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Composition and seasonality of avifauna found near the National Thermal Power Corporation area of Angul district, Odisha, India

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Abstract

The present study was undertaken from November 2020 to October 2021 to understand the bird species diversity, and variation in their seasonality, near the National Thermal Power Corporation (NTPC) area of Talcher located in Angul district of Odisha state in India. The identified birds included 668 individuals of 90 species (including three near-threatened species) belonging to 18 orders, 41 families and 75 genera. As per the study, Passeriformes is found to be most dominant with 34 species (38% of total bird species). Considering the feeding guilds of birds, insectivore bird species were found in higher number (32 species) followed by carnivores (16 species), and then omnivores and frugivores (10 species each). It was found that the winter season was the most species rich (70 species, 328 individuals), and the monsoon season the least (43 species, 127 individuals). The Shannon-Wiener index (H'= 3.48) was also found to be high in winter season but the evenness index (E= 0.65) was found to be higher in monsoon season. The cluster analysis showed that the bird composition of the summer season strongly correlates with bird composition of the winter and monsoon seasons, but the bird composition of the monsoon season is not significantly correlated with bird composition of the winter season. The results from the study can act as the baseline for further research on birds in the Angul district of Odisha.

Key words: Abundance, bird diversity, checklist, industrial area, Talcher

Introduction

An industrial area generally comes under the urbanized part of any town and is predominantly serving the primary purpose of accommodating all forms of manufacturing, assembling, processing or treating of raw materials. These industries are the major stockholders of the economy of any region and also are an integral part of economic development. Apart from their primary purpose, it is evident that industrial areas create negative impacts for the surrounding environment, as well as on the local avifaunal wealth (Jay et al., 2007; Yanhua et al., 2011; Mardiastuti et al., 2018; Putera et al., 2018). Birds have high ecological value because of their important roles as (1) excellent proxy taxa for detecting any environmental changes, (2) best insect control agents, (3) seed dispersers and (4) pollinators (Stratford and Şekercioğlu, 2015). Hence, studying the exact effect of industrial areas on local avifauna is a prerequisite to assess the risks associated with them (Mohanty et al., 2020). The industrial area will have little conservation significance yet may act as one of the points for locals to interact with wildlife. Understanding the interaction of birds with industrial settings helps us to learn more about their behavior, physiology, and ecology. Ultimately, this will help in decision making, formulating various counter measures for the restoration of environmental damage and will positively contribute toward avifauna sustainability (Gibson et al., 2013).

According to a prominent study on the detrimental effects of industrial areas on bird species diversity, bird species richness is less in the industrial area of Amaravaty city than it is in the surrounding rural forest areas of central India (Kale et al., 2011). In the same region, it has been revealed that the industrial regions are the second-least favorable habitat for bird species to live, after rural forest areas (Kale et al., 2018). Apart from these two studies conducted in India, only a couple of noteworthy studies could be added regarding the avifauna of major industrial areas present in Rourkela and Paradeep districts of Odisha (Palei et al., 2014; Priyadarshini et al., 2016). The Angul district is known as the 'Industrial capital' of Odisha due to the presence of numerous major, national-level, public sector and private industries such as National Aluminum Company (NALCO), Mahanadi Coalfield Limited (MCL), National Thermal Power Corporation (NTPC), Jindal Steel and Power Limited, Bhushan Power and Steel Limited and state operated public sector industries like Talcher Thermal Power Station (TTPS) (ENVIS Centre of Angul, 2023). Only three studies have been published documenting the avifaunal diversity of Angul district. Firstly, the sighting of a Black-bellied Tern (*Sterna acuticauda*) in Samal reservoir by Palei and Mohapatra (2011). Secondly, the checklist of aquatic birds of Angul, which was given by Pradhan et al. (2012). And the third, and most recent, study was carried out by the Government (Autonomous) College of Angul, where 46 bird species belonging to 40 genera within 26 families were identified (Bagha and Sahoo, 2022). In addition, despite Talcher town's significance within the Angul district, only one study on the subject of avifaunal diversity was conducted by Panda et al. (2021), who found that there were only 17 species present in this town. Considering this knowledge deficiency of avian species diversity in Talcher, the present study aims to document the first detailed and comprehensive information on the avian species diversity present near the industrial area of NTPC. It also attempts to explain the variation in their seasonality by comparing bird species richness and abundance across various seasons.

Material and Methods

Study area

Talcher town is situated in central Angul district of Odisha, having an area of 147 sq. km. with more than 60,000 inhabitants (ENVIS Centre of Odisha, 2023). The coal fields of this area are a subsidiary of MCL and harbor the largest natural coal storage in the state (Mishra and Das, 2017). The NTPC is one of the largest public sector thermal power plants present in Talcher town of Odisha. The NTPC industrial area lies between 21°5'44" and 21°5'48" N and 85°5'76" and 85°7'04" E. The elevation of the study area varies from 72 m to 85 m a.s.l.. The main source of water to the power plant is the second largest river of Odisha, the Brahmani, on its eastern side and the Tikera River (a tributary of the Brahmani River) on the northern side (Fig. 1). Three villages are present near NTPC industrial area: (1) Karadei, (2) Gadashila and (3) Kateni. Our study area is 13.3 sq. km. with a perimeter of 15.6 km. The entire area can be broadly categorized into: (1) open forest, (2) semi-evergreen forest, (3) agricultural area, (4) human habitation, (5) water bodies/wetlands and (6) barren land. A map of the study area was prepared using ArcGIS software (version 10.5) (Fig. 1). The composition of vegetation inside the forested area includes dominant plant species like *Shorea robusta*, *Abrus pracatorius*, *Achyranthes aspera*, *Argemone mexicana*, *Dalbergia sissoo*, *Terminalia bellirica* and rare species like *Acacia nilotica*, *Buchanania lanzan*, *Emblica officinalis* and *Woodfordia fruticose* (Mahalik et al., 2014). The agricultural area is composed of plant species such as *Oryza sativa*, *Lens culinaris*, *Vigna mungo*, *Macrotyloma uniflorum* and vegetables like *Solanum melongena*, *S. tuberosum* and *Pisum sativum*. The human inhabitants include the villagers from the above-mentioned three villages and residential quarters, market complexes, hospital and schools present inside the Permanent Township (PTS) of NTPC. The three distinct seasons felt here are summer (March to June), monsoon (July to October) and winter (November to February) (ENVIS Centre of Angul, 2023). The lowest temperature recorded was during the winter season (12.3 °C) and the highest was during the summer season (41.7 °C), and the annual mean temperature is 29.3 °C. The annual rainfall is 1401.9 mm and the lowest precipitation was recorded during December (0.50 mm) and highest in August (357 mm) (IMD, 2023).

