Building evidence for conservation globally

Journal of Threatened Taxa

Open Access

10.11609/jott.2023.15.12.24291-24450
www.threatenedtaxa.org

26 December 2023 (Online & Print)
15(12): 24291–24450
ISSN 0974-7907 (Online)
ISSN 0974-7893 (Print)

ISSN 0974-7907 (Online); ISSN 0974-7893 (Print)

Publisher
Wildlife Information Liaison Development Society
www.wild.zooreach.org

Host
Zoo Outreach Organization
www.zooreach.org

43/2 Varadarajulu Nagar, 5th Street West, Ganapathy, Coimbatore, Tamil Nadu 641006, India
Registered Office: 3A2 Varadarajulu Nagar, FCI Road, Ganapathy, Coimbatore, Tamil Nadu 641006, India
Ph: +91 9385339863 | www.threatenedtaxa.org
Email: sanjay@threatenedtaxa.org

For Focus, Scope, Aims, and Policies, visit https://threatenedtaxa.org/index.php/JoTT/aims_scope
For Article Submission Guidelines, visit https://threatenedtaxa.org/index.php/JoTT/about/submissions
For Policies against Scientific Misconduct, visit https://threatenedtaxa.org/index.php/JoTT/policies_various

continued on the back inside cover

Cover: The critically endangered *Lilium polyphyllum* in watercolour and acrylics. © Aishwarya S Kumar.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 December 2023 | 15(12): 24321–24330
ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)
https://doi.org/10.11609/jott.7647.15.12.24321-24330
#7647 | Received 04 September 2021 | Final received 31 August 2023 | Finally accepted 23 September 2023
OPEN ACCESS
ARTICLE

Diversity of wintering avifauna throughout the heterogeneous aquatic habitats of Bankura District, West Bengal, India

Biplob Kumar Modak [1], Subha Shankar Mukherjee [2], Susobhan Mondal [3], Mainak Sarkar [4] & Asif Hossain [5]

[1,2,3,4] Department of Zoology, SKB University, Purulia, West Bengal 723104, India.
[2,5] Department of Zoology, The University of Burdwan, Golapbag, Burdwan, West Bengal 713104, India.
[1] bkmodak09@gmail.com, [2] msubhashankar@gmail.com, [3] mainakbios@gmail.com, [4] susobhan.sm@gmail.com,
[5] asifhossain.bu@gmail.com (corresponding author)

Abstract: Birds play various crucial roles in the ecosystem including pollination, seed dispersal, and pest control. Assemblages of bird species in a particular landscape are useful predictors in various ecosystem services, this is evident from studies of forest bird assemblages, aquatic bodies and agro ecosystems. For developing conservation strategies, information on bird species assemblages in a particular geographical area is important. Diversity in aquatic ecosystem support a diversity of water bird species. In the present study, around 45 bird species were recorded in 21 aquatic bodies in Bankura, West Bengal, India, in which two species, namely, *Leptoptilos javanicus* and *Aythya ferina* declared 'Vulnerable' and three species such as *Mareca falcata, Threskiornis melanocephalus*, and *Limosa limosa* considered as 'Near Threatened' according to the IUCN Red list. *Dendrocygna javanica* and *Nettapus coromandelianus* were found to be the most abundant. In those 21 study areas, site6 has the highest species richness and site2 has the lowest. The dominance index was highest for site2 and lowest for site6. Pielou's index of evenness was highest for site20. The rarefaction curve showed species abundance was highest for site1. Classical cluster analysis for species abundance showsthat site20, site21, site3, site8, site4, site19, site5, site14, site12, site15, site7, site 10 site11, and site13 are closely related. This paper is aimed to generate interest among people to conserve aquatic birds and their habitats and to document baseline information for further study.

Keywords: Abundance, conservation, diversity, evenness, winter birds, Near Threatened, richness, Vulnerable.

Editor: S. Balachandran, Bombay Natural History Society, Mumbai, India. **Date of publication:** 26 December 2023 (online & print)

Citation: Modak, B.K., S.S. Mukherjee, S. Mondal, M. Sarkar & A. Hossain (2023). Diversity of wintering avifauna throughout the heterogeneous aquatic habitats of Bankura District, West Bengal, India. *Journal of Threatened Taxa* 15(12): 24321–24330. https://doi.org/10.11609/jott.7647.15.12.24321-24330

Funding: Financial assistance provided by WBBB (Memo no. 51./5k(Bio)-3/2018 dt 09/01/2019).

Competing interests: The authors declare no competing interests.

Author details: Biplob Kumar Modak is a professor in Department of Zoology, Sidho-Kanho-Birsha University, Purulia. Subha Shankar Mukherjee is a senior research fellow (UGC) in Department of Zoology, The University of Burdwan. Susobhan Mondal is a research scholar in Department of Zoology, Sidho-Kanho-Birsha University. Mainak Sarkar is a research scholar in Department of Zoology, Sidho-Kanho-Birsha University. Asif Hossain is an assistant professor in Department of Zoology, The University of Burdwan.

Author contributions: BKM conceptualised the idea, helped in data collection and drafting the manuscript. SSM contributed in data collection and analyses. SM helped in field survey and data analyses. MS helped in field survey and data analyses. AH helped data collection, analyses and drafting manuscript.

Acknowledgements: The authors thankfully acknowledge the head, Department of Zoology, SKB University, Purulia, India, and Head, Department of Zoology, The University of Burdwan, Golapbag, Burdwan, India, for the facilities provided. The authors thankfully acknowledge the critical comments of the anonymous reviewers and the suggestions of the respected chief editor that helped in transforming the manuscript into the present form. Financial assistance provided by WBBB (Memo no. 51./5k(Bio)-3/2018 dt 09/01/2019) is thankfully acknowledged.

INTRODUCTION

Birds are one of the most popular life forms on the planet and their diversity contributes to life's richness and beauty. Birds are important components of the ecosystem contributing substantively toecosystem function, especially pollination, seed dispersal, pest control, nutrient cycling, and others (Whelan et al. 2008; Sekercioglu 2012). Information on bird assemblages in forests (Aich & Mukhopadhyay 2008; Roy et al. 2011; Chatterjee et al. 2013), aquatic bodies (Kumar et al. 2006; Kumar & Gupta 2013), agricultural and otherlandscapes are useful tools in understanding the various ecosystem health (Dhindsa & Saini 1994; Borad et al. 2001; Basavarajappa 2006; Gopi Sundar 2011; Gopi Sundar & Kittur 2013; Hossain & Aditya 2014) and to develop strategies for conservation and further monitoring of ecosystem conditions and functions (Bradford et al. 1998; Browder et al. 2002). Millions of people rely on aquatic ecosystems for a better living through fishing, agricultural irrigation and other purposes. Birds can be found almost everywhere on the planet, in almost every climatic condition and at nearly every altitude. Birds are excellent environmental indicators because they respond quickly to changes in habitat structure, composition and other environmental factors (Hossain & Aditya 2014). Besides their aesthetic role, they also hold a unique position in the food chain. Aquatic ecosystems are highly productive ecosystems on Earth and provide people a source of food, animal farming, fisheries, aquaculture and also as a refuge for rare and endangered plant and animal species. The assemblage of foraging bird species is dependent on habitat type and stable condition of food resources. Migratory birds also play an important role in maintaining ecosystem health by influencing nutrient cycling during the migratory season. The present study deals with the documentation of avifauna in Bankura and similar areas in the Chota Nagpur Plateau. The study sites are heterogeneous in habitat structure as some of the aquatic bodies are in plains area while others are from hilly terrains, and forested areas while some from agricultural areas and a few of them are within the human settlements. The climate of the Bankura District is characterized by excessive heat in summer and highly humid throughout the year. The average daily maximum temperature varies 26–39 ^{0}C during summer and during winter temperature ranges 12–25 ^{0}C. The relative humidity is high throughout the year. Damodar, Dwarakeswar, Silabati, and Kangsabati are the four major rivers of Bankura District. These rivers constitute the main drainage system of this district. The Kangsabati dam is a major dam constructed on the river at Mukutmanipur of Bankura District to arrest flood and to provide irrigation facilities. There are many threats to the water bodies of Bankura that include pollution due to domestic sewage, pesticides, fertilizers, farming agriculture along the exposing periphery, eutrophication/blooms of surface water, partial reclamation of wetland, residential & commercial development, and sedimentation that are the primary factors for reducing species diversity including birds.

