

Diversity and Community Composition of Large Wading Birds Across Three Contrasting Wetlands of Kollam, Kerala

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ABSTRACT

Background: Wetlands along the southwest coast of India support diverse assemblages of large wading birds, many of which serve as ecologic indicators. **Materials and Methods:** This study assessed the diversity, abundance, and seasonal distribution of large wading birds across three wetlands in Kollam district, Kerala - Polachira wetland, Munroethuruthu backwaters, and Ashtamudi Lake. Monthly surveys using point counts were conducted between December 2024 and May 2025. Diversity was evaluated using Shannon–Wiener Index (H') and Simpson's Diversity Index (1-D). Species richness and species assemblage patterns were assessed using a Bray–Curtis dissimilarity matrix and NonMetric Multidimensional Scaling. **Results and Discussion:** A total of 12 species were recorded from Polachira, six species from Munroethuruthu, and five species from Ashtamudi Lake. Polachira exhibited the highest diversity ($H' = 2.19$, 1-D = .87), while Ashtamudi Lake showed significantly lower diversity ($H' = 1.09$, 1-D = .55). One species Asian Woollyneck *Ciconia episcopus* was Near Threatened, which was recorded only in Polachira. Seasonal peaks were observed during January and February, with a decline in May, in all three wetlands. NonMetric Multidimensional Scaling and beta diversity indexes showed a clear distinction of species assemblages in Polachira, compared to the other two sites. **Conclusion:** The study highlights Polachira as an important habitat for large wading birds in southern Kerala, and disturbance regulation in Ashtamudi Lake despite its Ramsar status. Regular monitoring of wading-bird assemblages is recommended as a bioindicator tool for wetland conservation planning.

Keywords: Bioindicators, Kerala, Near Threatened species, Ramsar site, Wading birds, Wetland conservation.

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INTRODUCTION

Wetlands are among the most productive and ecologically significant ecosystems globally, supporting disproportionately high biodiversity relative to their spatial extent (Mathibalan *et al.*, 2025; Rashiba *et al.*, 2022). In tropical regions such as peninsular India, wetlands function as hydrological regulators, nutrient sinks, carbon reservoirs, and critical habitats for resident and migratory avifauna. However, they are also among the most threatened ecosystems due to urban expansion, pollution, hydrological alteration, and land-use change (Naveen Kumar *et al.*, 2025).

Large wading birds, comprising herons, egrets, storks, ibises, and Spoonbills, occupy upper trophic positions in wetland food webs. Their dependence on shallow water systems for foraging, nesting,

and roosting makes them sensitive to fluctuations in hydrology, prey density, vegetation structure, and anthropogenic disturbance (Aarif *et al.*, 2025). Their population are highly impacted by factors such as water quality, wetland size and food availability (Sievers *et al.*, 2018). Because of this ecologic sensitivity, they are widely recognized as effective bioindicators of wetland health (Wen *et al.*, 2016).

India supports more than 30 species of large wading birds, several of which are globally threatened or Near Threatened according to the IUCN Red List. Species such as the Painted Stork *Mycteria leucocephala*, Black-headed Ibis *Threskiornis melanocephalus*, and Asian Woollyneck *Ciconia episcopus* have experienced population pressures due to habitat loss, agricultural intensification, and wetland drainage. Large wading birds are adaptive and have been recorded in diverse habitats such as coastal lagoons (Byju *et al.*, 2025; Byju *et al.*, 2024a; Byju *et al.*, 2023a), mangroves (Byju *et al.*, 2023b), irrigation tanks around human settlements on the southeast (Byju *et al.*, 2023c; Byju *et al.*, 2023d; Byju *et al.*, 2024b; Byju *et al.*, 2024c) and natural wetlands like estuaries, farmlands, backwaters or lakes on the southwest of India (Bindu and Sajitha, 2025; Narayanan *et al.*, 2011; Sashikumar and Palot, 2002;



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Sivaperuman and Jayson, 2009). Monitoring their populations provides critical insights into habitat integrity and conservation status.