Data collection

Weekly field visits were conducted in order to document the avifauna of this area covering all three seasons from November, 2020 to October, 2021. The point count method was applied to identify and record the number of individuals of a bird species, but a modified distant point count method was applied while surveying agricultural fields and waterbodies (Bibby et al., 2000). A 50 m radius circular area, encircling each point, was considered for the sighting and hearing the calls of any bird species. Each point was scanned for 15 to 20 minutes during early morning hours (06:00 AM to 10:00 AM) and early afternoon to evening hours (03:00 PM to 06:00 PM). A few localities inside the study area were visited regularly to increase the chances of recording maximum number of bird species. The distant bird species were scanned using NIKON (8×40) field binoculars and photographed using NIKON D5600 DSLR with 70–300 mm telephoto lens. The unidentified bird species were photographed during field survey and later identified from available field guides (Ali, 2002; Grimmett et al., 2011; Grewal et al., 2016).

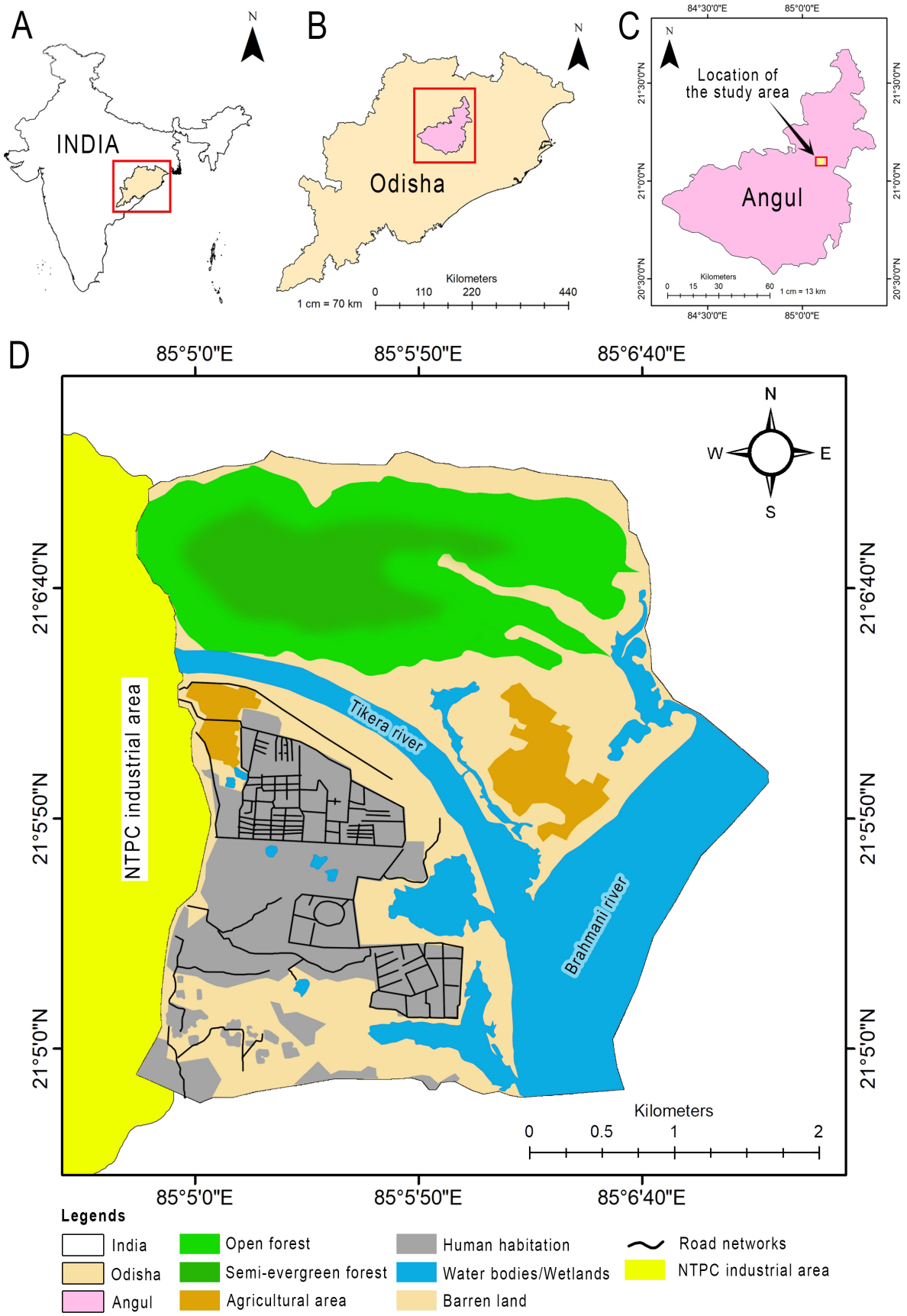

Figure 1: Location of the study area. (A) Odisha in India, (B) Angul in Odisha, (C) location of the study area inside Angul district and (D) stratified map of the study area.

Information on the scientific name of each bird species, its author and the year of description was taken from online resources and available literature (Avibase, 2023; Birdlife International, 2023; Praveen et al., 2016). The threat category of each bird species was determined by following the IUCN Red List (IUCN, 2023). The IUCN Red List threat category and schedule category of each bird species recognized under the Indian Wildlife Protection Act (IWPA), 1972 is also given in the final checklist (Table 1) (IWPA, 1972).

The abundance of each bird species was based upon the number of sightings of each bird species. The three categories of abundance are: (1) common (C- if the number of sightings is more than 10), (2) fairly common (FC- if the number of sightings is between 5 to 10) and (3) rare (R- if the number of sightings is less than 5) (Lenka and Singh, 2020). The resident status of each bird species was documented by categorizing them into three types: (1) Resident (RE- birds which are resident to that area and encountered in every field visit), (2) winter visitor (WV- bird species only encountered during the winter season and lastly), and (3) local migrant (LM- these bird species found to breed outside of the study area) (Lenka and Singh, 2020).