The current study's goal was to assess the diversity of wintering aquatic birds and create an avifauna checklist for the district of Bankura, West Bengal, India, which will aid in future aquatic bird management with appropriate conservation strategies.

MATERIALS AND METHODS

Study Area

The survey was carried out at 21 water bodies and adjoining landscapes in Bankura, West Bengal, India, namely Mukutmanipur Dam (Site 1), Lal Bandh (Site 2), Jamuna Bandh (Site 3), Krishna Bandh (Site 4), Kulaijurir Bandh (Site 5), Sal Bandh (Site 6), Kadam Deuli Dam (Site 7), Sutan Dam (Site 8), Gangdua Dam (Site 9), Bonkati Bandh (Site10), Bagjobra Bandh (Site11), Kesiakol Bandh (Site 12), Talberia Dam (Site 13), Kakila Daha (Site 14), Jhilimili Bandh (Site 15), Poabagan Bandh (Site 16), Chattna Bandh (Site 17), Nityanandapur Dam (Site 18), AmbikanagarBandh (Site 19), Saheb Bandh (Site 20), and Ranir Bandh (Site 21). All of the sites' coordinates are plotted in a raster plot (Figure 1a,b,c). The following are the specific characteristics of these aquatic bodies:

Mukutmanipur dam: This is a reservoir type of aquatic body, with rain water and streams as the primary sources of water. This body of water covers approximately 38.4 ha and has a maximum depth of 11 m. Vegetation covered 5% of the area, including submerged Hydrilla as well as shrubs and reeds in the bank.

Lal Bandh: Fresh water lake with 30% vegetation cover, including shrubs, reeds, Hydrilla, water hyacinth, and water lilies. The lake has a surface area of about 12 ha and a maximum depth of about 9 m.

Jamuna Bandh: This freshwater lake covers an area of 22 ha, with vegetation covering 90% of the area. This aquatic body has a maximum depth of approximately 8 m.

Krishna Bandh: Relying completely on rainfall and local streams, this freshwater lake spans 10 ha in surface area with a maximum depth of 5 m. Notably, 30% of the area hosts vegetation, including submerged Hydrilla,

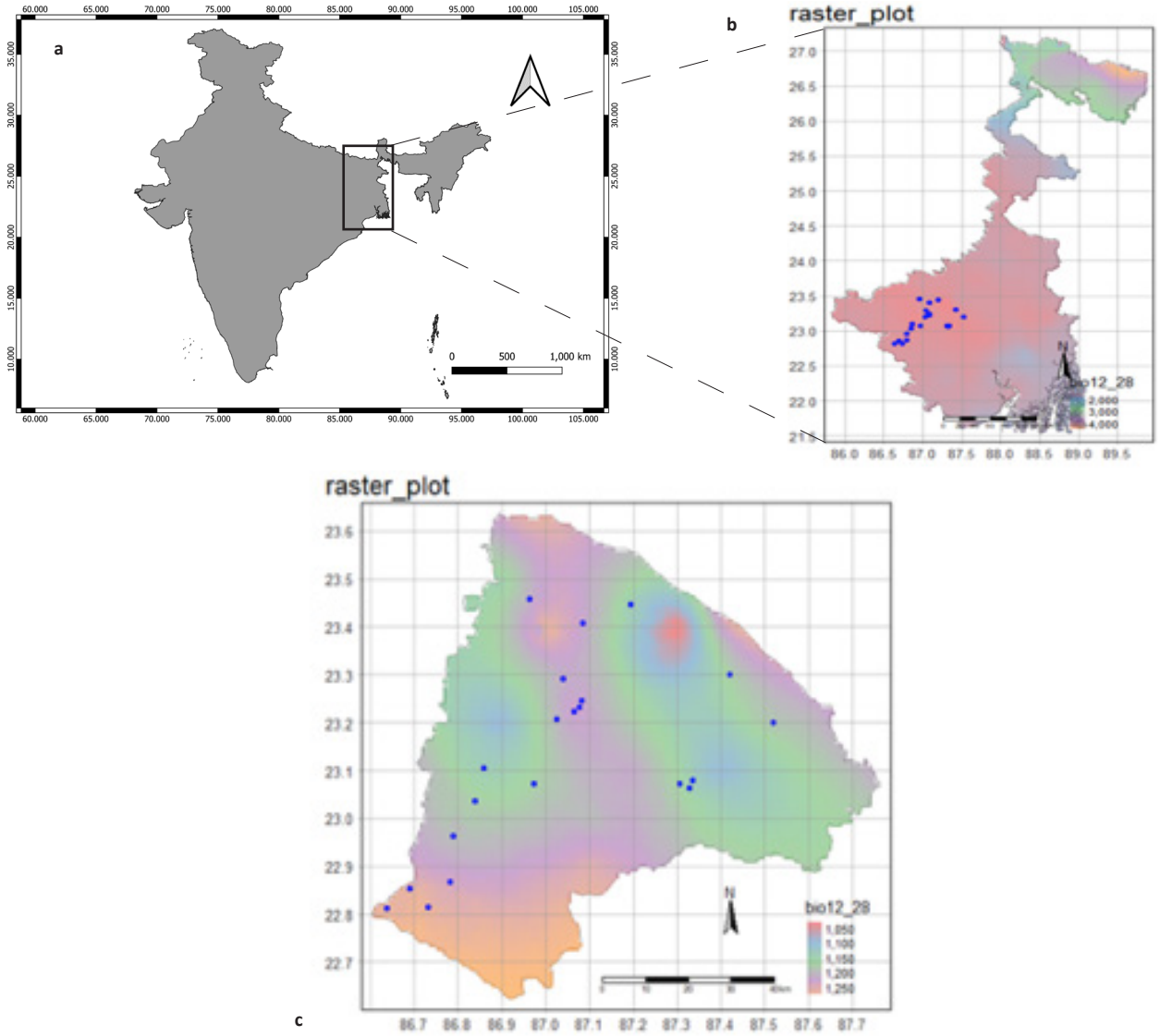

Figure 1. a—Coordinates of study area plotted in India State map | b—Raster plot of West Bengal | c—Raster plot of Bankura District.

free-floating water hyacinth, shrubs, and reeds along the banks.