Kerala, situated along the Central Asian Flyway, supports numerous wetlands of international importance, including Vembanad and Ashtamudi Lakes (WISA and CWRDM, 2024). Despite Ramsar recognition, several wetlands in Kerala face increasing anthropogenic pressures from urbanization, tourism, aquaculture, and domestic effluents. Kollam district in Kerala presents a mosaic of wetland ecosystems, estuaries, inland marshes, islands, backwater and beaches (Vijayan *et al.*, 2024). Yet, the studies focused exclusively on wetland dependent large wading birds are limited.

The present study aims to bridge the knowledge gap by conducting a comparative assessment across three important wetlands of Kollam district-Polachira, Munroe Thuruthu, and Ashtamudi Lake, each one being a unique wetland system, and Ashtamudi Lake being the Ramsar site. Understanding how large wading birds respond to differing levels of disturbance and habitat structure is crucial for site-specific management interventions. Hence, the specific objectives of the present study were to, (1) document the species composition and monthly abundance patterns of large wading birds across three wetlands of Kollam and (2) Compare diversity, richness and species composition among the wetlands.

MATERIALS AND METHODS

Study Area

The study was conducted in three diverse wetlands of Kollam District, Kerala, India (Figure 1):

- Polachira (8.840803 N, 76.70008 E) is a freshwater marsh system characterized by shallow waters, mudflats, emergent vegetation, and seasonal inundation. This wetland mainly comprises farmland. Human disturbance is relatively low in this wetland.
- Munroethuruthu (9.0000 N, 76.61666 E) is an estuarine island system formed at the confluence of Ashtamudi Lake and Kallada River. Habitat includes tidal creeks, mangroves, and coconut groves.
- Ashtamudi Lake (8.891772 N, 76.58787 E) is a Ramsar-designated estuarine wetland. The present study focused on the more urbanized and human-dominated point near Kollam city.

Bird Surveys

Monthly surveys were conducted from December 2024 to May 2025 across the three wetlands. Bird counts were carried out using fixed point-count methods (Bibby *et al.*, 2000), with six fixed vantage points at each site. At each point, observations were

made within an approximate radius of 100 m for a duration of 10 min. Surveys were conducted during peak bird activity periods (06:00 a.m.–09:00 a.m. hr and 4:00 p.m.–6:00 p.m. hr). Birds were observed using 10 × 50 binoculars and identified using standard field guides (Grimmett *et al.*, 2011). To minimize duplication of counting, the direction of movement and flock structure of individuals were carefully noted during observations.

Data Analysis

Species-wise abundance data were assessed for each site and month. Species richness was calculated as the total number of species recorded. Community diversity was assessed using the Shannon–Wiener index (H') and Simpson's index (1-D) following standard formulations (Magurran, 2004).

Differences in species composition as beta diversity values among wetlands were quantified using Bray–Curtis dissimilarity (Bray and Curtis, 1957). Nonmetric Multidimensional Scaling (NMDS) was employed to visualize patterns in community composition based on Bray–Curtis distances (Clarke, 1993). Stress value was 0.057, indicating a good ordination fit. All analyses were performed in R version 4.5.1.

RESULTS

Species Status, Richness and Abundance

A total of 12 species of large wading birds of the order Pelecaniformes and Ciconiiformes, belonging to three families, Ciconiidae, Ardeidae and Threskiornithidae, were recorded together from the three study sites. Ashtamudi recorded five species, Munroethuruthu recorded six species, and Polachira recorded the highest species richness (12 species). One species Asian Woollyneck, was Near Threatened, while the other 11 species were Least Concern in the IUCN Redlist. Except Glossy Ibis *Plegadis falcinellus* and Eurasian Spoonbill *Platalea leucorodia*, the other 10 species were Residents. Species such as Painted Stork, Glossy Ibis, Eurasian Spoonbill, Black-headed Ibis and Asian Woollyneck were recorded only in Polachira. In contrast, species such as Little Egret *Egretta garzetta*, Cattle Egret *Bubulcus ibis*, Intermediate Egret *Ardea intermedia*, and Indian Pond Heron *Ardeola grayii* were recorded across all wetlands but showed higher abundances at Polachira (Table 1).

