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ARTICLE

A preliminary checklist and seasonal diversity of wetland-associated birds in Bajali District, Assam, India

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Abstract: Wetlands sustain diverse avian assemblages and provide indispensable habitats for resident and migratory waterbirds; however, many wetlands in northeastern India remain inadequately documented. This study presents the first preliminary checklist and diversity assessment of wetland-associated birds from selected wetlands in Bajali District, Assam, northeastern India, based on systematic point-count surveys conducted across five sites between April 2024 and March 2025. Seasonal variations in species composition, abundance, migratory status, feeding guilds, conservation status, and community diversity were comprehensively evaluated. A total of 44 wetland-associated bird species representing 14 families were recorded. Ardeidae was the most species-rich family (10 species; relative diversity index = 22.72%), followed by Scolopacidae (7 species). Bird abundance exhibited pronounced seasonal fluctuations, peaking during winter (2,835 individuals), followed by monsoon (2,601), autumn (2,064), and summer (2,009). Species richness attained its maximum during autumn and winter (44 species each) but declined markedly during the monsoon (29 species). Diversity metrics consistently revealed greater species richness, diversity, evenness, and community stability during the post-monsoon and winter seasons, whereas monsoon assemblages were characterized by reduced diversity and elevated species dominance. Resident species constituted 65.91% of the recorded avifauna, while 34.09% were winter visitors. Most species (95.46%) were classified as 'Least Concern', whereas the Lesser Adjutant and Asian Woollyneck were categorized as 'Near Threatened', underscoring the conservation significance of the study area. This study provides the first comprehensive documentation of wetland-associated birds in Bajali District and highlights the ecological importance of its wetlands in sustaining diverse resident and migratory bird assemblages. The findings establish a valuable reference for long-term biodiversity monitoring, conservation planning, and sustainable wetland management in the lower Brahmaputra floodplain.

Keywords: Abundance, avian assemblages, biodiversity monitoring, community stability, conservation planning, feeding guild, migratory status, seasonal variation, species richness.

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INTRODUCTION

Birds significantly contribute to ecosystem functionality through pollination, regulation of insect populations, and modification of the physico-chemical properties of their habitats via diverse ecological interactions (Fraixedas et al. 2020; Basile et al. 2021). Consequently, avian species richness, community composition, habitat utilization patterns, and population dynamics are widely recognized as robust indicators of environmental quality, resource availability, and overall ecosystem health (Lindenmayer et al. 2006; Tanalgo et al. 2015). Birds occupy multiple trophic levels within food webs and play essential roles in ecological networks through predation, seed dispersal, scavenging, nutrient cycling, and other ecosystem functions, thereby contributing to ecosystem stability and resilience (Michel et al. 2020; Tobias et al. 2020; Signa et al. 2021**).**

Within urban landscapes, the availability and management of large green spaces are critical for the long-term persistence and conservation of avian assemblages (Campbell et al. 2022; Choudaj & Shaha 2023). Spatial heterogeneity in avian abundance and species richness can exert cascading effects on both terrestrial and aquatic ecosystems, which are ecologically linked through complex trophic pathways (Turner 2003). Nevertheless, a marked decline in bird populations—particularly within highly urbanized environments—has emerged as a growing ecological concern, closely associated with increasing levels of urban development and environmental pollution (Donaldson et al. 2007). Furthermore, climatic stability and seasonal variability function as key determinants of avian diversity, strongly influencing species distributions and community structure (Graham et al. 2006).

Accelerated urban expansion has substantially transformed natural landscapes, altered ecological processes, and modified ecosystem structure and functioning (Basu & Das 2021; Hersperger et al. 2021). Urbanization results in habitat loss, fragmentation, and degradation, leading to significant reductions in the diversity of plants, insects, and vertebrate taxa, with birds being among the most sensitive to these changes (Carrasco et al. 2018). Mitigating the negative impacts of urban growth on biodiversity and achieving a sustainable balance between anthropogenic development and ecological integrity therefore constitute major objectives of contemporary urban planning and biodiversity conservation research (Canedoli et al. 2018). As the most widespread and ecologically responsive vertebrate group in urban ecosystems, birds serve as reliable bioindicators of environmental conditions and biodiversity status (Shwartz et al. 2014). Given their ecological importance and contributions to human well-being in urban environments (Fuller et al. 2007), avian-focused research is particularly essential in regions experiencing rapid urbanization.