Kulaijurir bandh: This freshwater pond covers an area of 18 ha and has a maximum depth of about 5 m; 56% of the area is covered by vegetation, which includes various shrubs on the bank, free-floating water hyacinth, and submerged Hydrilla.

Sal bandh: Sal bandh is a 3.5-ha reservoir with a maximum depth of 3 m. It is dependent on local rain and is only temporary in nature. Vegetation covered 20% of this area.

Kadam Deuli dam: Featuring a 7 m maximum depth, this rainwater and stream-fed freshwater pond spans a total area of 14.94 ha. Impressively, 86% of this expanse is veiled by vegetation.

Sutan dam: This reservoir has a surface area of 6.5 ha and a maximum depth of 4 m. It is primarily dependent on rainfall and streams. Vegetation such as *Hydrilla* and various shrubs covered 15% of the area.

Gangdua dam: This lake's main source of water is local rainfall and streams. This body of water has an area of about 18 ha and a maximum depth of 7.5 m. Hydrilla and water lily vegetation covered 35% of the area.

Bonkati bandh: The main sources of water for this freshwater lake are local rainand streams. This water body covers an area of11.92 ha and has a maximum depth of about 5 m. The vegetation covered 66% of the land area.

Bagjobra bandh: This lake covers 5 ha, and 86% of it

is covered by vegetation such as shrubs and reeds growing on the bank, free floating water hyacinth, submerged Hydrilla, and floating, leaved-rooted water lilies.

Kesiakol bandh: This freshwater lake covers 10.26 ha and has a maximum depth of 4.5 m. The lake is 10.26 ha in size, with vegetation covering 38% of the area.

Talberia dam: Talberia dam is a freshwater lake with a surface area of 12.30 ha and a maximum depth of 5 m. It is reliant on rainwater and streams, and vegetation covers 53% of the area, including various shrubs in the bank, Hydrilla, water hyacinth, and water lilies.

Kakila Daha: Local rainwater and streams are the primary sources of water for this lake, which has a maximum depth of 5 m. This lake took up 4.94 ha of land, accounting for 39% of the total vegetation area.

Jhilimili bandh: This freshwater lake has a surface area of 12.37 ha and a maximum depth of 5.5 m. It is entirely dependent on rainwater and streams for its survival. The vegetation covered 66% of the land area.

Poabagan bandh: Spanning an area of 4.514 ha, this site relies on local rainfall and streams for sustained existence. Vegetation, encompassing shrubs, reeds, Hydrilla, and water hyacinth, blankets 46% of the area.

Chattna bandh: This freshwater lake has an area of 11.30 ha, with vegetation covering 69% of it. Its long-term survival is dependent on local rains and streams.

Nityanandapur dam: With a surface area of 24 ha and a maximum depth of 7 m, this reservoir relies on rainfall and local streams. About 90% of its area features vegetation, including various shrubs, Hydrilla, and water lilies.

Ambikanagar bandh: This freshwater lake, fed by local rain and streams, spans an area of 18 ha with a maximum depth of 12 m. Approximately 90% of the area is covered by vegetation

Saheb bandh: A freshwater lake with a surface area of 9.2 ha and a depth of 6 m. It is mainly dependent on local rainfall and stream flow. The area is covered by vegetation, accounting for 49% of the total area. This vegetation includes primarily shrubs growing along the banks, as well as submerged and free-floating aquatic plants.

Ranir bandh: This lake is seasonal in nature and relies on water from streams. It spans an area of 3 ha and has a maximum depth of 5 m. Vegetation covers 20% of the total area surrounding the lake.

Data Collection

The survey spanned from November to January in both 2018 and 2019, involving monthly visits to study sites from 0700 h to 1200 h and 1230 h to 1700 h with the participation of nine individuals. Transportation primarily relied on bicycles and motorcycles to cover the extensive distances. Executed through the point count method, the survey focused on cataloging bird species around water bodies and their environs. Birds were observed using Olympus 7 X 21 PS III binoculars and documented via Nikon Coolpix P600 camera. Identification of avian species utilized relevant keys from Grimmett et al. (1998), Kazmierczak & van Perlo (2000), and Ali (2002)

Statistical Analyses

Three biological indices are employed to compute species richness, species dominance, and evenness: the Shannon-Wiener index (Shannon & Wiener 1963), the Berger-Parker index (Berger & Parker 1970), and Pielou's index (Pielou 1969; Biswas et al. 2019; Mukherjee et al. 2021). The Shannon-Wiener index (Shannon & Wiener 1963) serves as a valuable statistical metric for determining the species richness within a community. This index can yield low values due to the contribution of rare species with small populations. The calculation is expressed as $Hs = -\Sigma pi \ln pi$, where Hs represents the Shannon index value and pi signifies the proportion of the ith species within the community. The Berger-Parker index (Berger & Parker 1970) is derived as $d = \max(pi)$, where d indicates dominance and pi denotes the proportion of the i^{th} species in the community. Higher values of the Berger-Parker index imply greater dominance by one or a few species. Pielou's index of species evenness (Pielou 1969) gauges how evenly species are distributed numerically within the community. The following formula quantifies it: $E = Hs / Hmax$, where E signifies evenness, Hs signifies the Shannon index value, and Hmax represents ln(S), where S signifies the number of species in the community. Pielou's evenness index ranges from 0 to 1, with values closer to 1 indicating higher species evenness in the community. All three indices underwent one-way ANOVA to assess the significance of differences in their means. Subsequently, the species-habitat-evenness (SHE) analysis was employed to interpret the relationship between species richness (H) and evenness (E) of the samples. This analysis was carried out to understand the log series distribution of species in the community. Furthermore, principal component analysis (PCA) was performed on the Shannon-Wiener index of species richness, Pielou's index of evenness, and the Berger-Parker index of dominance to elucidate the relationships between these three variables. For the species abundance across all 21 sites, classical clustering using the UPGMA algorithm (based on the Brey-Curtis index)

was executed (Mukherjee & Mondal 2020). All analyses were conducted using PAST 3.14 (Hammer et al. 2001) and R-Studio 3.6.3 (R Studio Team 2020).