The feeding guild of each bird species was also observed during the field surveys. Some bird species were observed to follow more than one type of diet or feeding guild but only a single type of feeding guild was assigned to each bird species and given in the final checklist (Table 1). The following feeding guilds were determined: (1) carnivore: feeds on flesh, meat and smaller mammals, reptiles; (2) herbivore: major diet are root and stems of a plant; (3) frugivore: largely dependent on ripen fruits, figs and berries; (4) insectivore: diet include small beetles, grasshoppers, caterpillars, butterflies, moths, bugs, etc.; (5) molluscivore: feeds on bivalves; (6) nectarivore: core diet is nectars of flowers and sweet saps of plants; (7) omnivore: take seeds, plant parts as well as smaller reptiles, mammals and insects; (8) piscivore: exclusive diet is fish and nothing else and (9) granivore: feeds on seeds and grains of different crops (Lenka et al., 2022). All these data are compiled and given in a final checklist (Table 1).

The relative abundance of different bird orders is calculated by the following formula.

$$\text{Relative abundance} = \frac{\text{Abundance of all bird species under an order}}{\text{Total abundance of all bird species}} \times 100$$

The total number of bird species, or the species richness, and the total number of individuals, or the abundance, of each bird species was documented by season for further data analysis. The seasonal abundance dataset of the entire avian community recorded in the study is given in Table 1.

Data analysis

Seasonal abundance data of the bird species was taken as a pre-requisite for data analysis. The bird species diversity was calculated by season using two diversity indices with the help of PAST software version 3.06 (PAST, 2020). The calculated diversity indices are as follows.

(1) Shannon-Wiener diversity index (H'): This index was given by Shannon (1948) and Shannon and Weaver (1998). The 'ni' is the total number of individuals found in a season and 'N' is the total species richness in a season. The higher value of this index suggests that the season is diverse when compared to other seasons. The index is calculated using the formula given below.

$$H' = -\sum_{i=1}^{s} \frac{ni}{N} \times ln\frac{ni}{N}$$

(2) Evenness index or Smith and Wilson's index (E): This is largely based upon the Shannon-Wiener diversity index. The higher value generally means the individuals of birds are distributed evenly in a season. This was given by Smith and Wilson (1996) and calculated using the following formula.

$$E = \frac{H'}{LogeS}$$

In order to check the seasonal distribution of avian species, the preference of season by different bird species were analyzed by cluster analysis in R software and visualized using matrix plot (R Core Developing Team, 2023).

Bray-Curtis similarity index was done with the help of PAST software in checking similarities between abundance of avifaunal diversity found in between three seasons in this study.

Results

Ninety bird species were identified from the study area belonging to 18 orders, 41 families and 75 genera. Passeriformes dominated with 34 species (38% of total bird species), followed by Charadriiformes (10 species, 11%), Pelecaniformes (8 species, 9%), Accipitriformes (7 species, 8%), Coraciiformes (5, 5.5%) and Columbiformes (4, 4.4%). Among different bird families, Accipitridae and Ardeidae family dominated among other families having 7 species each. Three families like Motacillidae, Scolopacidae, Sturnidae were having 5 species each followed by Columbidae (4 species). Alcedinidae, Anatidae, Estrildidae and Corvidae families were observed to each have 3 species. Among 90 bird species, 15 species (17%) were found to be common, 26 species (29%) were fairly common and remaining 49 species (54%) were rare. According to the residential status of bird species found here, 44 species (49%) were found to be

resident to this place, whereas 28 species were local migrants (31%) and 18 species (20%) were winter visitors (Table 1). Only three bird species i.e., (1) Alexandrine Parakeet (*Psittacula eupatria*), (2) Egyptian Vulture (*Neophron percnopterus*) and (3) Oriental Darter (*Anhinga melanogaster*) are found to be under Near Threatened category of IUCN (IUCN, 2023). The seasonal abundance (common, fairly common, rare) and residential status (resident, local migrant, winter visitor) of bird species found inside the study area are included in Table 1.

The relative abundance of different bird orders in this study was calculated and the highest was Passeriformes (324 individuals, 48.5% of total abundance) followed by Accipitriformes (61 individuals, 9.13%), Psittaciformes (54 individuals, 8.08%), Charadriiformes (52 individuals, 7.78%), and Columbiformes (37 individuals, 5.54%). The relative abundance was found to be lower in the Suliformes (n= 7 individuals, 1.05%), Caprimulgiformes (n= 5, 0.75%), Cuculiformes and Strigiformes (n= 4 each, 0.60%), Podicipediformes (n= 3, 0.45%) and lastly the least relative abundance was found in the order Ciconiiformes (n= 1, 0.15%).

As per the feeding guild, insectivore bird species dominated with 32 species followed by carnivore (17 species), frugivore (10 species), omnivore (9 species), piscivore and granivore (9 species each) and nectarivore (2 species). Only a single species was found under both herbivore and molluscivore feeding guild in this study (Fig. 2).

Bird species richness and abundance by season

Across three seasons, species richness was found to be highest during the winter season (70 species, 78% of all species), followed by summer (56 species, 62%), and then monsoon (43 species, 48%) (Fig. 3). A total of 668 individuals of birds were recorded during this study across three seasons. Like species richness, the total abundance of all bird species was observed in highest numbers during the winter season (328 individuals, 49% of total 668 individuals), less in summer (213 individuals, 32%), then least in winter (127 individuals, 19%).

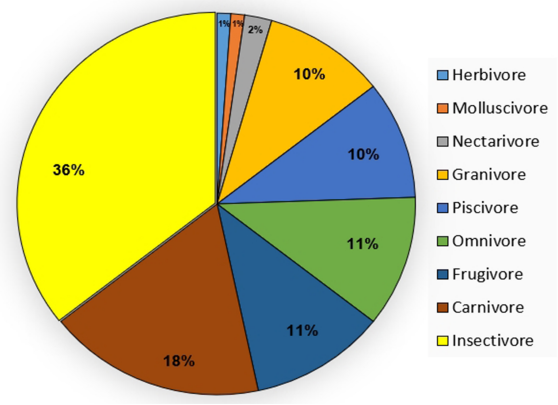

Figure 2: Percentage of each feeding guild observed among avian community present near NTPC.