Wetland ecosystems are among the most productive and biologically rich environments on Earth, yet they are highly fragile and sensitive to disturbance (Gibbs 1993; Van der Valk 2006). These ecosystems are primarily structured by hydrological processes, including water availability, hydroperiod, and local water cycles, which strongly influence species composition, habitat structure, and overall biodiversity (Urban 2004; Bronmark & Hansson 2005). Variations in hydrological regimes regulate ecological filtering and species assemblage patterns, making water dynamics a key driver of wetland community organization. Freshwater wetlands, particularly lakes and riverine systems, are of immense ecological and socio-economic importance, supporting agriculture, fisheries, livestock, and drinking water supplies while sustaining high biodiversity. They also provide critical ecosystem services such as flood regulation, groundwater recharge, nutrient retention, sediment control, and erosion mitigation (Mitsch & Gosselink 1986). However, increasing anthropogenic pressures—including agricultural expansion, aquaculture, industrial discharge, waste disposal, land reclamation, and dredging—have severely altered wetland structure and function, threatening both biodiversity and ecosystem services (Balachandran et al. 2002; Naveen et al. 2025).

Waterbirds, defined as bird species ecologically dependent on wetlands, constitute a major faunal component of these ecosystems. They occupy multiple trophic levels within wetland food webs and play an important role in nutrient cycling, prey–predator regulation, and ecosystem stability (Custer & Osborne 1977; Rajashekara & Venkatesha 2010). Because waterbirds respond rapidly to environmental change, their population trends and community structure serve as reliable biological indicators of wetland health and water quality (Grimmett & Inskipp 2007). Their assemblages are regulated by food availability, wetland size, habitat heterogeneity, productivity, and the duration and timing of flooding cycles (Cintra et al. 2007; Gajardo et al. 2009; Khan 2010; Cintra 2012; Rajpar 2022). Temporal factors, such as seasonal variations, tidal cycles, and climatic conditions, influence the quality and resource availability, thereby shaping waterbird abundance and assemblage structure in wetlands (Khan 2010; Pandiyan et al. 2010; Byju et al. 2025c). Wetlands containing diverse microhabitats, such as shallow open water, marshes, mudflats, and aquatic vegetation, generally support higher waterbird diversity by providing essential feeding, nesting, and roosting resources (Paracuellos 2006; Manikannan et al. 2011; Arya et al. 2014; Mathibalan et al. 2026).

In addition to natural wetlands, agricultural and agroforestry landscapes also contribute significantly to bird conservation, as protected areas cover only a limited proportion of land (Sundar & Subramanya 2010). Agroecosystems provide diverse food resources, including grains, seeds, fruits, insects, and small vertebrates, supporting avian communities that function both as crop pests and as natural pest-control agents (O'Connor & Shrubb 1986; Borad et al. 2000; Haslem & Bennett 2008; Asokan et al. 2009). Furthermore, birds contribute to seed dispersal, pollination, scavenging, and nutrient cycling, thereby enhancing ecosystem functioning in both natural and human-modified landscapes (Dhindsa & Saini 1994; Whelan et al. 2008; Sekercioglu 2012). Bird diversity in agricultural systems is strongly influenced by crop type, vegetation structure, land-use practices, and landscape composition, including the presence of wetlands, forest patches, grasslands, and agroforestry trees (Taft & Haig 2006; Bruggisser et al. 2010; Wretenberg et al. 2010).

Although wetland bird communities have been studied in several ecologically important wetlands of Assam and other parts of northeastern India, these investigations are largely restricted to protected areas and a few well-known floodplain wetlands. Consequently, many district-level wetlands remain poorly documented, resulting in limited knowledge of their avifaunal diversity, community composition, seasonal dynamics, and habitat use. Bajali District, situated in the lower Brahmaputra valley of western Assam and adjoining the foothills of Bhutan, contains a network of natural and human-modified wetlands that are likely to provide important habitats for both resident and migratory waterbirds. Despite their ecological significance, these wetlands have received little scientific attention, and baseline information on their bird communities is lacking. The present study was therefore undertaken to prepare the first preliminary checklist of wetland-associated birds and document their diversity, abundance, and seasonal dynamics in selected wetlands of Bajali District, Assam. The findings provide baseline ecological information to support long-term biodiversity monitoring, conservation planning, and sustainable wetland management in this understudied region.

