International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 09 Issue 06 June 2026
DOI: 10.47191/ijcsrr/V9-i6-10, Impact Factor: 8.048
IJCSRR @ 2026
www.ijcsrr.org

Community Structure and Seasonal Dynamics of Wetland Birds in a Tropical Inland Wetland, Kilpathi Lake, Vriddhachalam, Tamil Nadu, India

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ABSTRACT: Wetland ecosystems play a critical role in supporting avian biodiversity, particularly in tropical regions. The present study evaluates the diversity, habitat selection and seasonal dynamics of wetland bird communities in Kilpathi Lake, Tamil Nadu, India, over a six-month period from September 2025 to February 2026. Standard ornithological survey techniques, including point count and line transect methods were employed to document species composition and abundance. A total of 18 species belonging to 6 families and 5 orders were recorded. Simpson's Diversity Index (1–D) indicated higher diversity during winter (0.71 ± 0.02) compared to monsoon (0.68 ± 0.02). Seasonal analysis revealed variations in abundance, density and relative abundance of species with *Egretta garzetta*, *Ardeola grayii* and *Microcarbo niger* emerging as dominant taxa. The overall bird density was higher in winter (3984.19 individuals/km²) than in monsoon (2765.46 individuals/km²). Habitat selection was strongly influenced by water depth, vegetation structure and resource availability. The findings highlight the ecological importance of small inland wetlands as critical habitats for sustaining avian diversity and emphasize the need for targeted conservation strategies in human-modified landscapes.

KEYWORDS: Avifauna, Conservation ecology, Diversity index, Habitat selection, Wetland birds.

INTRODUCTION

Wetlands are among the most productive ecosystems globally supporting high levels of biodiversity and providing essential ecosystem services such as water purification, flood regulation and nutrient cycling (Singh *et al*., 2024). Avifauna constitute an integral component of wetland ecosystems and serve as reliable bioindicators due to their sensitivity to environmental changes (Canterbury *et al*., 2000).

India hosts a diverse assemblage of wetland bird species with freshwater ecosystems in Tamil Nadu functioning as important habitats for both resident and migratory birds (Grimmett *et al*., 2011). However, these ecosystems are increasingly threatened by anthropogenic pressures including pollution, habitat fragmentation and land-use changes (Kumar and Gupta, 2013). Small inland wetlands, particularly irrigation tanks, often remain underexplored despite their ecological significance.

Habitat selection is a key ecological process influencing species distribution and community structure, driven by environmental factors such as water depth, vegetation composition and food availability (Chatterjee *et al*., 2020). Understanding these patterns is essential for developing effective conservation strategies, especially in tropical regions where seasonal fluctuations strongly influence resource availability.

Therefore, the present study aims to (i) assess avian diversity in Kilpathi Lake, (ii) analyze habitat selection patterns of wetland bird communities and (iii) evaluate seasonal variation in species composition and abundance using quantitative ecological indices.

MATERIALS AND METHODS

Study Area

Kilpathi Lake (11.50° N, 79.31° E) is a tropical freshwater wetland situated in Vriddhachalam, Tamil Nadu, India. The lake is characterized by a mosaic of habitat types, including open water zones (approximately 0.25 km²), marshy regions (0.20 km²), vegetated patches (0.18 km²) and exposed mudflats (0.10 km²), each supporting distinct avian guilds. The total study area covered 0.73 km². The region experiences a tropical climate with monsoon (June–November) and winter (December–February) seasons.

Collection Site Plate-I Kilpathi Lake

Sampling Period

Field surveys were conducted over six months from September 2025 to February 2026, covering monsoon (September to December-2025) and winter (January to February-2026) seasons. Observations were made daily during peak bird activity periods; 06:00–10:00 AM (morning) and 15:30–18:30 PM (evening).

Data Collection Methods

Standard ornithological methods were employed:

Point Count Method: Fixed-radius counts (50 m radius) at 15 predetermined points to estimate species abundance. Each point was sampled for 10 minutes; **Line Transect Method**: Systematic movement along three predefined transects (each 1.2 km in length) covering all habitat types; **Direct Observation**: Assisted by binoculars (10×50 magnification) and digital imaging (Canon EOS 90D with 100-400 mm lens).

Species identification was performed using standard taxonomic guides and abundance data were recorded quantitatively.

