tringa glareola* Linnaeus, 1758	I	Pe/Pr	WM		+	+	+	
		Family: Laridae								
68	“Black-headed Gull”	*Chroicocephalus ridibundus* (Linnaeus, 1766)	C	Da/Pr/FT	WM				+	+
69	“River Tern”	*Sterna aurantia* J.E. Gray, 1831	C	PD	WM	+			+	+
		Family: Jacanidae								
70	“Pheasant-tailed Jacana”	*Hydrophasianus chirurgus* (Scopoli, 1786)	O	Pi	SM			+		
71	“Bronze-winged Jacana”	*Metopidius indicus* (Latham, 1790)	O	Pi	SM			+		
		Order: ACCIPITRIFORMES								
		Family: Pandionidae								
72	“Osprey”	*Pandion haliaetus* (Linnaeus, 1758)	C	FP	WM	+			+	+
		Family: Accipitridae								
73	“Brahminy Kite”	*Haliastur indus* (Linnaeus, 1758)	C	FP	WM	+		+	+	
74	“Western Marsh Harrier”	*Circus aeruginosus* (Linnaeus, 1758)	C	FP	WM	+			+	+
		Order: FALCANIFORMES								
		Family: Falconidae								
75	“Peregrine Falcon”	*Falco peregrinus* (Linnaeus, 1758)	C	FP	WM	+	+	+		

Contd…..

Table 2. Contd……..

		Order: CORACIFORMES								
		Family: Alcedinidae								
76	"Pied Kingfisher"	*Ceryle rudis* (Linnaeus, 1758)	C	PD	R	+	+	+	+	+
77	"White-throated Kingfisher"	*Halcyon smyrnensis* (Linnaeus, 1758)	C	PD	R	+	+	+	+	+
78	"Common Kingfisher"	*Alcedo atthis* (Linnaeus, 1758)	C	PD	WM		+		+	+
		Family: Meropidae								
79	"Blue-cheeked Bee-eater"	*Merops persicus* Pallas, 1773	I	C	SM	+	+	+		
		Order: PASSERIFORMES								
		Family: Motacillidae								
80	"Rosy Pipit"	*Anthus roseatus* Blyth, 1847	I	Pi/Pe	WM	+	+	+		
81	"Water Pipit"	*Anthus spinoletta* (Linnaeus, 1758)	I	Pi/Pe	WM	+			+	
82	"Western Yellow Wagtail"	*Motacilla flava* Linnaeus, 1758	I	Pi/C	WM	+	+	+	+	
83	"Citrine Wagtail"	*Motacilla citreola* Pallas, 1776	I	Pi/C	WM	+	+	+	+	
84	"White-browed Wagtail"	*Motacilla maderaspatensis* J.F. Gmelin, 1789	I	Pi/C	WM	+	+	+		
85	"White Wagtail"	*Motacilla alba* Linnaeus, 1758	I	Pi/C	WM	+	+	+	+	
		Family: Hirundinidae								
86	"Streak-throated Swallow"	*Petrochelidon fluvicola* (Blyth, 1855)	I	Sk	R	+	+			+
87	"Wire-tailed Swallow"	*Hirundo smithii* Leach, 1818	I	Sk	R	+	+	+		+
88	"Barn Swallow"	*Hirundo rustica* Linnaeus, 1758	I	Sk	WM	+			+	+
89	"Plain Martin"	*Riparia paludicola* (Vieillot, 1817)	I	C	WM	+		+		+
90	"Pale Martin"	*Riparia diluta* (Sharpe & Wyatt, 1893)	I	C	WM	+			+	+

FG: Foraging guild (C: Carnivore, H: Herbivore, O: Omnivore, I: Insectivore)
FT: Foraging technique (G- Grazing, S- Striking, U- Upending, C- Catching, F- Filtering, Da- Dabbling, Pi- Picking, Pe- Pecking, Pr- Probing, Sc- Scything, St- Stabbing, Sk-Skimming, Di- Diving, PD- Plunge Diving, FD- Feet Diving, FT- Foot trembling, SS- Standing Still, TT- Tactile Technique, SF- Surface Feeding, FP- Foot Plunging, SB- Sweeping Bill, WS- Walking Slow)
Habitat- TL: Terrestrial land, AL: Agricultural land, ML: Marsh land, SW: Shallow water, DW: Deep water
+ sign represents presence of species in the specific habitat preference.