MATERIALS AND METHODS

Study area

Bajali District, located in the western part of Assam, India, was formally established on 12 January 2021 following its separation from Barpeta District, where it previously functioned as a subdivision. The district is bordered by Baksa District to the north, Nalbari District to the east, and Barpeta District to the west and south. The administrative headquarters is situated at Madan Rauta Nagar in Pathsala. Geographically, Bajali lies between 26.7333–26.8333 °N and 91.0667–91.4000 °E, covering a total area of approximately 422.95 km² (163.30 square miles), which is comparable in size to the country of Barbados.

Bajali District is characterized by a heterogeneous landscape comprising low-lying alluvial plains interspersed with gentle uplands and traversed by several minor river systems, including the Palla, Deojara, Pahumara, and Kaldia, which render the area highly flood-prone. The district lies within Seismic Zone V, reflecting a high level of tectonic vulnerability. Its economy is predominantly agrarian, supported by fertile alluvial soils that sustain crops such as rice, mustard, and a variety of vegetables. The climate is tropical monsoonal, with hot and humid summers, heavy rainfall from May to September, and relatively cool, overcast winters. Vegetation is dominated by wet broadleaf forests containing sal, teak, mahogany, bamboo, and diverse fruit-bearing species. The district also hosts ecologically significant wetlands rich in aquatic macrophytes such as lotus and water lilies, underscoring Bajali's role as an important biodiversity reservoir within the Brahmaputra Valley. Bajali experiences a humid subtropical climate with hot, moisture-laden summers and cool, overcast winters. Peak rainfall occurs from May to September, followed by a mild post-monsoon period, while February–April remain comparatively dry. Seasonal flooding of the Kaldiya and Pahumara rivers frequently results in hydrological stress and socio-environmental disruption across the district.

Bird surveys

Surveys of wetland-associated birds in Bajali District were conducted from April 2024 to March 2025 using the point count method (Ralph et al. 1995; Drapeau et al. 1999; Bibby et al. 2000). A total of five-point count stations were established across the landscape (Table 1; Image 1), spaced 1.0–2.5 km apart to minimize the likelihood of double counting (Ralph et al. 1995). The sampling sites were randomly selected from relatively