Monthly variation in species richness and total abundance showed marked differences among wetlands (Figures 2 and 3). Polachira supported higher species richness in January and February (12 species each) and lowest in May (7 species). Total abundance was also the highest in Polachira (1394), with January ($n = 575$) and February ($n = 421$) recording the highest. In Polachira, predominant species were Intermediate Egret, Painted Stork and Indian Pond Heron (total abundance of 290, 242 and 185, respectively). Asian Woollyneck, Eurasian Spoonbill and Glossy Ibis were recorded only in January and February in Polachira. In

Munroethuruthu, the total abundance of all large wading species was 128, with higher numbers in February (n = 29) and March (n = 30). Species richness in Munroethuruthu varied between five and six in all the months. Among the three wetlands, Asthamudi Lake exhibited the lowest species richness, varying between four and five. Total species abundance in Ashtamudi was 402, with December 2024 being the highest (n = 129) and May 2025 the lowest (n = 23). Seasonal variation in large wading species abundance is distinct in all the wetlands, with peaks in January and February and a decline in May.

Community Composition and Diversity

Diversity indexes varied notably among wetlands (Figure 4). Polachira exhibited the highest diversity ($H' = 2.19$ and $1-D = .87$), while Munroethuruthu showed intermediate values ($H' = 1.43$, $1-D = .70$), and Ashtamudi consistently recorded the lowest diversity indexes ($H' = 1.09$, $1-D = .55$).

Community composition differed markedly among wetlands, as indicated by NMDS ordination (Figure 5). Monthly site-level samples clustered distinctly with minimal overlap, suggesting clear differences in species assemblages. In Polachira monthly variation in species assemblage was also distinct and varied. Bray–Curtis dissimilarity values further supported these patterns. Beta diversity values indicated greater dissimilarities in species composition between Munroethuruthu and Polachira (0.88), followed by Polachira and Ashtamudi (0.69), while Ashtamudi and Munroethuruthu were relatively more similar (0.58).

DISCUSSION

Marked differences in diversity and community composition among the three wetlands indicate reasonable influences of habitat structure and disturbances on large wading-bird assemblages. Diversity is an essential ecologic indicator used to assess ecosystem health and quality. Polachira supported the highest diversity and species richness, whereas Ashtamudi Lake consistently exhibited lower diversity, and Munroethuruthu showed intermediate values, indicating Polachira's shallow water regime, exposed mudflats, and relatively low disturbance likely provided optimal foraging conditions for species such as storks and ibises. Wading birds are known to respond strongly to water depth gradients, with most species preferring shallow water zones that maximize foraging efficiency (Aarif et al., 2025). The exclusive occurrence of the Near Threatened Asian Woollyneck at this site further underscores its conservation value. This species is known to depend on relatively undisturbed wetlands and agricultural fields as suitable foraging grounds (Kittur and Sundar, 2020). The distinct clustering of Polachira in NMDS, along with high beta diversity relative to the other wetlands, indicates a structurally and functionally distinct assemblage shaped by favorable habitat conditions. Bindu and Sajita (2025) recorded 14 large wading-bird species from Polachira and Pozhikkara wetlands, aligning closely with our study.

Munroethuruthu exhibited moderate diversity, likely influenced by fluctuations in water levels since it is in the confluence of two rivers. Periodic inundation, tidal stage and seasonal hydrological

Table 1: Large wading species recorded in all three wetlands with IUCN and migratory status.

