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WETLAND PREFERENCE BY WINTER MIGRATORY BIRDS WITH RESPECT TO THE WATER QUALITY OF FEW WETLANDS IN HARYANA

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Abstract:
Wetlands are essential ecosystems that support diverse plant and animal life, connecting aquatic and terrestrial environments. They provide numerous ecosystem services and serve as habitats for various bird species. Our research focused on understanding how water quality affects avifaunal preferences in four wetlands across three districts in Haryana. We collected avifaunal data and water samples during the winter season, analysing physical and chemical parameters of the water. Principal component analysis revealed that Total Suspended Solids and Turbidity had the greatest impact as physical parameters, while Total Alkalinity, Total Hardness, Bicarbonates, Sodium, Chloride, Sulphate, and Calcium significantly influenced water quality. Using Correspondence Conical Analysis, we found that certain birds, such as River Tern and River Lapwing, preferred areas with good water quality and open water spaces. In contrast, waders, stilts, and wagtails showed a preference for polluted water bodies with shallow water levels, while harriers, coots, and knob-billed ducks favored moderately clean water with natural habitats. The Vidkyar site did not exhibit specific preferences, falling between the water qualities of the other sites and being influenced by human activities. This study highlights the importance of monitoring water quality and habitat characteristics for a comprehensive understanding of bird preferences in wetlands.

Keywords: Wetland, Winter Migratory Birds, Avifauna, Water quality, Habitat preference.

INTRODUCTION

Wetlands are an important environment with diverse biodiversity and uniqueness. Wetlands are the strong connecting link between the terrestrial and aquatic ecosystems. Wetlands were neglected ecosystems for a long time but after the Ramsar Convention in 1971, their importance was highlighted and few wetlands were declared as areas of high importance. As per Ramsar definition, wetlands "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres." (Ramsar Convention, 1971, Article 1.1).

Wetland provides different ecosystem services, which includes Provisioning (Food, Freshwater, Fibre fuel, etc.), Regulating (Climate regulation, Water regulation, Erosion regulation, Pollution regulation, Water purification, and waste treatment, etc.), Cultural (Spiritual, Recreational, aesthetic, etc.) and Supportive (Soil formation and Nutrient cycling) (Leemans, 2002). Wetlands are important for water-dependent species, including water birds, wetland-dependent mammals, fresh-water fishes, amphibians, Turtle, and Crocodiles. As avifauna is concerned, wetlands are used by residents and migratory birds. Migratory birds use wetlands for resting, brooding, and feeding, etc.

Numerous research studies have been carried out in various regions to establish a connection between aquatic birds and wetlands. Several factors come into play when considering the diversity of bird species in a particular wetland. Certain studies have highlighted the significance of local climate elements such as rainfall and temperature in influencing the variety and preference of wetlands by different bird species (Bethke and Nudds, 1993). Furthermore, it has been found that the micro-climate within wetlands has a positive correlation with the distribution of water birds (Rajpar and Zakaria, 2014). The significance of wetlands for avifaunal diversity was demonstrated through a study conducted at a pond in a small village within the Thanesar block of Kurukshetra, which documented 46 distinct bird species, with a majority being winter migratory birds (22 species), showing the importance of small ponds in facilitating bird migration (Gupta *et al.*, 2012). Keeping this objective in mind, the current study aims to evaluate the wetland preferences of winter migratory birds in relation to the water quality of the respective water bodies.

MATERIALS AND METHODS

Study area

The present study was conducted in three different districts of Haryana. Sites were abbreviated as the S1 site (Bhidawas wetlands) and S2 site (Dighal Wetlands) located in the Jhajjar district, S3 site (Vidkyar lake) present in the Kaithal district while the S4 site (Kaushalya dam) is in Panchkula district (Fig.1). Data was collected on physicochemical parameters and avifaunal diversity in the year 2018 to 2020 for the winter seasons.

Water quality of wetlands

Physicochemical parameters like pH, TDS, and Temperature, etc. were recorded on the field with the help of a digital instrument. The water sample was collected and analysed for the remaining parameters in the laboratory with the standard methods (Rice *et al.*, 2012).

