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Avian Diversity in and around Wetland of National Importance 'Pariyej Community Reservoir', Gujarat, India

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Abstract

The Pariyej Community Reservoir (PCR) is a freshwater reservoir in the Kheda district of Gujarat State, India. The PCR is also listed in Asian Directory of Wetlands. It is an important water storage reservoir; falls in the 4-B Gujarat Rajwara region of Central Gujarat, India. The present study was carried out for the period of one year (March, 2021 to February, 2022) to assess the status of avian diversity in terms of its species richness, abundance, and density. 116 bird species from 20 orders, 51 families, and 100 genera were documented. 75 species (64.4%) were resident, whereas 41 (35.3%) were migratory or seasonal. With respect to abundance, 41species (35.34%) were abundant, 39 species (33.6%) common, and 36 rare species (31.0%). The maximum total abundance (1707 individuals) was found at Site 1 in winter season with mean abundance of 427 individuals, total density (114 individuals/sq.km) and mean density (29 individuals/sq.km). The minimum total abundance (288 individuals) was recorded at Site2 in monsoon season with mean abundance of 72 individuals, total density (19individuals/sq.km) and mean density (5 individuals/sq.km). The present investigation reflects the good species richness of avian specieswith respect to order: family: genera: species ratio i.e., 1: 2.55: 5.0: 5.8. This indicates the flourishing harboring capability of PCR during peak winter period, which could be due to sustenance of rich biotic elements. The PCR has been declared as *Sanctum sanctorum* for the refuge of migratory as well as local migrant birds, which is proved to be a wetland of national importance.

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Introduction

"*Wetlands are the areas of marsh, fen, peatland, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salty, including areas of marine water the depth of which allow tides does not exceed six meters".*[1] Wetland ecosystems provide a range of distinct and varied habitats, and are found in diverse topographical and environmental contexts. Wetlands play a crucial role in providing a wide array of ecosystem goods and services, while also serving as a vital habitat for a substantial amount of biological diversity.[2] India is currently offering wintering habitat grounds for migratory avifauna. Wetlands, both natural and man-made, in India are serving as a significant attraction for a substantial population of migratory birds, including those that are local and altitudinal in nature.[3] Located in the western region of India, Gujarat boasts a range of habitats and a diverse avian population. The avian fauna in Gujarat exhibits significant diversity owing to the distinct habitats present across various regions of the state.[4] Avian species hold significant economic value for human societies. They are essential to controlling insect and pest populations. Plant species benefit from their scavenging, pollination, and seed distribution. Throughout history, these entities have been recognized for their beneficial properties and their ability to provide nourishing sustenance for humanity.[5] Avian species are distributed globally and are closely linked to their respective habitats. They exhibit a high degree of sensitivity to alterations in their surroundings, and their existence may serve as an indicator of the functionality of the ecosystem.[6] The investigation of avifaunal diversity serves as a crucial ecological instrument that functions as a significant indicator for assessing various habitats in terms of both quality and quantity.[7] This study examines seasonal avifaunal diversity in and around the significant inland freshwater wetland "Pariyej Community Reservoir (PCR)" in Gujarat, India.

Materials and Methods

Study Area

The Pariyej Community Reservoir (PCR) is a freshwater reservoir in the Kheda district of Gujarat state. The PCR is also listed in Asian Directory of Wetlands.[8] It is on the plains north of the Gulf of Khambhat, in a natural depression ringed by a bank. It is about 45 km from Anand, a city in India that is known as the milk capital. Anand is at 22° 33' N latitude and 72° 38' E longitude. The height is between 13 and 14 meters above sea level. It has a circumference of about 12 km and a surface area of about 5 sq.km. The water level ranges from 1.2 m to 3.0 m. It is an important water storage reservoir in the 4-B Gujarat Rajwaraprovince of Central Gujarat. This wetland is surrounded by five villages, the water, food, fodder, and economy of the villages rely on this wetland. The climate is dry tropical monsoon, and most of the 800 mm of rain that falls each year falls in July, August, and September. The Narmada and Mahi canals bring water to this pond to keep its level the same all year. It helps villages around Pariyej and some villages in Saurashtra get the water they need to drink. Pipes bring water from this lake to other places. It is one of Gujarat's eight marshes that are important to the country as a whole. It is home to a lot of hydrophytes, like *Ipomoea aquatica, Marseliaquadrifolia, Nelumbo officinalis, Nymphea stellata,* and *Typha anugstifolia,* which grows in large beds along the banks, to support the diverse avian species of the State, Country, and World. It harbors about 30,000 birds that live there year-round, like Sarus Cranes, Egrets, Lapwings, and Storks.[9] Most of the migrating birds, like Flamingos, Sandpipers, Coots, and Greylag geese, from upper Asian regions visit the PCR during the peak winter(Fig. 1).