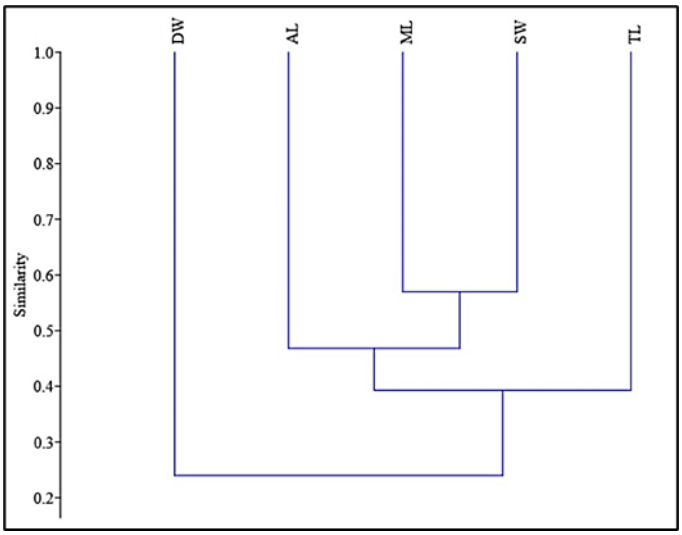

Fig. 2. *Cluster analysis based on Jaccard's similarity index using unweighted paired group method with athematic mean-UPGMA showing similarity of wetland bird species composition in different habitat in Dighal wetlands of Jhajjar district of Haryana (TL: Terrestrial land; AL: Agricultural land; ML: Marsh land; SW: Shallow water; DW: Deep water)*

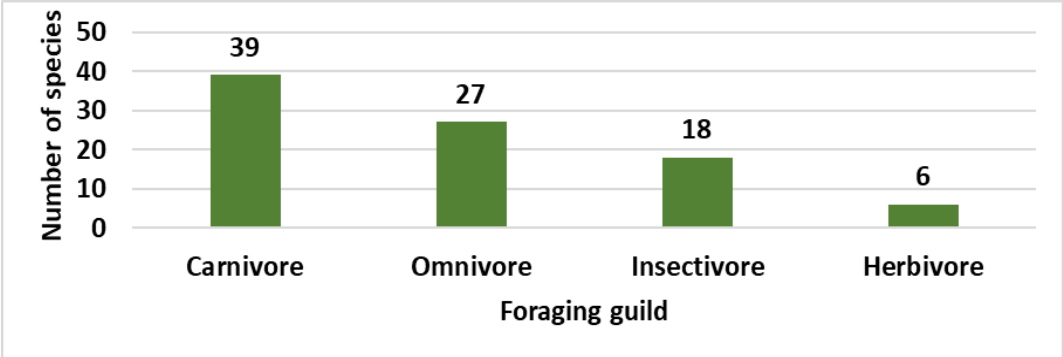

Fig. 3. *Richness of wetland bird species belonging to different foraging guilds in the study area*

and abundance of carnivorous species within wetland ecosystems (Kumar and Gupta, 2013; Kumar and Sharma, 2018; Sohil and Sharma, 2020; Rai and Vanita, 2021). The presence of a thriving carnivorous guild is further supported by the surrounding irrigated crop fields, which contribute to an enhanced food supply in the form of diverse fauna (Sohil and Sharma, 2020).

A total of 21 distinct foraging techniques were utilized among the wetland bird species. Dabbling emerged as the most commonly employed technique, documented in 18 species, followed by pecking (17 species), picking (16 species), and probing (14 species). Upending technique was also observed (11 species), while diving and catching (8 species each). Other techniques, such as foot trembling, were recorded in 6 species, grazing (5 species), and various other techniques were documented as well (Fig. 4). Certain foraging techniques were found to be exclusive to specific bird species. For instance, filtering was observed solely in flamingos, while stabbing was unique to the Oriental Darter, and sweeping bill movements were characteristic of Eurasian Spoonbills.