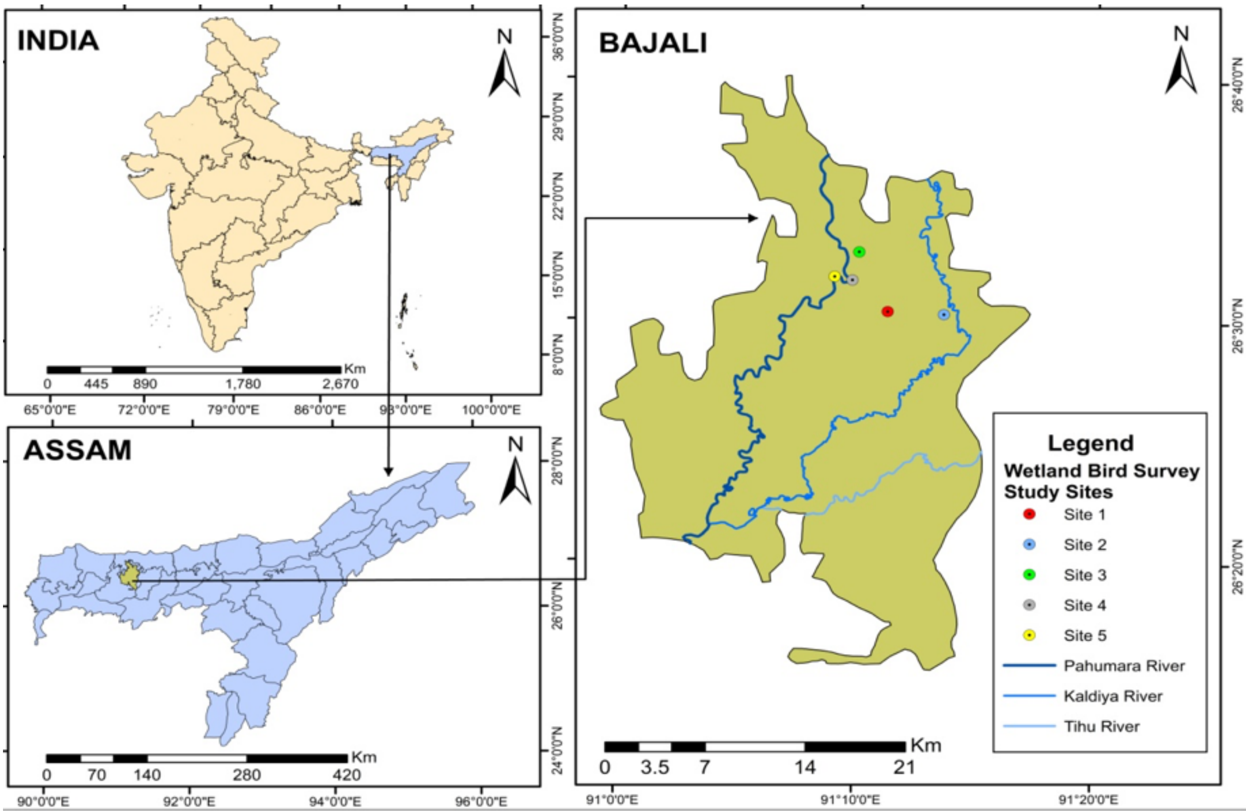

Image 1. Location map of the wetland-associated bird survey sites in Bajali District, Assam, India. Prepared using ArcGIS 10.2.

Table 1. The geographic coordinates, elevation, and habitat characteristics of the five bird survey sites.

	Survey sites	Coordinates		Habitat type and vegetation characteristics	Elevation (in m)
		Latitude (°N)	Longitude (°E)		
1	Site-1	26.5071	91.1876	Grass embankments of village ponds with standing freshwater and emergent aquatic vegetation	44
2	Site-2	26.5055	91.2272	Marshlands with extensive reedbeds fringing permanent wetlands	47
3	Site-3	26.5481	91.1671	Damp grasslands interspersed with cultivated paddy fields	49
4	Site-4	26.5287	91.1625	Seasonally flooded grasslands associated with rice-growing areas	47
5	Site-5	26.5310	91.1500	Riverbank habitats with riparian vegetation	45

species-rich areas, with site selection guided by vegetation structure, food availability, and overall habitat suitability for bird communities. The selected locations represented a range of habitat complexes supporting varying levels of wetland-associated bird species richness and community composition (Table 1). Surveys were conducted two days per week, twice daily between 0600–0900 h and 1500–1700 h under favorable weather conditions, and were postponed during periods of heavy rainfall or strong winds to minimize observational bias. Precise GPS coordinates were recorded for each station to ensure spatial accuracy. At each station, observers allowed a brief acclimatization period before initiating counts to reduce disturbance (Hostetler & Main 2001). Birds were then recorded during a 15-minute observation period, including all individuals detected visually or aurally within an unlimited radius (Drapeau et al. 1999; Bibby et al. 2000). Species identification was carried out using standard field guides (Kazmierczak 2002; Grimmett et al. 2016; Grewal et al. 2018), based on morphological characteristics, size, plumage, and vocalizations. When identification was uncertain, photographic and audio records were obtained for later verification. Observations were made using binoculars (Nikon, Monarch, 10 × 42 mm) and a spotting scope (20 × 60), with additional documentation captured using a Nikon

D7500 camera. Diversity indices were calculated using PAST software (version 4.03). The global conservation status of each species was determined following the IUCN Red List. Species were classified according to their frequency of occurrence during repeated field surveys following the classification proposed by Mackinnon & Phillips (1993) and subsequently adopted by Byju et al. (2024). Species recorded on 6–8 out of every 10 survey visits were categorized as Common (C), those observed on 3–5 out of 10 visits as Uncommon (UC), and those detected on only 1–2 out of every 10 survey visits as Rare (R). In addition, the relative diversity of each bird family was estimated using the relative diversity index (RDi) following Koli (2014), calculated as:

$$RDi = \frac{\text{Number of species in a family}}{\text{Total number of species recorded}} \times 100$$

Field observations conducted throughout the study period, together with information from standard ornithological literature (Ali et al. 1996; Feijen & Feijen 2008; Grimmett et al. 2016; Billerman et al. 2022), were used to assign all recorded bird species to seasonal occurrence categories comprising resident species, winter visitors, and summer migrants, as well as to feeding guilds comprising granivores, frugivores, nectivores, insectivores, carnivores, and omnivores. Assamese vernacular names were compiled and cross-verified using published regional sources (Gogoi 2006; Dutta 2011; Datta 2017).