Seasonal diversity indices

The Shannon-Wiener diversity index was calculated to be highest during the winter season (H'= 3.76), followed by summer (H'= 3.48) and lastly monsoon (H'= 3.33). But the evenness index (E) was calculated to be highest in the monsoon season (E= 0.65), followed by winter (E= 0.61) and the least was calculated during the summer season (E= 0.58). This means that individual birds are found to be more evenly distributed during the monsoon season, but randomly distributed during the summer season. The value of H' can be attributed to the fact that winter season is the most diverse season for the birds found here and the monsoon season is the least diverse for sustaining bird species found in all three seasons.

Relationship between bird species and different seasons

The matrix plot produced by the cluster analysis shows that the bird species were distributed along both axes in all three seasons yet have differences in their species diversity and composition. It also displays that the avian community observed during the summer season is strongly correlated with species composition of winter and monsoon seasons but the species composition of the monsoon season is not significantly correlated with the bird community of the winter season (Fig. 4).

The Bray-Curtis similarity index dendrogram clearly shows the similarity between summer and winter seasons, forming a single cluster, whereas the bird species recorded during the monsoon season are not shown to be similar with other seasons and form a separate cluster in the dendrogram (Fig. 5).

Photographs of some birds, along with the threatened bird species of the study area, are provided in the figure below (Fig. 6).

Discussion

The presence of different habitat types with different vegetation composition is mainly responsible for the existing avian fauna inside the study area. It ensures the availability of food for the majority of bird species in the different feeding guilds observed in the study area. Among them, plants like *Ficus bengalensis*, *F. religiosa*, *Cocos nucifera*, *Butea monosperma*, *Neolamarckia cadamba* provide food and shelter to the arboreal frugivore birds like the Indian Grey Hornbill (*Ocyceros birostris*), Brown-headed Barbet (*Psilopogon zeylanicus*), Coppersmith Barbet (*Psilopogon haemacephalus*), Indian Golden Oriole (*Oriolus kundoo*) and Black-hooded Oriole (*Oriolus xanthornus*). The presence of other sweet fruit plant species, like Black Currant (*Ribes nigrum*), Guava (*Psidium guajava*), Mango (*Mangifera indica*), and Pomegranate (*Punica granatum*) fulfill the food requirement of threatened bird species like the Alexandrine Parakeet (*Psittacula eupatria*) along with the abundant Rose-ringed Parakeet (*Psittacula krameri*).

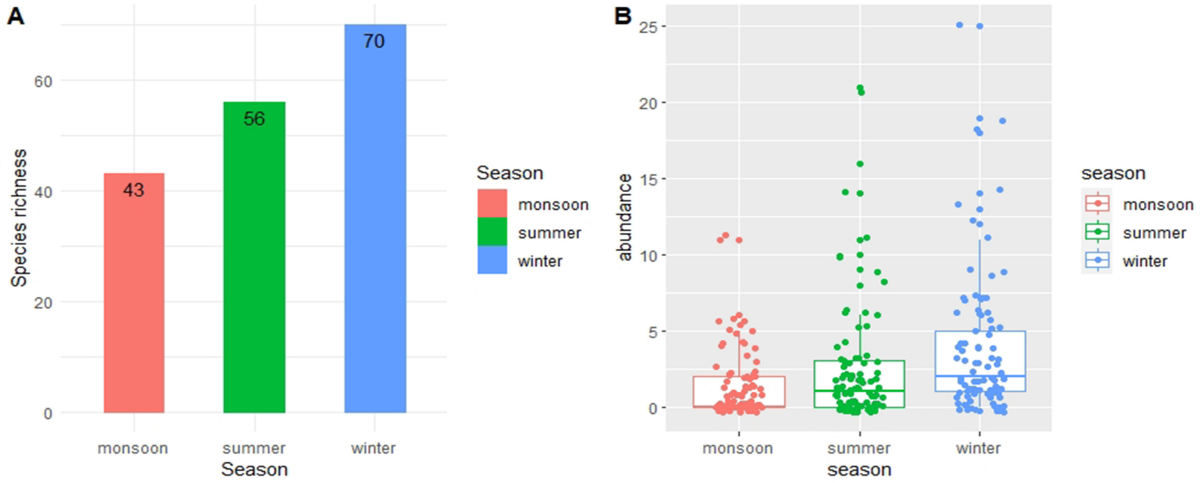

Figure 3: Seasonal species richness and abundance recorded near NTPC area. (A) Bird species richness and (B) Box-plot of bird species abundance.