Avifaunal Survey

The avifaunal survey was conducted in the early morning and late evening hours. Standard point count and line transect methods were used to collect species data. Birds were photographed and recorded using binoculars with a 10x50 mm magnification and a Nikon P 900 camera. Field guides were used to identify birds (Grimmet *et al.*, 2016, Ali *el al.*, 1987). The order and families of recorded birds were identified following Praveen *et al.*, (2017). Guilds status was also studied for the migratory birds and classified into carnivores, frugivores, insectivores, granivores, nectarivores and omnivores birds. They were further classified into different categories based on IUCN status (2022-2) i.e., Critically Endangered, Endangered, Vulnerable, Near Threatened, and least concern. Later further check their importance with respect to migratory and resident were also studied with the help of Grimmett and Inskipp (2003).

Statistical Analysis

Canonical Correspondence Analysis (CCA) has been developed to allow ecologists to relate the abundance of species to environmental variables (Ter Braak, 1986). A Canonical Correspondence analysis (CCA) was performed for the species relationship with environmental variables to assess the wetland preferences. In this, bird species recorded from the study area CCA was conducted with the most influencing water parameters those were analysed with the help of Principle Component Analysis (PCA).

RESULTS AND DISCUSSION

Different bird species have different patterns of a guild status like carnivores, frugivores, insectivores, and omnivores (Table 2). The bird guild was referred according to Gray *et al.* (2007) and Sohil *et al.* (2020).

Avifauna was classified on guild patterns that include carnivore, granivore, herbivore, insectivore, and omnivore and their distribution for the complete study area and specific sites. Omnivores were the most dominant guild having 30%, 35%, 40%, and 35% abundance in S1, S2, S3, and S4 sites, respectively. Among the remaining guilds, in the S1 site besides omnivores the dominant groups were carnivores and insectivores (26% each), granivores and herbivores (8% each), and nectivores (2%, Fig.2a). Similarly, in S2 site, the insectivores (%) were next dominant guild followed by carnivores, herbivores, granivores and nectivores (Fig.2b). In S3 site, granivores & insectivores were more abundant than carnivores & herbivores (Fig.2c). While in S4 site most species were carnivores & omnivores followed by insectivores and granivores & herbivores (Fig.2d). In general, most species in the present study were omnivores followed by carnivores, insectivores, herbivores, granivores, and lastly nectivores. However, the patterns were different in the individual sites.

Wetlands act as a suitable place for winter migratory birds for resting, breeding, and feeding grounds etc. Winter migratory bird species include birds that were recorded during the winter season which may be intercontinental and local migration within the continent/country to avoid severe weather conditions.

The International Union for Conservation of Nature (IUCN) serves as a global governing body responsible for gathering information on various flora and fauna and classifying them into different categories. According to the latest IUCN Status (2022-2), most of the species listed in the study are deemed to be of "Least Concern" (LC). However, two bird species falls under the "Near Threatened" (NT) category (*Vanellus duvaucelii* & *Threskiornis melanocephalus*), and two species are categorized as "Vulnerable" (VU) (*Aythya farina* & *Sterna aurantia*). (Table 3).

Water quality status of wetlands in Haryana

During winter seasons, species presence is the dependent variable in the current research. The exploratory physical and chemical water variables have a significant impact on water quality, which, in turn, affects the utilization of wetlands by waterbirds (Singh and Khalid., 2022a). To determine which environmental factors, have a considerable impact on water

quality during Winter (December and January) seasons, Principal Component Analysis (PCA) was carried out separately for physical and chemical parameters.

Physical Parameters
Of the selected 5 physical parameters tested, Principal Components 1 and 2 (PC1, PC2) explained more than 99.99 % of the variation in winter seasons. The temperature was negatively correlated with other physical parameters (Fig.3) it is evident that TSS and Turbidity play a significant role in the water quality of sites, while EC, TDS, and Temperature do not as is evident from eigenvalues.

Chemical parameters
Among the chemical properties of the 16 selected chemical parameters tested, Principal Components 1 and 2 (PC1, PC2) explained more than 99 % of the variation in winter seasons. DO, BOD, and COD were negatively correlated with the remaining chemical parameter. All chemical parameters except pH, nitrate, phosphate, bicarbonate, and BOD played a significant role in the water quality of the site. Among all chemical parameters, sodium, potassium, sulphates, and chloride heavily influenced the S2 site and negatively influenced the S1 site in winters while water quality in the S1 site showed mild dependency on COD respectively. The S3 site was influenced by Total hardness, bicarbonates, calcium, and total alkalinity while the S4 site was not influenced by any chemical properties (Fig 4).

The water quality in the S1 and S4 sites was not influenced by any chemical properties. S3 was influenced by Total Hardness and bicarbonate as is evident from eigenvalues. Water quality was negatively related to bicarbonate sodium and chlorine.