Common name	Scientific name	IUCN status	Migratory status	Wetlands		
				Polachira	Munroethuruthu	Ashtamudi
Ardeidae (order: Pelecaniformes)						
Little Egret	<i>Egretta garzetta</i>	LC	R	*	*	*
Cattle Egret	<i>Bubulcus ibis</i>	LC	R	*	*	*
Intermediate Egret	<i>Ardea intermedia</i>	LC	R	*	*	≠
Great Egret	<i>Ardea alba</i>	LC	R	*	*	*
Indian Pond Heron	<i>Ardeola grayii</i>	LC	R	*	*	*
Purple Heron	<i>Ardea purpurea</i>	LC	R	*	*	≠
Gray Heron	<i>Ardea cinerea</i>	LC	R	≠	*	*
Threskiornithidae (order: Pelecaniformes)						
Black-headed Ibis	<i>Threskiornis melanocephalus</i>	LC	R	*	≠	≠
Glossy Ibis	<i>Plegadis falcinellus</i>	LC	M	*	≠	≠
Eurasian Spoonbill	<i>Platalea leucorodia</i>	LC	M	*	≠	≠
Ciconiidae (order: Ciconiiformes)						
Asian Woollyneck	<i>Ciconia episcopus</i>	NT	R	*	≠	≠
Painted Stork	<i>Mycteria leucocephala</i>	LC	R	*	≠	≠

*species present in the wetland ≠ species absent in the wetland.

IUCN status: LC- Least Concern, NT- Near Threatened; Migratory status: R- Resident, M-Migratory.

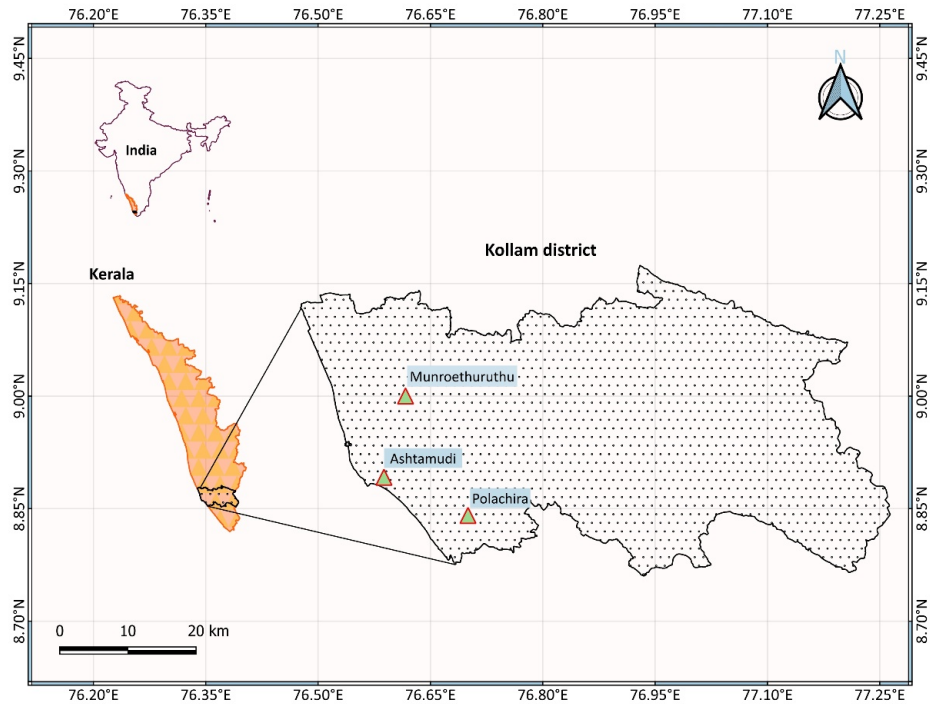


Figure 1: Map showing the three wetlands, Polachira, Munroethuruthu and Ashtamudi in Kollam district, Kerala.