The documentation of 21 distinct foraging techniques among wetland bird species further underscores the diverse array of feeding behaviors exhibited within the study area. Dabbling was the most prevalent foraging technique used by wetland birds in the study area. Other foraging techniques, such as upending, striking, picking, pecking, and grazing were also observed, consistent with previous studies (Mukherjee and Roy, 2021). Certain foraging techniques such as filtering, stabbing and sweeping bill observed in specific species highlight the importance of niche specialization in shaping the ecological roles of individual bird species within wetland ecosystems. These findings align with earlier observations, such as the filtering foraging technique observed in flamingos by Zweers (1995), stabbing observed in the Oriental Darter by Orta *et al.* (2020), and sweeping bill foraging in Eurasian Spoonbill by Swennen and Yu (2008).

Upon comparing the foraging guilds with the habitat preferences, it was revealed that marshland showed the most preferred habitat for the wetland birds (Fig. 5). Also, the least preferences were documented as herbivores on agricultural land, omnivores on terrestrial land, insectivores and carnivores in the deep water. Notably,

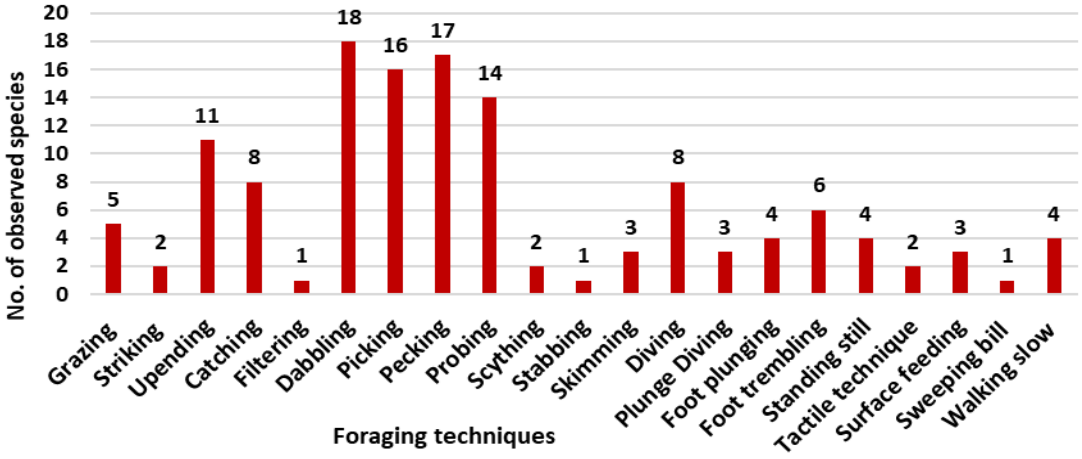

Fig. 4. *Distribution of wetland bird species across various foraging techniques in Dighal wetlands of Jhajjar district, Haryana*

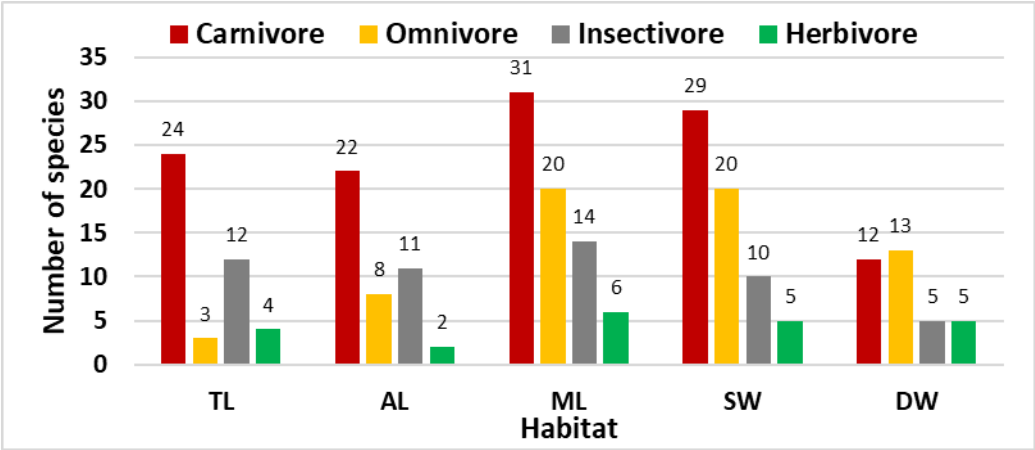

Fig. 5. *Comparative analysis of foraging behaviour and habitat preferences among wetland bird species recorded in Dighal wetlands of Jhajjar district, Haryana*