Avifaunal Survey and Identification

A year-long study was carried out from March, 2021 to February, 2022to assess the avifaunal communities using the Nikon Binocular 22x50 resolution, by employing a range of techniques, including point count, flock count, and group count on a monthly basis from 7:00 am to 6:00 pm.[10] The bird species encountered during field visit were identified using a variety of published literature.[11] Observing the bird diversity and density during study period, birds with less than ten records were categorized as rare, those with ten to fifty records as common, and those with more than fifty records as abundant.[12]

Statistical Analysis

Eight Diversity Indices (Dominance_D, Berger-Parker, Simpson_1-D, Shannon_H, Brillouin, Margalef, Evenness, Equitability_J) were employed to measure the avian diversity with the help of PAST (Version 4.03), U.S.A.[13]

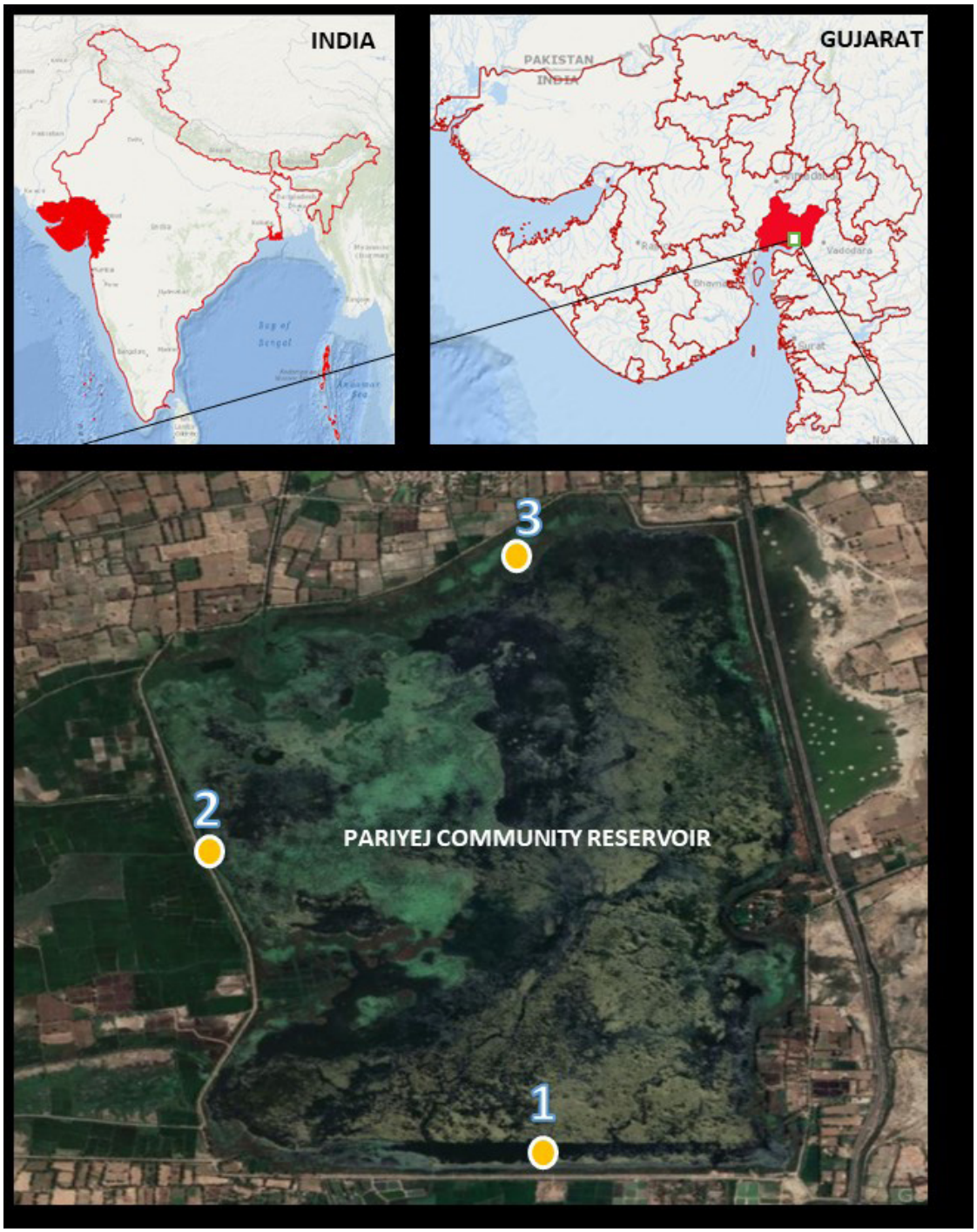

Fig. 1: Map showing three permanent sampling sites at PCR

Results and Discussion

During the study, 116 bird species from 20 orders, 51 families, and 100 genera were recorded. 75 species (64.4%) were resident, whereas 41 (35.3%) were migratory or seasonal. Abundant species included resident birds such as Purple Swamphen