We determined the water's most influential physical and chemical properties using PCA. In physical parameters, TSS and Turbidity were the most influential physical characteristics, while in chemical parameters the determining such as bicarbonates, total alkalinity, total hardness, sodium, and chloride were the most influential.

Wetland Preference by Avifauna Species as per Canonical Correspondence Analysis (CCA)
The Eigenvalues for the first 3 CCA axis were 0.50299, 0.20626, 0.011664 with p values of 0.297, 0.076, and 0.796 respectively. The cumulative total variance (85%) was explained by the first 2 axis. The CCA biplot for sites reveals that during the winter season, the water quality of S1 was directly influenced by Total alkalinity and Bicarbonates as compared to other sites while turbidity, total hardness, calcium, and sodium were recorded as more influencing factors for the water quality. Water quality S3 and S4 were least affected by these physicochemical parameters.

S1 site water quality significantly influenced physicochemical parameters including Total alkalinity and bicarbonate. S2 site water quality significantly influenced Physicochemical parameters including Chloride (Cl), Sodium (Na), Sulphate (SO4), Potassium (K), Calcium (Ca), TSS, Turbidity, and Total hardness of water. The S3 site was analyzed as very less affected by different physicochemical parameters while the water quality of the S4 site showed a distant influence from physicochemical parameters.

Among winter migratory birds, S4 site was mostly preferred by *Trichodroma muraria* (Wallcreeper), *Sterna aurantia* (River Tern), *Podiceps cristatus* (Great Crested Grebe), *Anser indicus* (Bar-headed Goose) and *Vanellus duvaucelii* (River lapwing) as compared to other study sites. The Great Crested Grebe and River Tern were documented as migratory birds during the winter season in northern India. They were observed in various regions of Haryana (Singh and Khalid, 2022b, Kaushik *et al.*, 2017) and in the district. These bird species typically favoured open water surfaces for their feeding habits and tended to avoid areas populated by humans. The dam water's quality was found to be minimally impacted by various physicochemical parameters. The observations revealed that species recorded from the S4 site typically preferred water bodies with minimal influence from such parameters. The S2 site water quality was influenced by different physicochemical parameters and this type of water body was preferences observed by bird species including *Charadrius dubius* (Little Ringed Plover), *Himantopus himantopus* (Black Winged Stilt), *Anser indicus* (Bar-headed Goose), *Threskiornis melanocephalus* (Black-headed Ibis), *Tringa totanu* (Common Redshank), *Aythya nyroca* (Ferruginous Duck), *Phoenicopterus roseus (*Greater Flamingo), *Netta rufina* (Red-crested Pochard), *Motacilla flava* (Yellow Wagtail) and *Motacilla citreola* (Citrine Wagtail). In comparison to other study areas, the S2 site is characterized by shallow water depths. This could be the reason that wader species, such as the little ringed plover and Common Redshank, along with Black Winged Stilt and Wagtails are often observed feeding in shallow water and along the banks of water bodies. The presence of Ibis species is predominantly documented in agricultural fields, and the S2 site is directly encompassed by such fields. This proximity to agricultural areas could potentially explain their occurrence in that specific location. Similar avifaunal species were also recorded from a village pond in Punjab which had similar habitat characteristics as of S2 site (Kaur *et al.*, 2018). S1 site was mostly preferred by *Circus aeruginosus* (Marsh Harrier), *Fulica atra* (Eurasian Coot), *Sarkidiornis melanotos* (Knob Billed Duck), and *Luscinia svecica* (Blue Throat). The study area encompasses an expanse of open water, vegetation, and shallow water, forming a holistic natural habitat

for birds due to which open water species Marsh harrier was recorded from this site along with ducks. At the S1 site, a comparable study on avifaunal diversity was carried out, revealing the presence of 104 recorded bird species from 39 distinct families (Chopra *et al.*, 2017). However, the S3 site was as such not preferred by specific bird species. Birds including *Motacilla citreola* (Citrine Wagtail), *Tringa ochropus* (Green Sand Piper), *Actitis hypoleucos* (Common Sand Piper) and *Anas clypeata* (Northern Shoveler) preferred site S2 and site S4 but did not prefer physicochemical parameters like total alkalinity and bicarbonates. On the other hand, birds including *Tadorna ferruginea* (Ruddy Shelduck Duck), *Anas platyrhynchos* (Mallard Duck), *Anas poecilorhyncha* (Indian Spot-billed Duck), and *Anas strepera* (Gadwall) did not prefer hard physicochemical parameters including chloride, sodium, and turbidity in wetland water. Birds including Marsh Harrier (*Circus aeruginosus*) and Eurasian Coot (*Fulica atra)* preferred to live near S1 while *Anas querquedula* (Garganey), and *Gallinula chloropus* (Common Moorhen) birds preferred to live near S2-type wetlands.