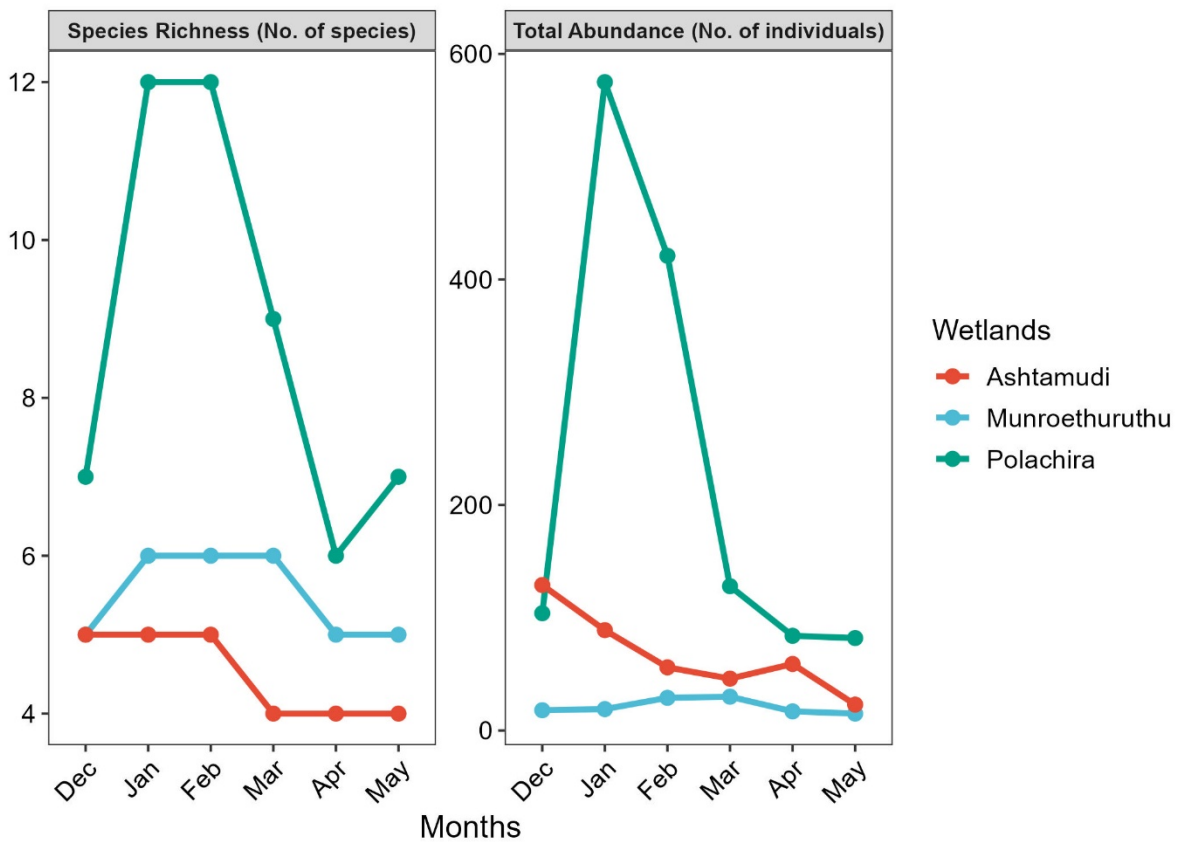


Figure 2: Monthly species richness and total abundance of large wading birds in the three wetlands.