(*Porphyrio porphyrio*), Black Kite(*Milvus migrans*), Pheasant-tailed Jacana (*Hydrophasianus chirurgus*), and Rose-ringed Parakeet (*Psittacula krameri*), and migratory birds such as Eurasian Coot (*Fulica atra*), Greylag Goose (*Anser anser*), Brahminy Starling (*Sturniapagodarum*), and Common Rosefinch (*Carpodacus erythrinus*). Banu *et al.* (2016) reported a fairly distribution of bird species in urban wetlands in and around Dhaka, Bangladesh.With respect to abundance, in total 39 species of common birds (33.6%) were recorded; while only 36 species (31.0%) were found to be rare, which includes Black-necked Stork (*Ephippiorhynchus asiaticus*), Lesser Goldenback (*Dinopiumbenghalense*), Greater Painted-snipe(*Rostratulabenghalensis*), White-browed Fantail (*Rhipiduraaureola*), Woolly-necked Stork (*Ciconia episcopus*), Cinnamon Bittern(Ixobrychuscinnamomeus).Moreover, an identical abundance pattern was also observed by some researchers at Thol Lanke Bird Sanctuary, Gujarat, India.[14] (Fig. 2).

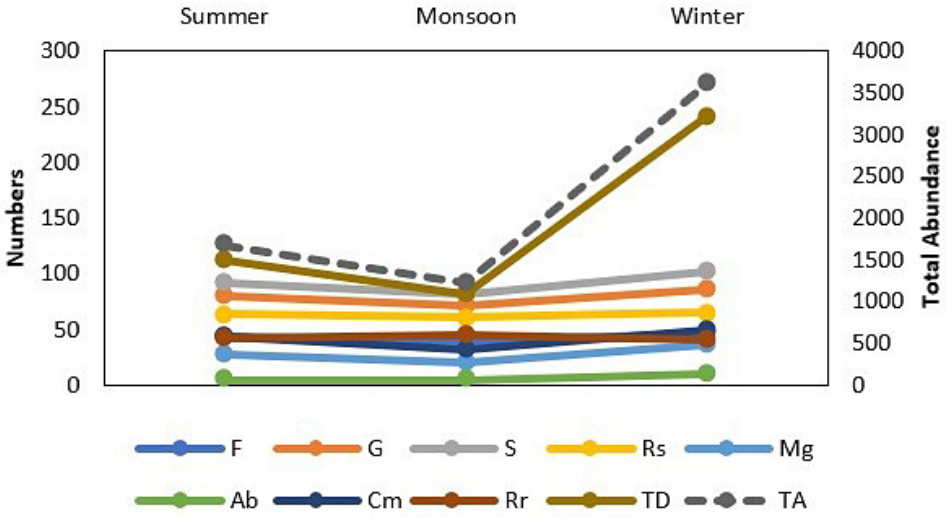

Fig. 2: Seasonal patterns of waterbird abundance at PCR

F:Family, G:Genera, S: Spices, Rs:Resident, Mg: Migrant, Ab: Abundant, Cm: Common, Rr:Rare, TD: Total Density, TA: Total Abundance