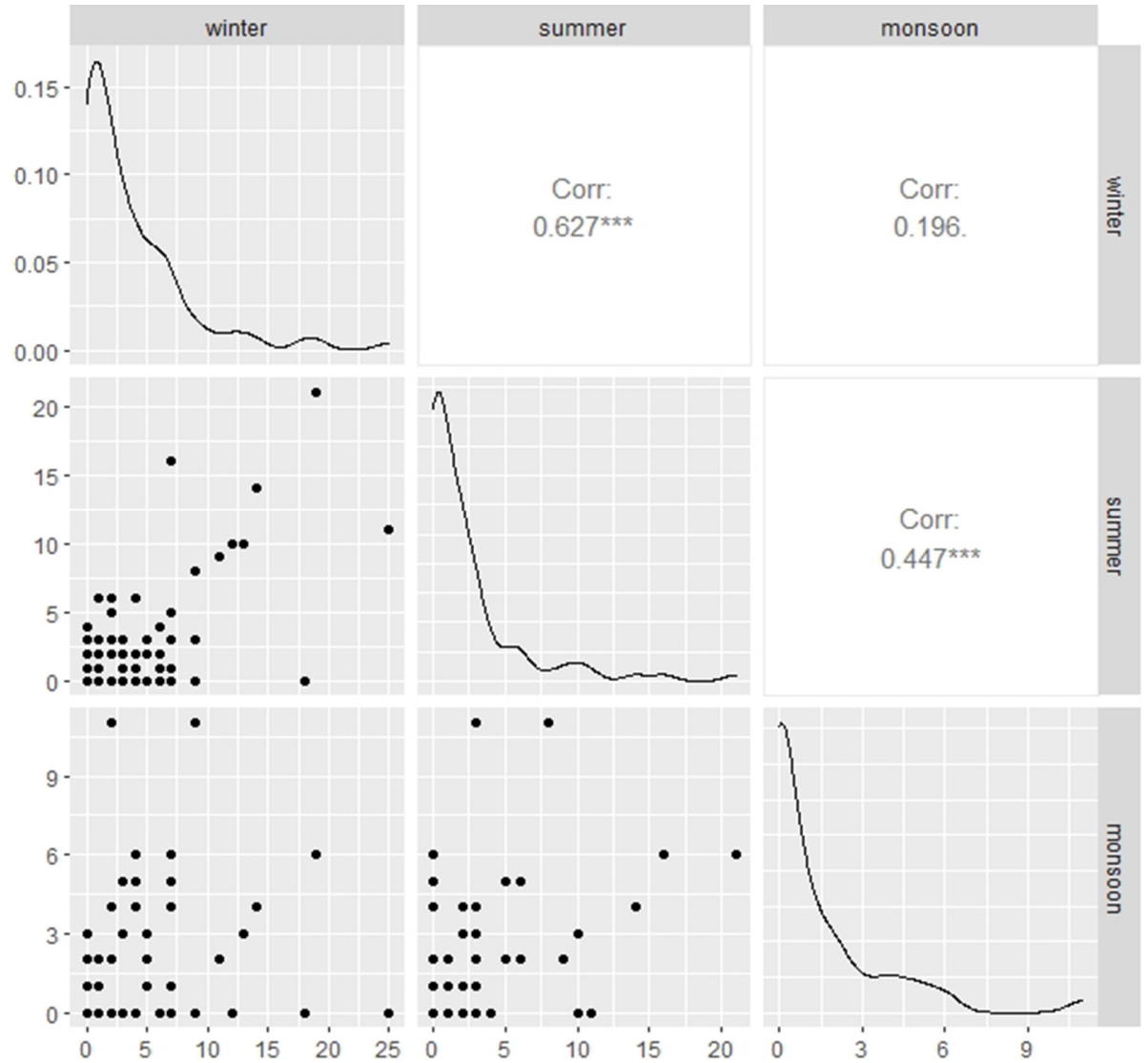

Figure 4: Matrix plot showing the distribution and preference of season for different bird species near NTPC. In this plot, the abundance of bird is checked to find the correlation with seasons (winter, summer and monsoon) which is the response variable. Here the minitabs (three in number) on the lower left portion are displaying the scatter plots of season wise bird species abundance whereas the minitabs (three) of upper right portion is showing the correlation values between bird species abundance and seasons. The diagonal minitabs (three) are showing the histogram (line) of each dimension of this correlation matrix plot.

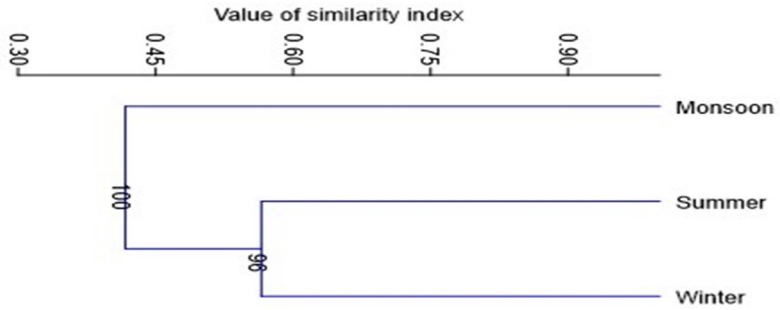

Figure 5: Bray-Curtis similarity index dendrogram showing the similarity among seasons.

Figure 6: Photographs (A-L) of birds found near NTPC industrial area. Note: NT (written in bold and red color) = Near Threatened category of IUCN. All the photographs were taken by Rajesh Lenka.

Table 1: Annotated checklist of birds with their abundance recorded across three seasons near NTPC area, Talcher, Odisha, India. Note: R. status: Residential status, C: Common, FC: Fairly common, R: Rare; WV: Winter visitor, RE: Resident and LM: Local migrant, NT: Near Threatened species of IUCN. Schedule category of each bird species according to the Indian Wildlife Protection Act (IWPA), 1972 (Schedule I, Schedule II, Not listed).

Sl. No.	Common name	Scientific name	Winter	Summer	Monsoon	Abundance	R. status	Feeding guild	IWPA (Indian Wildlife Protection Act), 1972 schedule
			Order Anseriformes Family Anatidae						
1	Lesser whistling duck	*Dendrocygna javanica* (Horsefield, 1821)	25	11	0	C	WV	Omnivore	Schedule II
2	Cotton pygmy goose	*Nettapus coromandelianus* (J.F. Gmelin, 1789)	6	1	0	FC	RE	Omnivore	Schedule I
3	Garganey	*Spatula querquedula* (Linnaeus, 1758)	9	0	0	FC	RE	Herbivore	Schedule II
			Order Podicipediformes Family Podicipedidae						
4	Little grebe	*Tachybaptus ruficollis* (Pallas, 1764)	1	1	1	R	RE	Piscivore	Schedule II
			Order Columbiformes Family Columbidae						
5	Rock pigeon	*Columba livia* J.F. Gmelin, 1789	11	9	2	C	RE	Granivore	Not listed
6	Laughing dove	*Streptopelia senegalensis* (Linnaeus, 1766)	1	2	1	R	LM	Granivore	Schedule II
7	Eurasian collared dove	*Streptopelia decaocto* (Frivaldszky, 1838)	3	0	0	R	LM	Granivore	Schedule II
8	Spotted dove	*Spilopelia chinensis* (Scopoli, 1786)	3	0	5	FC	RE	Granivore	Schedule II
			Order Caprimulgiformes Family Apodidae						
9	Asian palm-swift	*Cypsiurus balasiensis* (J.E. Gray, 1830)	4	1	0	R	LM	Insectivore	Schedule II
			Order Cuculiformes Family Cuculidae						
10	Greater coucal	*Centropus sinensis* (J.F. Gmelin, 1788)	0	0	1	R	LM	Omnivore	Schedule II
11	Asian koel	*Eudynamys scolopaceus* (Linnaeus, 1758)	1	0	2	R	LM	Omnivore	Schedule II
			Order Gruiformes Family Rallidae						
12	White-breasted waterhen	*Amaurornis phoenicurus* (Pennant, 1769)	1	0	0	R	WV	Omnivore	Schedule II
13	Grey-headed swamphen	*Porphyrio porphyrio* (Linnaeus, 1758)	5	3	2	FC	RE	Omnivore	Schedule II
			Order Galliformes Family Phasianidae						
14	Gray francolin	*Francolinus pondicerianus* (J.F. Gmelin, 1789)	0	1	0	R	LM	Omnivore	Schedule II
			Order Ciconiiformes Family Ciconiidae						
15	Asian openbill stork	*Anastomus oscitans* (Boddaert, 1783)	0	0	1	R	LM	Molluscivore	Schedule II
			Order Pelecaniformes Family Ardeidae						
16	Black-crowned night heron	*Nycticorax nycticorax* (Linnaeus, 1758)	0	3	1	FC	LM	Piscivore	Schedule II
17	Indian pond heron	*Ardeola grayii* (Sykes, 1832)	7	0	1	FC	RE	Carnivore	Schedule II
18	Purple heron	*Ardea purpurea* Linnaeus, 1766	0	1	0	R	LM	Carnivore	Schedule II
19	Little egret	*Egretta garzetta* (Linnaeus, 1766)	0	3	1	R	LM	Piscivore	Schedule II
20	Cattle egret	*Bubulcus ibis* (Linnaeus, 1758)	0	2	3	R	RE	Insectivore	Schedule II
21	Intermediate egret	*Ardea intermedia* Wagler, 1829	7	0	4	C	RE	Carnivore	Schedule II
22	Great egret	*Ardea alba* (Linnaeus, 1758)	0	1	0	R	LM	Carnivore	Schedule II