Data Analysis

- **Species Richness (S):** Total number of species recorded
- **Relative Abundance (RA %)**

  $RA(\%) = \frac{(ni)}{N} \times 100$
- **Simpson's Diversity Index (1–D)**

  $D = \frac{\sum ni(ni-1)}{N\,(N-1)}$,

Where:

- ni = number of individuals of species i
- N = total number of individuals

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Values range from 0 to 1:

- Closer to 1 → higher diversity
- Closer to 0 → lower diversity

The study area of 0.73 km² was used for all density calculations. Seasonal average counts were calculated by dividing total individuals by 4 months for monsoon and 2 months for winter, as the sampling intensity differed between seasons.

Statistical Analysis

Data were analyzed using PAST software (version 4.03). Results are presented as mean ± standard deviation where applicable.

RESULTS

Species Composition and Conservation Status

A total of 18 wetland bird species belonging to 6 families and 5 orders were recorded during the study period (Table-1). The family Ardeidae was dominant, represented by 7 species, indicating the ecological significance of shallow water habitats. Most species (17) were categorized as Least Concern (LC) on the IUCN Red List, while Threskiornis melanocephalus (Black-headed Ibis) was classified as Near Threatened (NT), highlighting the conservation value of the habitat.

Table 1. Checklist of wetland bird species recorded in Kilpathi Lake with their family, habitat type and IUCN conservation status.

S. No.	Common Name	Scientific Name	Family	Habitat Type	IUCN Status
1	Black-crowned Night Heron	*Nycticorax nycticorax*	Ardeidae	Vegetated	LC
2	Black-headed Ibis	*Threskiornis melanocephalus*	Threskiornithidae	Marshy	NT
3	Cattle Egret	*Bubulcus ibis*	Ardeidae	Vegetated	LC
4	Common Kingfisher	*Alcedo atthis*	Alcedinidae	Open water	LC
5	Common Moorhen	*Gallinula chloropus*	Rallidae	Marshy	LC
6	Common Sandpiper	*Actitis hypoleucos*	Scolopacidae	Mudflats	LC
7	Glossy Ibis	*Plegadis falcinellus*	Threskiornithidae	Shallow	LC
8	Great Cormorant	*Phalacrocorax carbo*	Phalacrocoracidae	Open water	LC
9	Great Egret	*Ardea alba*	Ardeidae	Shallow	LC
10	Grey-headed Swamphen	*Porphyrio poliocephalus*	Rallidae	Marshy	LC
11	Grey Heron	*Ardea cinerea*	Ardeidae	Open water	LC
12	Indian Pond Heron	*Ardeola grayii*	Ardeidae	Marshy	LC
13	Intermediate Egret	*Ardea intermedia*	Ardeidae	Shallow	LC
14	Little Cormorant	*Microcarbo niger*	Phalacrocoracidae	Open water	LC
15	Little Egret	*Egretta garzetta*	Ardeidae	Vegetated	LC
16	Little Grebe	*Tachybaptus ruficollis*	Podicipedidae	Open water	LC
17	Little Stint	*Calidris minuta*	Scolopacidae	Mudflats	LC
18	White-throated Kingfisher	*Halcyon smyrnensis*	Alcedinidae	Open water	LC

*(Least Concern (LC), Near Threatened (NT))

Seasonal Diversity Patterns

Simpson's Diversity Index (1–D) indicated higher diversity during winter (0.71 ± 0.02) compared to monsoon (0.68 ± 0.02), reflecting seasonal variation in species composition and evenness. This moderate increase during winter suggests that seasonal influx of species contributes to enhanced community complexity.

Seasonal Abundance Patterns

A total of 8,049 individuals were recorded during the monsoon season, whereas 5,817 individuals were observed during winter (Table-2). Despite the higher total count in monsoon, the cumulative average abundance was higher in winter (2,098.5) compared to monsoon (1,994.43), indicating a more concentrated distribution of individuals during the winter period.

Table 2. Seasonal variation in species abundance (ni) and average population of wetland birds during monsoon and winter seasons

S. No.	Common Name	Monsoon		Winter	
		ni	Average for 4 months	ni	Average for 2 months
1.	Black crowned night Heron	925	231.25	639	319.5
2	Black headed Ibis	225	56.25	179	89.5
3.	Cattle Egret	832	208	650	325
4.	Common Kingfisher	165	41.25	113	56.5
5.	Common Moorhen	50	12.5	95	47.5
6.	Common Sandpiper	28	7	45	22.5
7.	Glossy Ibis	225	56.25	276	138
8.	Great Cormorant	70	17.5	49	24.5
9.	Great Egret	93	23.25	172	86
10	Grey-headed Swamphen	556	139	427	213.5
11.	Grey Heron	123	30.75	229	114.5
12.	Indian Pond Heron	1277	319.25	735	367.5
13.	Intermediate Egret	809	202.25	447	223.5
14.	Little Cormorant	1137	284.25	733	366.5
15.	Little Egret	1325	331.25	778	389
16.	Little Grebe	17	4.25	68	34
17.	Little Stint	120	30	135	67.5
18	White throated Kingfisher	72	18	47	23.5
	Σ	8049	1994.43	5817	2098.5