The abundance status of avian species was congruent with the observations of in Fatehabad, Haryana, India.[15] The winter season exhibited the highest congregation of families in winter (90.1%), followed by summer (86.2%) and monsoon (76.4%). The data indicates that the maximum occurrence based on the genus was observed during the winter season (86%), followed by summer (80%), and monsoon (71%). Similar observations were also reportedin semi-natural wetlands of arid landscape (Kachchh), Gujarat, India.[16] parallel tendency of bird species in wetlands of Central Gujarat were also reported, India.[17] A comparable trend was observed among bird species with the momentum occurrence during the winter season (87.9%), followed by summer (79.3%) and monsoon (70.6%). The findings of the seasonal variation of avian community composition study indicate that a greater number of birds were observed during the peak winter season.[18,19] also reported similar results in freshwater wetlands of Kerala. In terms of seasonal pattern, the findings of the present study are well-congruent with the previous studies in Deepor Beel Wetland, Kamrup, Assam.[20]

The number of resident species observed during the winter and summer seasons were nearly identical (85.5% and 84.2%, respectively), due to flourishing hydrological regime of PCR, which would scarcely result into waterless spot during the peak summer, owing to the vast span of the surface water expansion through incessant flooding of the region

by Mahi-Narmada main canals.[21] However, during the monsoon season, the occurrence of resident bird species observed was slightly lower (80.2%), might be due to the over-flooding of the region. Wetland birds in Komaranahalli Lake, showed the same pattern.[22] The migratory species exhibited their most significant contribution during the winter season, accounting for 90% of their overall contribution. This was followed by 70% during the summer season, and 52.5% during the monsoon season.[23] The species that were deemed abundant were observed to occur predominantly during the winter season (100%), with an equal distribution of 50% during both the summer and monsoon seasons.[24]

Furthermore, the species that were commonly observed exhibited peak occurrence during the winter season (100%), followed by the summer season (88%) and the monsoon season (64%). The study found that the majority of average of all sites rare species were observed during the summer (100%), followed by monsoon (95%), and winter (91%).[25] Subsequently, the winter season exhibited the second highest dominance (25.7%), while the monsoon season had the lowest congregation (18.8%). Migratory avifauna exhibit greater vulnerability to slight alterations in water levels, which can be attributed to the impact of flooding or drought on their respective breeding and wintering habitats.[26] The wetlands may experience flood conditions as a result of elevated precipitation levels during the monsoon season.[27] (Fig. 2).

Seasonal Abundance

Site 1 exhibited the low (50.9%) and high number (76.4%) of avian families during the monsoon and winter seasons, respectively. The results indicate that during the monsoon season, the lowest abundance among genera was observed at Site 2 (31%), whereas during the winter season, the highest abundance was recorded at Site 1 (86%). The findings of the present study are well-corroborated with results of Muchi Lake Wetland in Maharashtra state, India.[28] Conversely, it was observed that Site 3 exhibited the least species diversity (24%) in the summer season, whereas Site 1 revealed the highest diversity (72%) during the winter season. Site 2 exhibited a recording of merely 44.7% of resident species during the monsoon season, whereas Sites 3 and 6 characterized a predominance of 68% of resident species during the same period. The site fidelity of the present investigation is well-substantiated with the previous studies in and around upper lake, Bhopal, India.[29]

During the summer season, Site 1 and Site 2 exhibited a fewer count of migratory species, with an aggregate of 55% of the species reported at both sites. However, during the winter season, Site 1 recorded a voluminous presence of migratory species, with almost 65% of the species being observed. Number of abundant species were low (25%) during the summer season; whereas higher (50%) during the winter season.[30] During the summer season, the presence of common species at Site 3 was observed to be only 22%; whereas during the winter season, almost 80% of the species were found to be common at Site 1. In case rare species, all sampling locations have exhibited a peak number of species (92.9%) during the summer season, while the minimum number of species (29.8%) was observed during the winter season.[31] Overall, it was observed that Site 2 exhibited a comparatively lower abundance of birds during the monsoon season, while Site 1 represented by the highest bird populations during the winter season. An intensified gradient was observed in the bird species richness across the study sites, with Site 1 being the most abundant, followed by Site 3 and then Site 2. (Fig.3).

Abundance and Density

Results indicate that Site 1 is endowed with the highest total abundance of bird species, accounting for 47% of the observed total bird population. The mean abundance per month at this site was 427 birds, with a total density of 114 individuals/sq.km and a mean density per month of 29 individuals/sq.km.[27] Contrastingly, Site 2 was found to harbor the lowest abundance, accounting for 23.4% of the observed total bird population during the monsoon season. The mean abundance per month at this site was 120 birds, with a total density of 32 individuals/sq.km and a mean density per month of 8 individuals/sq.km.[32] According to the findings of the study, it was observed that during the summer season, Site 1 exhibited the highest abundance of birds, constituting approximately 44.2% of the overall bird population. The mean abundance per month at this site was 186 birds, with a total density of 50 individuals/km^2 and a mean density per month of 12 individuals/sq.km.