RESULTS

In Bankura, 45 species of aquatic birds were recorded during winter in 21 different locations (Table 1). The results of one-way ANOVA for the Shannon-Wiener index ($F = 11.06$, $p < 0.001$) (Table 2), Berger-Parker index of dominance ($F = 6.519$, $p < 0.001$) (Table 2) and Pielou's index of evenness ($F = 27.92$, $p < 0.001$) (Table 2) demonstrated that there was a significant difference in the mean of all the indices present in all of the study sites. The Shannon-Wiener index, or species richness, was highest at site 6 (2.280±0.10) and lowest at site 2 (0.82±0.015) (Figure 2). These findings indicate that the community at site 6 is a natural one with high species richness. As the dominance index increases, species richness decreases because the highest dominance index recommends the predominance of one or a few species in an ecosystem. Site 2 has the highest dominance index (0.84±0.13) and Site 6 has the lowest (0.32±0.04) (Figure 3). The highest species evenness (0.91±0.06) is found at Site 20 (Figure 4). The results of SHE analysis show a log-series distribution of bird species in the studied area (Figure 5). Individual rarefaction analysis of taxa plotted at the 95 percent confidence level shows that the highest specimen is more likely to be found in site 1, followed by site 2 (Figure 6). PCA results show that dimension 1 has an Eigen value of 2.04390180, followed by dimension 2 with a value of 0.92147965; in terms of percent variance, dimensions 1 and 2 contribute 68.130060 and 30.715988, respectively (Table 3). The PCA scree plot shows that dimensions 1 and 2 contribute the majority of the percent variance (Figure 7). In terms of species abundance, classical cluster analysis using the Brey-Curtis index reveals that sites 20-site 21, site 3, site 8, site 4, site 19, site 5, site 14, site 12, site15, site7, site 10 and site 11, site 13 are closely related (Figure 8).

DISCUSSION

During the current study, 45 bird Species of 13 families such as Accipitridae, Alcedinidae, Anatidae, Ardeidae, Charadriidae, Ciconiidae, Jacanidae, Motacillidae, Phalacrocoracidae, Podicipedidae, Rallidae, Scolopacidae, and Threskiornithidae were recorded in aquatic bodies in the Bankura district, including two 'Vulnerable' species *Leptoptilos javanicus*and *Aythya farina*, three

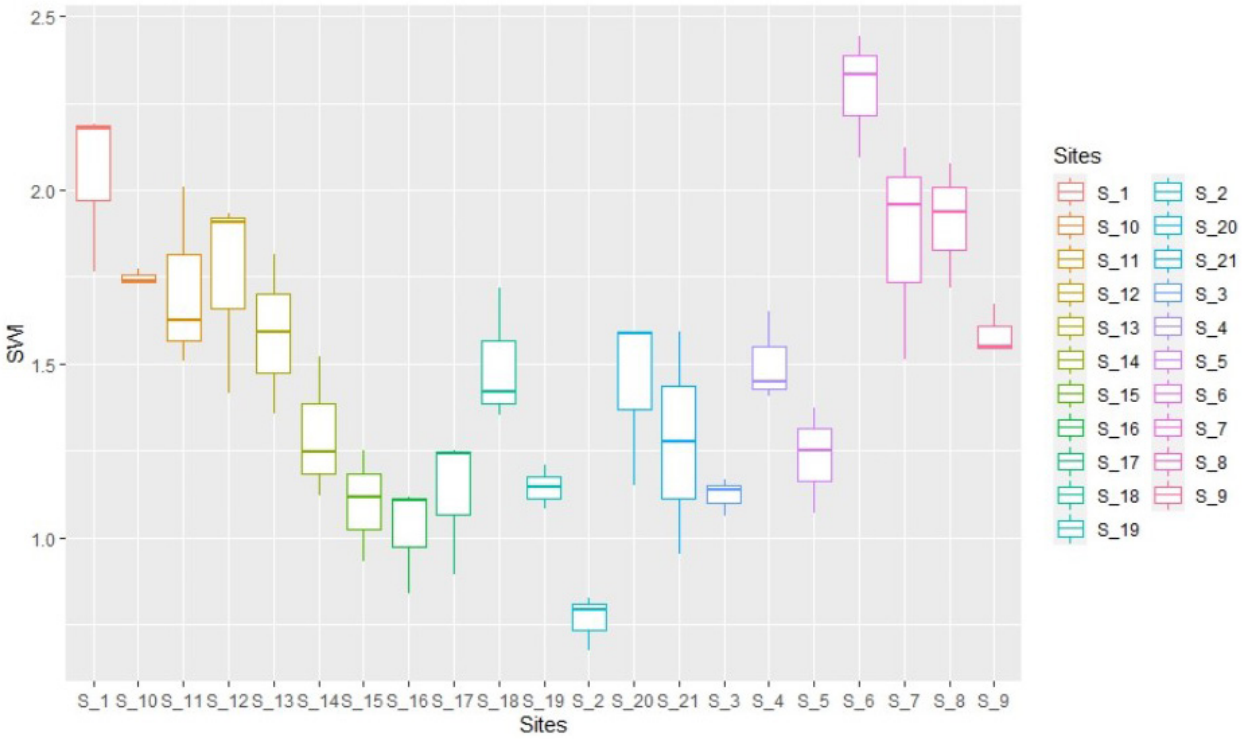

Figure 2. Ggplot of Shannon-Wiener index showing Site 6 has the highest and Site 2 has the lowest species richness.

Table 1. List of aquatic and migratory birds observed in Bankura district during thestudy period, 2018–2019. W —Winter Migratory | R—Resident | L—Local migratory | VU—Vulnerable | LC—Least Concern | NT–Near Threatened.