Table 1. Location of selected wetlands with their latitude and longitude

Site Code	Location Details	Latitude and Longitude (GPS Coordinates)	Site Description
S1	Bhindawas wetlands	$28^0$31’5675” N $76^0$33’0617” E	Surrounded by five villages Kanwash, Nawada, Sajapur, Chadwana, and Radhuwas.
S2	Dighal wetlands	$28^0$45’5850” N $76^0$37’4248” E	It is a group of shallow ponds present in the village of Dighal.
S3	Vidkyar lake	$29^0$48’0645” N $76^0$23’5966” E	Surrounded by cemented pavement and a grass garden.
S4	Kaushlya Dam	$30^0$46’4215” N $76^0$54’5842” E	This dam was fully operational in 2012 with the primary purpose of drinking water

Table 2. Guild Status and explanation of criteria category

Guild Status	Explanation of Criteria category
Carnivor	
Omnivor	
Insectiv	
Granivor	
Nectariv	
Frugivor	

S. No.	Common Name	Scientific Name	Short Form	Guilds	IUCN Status
1	Bar Headed Goose	*Anser indicus*	Ans Ind	Herbivores	LC
2	Black Headed Ibis	*Threskiornis melanocephalus*	Thr mel	Carnivores	NT
3	Common Redshank	*Tringa totanus*	Tri tot	-----	LC
4	Common Sandpiper	*Actitis hypoleucos*	Act hyp	Carnivores	LC
5	Eurasian Wigeon	*Anas penelope*	Ana pen	Herbivores	LC
6	Ferruginous Duck	*Aythya nyroca*	Ayt nyr	Herbivores	LC
7	Green Sandpiper	*Tringa ochropus*	Tri och	Carnivores	LC
8	Greater Flamingo	*Phoenicopterus roseus*	Pho ros	Omnivores	LC
9	Little Ringed Plover	*Charadrius dubius*	Cha dub	-----	LC
10	Red Creasted Pochard	*Netta rufina*	Net ruf	-----	LC
11	Temminck stint	*Calidris temminckii*	Cal tem	-----	LC
12	Common Moorhen	*Gallinula chloropus*	Gal chl	Omnivores	LC
13	Common Pochard	*Aythya ferina*	Ayt fer	Omnivores	VU
14	Common Teal	*Anas crecca*	Ana Cre	-----	LC
15	Gadwall	*Anas strepera*	Ana str	Herbivores	LC
16	Garnary	*Anas querquedula*	Ans que	Herbivores	LC
17	Great Cormorant	*Phalacrocorax carbo*	Pha car	Carnivores	LC
18	Indian Spot Billed Duck	*Anas poecilorhyncha*	Ana poe	Herbivores	LC
19	Greylag Goose	*Anser anser*	Ans ans	Herbivores	LC
20	Northern Pintail	*Anas acuta*	Ans acu	Herbivores	LC
21	Northern Shoveler	*Anas clypeata*	Ana cly	Omnivores	LC
22	Ruddy Shelduck	*Tadorna ferruginea*	Tad fer	Omnivores	LC
23	Yellow Wagtail	*Motacilla flava*	Mot fla	Insectivores	LC
24	Citrine Wagtail	*Motacilla citreola*	Mot cit	Insectivores	LC

25	Black Winged Stilt	*Himantopus himantopus*	Him him	Carnivores	LC
26	Bluethroat	*Luscinia svecica*	Lus sve	Insectivores	LC
27	Eurasian Coot	*Fulica atra*	Ful atr	Omnivores	LC
28	Knob Billed Duck	*Sarkidiornis melanotos*	Sar mel	Omnivores	LC
29	Mallard	*Anas platyrhynchos*	Ana pla	Herbivores	LC
30	Marsh Harrier	*Circus aeruginosus*	Cir aer	Carnivores	LC
31	Brown Headed Gull	*Chroicocephalus brunnicephalus*	Chr bru	Carnivores	LC
32	Great Crested Grebe	*Podiceps cristatus*	Pod cri	Omnivores	LC
33	River Lapwing	*Vanellus duvaucelii*	Van duv	Insectivores	NT
34	River Tern	*Sterna aurantia*	Ste aur	Carnivores	VU
35	Wallcreeper	*Trichodroma muraria*	Tri mur	-----	LC