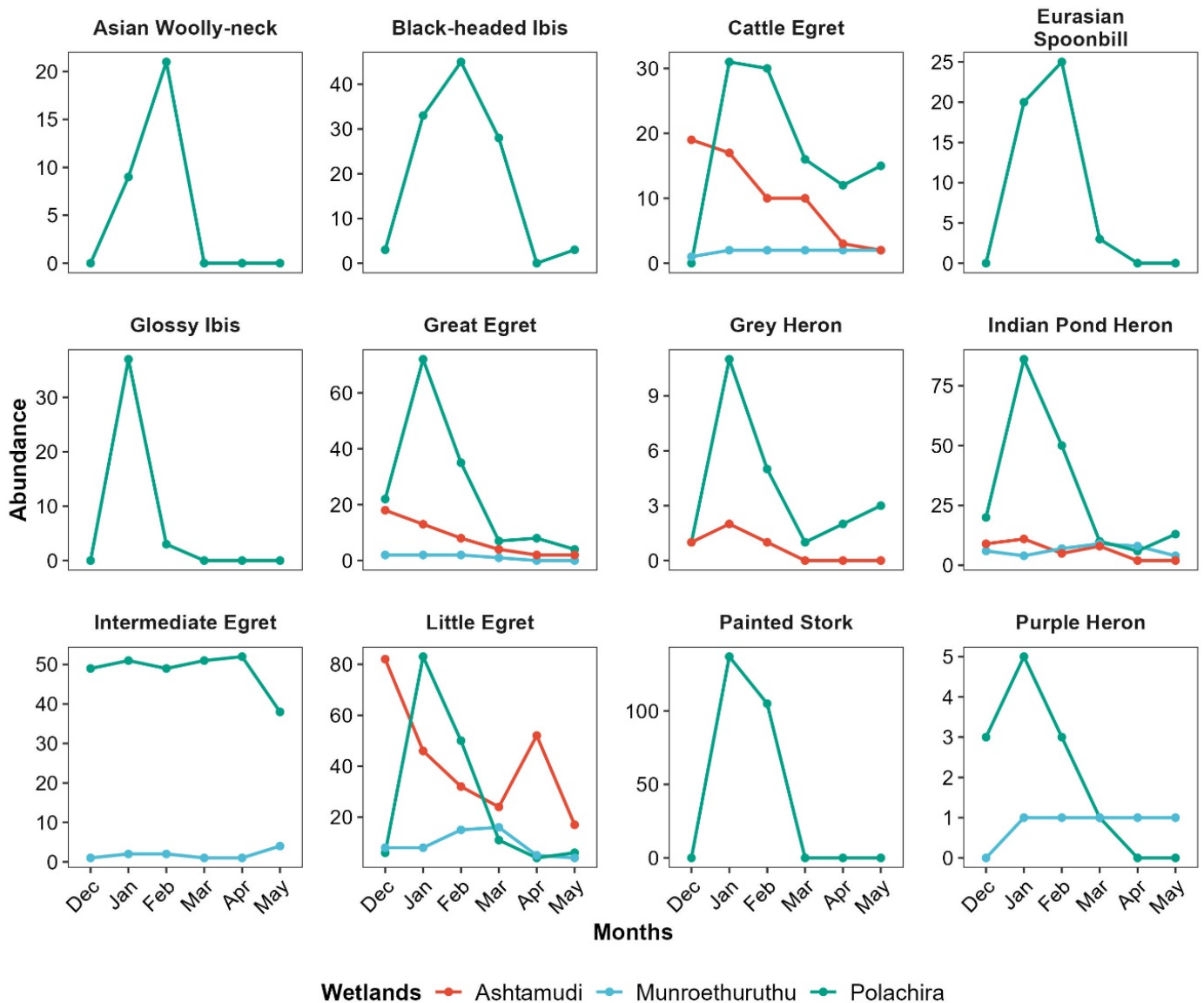


Figure 3: Monthly abundance of the large wading species in the three wetlands.

conditions can alter prey availability and accessibility, thereby influencing bird distribution and abundance (Lorenzón *et al.*, 2019), which may explain the intermediate diversity and partial overlap in species composition with Ashtamudi. Only the generalist species, like egrets and herons, were recorded in Munroethuruthu, showing the adaptability of the species.

Despite its designation as a Ramsar site, Ashtamudi Lake showed reduced diversity and species richness. Ashtamudi has greater similarity in species composition to Munroethuruthu (beta diversity = 0.58). This pattern likely reflects the influence of anthropogenic disturbance by tourism, fishing, pollution, and industrial effluent discharge at the lake (Pournami *et al.*, 2023). Pollution causes significant damage to zooplanktons, aquatic

insects, invertebrates and fishes which in turn affects waterbird populations (Mallin *et al.*, 2016). Disturbance has been shown to reduce habitat suitability for sensitive wading birds and favor more tolerant, opportunistic species such as Indian Pond Heron, Cattle Egret, and so on, leading to simplified community structure and disturbance-mediated homogenization of species assemblages (Naveen Kumar *et al.*, 2025; Rajashekara and Venkatesha, 2018).