Common name	Scientific name	Family	IUCN Red List status	Migratory status	Abundance
Lesser Whistling-Duck	*Dendrocygna javanica*	Anatidae	LC	W	2125
Cotton Pygmy-Goose	*Nettapus coromandelianus*	Anatidae	LC	W	3351
Common Teal	*Anas crecca*	Anatidae	LC	L	62
Northern Pintail	*Anas acuta*	Anatidae	LC	W	62
Falcated Duck	*Mareca falcata*	Anatidae	NT	W	19
Garganey	*Spatula querquedula*	Anatidae	LC	W	12
Tufted Duck	*Aythya fuligula*	Anatidae	LC	L	7
Common Pochard	*Aythya ferina*	Anatidae	VU	L	85
Gadwall	*Mareca strepera*	Anatidae	LC	W	60
Red-crested Pochard	*Netta rufina*	Anatidae	LC	W	34
Indian PondHeron	*Ardeola grayii*	Ardeidae	LC	R	209
Cattle Egret	*Bubulcus ibis*	Ardeidae	LC	R	182
Purple Heron	*Ardea purpurea*	Ardeidae	LC	R	23
Great Egret	*Ardea alba*	Ardeidae	LC	R	38
Little Egret	*Egretta garzetta*	Ardeidae	LC	R	47
Yellow Bittern	*Ixobrychus sinensis*	Ardeidae	LC	L	32
Cinnamon Bittern	*Ixobrychus cinnamomeus*	Ardeidae	LC	R	18
Little Cormorant	*Microcarbo niger*	Phalacrocoracidae	LC	R	283
Great Cormorant	*Phalacrocorax carbo*	Phalacrocoracidae	LC	R	41
Pheasant-tailed Jacana	*Hydrophasianus chirurgus*	Jacanidae	LC	R	35
Bronze-winged Jacana	*Metopidius indicus*	Jacanidae	LC	R	48
Asian Openbill	*Anastomus oscitans*	Ciconiidae	LC	R	31
Lesser Adjutant	*Leptoptilos javanicus*	Ciconiidae	VU	L	28
White-brested Kingfisher	*Halcyon smyrnensis*	Alcedinidae	LC	R	17
Common Kingfisher	*Alcedo atthis*	Alcedinidae	LC	R	91
Pied Kingfisher	*Ceryle rudis*	Alcedinidae	LC	R	18
Stork-billed Kingfisher	*Pelargopsis capensis*	Alcedinidae	LC	R	21
Common Sandpiper	*Actitis hypoleucos*	Scolopacidae	LC	W	55
Green Sandpiper	*Tringa ochropus*	Scolopacidae	LC	W	11
Common Greenshank	*Tringa nebularia*	Scolopacidae	LC	W	15
Common Redshank	*Tringa totanus*	Scolopacidae	LC	W	2
Black-tailed Godwit	*Limosa limosa*	Scolopacidae	NT	W	9
Little Grebe	*Tachybaptus ruficollis*	Podicipedidae	LC	L	316
Ruddy-breasted Crake	*Zapornia fusca*	Rallidae	LC	R	4
Purple Swamphen	*Porphyrio poliocephalus*	Rallidae	LC	R	8
Common Moorhen	*Gallinula chloropus*	Rallidae	LC	R	105
Common Coot	*Fulica atra*	Rallidae	LC	L	19
White-breasted Waterhen	*Amaurornis phoenicurus*	Rallidae	LC	R	86
Western Marsh-Harrier (Eurasian Marsh-Harrier)	*Circus aeruginosus*	Accipitridae	LC	R	25
Yellow-wattled Lapwing	*Vanellus malabaricus*	Charadriidae	LC	R	4
White Wagtail	*Motacilla alba*	Motacillidae	LC	W	2
Western Yellow Wagtail	*Motacilla flava*	Motacillidae	LC	W	9
Citrine Wagtail	*Motacilla citreola*	Motacillidae	LC	W	12
Black-headed Ibis	*Threskiornis melanocephalus*	Threskiornithidae	NT	L	41
Red-naped Ibis	*Pseudibis papillosa*	Threskiornithidae	LC	L	8

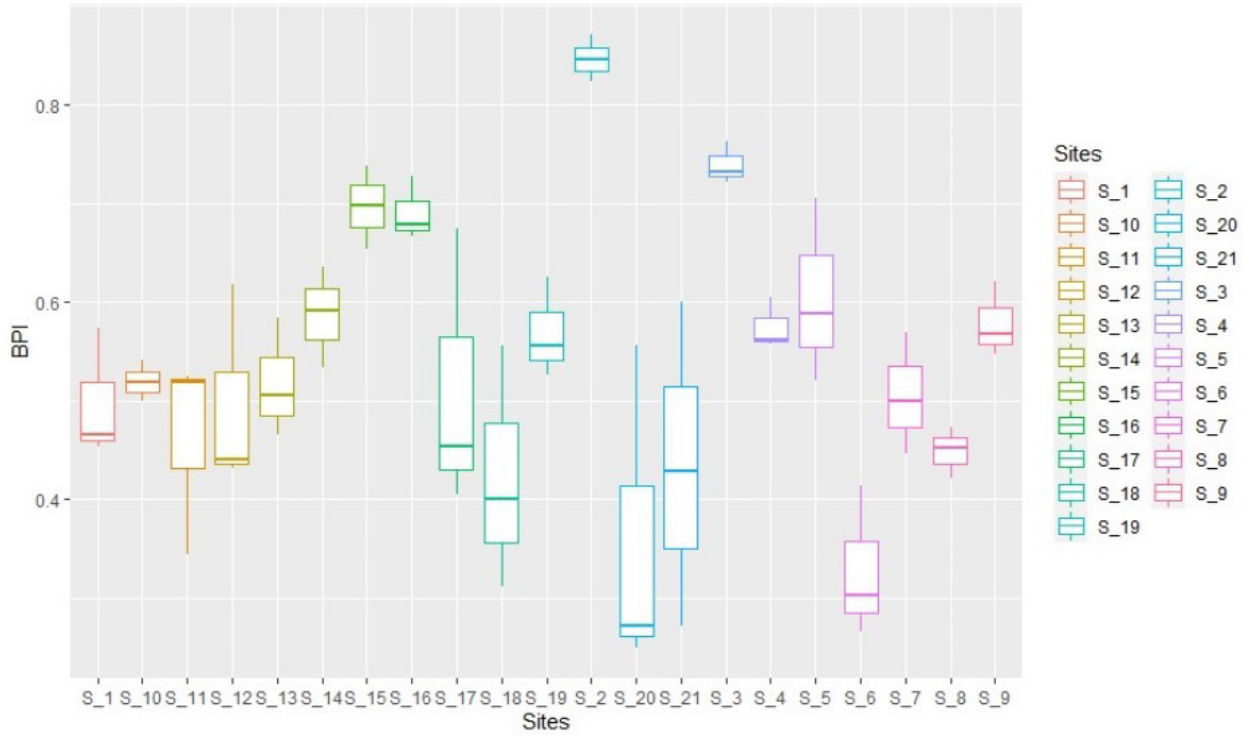

Figure 3. Ggplot of Berger-Parker index of dominance showing Site 2 has the highest and Site 6 has the lowest dominance.