Among the recorded species, *Egretta garzetta* exhibited the highest average abundance in both monsoon (331.25) and winter (389.0) followed by *Ardeola grayii* and *Microcarbo niger*. Several species, including *Porphyrio poliocephalus* and *Ardea*

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cinerea, showed a marked increase in average counts during winter, whereas others such as *Bubulcus ibis* and *Nycticorax nycticorax* maintained relatively high abundance across both seasons. In contrast, species such as *Tachybaptus ruficollis* and *Actitis hypoleucos* recorded comparatively lower average values indicating limited numerical representation during the study period.

Density and Relative Abundance

The overall bird density was higher in winter (3,984.19 individuals/km²) than in monsoon (2,765.46 individuals/km²) (Table-3). *Egretta garzetta* exhibited the highest density in both monsoon (453.77 individuals/km²) and winter (532.88 individuals/km²) along with the highest relative abundance (16.61% and 13.37%, respectively). A few dominant species contributed disproportionately to total abundance, while several species showed lower density values, indicating an uneven community structure characterized by a few numerically dominant species and several less abundant taxa.

Formula

$$Density(Birds\ per\ \mathrm{km}^2) = \frac{Average\ No\ of\ Individuals}{Area\ of\ Study(\mathrm{km}^2)}; Area = 0.73\ \mathrm{km}^2$$

$$RA(\%) = \frac{Average\ No\ of\ Individuals\ of\ a\ species}{Total\ Average\ of\ all\ species} \times 100$$

Table-3. Seasonal Density (individuals/km²) and Relative Abundance (%) of Wetland bird Species in Kilpathi Lake

S. No.	Common Name	Monsoon		Winter	
		Density (individuals/km²)	RA (%)	Density (individuals/km²)	RA (%)
1.	Black crowned night Heron	316.78	11.60	437.67	10.98
2	Black headed Ibis	77.05	2.82	122.60	3.08
3.	Cattle Egret	284.93	10.43	445.20	11.18
4.	Common Kingfisher	56.50	2.07	77.39	1.94
5.	Common Moorhen	17.123	0.63	65.06	1.63
6.	Common Sandpiper	9.59	0.35	30.82	0.77
7.	Glossy Ibis	77.05	2.82	189.04	4.75
8.	Great Cormorant	23.97	1.17	33.56	2.96
9.	Great Egret	31.85	0.88	117.80	0.84
10	Grey-headed Swamphen	190.41	6.97	292.46	7.34
11.	Grey Heron	42.12	1.54	156.85	3.94
12.	Indian Pond Heron	437.33	16.01	503.424	12.63
13.	Intermediate Egret	277.05	10.14	306.16	7.69
14.	Little Cormorant	389.38	14.25	502.05	12.60
15.	Little Egret	453.77	16.61	532.88	13.36
16.	Little Grebe	5.822	0.21	46.57	1.17

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17.	Little Stint	41.09	1.50	92.47	2.32
18	White throated Kingfisher	24.65	0.90	32.19	0.81
	Σ	2765.465	100	3984.199	100

Habitat Selection Patterns

Species distribution varied distinctly across habitat types: Open water zones: cormorants (*Microcarbo niger*, *Phalacrocorax carbo*) and grebes (*Tachybaptus ruficollis*); Marshy areas: moorhens (*Gallinula chloropus)* and swamphens (*Porphyrio poliocephalus*); Vegetated zones: herons and egrets (*Ardeola grayii*, *Bubulcus ibis*, *Egretta garzetta*); Mudflats: waders (*Actitis hypoleucos*, *Calidris minuta*).

Habitat selection was strongly influenced by water depth, vegetation structure and prey availability. The heterogeneous habitat mosaic supported distinct foraging guilds and reduced interspecific competition.