Table 3. Complete list of species recorded from the study areas along with their guilds and IUCN status

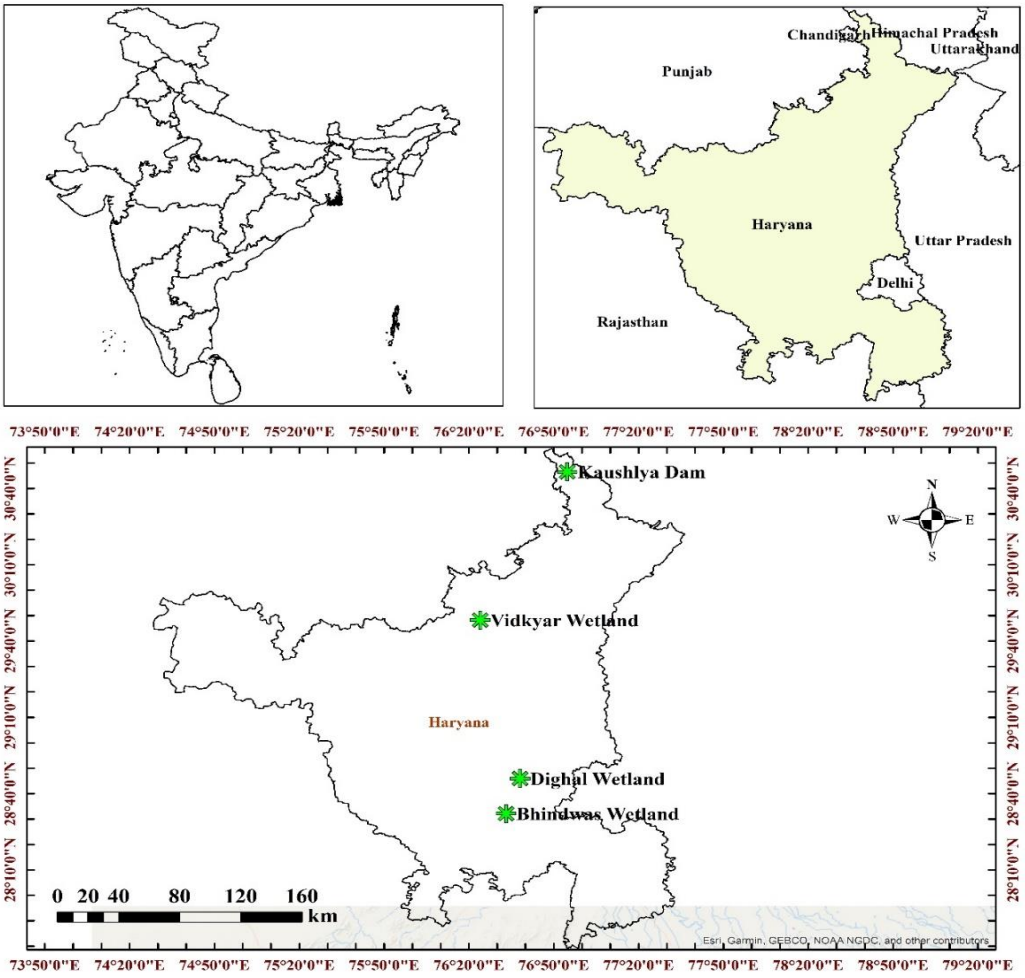
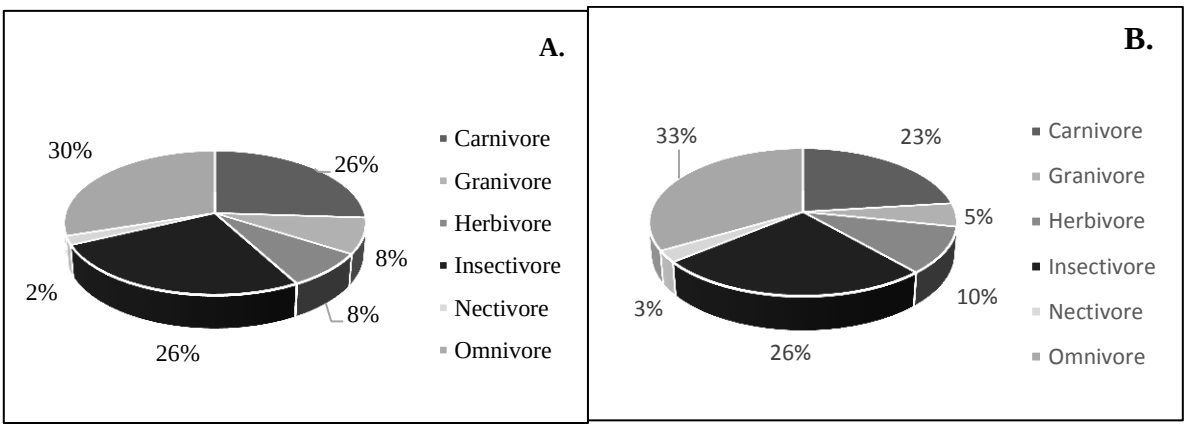