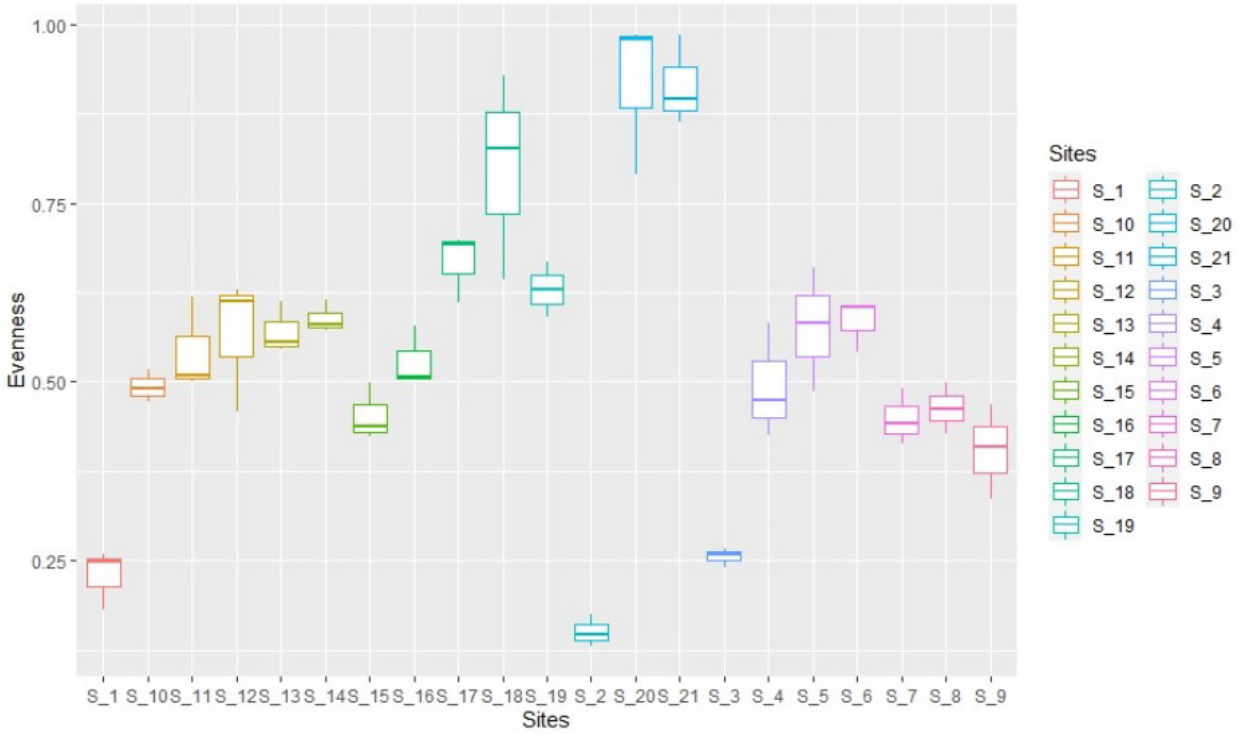

Figure 4. Ggplot of Pielou's index of evenness showing site 20 has the highest species evenness.

Table 2. Result of one-way ANOVA of Shannon-Wiener index, Berger-Parker index and Pielou's index of evenness of 21 sampling sites. F values are significant at p <0.001 level.

Index		D_f	Sum Sq	Mean Sq	F value	Pr (>F)
Shannon-Wiener index	Sites	20	8.712	0.4536	11.06	<0.001
	Residuals	42	1.655	0.0394		
Berger- Parker index	Sites	20	0.9414	0.04707	6.519	<0.001
	Residuals	42	0.3033	0.00722		
Pielou's index of evenness	Sites	20	2.2621	0.11311	27.92	<0.001
	Residuals	42	0.1701	0.00405		

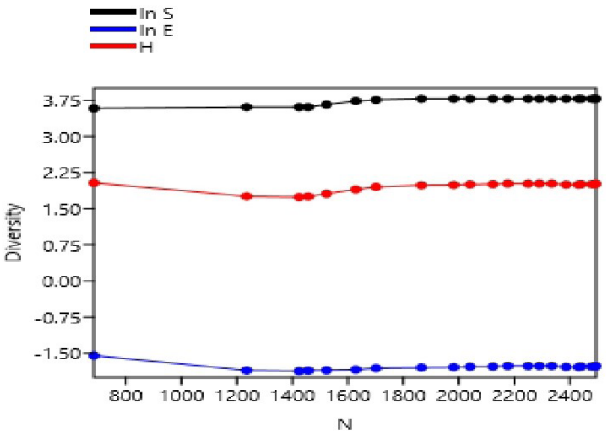

Figure 5. Graphical representation of SHE analysis.

Table 3. Results of Principal component analysis showing that dimension 1 has the highest eigenvalue and percent variance followed by dimension 2.

Dimensions	Eigen value	Percent variance	Cumulative percent variance
Dim.1	2.04390180	68.130060	68.13006
Dim.2	0.92147965	30.715988	98.84605
Dim.3	0.03461855	1.153952	100.00000

'Near Threatened' species *Mareca falcata, Threskiornis melanocephalus* and *Limosa limosa* as listed under *Dendrocygna javanica* and *Nettapus coromandelianus* are the most abundant. This is the first report of its kind on birds in 21 aquatic bodies and their surroundings in Bankura. Birds are vulnerable to changes in the landscape, pollution, hunting and other factors, so proper precautions must be taken to protect them. The Shannon-Wiener index is highest at site 6 and lowest at site 2, and the Berger-Parker index is highest at site 2 and lowest at site 6. Site 20 has the highest level of evenness. The results of SHE analysis show that the distribution of bird species in the studied area is a log series. The rarefaction curve depicts the likelihood of finding the most specimens at site 1, followed by site 2. The richness value observed during the current survey is higher than the values reported in 2000 for Purulia Saheb bandh (24 species) (Nandi et al. 2004), Santragachi lake in Howrah District, West Bengal (22 species) (Roy et al. 2011), Bakreswar and Hinglo reservoirs and Adra Saheb bandh lake (24 species) (Khan et al. 2016), but lower than the Kolkata surroundings (48 species) (Sengupta et al. 2013), Purulia town and its outskirts (115 species) (Mahato et al. 2021), agricultural landscape in Burdwan (Hossain & Aditya 2014). The Shannon index (2.28) in Sal Bandh (Site 6), which was the highest during the current survey, was lower than the Mukkali moist deciduous forest (3.45) and Purulia town and its outskirts (3.66) (Jayson & Mathew 2000; Mahato et al. 2021). In 2018 it was reported that the species richness of Mukutmanipur dam (81 species) (Singh et al. 2018) was much higher than the richness value in this dam during the present survey (36 species). The richness value for Jamuna bandh (12 species), Krishna bandh (11 species), and Kulaijurir bandh (6 species) was lower, but the Lal bandh (15 species) richness value was higher than the previous survey that was conducted in 2000 (Nandi et al. 2007). Apart from this, it was also found during the present survey Sal bandh (site 6), Kadam Deuli Dam (Site 7), Sutan Dam (Site 8), Gangdua Dam (Site 9), Bonkati Bandh (Site 10), Bagjobra Bandh (Site 11), Kesiakol Bandh (Site 12), Talberia Dam (Site 13), Kakila Daha (Site 14), Jhilimili Bandh (Site 15), Poabagan Bandh (Site 16), Chattna Bandh (Site 17), Nityanandapur Dam (Site 18), Ambikanagar Bandh (Site 19), Saheb Bandh (Site 20) and Ranir Bandh (Site 21) contain 19, 16, 15, 14, 12, 12, 10, 10, 8, 6, 6, 5, 6, 5, 5, and 5 species, respectively. The present study investigates that the reduction in richness value may be due to pollution by domestic sewage, pesticides, fertilizers, eutrophication and residential & commercial development in the bank of these aquatic bodies. The loss of avian diversity can have a significant impact on species

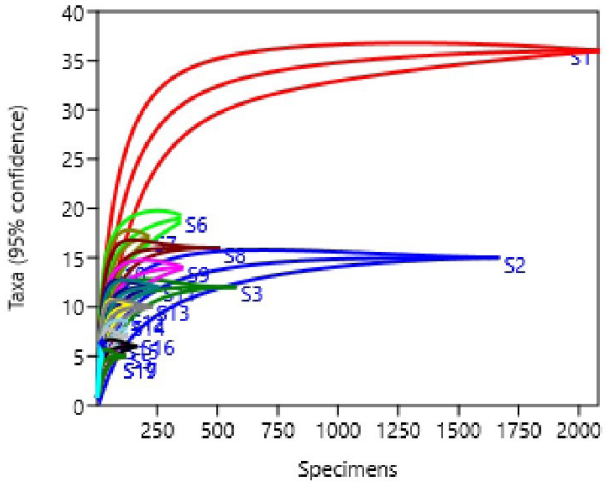

Figure 6. Rarefaction curve indicating site1 has the probability of finding the highest specimen in site1 followed by site 2.