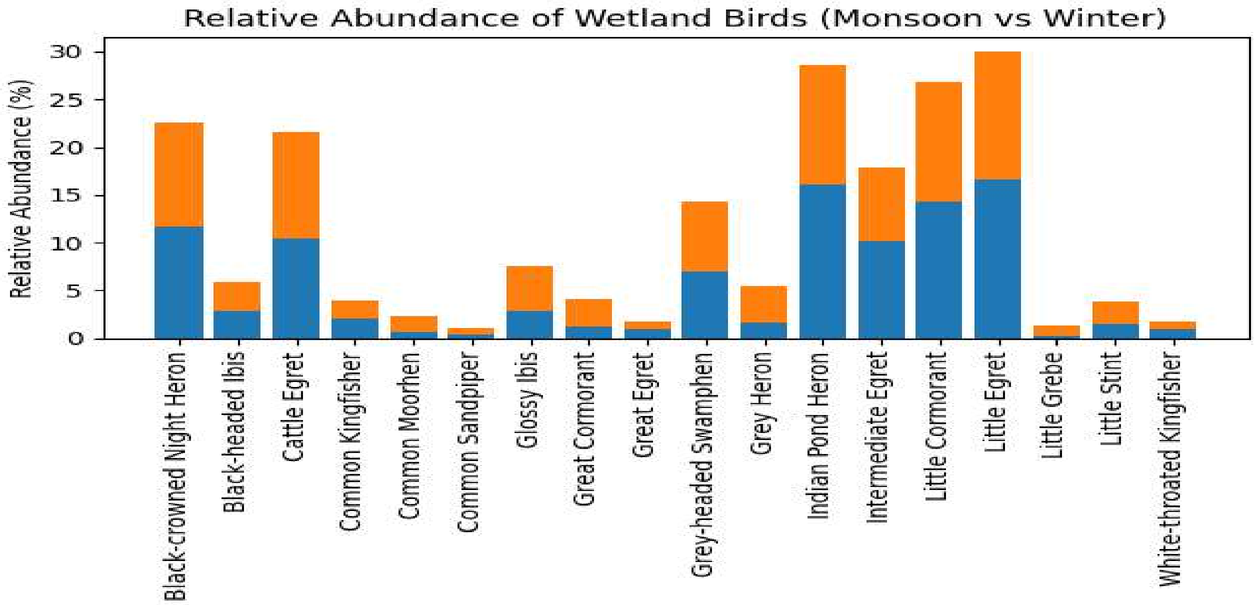

Fig.1. Relative abundance of wetland Birds(Monsoon Vs Winter)

The diagram (Fig-1) illustrates the species-wise variation in relative abundance (%) of wetland birds recorded in Kilpathi Lake during the monsoon and winter seasons. A clear variation in community composition between the two seasons is evident with certain species exhibiting marked dominance. *Egretta garzetta* showed the highest relative abundance in both monsoon (16.61%) and winter (13.37%), followed by *Ardeola grayii* and *Microcarbo niger*, indicating their consistent ecological dominance across seasons. Several species, including *Porphyrio poliocephalus* and *Ardea cinerea* displayed comparatively higher values during the winter season, suggesting seasonal shifts in habitat utilization and resource availability. In contrast species such as *Tachybaptus ruficollis* and *Actitis hypoleucos* exhibited lower relative abundance, reflecting limited distribution or niche specialization. Overall, diagram highlights an uneven community structure characterized by a few dominant species and several less abundant taxa, with noticeable seasonal variation in species composition and population distribution.

DISCUSSION

The observed avian diversity patterns in Kilpathi Lake reflect the combined influence of habitat heterogeneity, resource availability and seasonal dynamics. The dominance of piscivorous and wading birds (Ardeidae and Phalacrocoracidae) indicates the ecological importance of shallow water habitats rich in prey (Rajpar and Zakaria, 2015; Evans and Dugan, 1984). Similar patterns have been reported from other tropical wetlands, where ardeids often constitute the most speciose and abundant group due to their adaptability to varying water levels and foraging strategies (Kaur and Brraich, 2021).

Seasonal Dynamics

The higher diversity recorded during winter (Simpson's 1-D = 0.71) compared to monsoon (0.68) is consistent with migratory influx patterns reported in tropical wetlands, where seasonal movements enhance species richness and community complexity (Mukherjee *et al.*, 2021; Jha and McKinley, 2015). Winter sampling (January–February) coincided with the peak presence of migratory shorebirds including *Actitis hypoleucos* and *Calidris minuta* which contributed to increased diversity indices despite lower total individual counts.

The higher total abundance during monsoon (8,049 individuals) compared to winter (5,817 individuals) initially suggests greater bird use during the wet season. However, the higher cumulative average abundance in winter (2,098.5 vs. 1,994.43) indicates that winter months supported more individuals per sampling unit, reflecting seasonal concentration of birds around receding water bodies-a phenomenon documented in other seasonal tropical wetlands (Basaula *et al*., 2021; Mandal *et al*., 2021).