the intricate web of interactions within wetland ecosystems, particularly among diverse feeding guilds of wetland birds, underscores the importance of understanding and conserving these vital habitats. By unravelling the complexities of feeding guild dynamics, the study paves the way for informed conservation strategies that safeguard the avian residents and the delicate balance of wetland ecosystems.

Conclusion

The documentation of 90 bird species across 12 orders, 23 families, and 62 genera underscores the significance of the Dighal wetlands as a vital habitat for wetland birds. The Charadriiformes order and the Anatidae family exhibit the highest species richness. Marshlands emerged as the most preferred habitat, supporting the largest number of species, while deep water habitats showed the greatest dissimilarity compared to agricultural land in terms of bird species distribution. Carnivores were identified as the most prevalent feeding guild, followed by omnivores, insectivores, and herbivores, with marshlands serving as the primary habitat for carnivorous species. The study also documented a diverse range of foraging techniques, with dabbling being the most common, reflecting the varied foraging strategies employed by wetland birds. These findings emphasize the ecological importance of the Dighal wetlands, not only as a crucial feeding ground for a wide variety of bird species but also as a dynamic ecosystem that fosters an array of foraging behaviours and guilds. The insights gained from this research can inform conservation management strategies to preserve these wetlands' biodiversity and ecological integrity, which are essential for resident and migratory bird populations. Sustainable management practices are critical for maintaining the intricate ecological interactions and ensuring the long-term health of wetland bird communities.

ACKNOWLEDGEMENTS

We sincerely appreciate the necessary facilities provided by Kurukshetra University's Department of Zoology in Kurukshetra. The University Grants Commission (UGC), New Delhi, India, is acknowledged by one of the authors, Parul, for giving funding as an SRF to carry out the research work.