Table 1: (Continued).

Sl. No.	Common name	Scientific name	Winter	Summer	Monsoon	Abundance	R. status	Feeding guild	IWPA (Indian Wildlife Protection Act), 1972 schedule
			Family Anhingidae						
23	Oriental darter (NT)	*Anhinga melanogaster* Pennant, 1769	1	0	0	R	WV	Piscivore	Schedule II
			Order Suliformes Family Phalacrocoracidae						
24	Little cormorant	*Microcarbo niger* (Vieillot, 1817)	0	1	0	R	LM	Piscivore	Schedule II
25	Indian cormorant	*Phalacrocorax fuscicollis* Stephens, 1826	4	2	0	FC	RE	Piscivore	Schedule II
			Order Charadriiformes Family Recurvirostridae						
26	Black-winged stilt	*Himantopus himantopus* (Linnaeus, 1758)	9	3	0	C	RE	Carnivore	Schedule II
			Family Charadriidae						
27	Little ringed plover	*Charadrius dubius* Scopoli, 1786	3	2	0	R	LM	Insectivore	Schedule II
28	Red-wattled lapwing	*Vanellus indicus* (Boddaert, 1783)	2	2	4	FC	RE	Insectivore	Schedule II
			Family Jacanidae						
29	Pheasant-tailed jacana	*Hydrophasianus chirurgus* (Scopoli, 1786)	5	0	1	FC	RE	Carnivore	Schedule II
30	Bronze-winged jacana	*Metopidius indicus* (Latham, 1790)	4	0	6	FC	RE	Carnivore	Schedule II
			Family Scolopacidae						
31	Common snipe	*Gallinago gallinago* (Linnaeus, 1758)	1	0	0	R	WV	Insectivore	Schedule II
32	Wood sandpiper	*Tringa glareola* Linnaeus, 1758	4	0	0	R	WV	Insectivore	Schedule II
33	Common sandpiper	*Actitis hypoleucos* (Linnaeus, 1758)	2	0	0	R	WV	Insectivore	Schedule II
34	Common greenshank	*Tringa nebularia* (Gunnerus, 1767)	2	0	0	R	WV	Insectivore	Schedule I
35	Common redshank	*Tringa tetanus* (Linnaeus, 1758)	2	0	0	R	WV	Insectivore	Schedule II
			Order Accipitriformes Family Accipitridae						
36	Shikra	*Accipiter badius* (J.F. Gmelin, 1788)	1	1	0	R	LM	Carnivore	Schedule I
37	Black-winged kite	*Elanus caeruleus* (Desfontaines, 1789)	1	0	0	R	WV	Carnivore	Schedule II
38	Black kite	*Milvus migrans* (Boddaert, 1783)	4	6	5	C	RE	Carnivore	Schedule II
39	Brahminy kite	*Haliastur indus* (Boddaert, 1783)	1	3	1	FC	LM	Carnivore	Schedule I
40	Short-toed snake eagle	*Circaetus gallicus* (J.F. Gmelin, 1788)	0	1	0	R	WV	Carnivore	Schedule I
41	Egyptian vulture (NT)	*Neophron percnopterus* (Linnaeus, 1758)	3	0	0	R	RE	Carnivore	Schedule I
42	Crested serpent-eagle	*Spilornis cheela* (Latham, 1790)	0	0	1	R	WV	Carnivore	Schedule I
			Order Strigiformes Family Strigidae						
43	Barn owl	*Tyto alba* (Scopoli, 1769)	1	1	0	R	LM	Carnivore	Schedule II
44	Spotted owlet	*Athene brama* (Temminick, 1821)	0	1	1	R	LM	Carnivore	Schedule II
			Order Bucerotiformes Family Upupidae						
45	Eurasian hoopoe	*Upupa epops* Linnaeus, 1758	1	0	2	R	LM	Carnivore	Schedule II
			Family Bucerotidae						
46	Indian grey-hornbill	*Ocyceros birostris* (Scopoli, 1786)	2	5	2	FC	RE	Frugivore	Schedule II

Table 1: (Continued).