Fig.1. Locations of study sites in different districts of Haryana.



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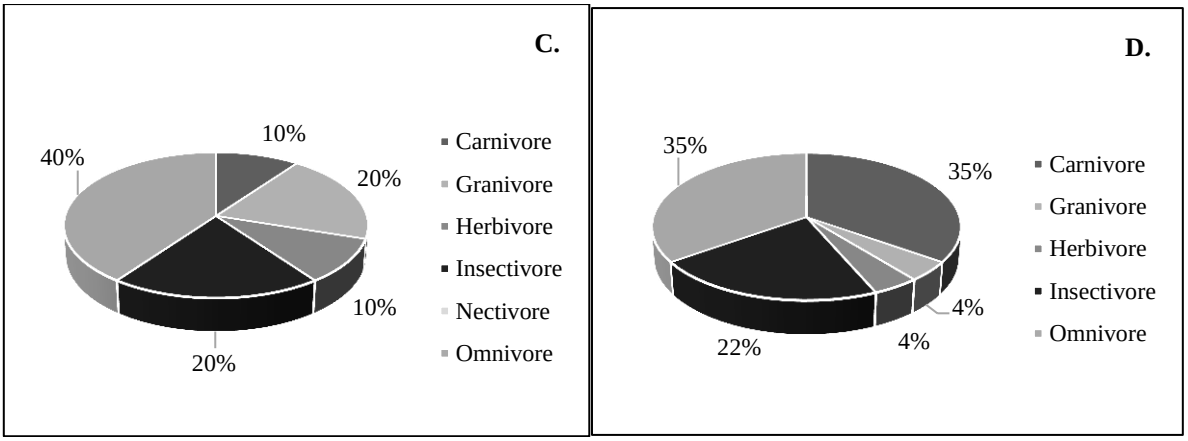

Fig. 2. Percentage wise guilds distribution **A.** study site S1, **B.** study site S2, **C.** study site S3, and **D.** study site S4