RESULTS AND DISCUSSION

Species composition and seasonal abundance of wetland-associated birds

A total of 44 wetland-associated bird species, representing 14 avian families, were recorded from the selected wetlands of the Bajali landscape during the study period (April 2024–March 2025) (Table 2). The recorded assemblage comprised both resident and migratory species occupying diverse ecological niches within the wetland ecosystem, indicating the importance of these habitats in supporting a taxonomically diverse avifaunal community.

Seasonal surveys conducted during summer (pre-monsoon; March–May), monsoon (June–September), autumn (post-monsoon; October–November), and winter (December–February) revealed pronounced temporal variation in bird abundance (Table 3). The total abundance was highest during winter (2,835 individuals), followed by monsoon (2,601 individuals), autumn (2,064 individuals) and summer (2,009 individuals). The marked increase in winter abundance was primarily associated with the seasonal arrival of migratory waterbirds, whereas relatively lower abundance during summer reflected the predominance of resident species prior to the onset of migration.

Seasonal fluctuations were also evident in species richness, reflecting changes in community composition throughout the annual hydrological cycle. Wetland habitats supported a greater diversity of species during autumn and winter, whereas comparatively

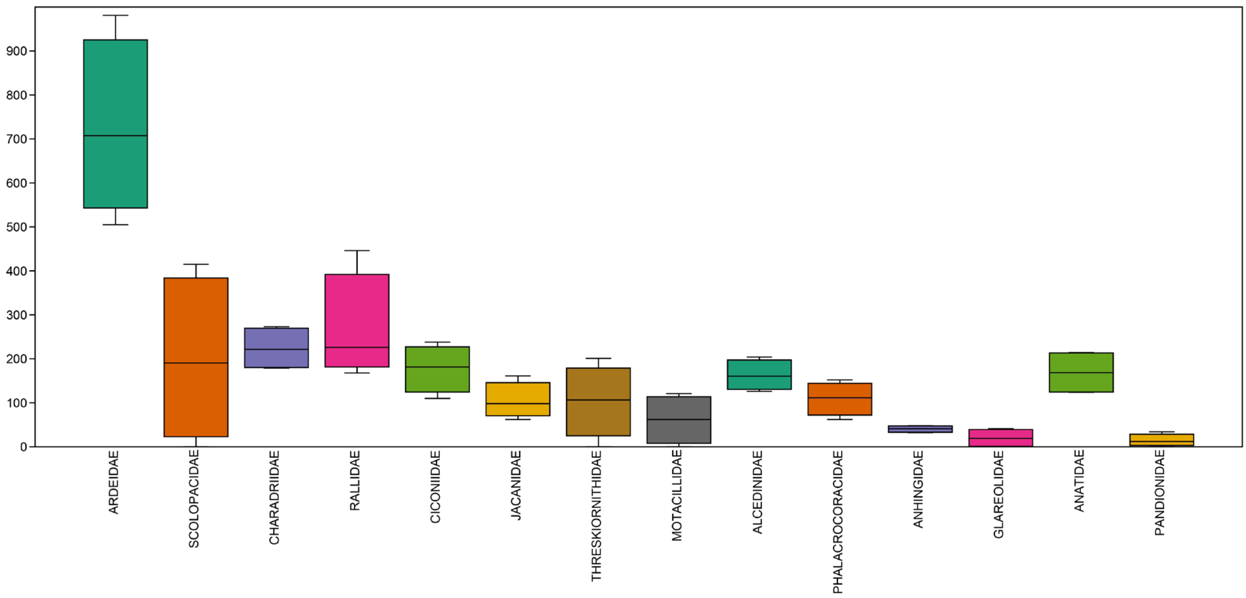

Image 2. Box plots illustrating variation in the abundance of wetland-associated bird families.

Table 2. Checklist of wetland-associated bird species recorded in Bajali District, Assam, with taxonomic details, local names, habitat, feeding guilds, abundance, phenology, and conservation status.