Sl. No.	Common name	Scientific name	Winter	Summer	Monsoon	Abundance	R. status	Feeding guild	IWPA (Indian Wildlife Protection Act), 1972 schedule
		Order Piciformes Family Picidae							
47	Black-rumped woodpecker	*Dinopium benghalense* (Linnaeus, 1758)	1	0	0	R	WV	Insectivore	Schedule II
		Family Megalaimidae							
48	Brown-headed barbet	*Psilopogon zeylanicus* (J.F. Gmelin, 1788)	0	0	2	R	LM	Frugivore	Schedule II
49	Coppersmith barbet	*Psilopogon haemacephalus* (Statius Muller, 1776)	3	3	3	FC	RE	Frugivore	Schedule II
		Order Coraciiformes Family Meropidae							
50	Blue-tailed bee-eater	*Merops philippinus* Linnaeus, 1767	7	1	0	FC	RE	Insectivore	Schedule II
		Family Alcedinidae							
51	Indian roller	*Coracias benghalensis* (Linnaeus, 1758)	5	2	3	FC	RE	Insectivore	Schedule II
52	Common kingfisher	*Alcedo atthis* (Linnaeus, 1758)	2	0	0	R	WV	Piscivore	Schedule II
53	Pied kingfisher	*Ceryle rudis* (Linnaeus, 1758)	1	1	1	R	LM	Piscivore	Schedule II
54	White-throated kingfisher	*Halcyon smyrnensis* (Linnaeus, 1758)	0	2	1	R	LM	Piscivore	Schedule II
		Order Psittaciformes Family Psittacidae							
55	Alexandrine parakeet (NT)	*Psittacula eupatria* (Linnaeus, 1766)	12	10	0	C	RE	Frugivore	Schedule II
56	Rose-ringed parakeet	*Psittacula krameri* (Scopoli, 1769)	14	14	4	C	RE	Frugivore	Schedule II
		Order Passeriformes Family Oriolidae							
57	Indian golden oriole	*Oriolus kundoo* Sykes, 1832	1	0	0	R	WV	Frugivore	Schedule II
58	Black-hooded oriole	*Oriolus xanthornus* (Linnaeus, 1758)	2	0	0	R	WV	Frugivore	Schedule II
		Family Dicruridae							
59	Black drongo	*Dicrurus macrocercus* Vieillot, 1817	7	5	5	C	RE	Insectivore	Schedule II
		Family Laniidae							
60	Brown shrike	*Lanius cristatus* Linnaeus, 1758	1	0	1	R	LM	Insectivore	Schedule II
61	Long-tailed shrike	*Lanius schach* Linnaeus, 1758	1	0	0	R	WV	Insectivore	Schedule II
		Family Corvidae							
62	Rufous treepie	*Dendrocitta vagabunda* (Latham, 1790)	0	2	0	R	LM	Frugivore	Schedule II
63	House crow	*Corvus splendens* Vieillot, 1817	13	10	3	C	RE	Omnivore	Not listed
64	Jungle crow	*Corvus macrorhynchos* Wagler, 1827	9	8	11	C	RE	Omnivore	Schedule II
		Family Ploceidae							
65	Baya weaver	*Ploceus philippinus* (Linnaeus, 1766)	18	0	0	C	RE	Granivore	Schedule II
		Family Estrildidae							
66	Red avadavat	*Amandava amandava* (Linnaeus, 1758)	7	16	6	C	RE	Granivore	Schedule II
67	Indian silverbill	*Euodice malabarica* (Linnaeus, 1758)	7	3	0	FC	RE	Granivore	Schedule II
68	Scaly-breasted munia	*Lonchura punctulata* (Linnaeus, 1758)	6	1	0	FC	RE	Granivore	Schedule II
		Family Passeridae							
69	House sparrow	*Passer domesticus* (Linnaeus, 1766)	2	6	2	FC	RE	Granivore	Schedule II

Table 1: (Continued).

Sl. No.	Common name	Scientific name	Winter	Summer	Monsoon	Abundance	R. status	Feeding guild	IWPA (Indian Wildlife Protection Act), 1972 schedule
		Family Motacillidae							
70	Paddyfield pipit	*Anthus rufulus* Vieillot, 1818	2	3	4	FC	RE	Insectivore	Schedule II
71	Yellow wagtail	*Motacilla flava* Linnaeus, 1758	6	0	0	FC	RE	Insectivore	Schedule II
72	Citrine wagtail	*Motacilla citreola* Pallas, 1776	3	2	0	R	RE	Insectivore	Schedule II
73	White-browed wagtail	*Motacilla maderaspatensis* J.F. Gmelin, 1789	6	2	0	FC	RE	Insectivore	Schedule II
74	White wagtail	*Motacilla alba* Linnaeus, 1758	3	2	0	R	RE	Insectivore	Schedule II
		Family Alaudidae							
75	Indian bushlark	*Mirafra erythroptera* Blyth, 1845	0	2	0	R	LM	Insectivore	Schedule II
		Family Cisticolidae							
76	Plain prinia	*Prinia inornata* Sykes, 1832	1	0	0	R	WV	Insectivore	Schedule II
77	Common tailorbird	*Orthotomus sutorius* (Pennant, 1769)	4	6	5	C	RE	Insectivore	Schedule II
		Family Hirundinidae							
78	Barn swallow	*Hirundo rustica* Linnaeus, 1758	0	1	0	R	WV	Insectivore	Schedule II
		Family Pycnonotidae							
79	Red-whiskered bulbul	*Pycnonotus jocosus* (Linnaeus, 1758)	19	21	6	C	RE	Frugivore	Schedule II
80	Red-vented bulbul	*Pycnonotus cafer* (Linnaeus, 1766)	1	6	2	FC	RE	Frugivore	Schedule II
		Family Leiothrichidae							
81	Jungle babbler	*Turdoides striata* (Dumont, 1823)	3	1	0	R	RE	Insectivore	Schedule II
		Family Sturnidae							
82	Asian pied starling	*Gracupica contra* (Linnaeus, 1758)	6	2	0	FC	RE	Insectivore	Schedule II
83	Common myna	*Acridotheres tristis* (Linnaeus, 1766)	2	3	11	C	RE	Insectivore	Schedule II
84	Bank myna	*Acridotheres ginginianus* (Latham, 1790)	0	4	0	R	LM	Insectivore	Schedule II
85	Jungle myna	*Acridotheres fuscus* (Wagler, 1827)	0	2	0	R	LM	Insectivore	Schedule II
86	Brahminy starling	*Sturnia pagodarum* (J.F. Gmelin, 1789)	4	0	4	FC	RE	Insectivore	Schedule II
		Family Muscicapidae							
87	Indian robin	*Saxicoloides fulicatus* (Linnaeus, 1766)	5	0	1	FC	RE	Insectivore	Schedule II
88	Oriental magpie robin	*Copsychus saularis* (Linnaeus, 1758)	0	1	2	R	LM	Insectivore	Schedule II
		Family Nectariniidae							
89	Purple-rumped sunbird	*Leptocoma zeylonica* (Linnaeus, 1766)	1	0	2	R	LM	Nectarivore	Schedule II
90	Purple sunbird	*Cinnyris asiaticus* (Latham, 1790)	6	4	0	FC	RE	Nectarivore	Schedule II

The Brahmani River has sixty species of fish with strong biotic integrity (Das et al., 2016). This river, along with the Tikera River and other inland aquatic bodies, provides the basic requirement of food, shelter, and breeding grounds to all aquatic, piscivorous and migratory bird species found in the study area. About 40% of the study area is covered with aquatic habitat, hence the bird orders like Charadriiformes and Pelecaniformes are found to have more bird species than other bird orders. This also includes one of the threatened bird species like the Snake Bird or Oriental Darter (*Anhinga melanogaster*) which is found near the Tikera River. The patches of aquatic plants in these rivers are acting as a resource for the foraging aquatic bird species like the Wood Sandpiper (*Tringa glareola*), Common Sandpiper (*Actitis hypoleucos*), Pheasant-tailed Jacana (*Hydrophasianus chirurgus*) and Bronze-winged Jacana (*Metopidius indicus*). Sandy riverbanks of the Brahmani River are also acting as one of the best breeding sites for the Blue-tailed Bee Eater (*Merops philippinus*). The agricultural fields satisfy the food requirements of many granivorous bird species throughout the year in the study area.