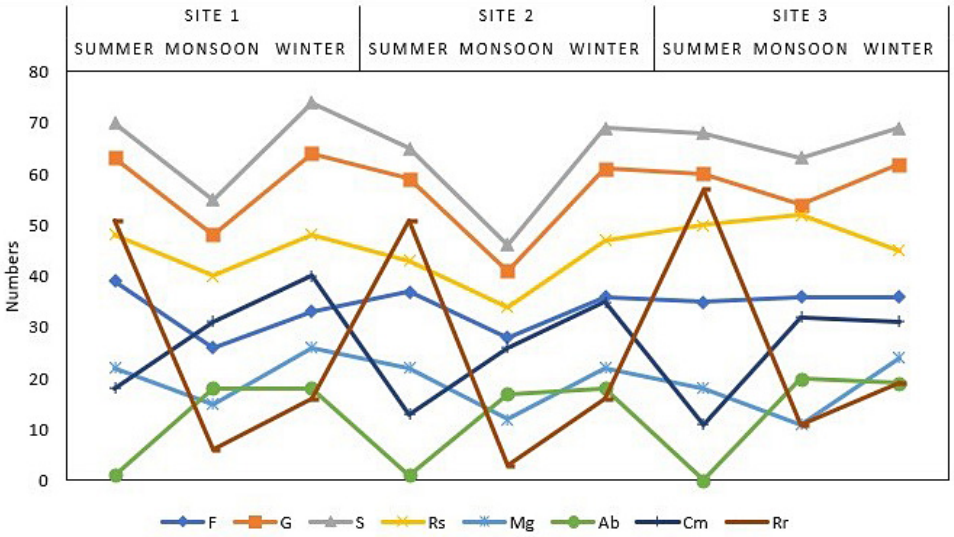

Fig. 3: Site-specific occurrence of waterbirds at PCR (Seasonal).

F:Family, G:Genera, S: Spices, Rs:Resident, Mg: Migrant, Ab: Abundant, Cm: Common, Rr: Rare,

Table 1: Abundance and Density is avian spices in different seasons at PCR

	TA			MA/Month			TD			MD/Month		
Site	**S**	**M**	**W**	**S**	**M**	**W**	**S**	**M**	**W**	**S**	**M**	**W**
1	744	460	1707	186.0 ± 91.7	115 ± 66.8	426.7 ± 63.1	49.6	30.7	113.8	12.4 ± 5.2	7.7± 14.1	28.5 ± 6.5
2	530	288	1194	132.5 ± 12.5	72 ± 21.8	298 ± 25.2	35.3	19.2	79.6	8.8 ± 2.5	4.8 ± 11.3	19.9 ± 3.9
3	407	483	725	101.8 ± 52.6	120 ± 38.7	906 ± 15.4	27.1	32.2	48.3	6.8 ± 7.3	8.1± 4.3	12.1 ± 1.7
PCR	1681	1231	3626	420.3 ± 245.4	307.75 ± 85.9	906.5 ± 63.3	112.1	82.1	241.7	28± 7.2	20.5 ± 29.0	60.4 ± 2.0
Mean	597.7	410.3	1208.6	149.4	102.6	302.2	66.3	45.7	136.3	16.6	11.4	34.1

(S-Summer, M-Monsoon, W-Winter, TA-Total Abundance, MA-Mean Abundance, TD-Total Density, MD-Mean Density, PCR-Pariyaj Community Raservoir, all numbers indicate number of Individual with standard deviation after sign ±)

However, the lowest abundance of birds was observed during the monsoon season at Site 3, accounting for 24.2% of the total bird population. The mean abundance per month at this site was 102 birds, with a total density of 27 individuals/sq.km and a mean density per month of 7 individuals/sq.km. Site 3 exhibited the highest level of abundance during the monsoon season, with a reported occurrence of 39.2%. The mean abundance per month at this site was 120 birds, while the total density was 32 individuals/sq.km, and the mean density per month was 8 individuals/sq.km.[33] The findings of the present study reveal that Site 2 exhibited the lowest abundance, which was recorded

with 23.4%. The mean abundance per month at this site was 72 birds, while the total density was 19 individuals/sq.km and the mean density per month was 5 individuals/sq.km. The winter season witnessed a notable variation in the bird abundance across different study sites. Site 1recorded the uppermost abundance, with a reported percentage of 47%.[16] The mean abundance per month at this site was 426 birds, while the total density was 114 individuals/sq.km, and the mean density per month was 29 individuals/sq. km. On the other hand, Site 3 reported the lowest abundance, with a percentage of 19.9%. The mean abundance per month at this site was 181 birds, while the total density was 48 individuals/sq.km, and the mean density per month was 12 individuals/sq.km. (Table 1)