Conflict of interest

The author declares that they have no conflict of interest

REFERENCES

1. Albrecht, M. & Gotelli, N.J. (2001). Spatial and temporal niche partitioning in grassland ants. *Oecologia*, 126, 134-141
2. Ali, S. & Ripley, S.D. (1987). *Handbook of the Birds of India and Pakistan*. Oxford University Press, Mumbai.
3. Berg, Å. (2002). Composition and diversity of bird communities in Swedish farmland–forest mosaic landscapes. *Bird study*, 49(2), 153-165
4. Bibby, C.J., Burgess, N.D., Hill, D.A. & Mustoe, S.H. (2000). *Bird Census Techniques.* Academic Press, London, 302 pp.
5. Bonilla, E.P.D., León- Cortés, J.L. & Rangel, J.L. (2012). Diversity of Bird feeding guilds in relation to habitat heterogeneity and land-use cover in a human-modified landscape in southern Mexico. *Journal of Tropical Ecology*, 28, 369-376
6. Canterbury, G.E., Martin, T.E., Petit, D.R., Petit, L.J. & Bradford, D.F. (2000). Bird communities and habitat as ecological indicators of forest condition in regional monitoring. *Conservation Biology*, 14(2), 544-558
7. Chatterjee, A., Adhikari, S., Pal, S. & Mukhopadhyay, S.K. (2020). Foraging guild structure and niche characteristics of waterbirds wintering in selected sub-Himalayan wetlands of India. *Ecological Indicators*, 108, 105693
8. Clough, Y., Dwi Putra, D., Pitopang, R. & Tscharntke, T. (2009). Local and landscape factors determine functional bird diversity in Indonesian cacao agroforestry. *Biological Conservation*, 142(5), 1032-1041. http://doi.org/10.1016/j.biocon.2008.12.027
9. Cornell lab of ornithology (2023). Cornell University, Ithaca, New York. https://www.birds.cornell.edu/home/
10. Dodge, K.M., Whitmore, R.C. & Harner, E.J. (1990). Analyzing foraging use versus availability using regression techniques. *Studies in Avian Biology*, 13, 318-324
11. Evans, P.R. & Dugan, P.J. (1984). *Coastal birds: numbers in relation to food resources*. In: Evans PR, Goss-Custard JD, Hale WG (eds) Coastal waders and wildfowl in winter. Cambridge University Press, United Kingdom.
12. Fahrig, L. & Nuttle, W.K. (2005). Population ecology in spatially heterogeneous environments. In: *Ecosystem function in heterogeneous landscapes* (pp. 95-118). New York, NY: Springer New York.
13. Grimmett, R., Inskipp, C. & Inskipp, T. (2016). *Birds of the Indian Subcontinent: India, Pakistan, Sri Lanka, Nepal, Bhutan, Bangladesh and the Maldives.* Bloomsbury Publishing.
14. Gupta, R.C., Parashar, M. & Kaushik, T.K. (2012). Documentation of avian diversity of Khaparwas Bird Sanctuary in Jhajjar district in Haryana, India. *International journal of life sciences*, 6(1), 20–30
15. Harisha, M.N. & Hosetti, B.B. (2018). Status and conservation issues of wetland birds in Komaranahalli Lake, Davanagere district, Karnataka, India. *Journal of Threatened Taxa*, 10(2), 11290-11294
16. Holmes, R.T. & Recher, H.F. (1986). Determinants of guild structure in forest bird communities: an intercontinental comparison. *Condor*, 88, 421-439
17. Jangral, S. & Vashishat, N. (2023). Structure and Composition of Bird Assemblage in Keshopur Wetland of Punjab, India. *Indian Journal of Entomology*, 1-9
18. Jha, K.K. & 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
19. Kattan, G.H. & Franco, P. (2004). Bird diversity along elevational gradients in the Andes of Colombia: area and mass effects. *Global Ecology and Biogeography*, 13, 451-458. http://doi.org/10.1111/j.1466-822X.2004.00117.x
20. Kumar, P. & Gupta, S.K. (2013). Status of wetland birds of Chhilchhila Wildlife Sanctuary, Haryana, India. *Journal of Threatened Taxa*, 5(5), 3969–3976. https://doi.org/10.11609/JoTT.o3158.3969-76
21. Kumar, P. & Sharma, A. (2018). Diversity and status of avifauna in man-made sacred ponds of Kurukshetra, India. *Journal of Threatened Taxa*, 10(9), 12173–12193
22. Kumar, P. & Sharma, A. (2019). Wetland birds assemblages in man-made sacred ponds of Kurukshetra, India. *Proceedings of the Zoological Society*, 72(1), 61–73. http://dx.doi.org/10.1007/s12595-018-0259-x
23. Kumar, V., Mishra, H. & Kumar, A. (2021). Foraging behavior in river lapwing, *Vanellus duvaucelii* (Lesson, 1826) (Charadriiformes: Chradriidae): Differences in technique, prey, and habitat. *Journal of Asia- Pacific Biodiversity*, 14 (1), 33-39
24. Malik, D.S. & Joshi, N. (2013). Habitat selection pattern of migratory avifauna in relation to nutrients in Asan wetland at Doon Valley (Garhwal Himalaya), India. *International Journal of Recent Scientific Research*, 4(10), 1470-1475
25. Mandal, M.H., Roy, A. & Siddique, G. (2021). A geographical assessment of Chariganga and Arpara Beel (wetlands) of Nadia, West Bengal as a habitat of wetland birds. *Journal of Threatened Taxa*, 13(13), 19964-19975
26. Manral, U., & 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
27. Mishra, H., Kumar, V. & Kumar, A. (2016). Foraging guild status, diversity and population structure of waders of the River Ganges in district Rae Bareli, Uttar Pradesh, India. *Journal of Entomology and Zoology Studies*, 4(6), 415-419
28. Mukherjee, A. & Roy, U.S. (2021). Community structure and foraging guilds of winter avifauna of an urban, perennial wetland of West Bengal, India. *International Journal of Conservation Science*, 12(1), 281-290
29. Orta, J., Garcia, E.F.J. & Boesman, P.F.D. (2020). Oriental Darter (*Anhinga melanogaster*), version 1.0. In: Birds of the World (J. del Hoyo, A. Elliott, J. Sargatal, D. A. Christie, and E. de Juana, Editors). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bow.darter2.01
30. Palmer, T.M., Stanton, M.L. & Young, T.P. (2003). Competition and coexistence: exploring mechanisms that restrict and maintain diversity within mutualist guilds. *The American Naturalist*, 162, 63-79
31. Parul & Kumar, P. (2023). Assessing avian diversity and conservation status in Dighal Wetlands, Haryana, In-