The variety of flowering plants, like *Hibiscus* sp., *Dahlia pinnata*, *Cassia fistula*, *Delonix regia*, *Caesalpinia pulcherrima* are abundantly found inside the residential complexes present in the study area. They provide food for nectivorous bird species like the Purple-rumped Sunbird (*Leptocoma zeylonica*) and Purple Sunbird (*Cinnyris asiaticus*). The large sewage disposal area near to the waste management unit of PTS acts as a haven for urban exploiter bird species like the Black Kite (*Milvus migrans*) and Common House Crow (*Corvus splendens*).

The forest present on the north side of the Tikera River is mainly responsible for providing shelter and food for the major raptor species, like the Shikra (*Accipiter badius*), Black-winged Kite (*Elanus caeruleus*), Short-toed Snake Eagle (*Circaetus gallicus*) and Crested Serpent-Eagle (*Spilornis cheela*); along with the Spotted Owlet (*Athene brama*). Shrubs surrounding the edge of open forest often harbor Plain prinia (*Prinia inornata*), House sparrows (*Passer domesticus*) and Brown shrikes (*Lanius cristatus*). Illegal tree cutting and forest product exploitation is committed by the local villagers which is the main cause of forest loss in the study area. It is adversely affecting the abundance and richness of forest-associated bird species. Places like the central park, helipad, recreational centre (RC) are situated inside PTS of NTPC, acting as a safe haven for bird species like the Indian Robin (*Saxicoloides fulicatus*), Asian Pied Starling (*Gracupica contra*) and the Indian Silverbill (*Euodice malabarica*). The presence of diverse tree species is mainly responsible for increased insect diversity and other forest-associated taxa (Ampoorter et al., 2020). This in turn is the main cause of abundant forest dwelling bird species and fulfills the food requirement of the insectivorous bird community (dominant inside the study area among all other feeding guilds). Mostly passeriform bird species are insectivorous in nature (Turshak and Mwansat, 2021). Hence, the reason for the dominant insectivore bird community in the present study can be attributed to the higher abundance and richness of passeriform birds.

The winter season (also the wet season) is found to be the most abundant and species rich due to the presence of winter migrants in the rivers and water bodies present inside the study area. These results of the present study are consistent with a previous study conducted by Almasieh and Moazami (2020) in the Agricultural Sciences and Natural Resources University of Khuzestan campus located in southwest Iran; having a riparian zone and a mild winter season. The native waterbirds at NTPC, along with the winter visitors, are exploiting the naturally available food on a large scale. Whereas, existing vegetation during the summer season in the study area acts as a refuge for most resident bird species. The monsoon season was found to be the least suitable season for the avian community due to the adverse conditions, like heavy rainstorms, which effect the temporal activities of birds (Robbins, 1981). Earlier studies revealed that the rainy season was found to be largely affecting the native avian community (MacArthur, 1964; Santillán et al., 2018). These reasons may be accredited to lowering the value of diversity indices, separate clusters of bird species composition in the dendrogram and also the non-significant correlation during monsoon season, with other two seasons inside the study area.

Fractions of villagers residing in the study area are working in the nearest power plant and more of them are increasingly dependent on forests and agriculture. Although the PTS is well maintained and organized, the villages are somewhat ignored in terms of development by the local authority. Hence, the villagers are getting less facilities than the people residing inside PTS of NTPC. This has led them to exploit naturally available resources, such as wood plants, fuel plants and forest products by cutting trees. This exploitation poses concerning threats like deforestation, and habitat loss for the local avifauna. Most of the village households still use traditional coal stoves for cooking, which can be a reason for significant air pollution in this area. Two positive aspects for the existing avifauna near NTPC are: (1) the large sewage treatment unit inside PTS which helps in treating the sewage water and this in turn ensure the release of clean water into the rivers, and (2) presence of a 10 MW solar plant which is home to several bird species, and it acts as the best alternative for coal-based thermal electricity production. The results of the present study will help in understanding the baseline information on the

avifauna present near NTPC. This study will also help in creating awareness regarding the importance of birds in this environment among students, local villagers, policy makers, and local authorities for formulating more action-oriented measures in order to sustain the avifaunal diversity of the NTPC area.

Conclusion

The study area is harboring a rich avian diversity. A total of 668 individuals, belonging to 90 bird species, were identified from the study area from 75 genera within 41 families. Passeriformes birds were the most diverse and abundant with 34 species. The Accipitridae and Ardeidae families dominated among the other families present, having 7 species each. Among the 90-bird species, 15 species (17%) were common, 26 species (29%) were fairly common and rest, 49 species (54%), were rare. According to their residential status, 44 species (49%) were found to be resident, 28 species were local migrants (31%) and 18 species (20%) were winter visitors. Insectivorous bird species dominate with 32 species inside the study area. Among the three seasons, winter was found to be most species rich (32 species) and was found to have a higher value of H' (3.76) followed by summer (H'= 3.48). The smallest value of evenness index was calculated during the summer season (E= 0.58). The matrix plot exhibited that the bird species spread equally across three seasons but have differences in their species diversity and composition. The correlation analysis displays that the avian community observed during the summer season is strongly correlated with the species composition of winter and monsoon seasons, but the species composition of monsoon season is not significantly correlated with bird community of winter season. The dendrogram (Fig. 5) shows the similarity between summer and winter season, whereas the bird species recorded during the monsoon season do not show similarity with any other season.

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Author contributions

R.L. conducted the field surveys and collected all data from the field. He compiled, arranged and analyzed the data entirely. Data visualization and plotting were also done by R.L.

Conflict of interest

I declare that there are no conflicting issues related to this research article.

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