	Family	English name	Scientific name	Local name/ Assamese name	IUCN Red List status	IWPA	Habitat location	Feeding habits/ Feeding guilds	Abundance status	Phenological status
1	Ardeidae	Little Egret	*Egretta garzetta* (Linnaeus, 1766)	টেটেৰী বগ	LC	Schedule II	WE, OW, T	CA	COM	R
2		Grey Heron	*Ardea cinerea* (Linnaeus, 1758)	হালখেদা	LC	Schedule II	WE	CA	COM	R
3		Indian Pond Heron	*Ardeola grayii* (Sykes, 1832).	কণামুচৰি	LC	Schedule II	WE	CA	COM	R
4		Yellow Bittern	*Ixobrychus sinensis* (Gmelin, 1789).	হালধি কণা/ হালধীয়া বগুলা	LC	Schedule II	WE	CA	UNCOM	R
5		Great Egret	*Ardea alba* (Linnaeus, 1758)	বৰ বগ	LC	Schedule II	OW, WE, T	CA	COM	R
6		Cattle Egret	*Bubulcus ibis* (Linnaeus, 1758)	গো বগ	LC	Schedule II	WE	CA	COM	R
7		Purple Heron	*Ardea purpurea* (Linnaeus, 1766)	আজান	LC	Schedule II	OW, WE	CA	UNCOM	R
8		Medium Egret	*Ardea intermedia* (Wagler, 1829.)	মাজু বগ	LC	Schedule II	OW, WE	CA	COM	R
9		Cinnamon Bittern	*Ixobrychus cinnamomeus* (Gmelin, 1789).	ইটাগুড়ীয়া	LC	Schedule II	WE	CA	LOC COM	R
10		Black- crowned Night Heron	*Nycticorax nycticorax* (Linnaeus, 1758)	ৰাক চৰাই	LC	Schedule II	WE	CA	UNCOM	R
11	Scolopacidae	Common Sandpiper	*Actitis hypoleucos* (Linnaeus, 1758).	বালি খোঁচৰা	LC	Schedule II	WE	CA	COM	WM
12		Marsh Sandpiper	*Tringa stagnatilis* (Bechstein, 1803)	বোকাপানী খোঁচৰা / পিতনিৰ বালি খোঁচৰা	LC	Schedule II	OW, WE	CA	UNCOM	WM
13		Common Greenshank	*Tringa nebularia* (Gunnerus, 1767).	পাত ঠেঙী	LC	Schedule I	OW, WE	CA	UNCOM	WM
14		Green Sandpiper	*Tringa ochropus* (Linnaeus, 1758)	বালি বগুৰা/ সেউজীয়া বালি খোঁচৰা	LC	Schedule II	WE	CA	RARE	WM
15		Common Snipe	*Gallinago gallinago* (Linnaeus, 1758)	চেৰেকা চৰাই / বালিটোকা	LC	Schedule II	WE	CA	UNCOM	WM
16		Spotted Redshank	*Tringa erythropus* (Pallas, 1764).	ফুটুকী ৰঙা বালি খোঁচৰা	LC	Schedule II	OW, WE	CA	UNCOM	WM
17		Temminck's Stint	*Calidris temminckii* (Leisler, 1812)		LC	Schedule II	OW, WE	CA	UNCOM	WM
18	Charadriidae	Pacific Golden Plover	*Pluvialis fulva* (Gmelin, 1789)	সোণালী লৰিয়লি	LC	Schedule I	OW, WE	OM	UNCOM	WM
19		Grey-headed Lapwing	*Vanellus cinereus* (Blyth, 1842).	দলঘোঁৰা	LC	Schedule II	WE	INSEC	COM	WM
20		Red-wattled Lapwing	*Vanellus indicus* (Boddaert, 1783)	বালিঘোঁৰা / টিটিহুট	LC	Schedule II	WE	OM	COM	R
21		Little Ringed Plover	*Charadrius dubius* (Scopoli, 1786.)	সৰু লৰিয়লি	LC	Schedule II	WE	CA	UNCOM	R