dia. *Journal of Threatened Taxa*, 15(10), 23996-24008
32. Praveen, J. & Jayapal R. (2023). Taxonomic updates to the checklists of birds of India and the South Asian region. *Indian Birds*, 18(5), 131–134. http://www.indianbirds.in/india/
33. Rai, D. & 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
34. Rai, D. & Yadav, A. (2023). Avian community composition in and around Mandothi Wetlands, Haryana, India. *Journal of Applied and Natural Science*, *15*(1), 408-421
35. Rai, D., Gulia, R. & Chopra, G. (2017). Status of migratory avifaunal diversity of Basai wetlands, Haryana (India). *J. Exp. Zool. India*, 20(2), 981-985
36. Rathod, J. & Padate, G. (2017). Feeding guilds of urban birds of Vadodara city. *International Journal of Faunal Biological Studies*, 4, 78-85
37. Ruffino, L., Salo, P., Koivisto, E., Banks, P. B. & Korpimäki, E. (2014). Reproductive responses of birds to experimental food supplementation: a meta-analysis. *Frontiers in zoology*, 11, 1-13
38. Rahmani, A. R., Islam, M. Z. & Kasambe, R. M. (2016). *Important Bird and Biodiversity Areas in India: Priority Sites for Conservation (Revised and updated).* Bombay Natural History Society, Indian Bird Conservation Network, Royal Society for the Protection of Birds and BirdLife International (U.K.), pp. 1992 + xii.
39. Sekercioglu, C. H. (2012). Bird functional diversity and ecosystem services in tropical forests, agroforests and agricultural areas. *Journal of Ornithology*, 153, 153-161
40. Sekercioglu, C.H. (2006). Increasing awareness of avian ecological function. *Trends in ecology & Evolution*, 21, 464-471. http://doi.org/10.1016/j.tree.2006.05.007
41. Sharma, K.K. & Saini, M. (2014). Community structure and population dynamics of aquatic avifauna of Gharana wetland (Reserve), Jammu, India. *International Research Journal of Biological Sciences*, 3(2), 1-8
42. Sohil, A. & Sharma, N. (2020). Assessing the bird guild patterns in heterogeneous land use types around Jammu, Jammu and Kashmir, India. *Ecological Processes*, 9(1), 49
43. Stein, A., Gerstner, K. & Kreft, H. (2014). Environmental heterogeneity as a universal driver of species richness across taxa, biomes and spatial scales. *Ecology Letters*, 17 (7), 866-880
44. Swennen, C., & Yu, Y. T. (2008). Bill sweeping in spoonbills Platalea: no evidence for an effective suction force at the tip. *Journal of Avian Biology*, *39*(1), 3-6
45. Thiollay, J.M. (1995). The role of traditional agroforests in the conservation of rainforest bird diversity in Sumatra. *Conservation Biology*, 9, 335–353. https://doi.org/10.1046/j.1523-1739.1995.9020335.x
46. Veech, J.A., Small, M.F. & Baccus, J.T. (2011). The effect of habitat on the range expansion of a native and an introduced bird species. *Journal of Biogeography*, 38(1), 69-77. https://doi.org/10.1111/j.1365-2699.2010.02397.x
47. Yashmita-Ulman & Singh, M. (2022). Avifaunal diversity in unprotected wetlands of Ayodhya District, Uttar Pradesh, India. *Journal of Threatened Taxa*, 14(8), 21561–21578
48. Zweers, G., de Jong, F., Berkhoudt, H. & Vanden Berge, J.C. (1995). Filter feeding in Flamingos (Phoenicopterus ruber). *The Condor*, 97(2), 297-324. https://doi.org/10.2307/1369017