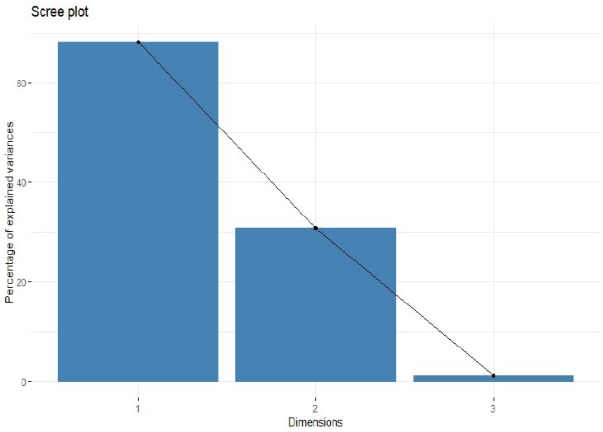

Figure 7. PCA scree plot indicates dimension 1 and dimension 2 contribute most of the percent variance.

interactions and ecosystem functions. Changes in avian diversity have an impact on the food chain (Hossain & Aditya 2014). Assessing avifauna assemblages to govern foraging behaviour and habitat preferences is critical for determining their importance in ecosystem services (Lawton et al. 1998; Sekercioglu 2006). It was observed that species richness values were lower for the Mukutmanipur dam, Jamuna bandh, Krishna bandh, and Kulaijurir bandhbut richness value was higher for Lal bandh than the previous survey (Nandi et al. 2004). A survey of sixteen new aquatic bodies was conducted that had not previously been done (Nandi et al. 2004). So, to begin the assessment of ecological services in a specific landscape, a document of species richness and composition of birds must be created and maintained as present study. This document aids in the comparison of aquatic bird diversity for future research. The primary step in the conservation of bird species and the maintenance of ecosystem services is the species-specific ecological role, which is far from complete in the Indian context (Dhindsa & Saini 1994; Singh &Banyal 2013; Sengupta et al. 2013; Sundar & Kittur 2013). This report can pique people's interest in conserving aquatic birds and their habitats and conservation of this avifauna is necessary for long-term development.

REFERENCES

Ali, S., (2002). *The Book of Indian Birds*. Oxford University Press, New Delhi, 486 pp.

Aich, A. & S.K. Mukhopadhyay (2008). Comparison of avifauna at the edges of contrasting forest patches in Western Ghat Hills of India. *Ring* 30(1/2): 71–79. https://doi.org/10.2478/v10050-008-0001-6

Basavarajappa, S. (2006). Avifauna of agro-ecosystems of Maidan area of Karnataka. *Zoos' Print Journal* 21(7): 2217–2219. https://doi.org/10.11609/JoTT.ZPJ.1277.2217-9

Basu, P., S. Sao & R. Singh (2018). Diversity, seasonal, variation, abundance and migratory behavior of local and migratory water birds of Mukutmanipur Dam, Bankura, West Bengal, India. *World Journal of Pharmaceutical Research* 7(11): 855–869.

Berger, W.H., & F.L. Parker (1970). Diversity of Planktonic foraminifera in deep- sea sediments. *Science* 168: 1345–1347. https://doi.org/10.1126/science.168.3937.1345

Biswas, S.J.B., D. Patra, S. Roy, S.K. Giri, S. Paul & A. Hossain (2019). Butterfly diversity throughout Midnapore urban area in West Bengal, India *Journal of Threatened Taxa* 11(4): 14816-14826. https://doi.org/10.11609/jott.4587.11.14.14816-14826

Borad, C.K., A. Mukherjee & B.M. Parasharya (2001). Damage potential of Indian Sarus Crane in paddy crop agro-ecosystems in Kheda district, Gujarat, India. *Agriculture, Ecosystems and Environment* 86: 211–215. https://doi.org/10.1016/S0167-8809(00)00275-9

Bradford, D.F., S.E. Franson, A.C. Neale, D.T. Heggem, G.R. Miller & G.E. Canterbury (1998). Bird species assemblages as indicators of biological integrity in Great Basin Rangeland. *Environmental Monitoring and Assessment* 49: 1–22. https://doi.org/10.1023/A:1005712405487

Browder, S.F., D.H. Johnson & I.J. Ball (2002). Assemblages of breeding birds as indicators of grassland condition. *Ecological Indicators* 2: 257–270. https://doi.org/10.1016/S1470-160X(02)00060-2

Chatterjee, A., S. Adhikari, A. Barik & S.K. Mukhopadhyay (2013). The mid-winter assemblage and diversity of bird populations at Patlakhawa Protected Forest, Coochbehar, West Bengal, India. *Ring* 35: 31–53. https://doi.org/10.2478/ring-2013-0002

Dhindsa, M.S. & H.K. Saini (1994). Agricultural ornithology: An Indian perspective. *Journal of Biosciences* 19(4): 391–402. https://doi.org/10.1007/BF02703176

Grimmett, R., C. Inskipp & T. Inskipp (1998). *Birds of the Indian Subcontinent*. Oxford University Press, New Delhi, 528 pp.

Hammer, Ø., D.A.T. Harper & P.D. Ryan (2001). PAST: paleontological statistics software package for education and data analysis. *Palaeontology* 4(1): 9.

Hossain, A. & G. Aditya (2014). Avian Diversity in Agricultural Landscape: Records from Burdwan, West Bengal, India. *Proceedings of the Zoological Society* 69(1): 38–51. https://doi.org/10.1007/s12595-014-0118-3

Jayson, E. & D.N. Mathew (2000). Diversity and species abundance distribution of birds in the tropical forests of Silent Valley, Kerala. *Journal of the Bombay Natural History Society* 97: 390–400.