	Family	English name	Scientific name	Local name/ Assamese name	IUCN Red List status	IWPA	Habitat location	Feeding habits/ Feeding guilds	Abundance status	Phenological status
22	Rallidae	White-breasted Waterhen	*Amaurornis phoenicurus* (Pennant, 1769).	ডাউক	LC	Schedule II	WE	OM	COM	R
23		Watercock	*Gallicrex cinerea* (Gmelin, 1789)	পানী কুকুৰা	LC	Schedule II	WE	OM	UNCOM	R
24		Grey-headed Swamphen	*Porphyrio poliocephalus* (Latham, 1801).	কাম চৰাই	NE	Schedule II	WE	OM	COM	R
25		Common Moorhen	*Gallinula chloropus* (Linnaeus, 1758).	দেশী কোৰা ঢেকৰ	LC	Schedule II	WE	OM	COM	R
26	Ciconiidae	Asian Openbill	*Anastomus oscitans* (Boddaert, 1783).	শামুক ভঙা	LC	Schedule II	WE	CA	COM	R
27		Lesser Adjutant Stork	*Leptoptilos javanicus* (Horsfield, 1821).	বৰটোকোলা/ হদং	NT	Schedule I	WE	CA	LOC COM	R
28		Asian Woollyneck	*Ciconia episcopus* (Boddaert, 1783).	কনুৰা চৰাই	NT	Schedule IV	WE	CA	LOC COM	R
29	Jacanidae	Bronze-winged Jacana	*Metopidius indicus* (Latham, 1790).	দলপুঙা	LC	Schedule II	WE	OM	COM	R
30		Pheasant-tailed Jacana	*Hydrophasianus chirurgus* (Scopoli, 1786).	দলম'ৰা/ জলময়ূৰ	LC	Schedule II	WE	OM	COM	R
31	Threskiornithidae	Black-headed Ibis	*Threskiornis melanocephalus* (Latham, 1790).	আঁকুহী বগ	LC	Schedule II	WE	CA	COM	WM
32		Glossy Ibis	*Plegadis falcinellus* (Linnaeus, 1766).	ইটাগুড়ীয়া আঁকুহী বগ	LC	Schedule II	WE	CA	LOC COM	WM
33	Motacillidae	White Wagtail	*Motacilla alba* (Linnaeus, 1758)	বগা বালিমাহী/ খঞ্জন	LC	Schedule II	WE	INSEC	COM	WM
34		Citrine Wagtail	*Motacilla citreola* (Pallas, 1776)	হালধিমূৰীয়া বালিমাহী	LC	Schedule II	WE, WA	INSEC	COM	WM
35	Alcedinidae	Stork-billed Kingfisher	*Pelargopsis capensis* (Linnaeus, 1766)	বৰটোকোলাঠুঁটীয়া মাছৰোকা	LC	Schedule II	T	CA	LOC COM	R
36		White-throated Kingfisher	*Halcyon smyrnensis* (Linnaeus, 1758)	বগাবুকুৰা মাছৰোকা	LC	Schedule II	T	CA	COM	R
37		Common Kingfisher	*Alcedo atthis* (Linnaeus, 1758)	সাধাৰণ মাছৰোকা	LC	Schedule II	T	CA	COM	R
38		Pied Kingfisher	*Ceryle rudis* (Linnaeus, 1758)	পখৰা মাছৰোকা	LC	Schedule II	T	CA	COM	R
39	Phalacrocoracidae	Little Cormorant	*Phalacrocorax niger* (Vieillot, 1817)	পানী কাউৰী	LC	Schedule II	OW	CA	COM	R
40	Anhingidae	Oriental Darter	*Anhinga melanogaster* (Pennant, 1769)	মণিয়ৰি	LC	Schedule II	OW, WE, T	CA	LOC COM	R
41	Glareolidae	Small Pratincole	*Glareola lacteal* (Temminck, 1820)	তিতিয়লী	LC	Schedule II	OW	INSEC	UNCOM	R
42	Anatidae	Lesser Whistling Duck	*Dendrocygna javanica* (Horsfield, 1821)	শৰালি হাঁহ	LC	Schedule II	OW	OM	COM	R
43		Ruddy Shelduck	*Tadorna ferruginea* (Pallas, 1764)	চাকৈ-চকোৱা	LC	Schedule II	OW	OM	COM	WM
44	Pandionidae	Osprey	*Pandion haliaetus* (Linnaeus, 1758)	চিল কুকুৰা	LC	Schedule I	OA, WA	**Pisc**	UNCOM	WM

OA—Open Area | OW—Open Water | WE—Water Edge | T—Trees | WA—Water Associated | COM—Common | UNCOM—Uncommon | LOC COM—Locally common | CA—Carnivorous | INSEC—Insectivorous | OM—Omnivorous | Pisc—Piscivorous | R—Resident | WM—Winter Migrant | LC—Least Concern | NT—Near Threatened.

fewer species were encountered during the monsoon. These seasonal differences indicate that hydrological fluctuations strongly influence the availability of suitable foraging and roosting habitats, thereby regulating the distribution and abundance of wetland-associated birds. Similar seasonal patterns have been reported from other wetland ecosystems in India, where post-monsoon habitat stabilization and winter migration substantially enhance bird diversity and abundance (Verma 2008; Nair & Krishna 2013; Kar & Debata 2019).