Community Structure and Dominance

The uneven community structure, characterized by a few dominant species (*Egretta garzetta, Ardeola grayii, Microcarbo niger*) contributing >40% of total abundance, suggests that niche partitioning and resource availability shape species distributions. From a niche theory perspective, functional guild differentiation reduces interspecific competition, enabling coexistence within limited habitat space and promoting stable community structure (Chatterjee *et al*., 2020; Clough *et al*., 2009).

The consistent dominance of *Egretta garzetta* across both seasons (16.61% RA in monsoon; 13.36% RA in winter) reflects its ecological plasticity and ability to exploit diverse microhabitats. This species is known to forage in both shallow open water and vegetated margins giving it a competitive advantage over more specialized feeders (Ali, 2002).

Habitat Selection and Environmental Drivers

The clear habitat segregation observed-cormorants in open water, rallids in marshy areas, ardeids in vegetated zones and scolopacids on mudflats-demonstrates the importance of habitat heterogeneity in supporting diverse avian communities. Water depth emerged as a primary determinant of species distribution, consistent with findings from other tropical wetlands where water level fluctuations drive habitat availability and foraging efficiency (Rajpar and Zakaria, 2015).

The presence of the Near Threatened *Threskiornis melanocephalus* (Black-headed Ibis) in marshy habitats underscores the conservation value of Kilpathi Lake. This species has shown declining populations across its range due to wetland drainage and agricultural intensification (IUCN, 2023) making its occurrence in this small inland wetland significant.

Conservation Implications

Anthropogenic disturbances, including localized pollution (plastic waste, agricultural runoff) and occasional livestock grazing, were observed to alter habitat structure and resource availability. These pressures could lead to long-term shifts in community composition if not addressed. Similar concerns have been raised for other Indian wetlands, where human activities increasingly encroach upon bird habitats (Aarif *et al.*, 2017; Kumar and Gupta, 2013).

The density values recorded in this study (2,765–3,984 birds/km²) are comparable to or higher than those reported from larger protected wetlands in the region (Kaur *et al*., 2018; Jamwal *et al*., 2017), suggesting that small inland water bodies can function as critical refugia for wetland birds, particularly in human-modified agricultural landscapes.

CONCLUSION

This study provides a comprehensive ecological assessment of wetland bird communities in Kilpathi Lake, demonstrating that habitat heterogeneity and seasonal dynamics are key determinants of avian diversity in small tropical inland wetlands. The following conclusions emerge:

1. Kilpathi Lake supports a moderate diversity of wetland birds (18 species, 6 families), including one Near Threatened species (*Threskiornis melanocephalus*).

2. Seasonal variation significantly influences community structure, with higher diversity during winter (Simpson's 1-D = 0.71) and higher density during the same season (3,984 individuals/km²).

3. A few dominant species (*Egretta garzetta, Ardeola grayii, Microcarbo niger*) disproportionately contribute to total abundance, reflecting an uneven community structure shaped by habitat filtering and resource availability.

4. Habitat heterogeneity (open water, marshes, vegetated zones, mudflats) supports distinct avian guilds and reduces interspecific competition.

5. Small inland wetlands, often overlooked in conservation planning, serve as critical habitats for sustaining avian diversity and require targeted protection strategies, particularly in human-modified landscapes.

Future research should focus on long-term monitoring to assess population trends, detailed foraging ecology studies to understand resource partitioning and assessment of anthropogenic impacts to inform evidence-based conservation management.

ACKNOWLEGMENT

The authors are grateful to the esteemed institution, Thiru Kolanjiappar Government Arts College, Vriddhachalam-606001, for providing the necessary facilities and workspace to carry out this research. We thank the Tamil Nadu Forest Department for granting permission to conduct field surveys. Special thanks to the local community for their cooperation during field observations.

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Cite this Article: Kumar, S.G., Venkadesh, R., Kalaimagal, P., Muthalagi, S., Vijayapathi, P., Ariharan, R., Prabhakaran, P. (2026). Community Structure and Seasonal Dynamics of Wetland Birds in a Tropical Inland Wetland, Kilpathi Lake, Vriddhachalam, Tamil Nadu, India. International Journal of Current Science Research and Review, 9(6), pp. 3037-3045. DOI: https://doi.org/10.47191/ijcsrr/V9-i6-10