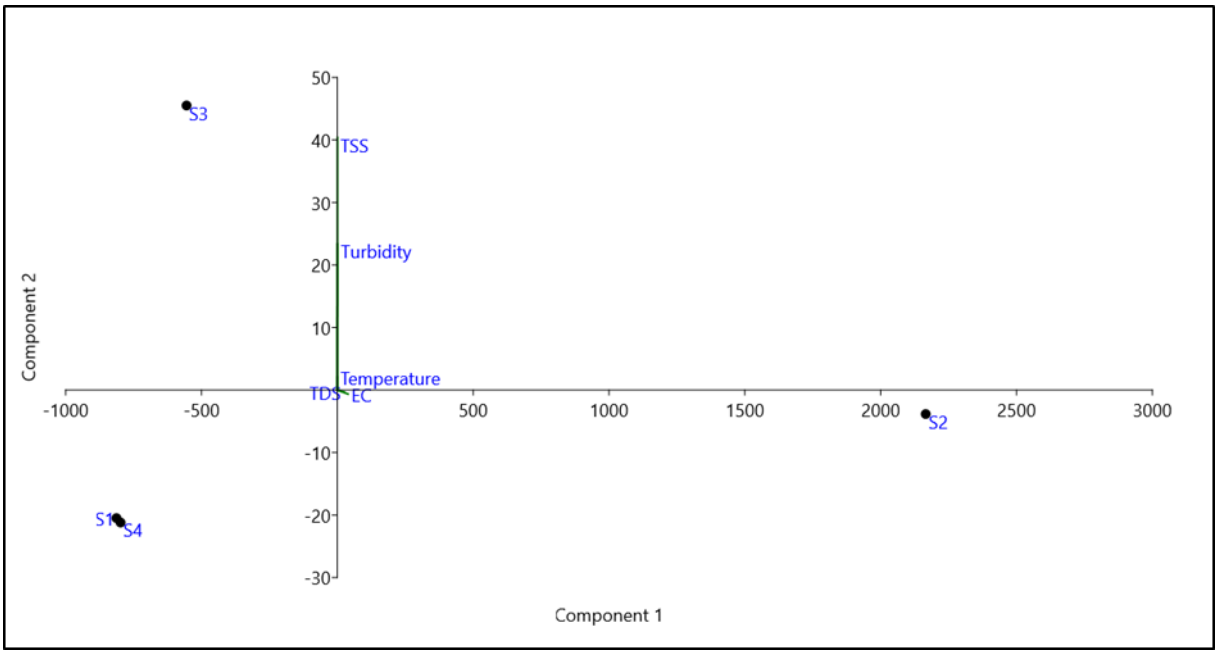

Fig.3. Biplot showing the relationship of water physical parameters with Sites.