Seasonal patterns further support the role of ecologic drivers, with peak diversity observed during January–February and a decline in May across all sites. This likely reflects a combination of local migration during winter (December–February) and reduced habitat suitability in late summer (April–May) due to increased temperatures and water level changes. Seasonal dynamics in

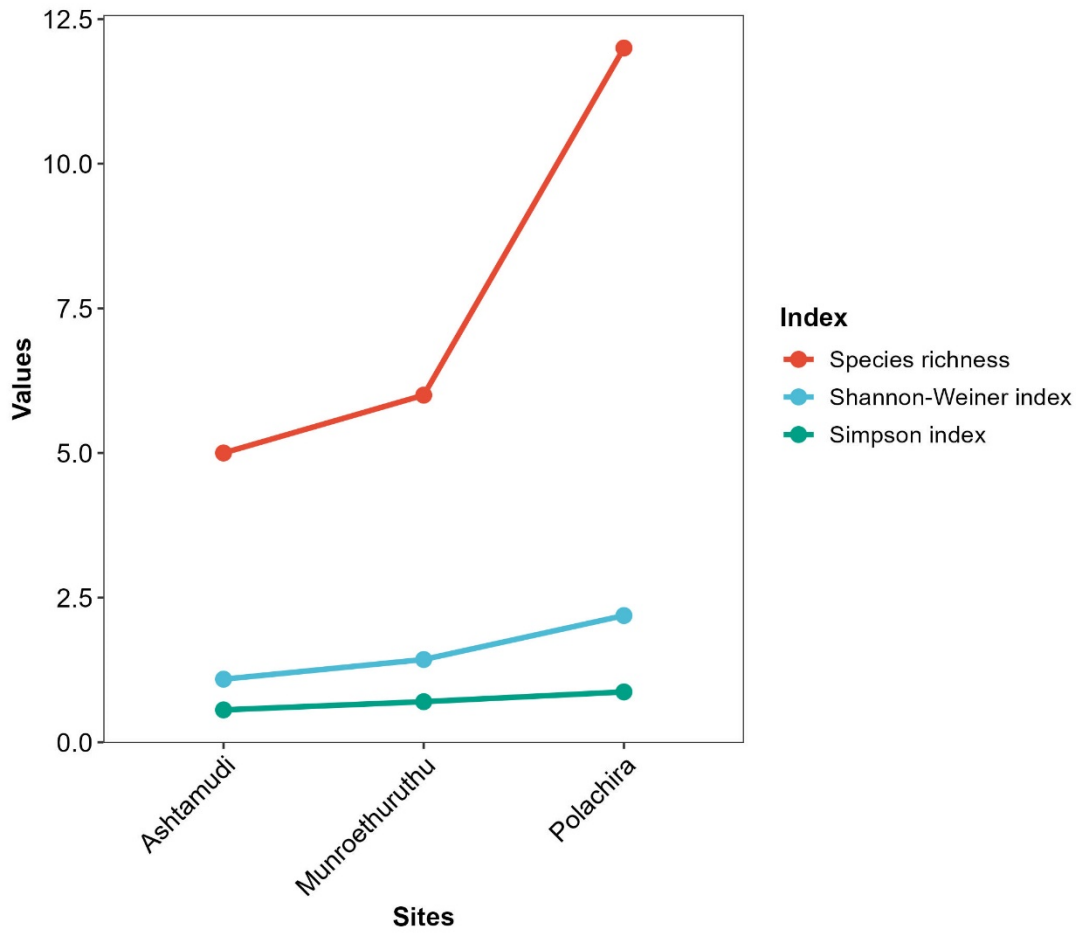


Figure 4: Overall species richness (no. of species), Shannon and Simpson diversity indexes across the three wetlands.