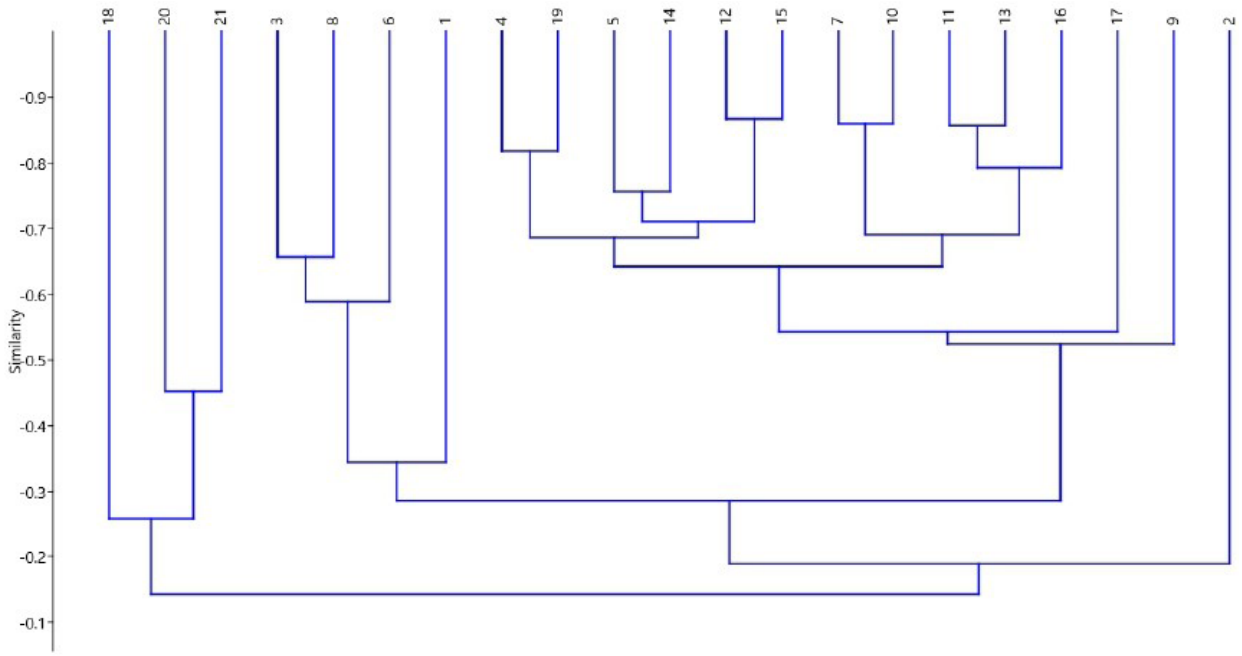

Figure 8. Results of classical cluster analysis by using algorithm UPGMA (Brey-Curtis index) showing similarity between all 21 study sites.

Kazmierczak, K. & B. van Perlo (2000). *Birds of India*. Om Books International, New Delhi.

Khan, T.N., A. Sinha & P. Hazra (2016). Population trends and community composition of migratory waterbirds in three emerging wetlands of global significance in southwestern Bengal, India. *Journal of Threatened Taxa* 8(3): 8541–8555. https://doi.org/10.11609/jott.2652.8.3.8541-8555

Kumar, A., P.C. Tak & J.P. Sati (2006). Residential, population and conservation status of Indian wetland birds. In: Boere, G.C., C.A. Galbraith & D.A. Stroud (eds.). *Waterbirds Around the World* ed. The Stationery Office, Edinburgh, UK.

Kumar, P. & S.K. Gupta (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

Lawton, J.H., D.E. Bignell, B. Bolton, G.F. Bloemers, P. Eggleton, P.M. Hammond, M. Hodda, R.D. Holt, T.B. Larsen, N.A. Mawdsley, N.E. Stork, D.S. Srivastava & A.D. Watt (1998). Biodiversity inventories, indicator taxa, and effects of habitat modification in tropical forest. *Nature* 391: 72–76. https://doi.org/10.1038/34166

Mahato, S., S. Mandal & D. Das (2021). An appraisal of avian species diversity in and around Purulia Town, West Bengal, India. *Journal of Threatened Taxa* 13(3): 17906–17917. https://doi.org/10.11609/jott.4733

Mukherjee, K. & A. Mondal (2020). Butterfly diversity in heterogeneous habitat of Bankura, West Bengal, India. *Journal of Threatened Taxa* 12(8): 15804–15816. https://doi.org/10.11609/jot.5136.12.8.15804-15816

Mukherjee, S.S., M.T. Ahmed & A. Hossain (2021). Role of a Global Invasive Species (GIS), *Lantana camara* in conservation and sustenance of local butterfly community. *Acta Ecologica Sinica* 42(6): 600–604. https://doi.org/10.1016/j.chnaes.2021.02.008

Nandi, N.C., K. Bhenkataraman, S.R. Das & S.K. Das (2007). Notes on mid-winter water bird population of some selected wetlands of Bankura and Purulia districts, West Bengal. *Records of the Zoological Survey of India* 107(Part 2): 61–91.

Nandi, N.C., S. Bhuinya & S.R. Das (2004). Notes on mid-winter water bird population of some selected wetlands of Bankura and Purulia districts, West Bengal. *Records of the Zoological Survey of India* 102(Part 1–2): 47–51.

Pielou, E.C. (1969). *An Introduction to Mathematical Ecology*. John Wiley, New York, 286 pp.

Roy, U.S., A.R. Goswami, A. Aich & S.K. Mukhopadhyay (2011). Changes in densities of water bird species in Santragachi Lake, India: potential effects on limnochemical variables. *Zoological Studies* 50(1): 76–84.

RStudio Team (2020). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA. http://www.rstudio.com/.

Sekercioglu, C.H. (2006). Increasing awareness of avian ecological function. *Trends in Ecology and Evolution* 21(8): 464–471.

Sekercioglu, C.H. (2012). Bird functional diversity and ecosystem services in tropical forests, agroforests and agricultural areas. *Journal of Ornithology* 153(Suppl 1): 153–S161.

Sengupta, S., M. Mondal & P. Basu (2013). Bird species assemblages across a rural urban gradient around Kolkata. *Urban Ecosystems* 17: 585–596. https://doi.org/10.1007/s11252-013-0335-y

Shannon., C.E. & W. Wiener (1963). *The Mathematical Theory of Communications*. University of Illinois Press, Urbana, Illinois, 117 pp.

Singh, V. & H.S. Banyal (2013). Avian fauna of Khajjar Lake, district Chamba, Himachal Pradesh, India. *Proceedings of the Zoological Society* 66(2): 130–136. https://doi.org/10.1007/s12595-012-0049-9

Sundar, K.G.G. (2011). Agricultural intensification, rainfall patterns, and large waterbird breeding success in the extensively cultivated landscape of Uttar Pradesh, India. *Biological Conservation* 144: 3055–3063. https://doi.org/10.1016/j.biocon.2011.09.012

Sundar, K.G.G. & S. Kittur (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. https://doi.org/10.1016/j.biocon.2013.09.016

Whelan, C.J., D.G. Wenny, & R.J. Marquis (2008). Ecosystem services provided by birds. *Annals of the New York Academy of Sciences* 1134: 25–60.

Journal of Threatened Taxa is indexed/abstracted in Bibliography of Systematic Mycology, Biological Abstracts, BIOSIS Previews, CAB Abstracts, EBSCO, Google Scholar, Index Copernicus, Index Fungorum, JournalSeek, National Academy of Agricultural Sciences, NewJour, OCLC WorldCat, SCOPUS, Stanford University Libraries, Virtual Library of Biology, Zoological Records.

NAAS rating (India) 5.64

Print copies of the Journal are available at cost. Write to:
The Managing Editor, JoTT,
c/o Wildlife Information Liaison Development Society,
43/2 Varadarajulu Nagar, 5th Street West, Ganapathy, Coimbatore,
Tamil Nadu 641006, India
ravi@threatenedtaxa.org

Journal of Threatened Taxa

www.threatenedtaxa.org

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

December 2023 | Vol. 15 | No. 12 | Pages: 24291–24450
Date of Publication: 26 December 2023 (Online & Print)
DOI: 10.11609/jott.2023.15.12.24291-24450

Articles

Communications

Short Communications

Publisher & Host

WILD zoo reach
Zoo Outreach Organisation

Threatened Taxa