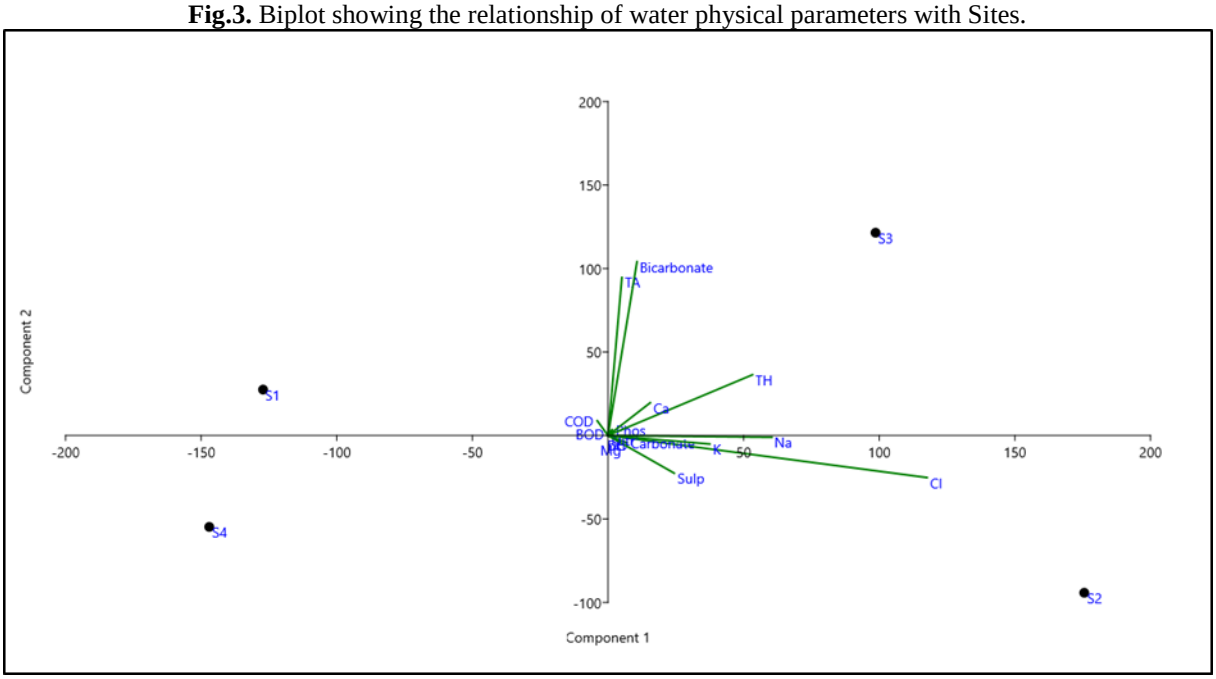

Fig. 4. Biplot showing the relationship of water chemical parameters with Sites

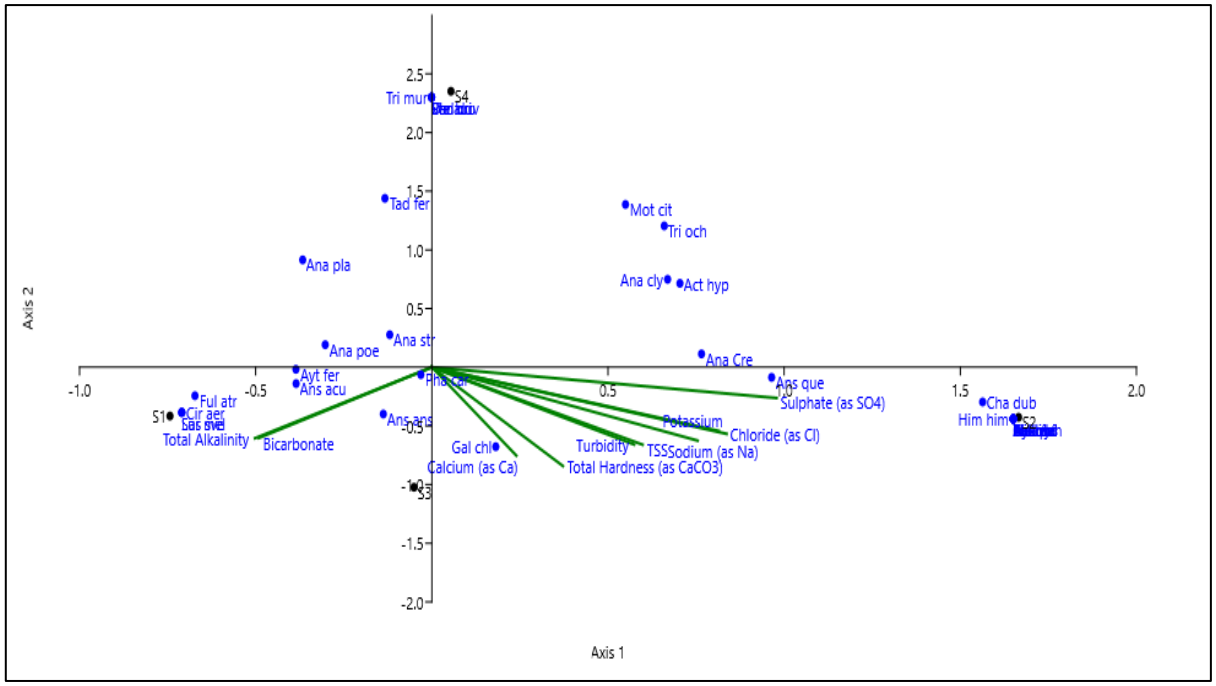

Fig. 5. Canonical Correspondence Analysis (CCA) Winter (*Anser indicus*, *Threskiornis melanocephalus* (Thr mel),*Tringa totanus*(Tri tot), *Actitis hypoleucos* (Act hyp), *Anas penelope* (Ana pen), *Aythya nyroca* (Ayt nyr), *Tringa ochropus* (Tri och), *Phoenicopterus roseus* (Pho ros), *Charadrius dubius* (Cha dub), *Netta rufina* (Net ruf), *Calidris temminckii* (Cal tem), *Gallinula chloropus* (Gal chl), *Aythya ferina* (Ayt fer), *Anas crecca* (Ana Cre), *Anas strepera* (Ana str), *Anas querquedula* (Ans que), *Phalacrocorax carbo* (Pha car), *Anas poecilorhyncha* (Ana poe), *Anser anser* (Ans ans), *Anas acuta* (Ans acu), *Anas clypeata* (Ana cly), *Tadorna ferruginea* (Tad fer), *Motacilla flava* (Mot fla), *Motacilla citreola* (Mot cit), *Himantopus himantopus* (Him him), *Luscinia svecica* (Lus sve), *Fulica atra* (Ful atr), *Sarkidiornis melanotos* (Sar mel), *Anas platyrhynchos* (Ana pla), *Circus aeruginosus* (Cir aer), *Chroicocephalus brunnicephalus* (Chr bru), *Podiceps cristatus* (Pod cri), *Vanellus duvaucelii* (Van duv), *Sterna aurantia* (Ste aur), *Trichodroma muraria* (Tri mur)

CONCLUSION

The study revealed that physicochemical parameters influence waterbody preferences in avifauna, but some bird species are unaffected, indicating other unexplored factors. Local water bodies are vital habitats for winter migratory birds, including IUCN-listed species. To gain deeper insights, continuous monitoring focused on other features is essential. Protecting these habitats is crucial for migratory birds and endangered species. Comprehensive research is needed to formulate effective conservation strategies and preserve biodiversity, enhancing our understanding of avian ecology.

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CONFLICT OF INTEREST

The authors affirm that there are no conflicts of interest to disclose.

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