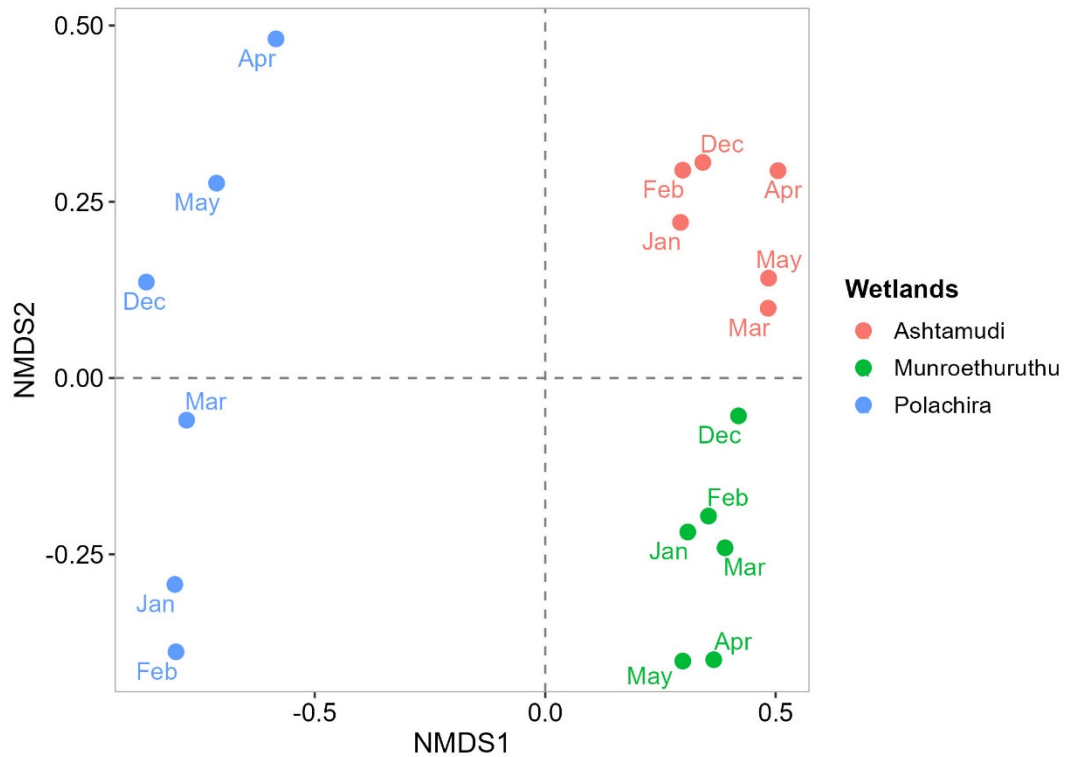


Figure 5: Non-Metric Multidimensional Scaling (NMDS) ordination plot showing the variation in species assemblages across months in the three wetlands.

waterbird abundance are well documented in Indian wetlands, where winter months typically support higher species richness and abundance and marked declines in summer (George *et al.*, 2024).

Together, these findings indicate that both physical habitat characteristics and levels of anthropogenic disturbance govern community structure in wetland bird assemblages.

The clear separation of assemblages in NMDS ordination and high beta diversity values indicates that each wetland contributes uniquely to regional diversity. Polachira, in particular, functions as a distinct ecologic unit supporting a higher diversity of species. In contrast, the reduced diversity and homogenized assemblage in Ashtamudi suggest habitat degradation and the need for targeted management interventions.

Conservation Implications

While Polachira emerges as an important conservation site due to its high diversity, distinct community composition, and support for a Near Threatened species, Ashtamudi stands out as an example of poor management in an urbanized area. Protection measures should focus on maintaining appropriate water regimes, preventing encroachment, and minimizing disturbance. In Ashtamudi, efforts should prioritize habitat restoration, regulation of boat traffic, tourism and control of effluent discharge to improve habitat quality. Regular, standardized monitoring across all sites is necessary to detect temporal trends and guide adaptive management. Finally, community-based conservation approaches are essential, particularly in human-dominated landscapes, to ensure long-term sustainability of wetland habitats and associated bird populations.

CONCLUSION

Large wading bird diversity varied significantly across the wetlands of Kollam district, with Polachira emerging as the most ecologically intact site. Munroethuruthu showed moderate habitat suitability, while Ashtamudi Lake exhibited signs of ecologic stress despite international recognition. Conservation planning should prioritize shallow marsh systems supporting threatened species and address urban disturbances in Ramsar wetlands in future.

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ABBREVIATIONS

NMDS: Nonmetric Multidimensional Scaling.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS

Sreelal R S- experimental studies, data acquisition; Reshmi Vijayan- manuscript editing and manuscript review; Maitreyi H- manuscript preparation, data analysis, statistical analysis.

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