Diversity Indices

Species Dominance Index

Dominance (D), also called Simpson's D, has a value between 0 and 1. 0 means there is no diversity, and 1 means there is infinite diversity. This means that the smaller the value of D, the less diverse the population is 34.Simpson's D and Berger-Parker indices showed the minimum dominance value during monsoon (0.031) and (0.094), respectively; and the maximum dominance in post-monsoon (0.11) and (0.32), respectively. similar results were reported in Jagdishpur reservoir, a Ramsar site and an important bird area (IBA) of Nepal.[35] It shows that during the monsoon season, a smaller group of species dominates the bird community. After the monsoon season, however, a big group of bird species share the leadership (Table 2).[36]

Species Diversity Index

Simpson diversity index values revealed highest value in Pre-monsoon period (0.96), and the lowest in post-monsoon (0.88). The Shannon-Wiener diversity index has a theoretical range from zero to infinity. However, its values typically span from 0 to 4.[35] Shannon-Wiener diversity index has shown same seasonal pattern with highest in summer and lowest during post-monsoon season. Brillouin diversity index have shown highest value in summer (3.86) and lowest (3.32) during post-monsoon season.[27] These results displayed that maximum diversity of birds was recorded at Site 1 during pre-monsoon season and minimum diversity was recorded in winter season, though it is having a greater number of species[37](Table 2).

Table 2: Diversity, dominance and evenness index for avifauna at PCR (Seasonal)

Type	Diversity Indices	S	M	W
Dominance	Dominance_D	0.031	0.031	0.1192
	Berger-Parker	0.1136	0.09423	0.3296
Species Diversity	Simpson_1-D	0.9697	0.9681	0.8808
	Shannon_H	3.972	3.821	3.387
	Brillouin	3.861	3.695	3.326
Species Richness	Margalef	12.25	11.38	12.20
Evenness	Evenness_e^H/S	0.577	0.5568	0.293
	Equitability_J	0.8784	0.8671	0.734

Species Richness Index

A high Margalef index signifies a substantial level of diversity in the tested sample. The observed phenomenon can be understood as an indication of the strong and adaptable nature of the ecosystem being studied. A high Margalef index suggests that the ecosystem being sampled has the capacity to sustain a diverse range of species and is capable of adapting to changes in external conditions.[34] The Margalef index value of 12.25 was observed during both the summer and winter seasons, while the monsoon season exhibited a minimum value of 11.38[37](Table 2).

Species Evenness Index

Evenness and Equitability indices showed the minimum evenness during post-monsoon (0.29) and (0.73), respectively, and maximum in summer (0.57) and (0.8), respectively.[37]

Conclusion

The present study about bird diversity at PCR revealed that during the winter season,the PCR witnessed the utmost number of bird species, followed by summer and monsoon seasons. The evident high species richness of birds during winter season could be due to occurrence of migratory as well as local migrant birds, which use the PCR as a transitory refuge site for roosting, foraging, and feeding activities to avoid the scorching atmospheric heat in their permanent home ranges. Comparing the site fidelity of PCR, it has been observed that Site 1 exhibited a higher concentration of avifaunal diversity during post-winter season, compared to other two sites (Sites 3 and 2), which were endowed with average or low bird diversity. The more species richness at Site 1 could be attributed to the availability of a diverse range of microhabitats that serve to nesting and roosting habitats for resident bird species. This could be due to profuse growth of macrophytes along with micro- and macro-algae, and diverse abundance of planktonic forms. This provides the effortless procurement of food and nesting materials to the local migrant as well as resident bird species. Additionally, Site 1 also provides a relatively larger expanse of open water, which is conducive to the foraging habitat of avifaunal communities. The presence of benthivorous waders during the summer season, facilitated by the extensive marshlands, and cultivated, ploughed, and inundated agricultural fields in the adjoining areas of PCR, which can be considered as a contributing and accentuating factor to the high richness of avian species for better sustenance and prevailing biodiversity of the province.

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Conflict of Interest

The author(s) declares no conflict of interest

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