Overall, the observed seasonal variation demonstrates that the wetland bird community in the Bajali landscape is strongly influenced by annual hydro-climatic conditions. The higher abundance recorded during winter highlights the ecological significance of these wetlands as important seasonal habitats for migratory waterbirds, whereas the persistence of numerous resident species throughout the year emphasizes their role in sustaining breeding and foraging populations under varying environmental conditions. These findings are consistent with studies demonstrating that seasonal abundance, species composition, and migration dynamics of wetland birds are closely regulated by habitat quality, hydrological conditions, prey availability, and anthropogenic disturbances, which collectively determine habitat suitability and community structure (Ellis et al. 2021; Jagadeesan & Pandiyan 2021; Kularatne 2021; Rashiba et al. 2022).

Family composition and seasonal dynamics

The wetland-associated bird assemblage exhibited marked variation in taxonomic composition and seasonal abundance among avian families (Image 2; Table 3). Based on relative diversity (RDi), Ardeidae was the most species-rich family, comprising 10 species (RDi = 22.72%), followed by Scolopacidae with seven species (RDi = 15.90%). Rallidae, Charadriidae, and Alcedinidae were each represented by four species (RDi = 9.09%), while Ciconiidae included three species (RDi = 6.81%). Jacanidae, Threskiornithidae, Motacillidae, and Anatidae each contributed two species (RDi = 4.54%), whereas Phalacrocoracidae, Anhingidae, Glareolidae, and Pandionidae were represented by a single species each (RDi = 2.27%). The predominance of Ardeidae and Scolopacidae indicates that the wetlands provide a broad range of shallow-water and marsh habitats capable of supporting taxonomically diverse wading and shorebird communities.

Pronounced seasonal variation was evident in family-level abundance, although species within individual families differed considerably in their numerical dominance and seasonal occurrence (Image 3). These patterns indicate that family-level abundance was primarily influenced by a limited number of dominant species rather than by uniform contributions from all constituent species.

Among all families, Ardeidae remained the most abundant throughout the study period, with abundance increasing from 758 individuals in summer to a peak of 981 individuals during the monsoon, before declining to 505 individuals in autumn and increasing slightly to 657 individuals in winter. This dominance was largely attributable to the Cattle Egret *Bubulcus ibis* (651 individuals) and Indian Pond Heron *Ardeola grayii* (624 individuals), followed by the Purple Heron *Ardea purpurea* (444 individuals). The remaining species, including the Great Egret *Ardea alba* (228 individuals), Medium Egret *Ardea intermedia* (228 individuals), Little Egret *Egretta garzetta* (215 individuals), Cinnamon Bittern *Ixobrychus cinnamomeus* (156 individuals), Grey Heron *Ardea cinerea* (155 individuals), Black-crowned Night Heron *Nycticorax nycticorax* (109 individuals), and Yellow Bittern *Ixobrychus sinensis* (91 individuals) occurred in comparatively lower numbers. The consistently high abundance of Ardeidae reflects the availability of shallow-water foraging habitats and abundant aquatic prey throughout much of the year, particularly during the monsoon when extensive inundation enhances feeding opportunities for herons and egrets.

In contrast, Scolopacidae exhibited the most pronounced seasonal variation among all recorded families. The family was absent during the monsoon, moderately represented during summer (91 individuals), increased substantially during autumn (290 individuals), and attained its highest abundance during winter (415 individuals). Although the family showed a pronounced seasonal influx, abundance was unevenly distributed among species. The Common Snipe *Gallinago gallinago* (215 individuals) was the dominant representative, followed by the Common Greenshank *Tringa nebularia* (130 individuals), Green Sandpiper *Tringa ochropus* (126 individuals), Common Sandpiper *Actitis hypoleucos* (110 individuals), and Marsh Sandpiper *Tringa stagnatilis* (106 individuals), whereas Temminck's Stint *Calidris temminckii* (66 individuals) and Spotted Redshank *Tringa erythropus* (43 individuals) were comparatively less abundant. The complete absence of Scolopacidae during the monsoon, followed by a substantial increase during autumn and winter, highlights the importance of exposed mudflats and shallow wetlands created after floodwaters recede, providing favourable foraging

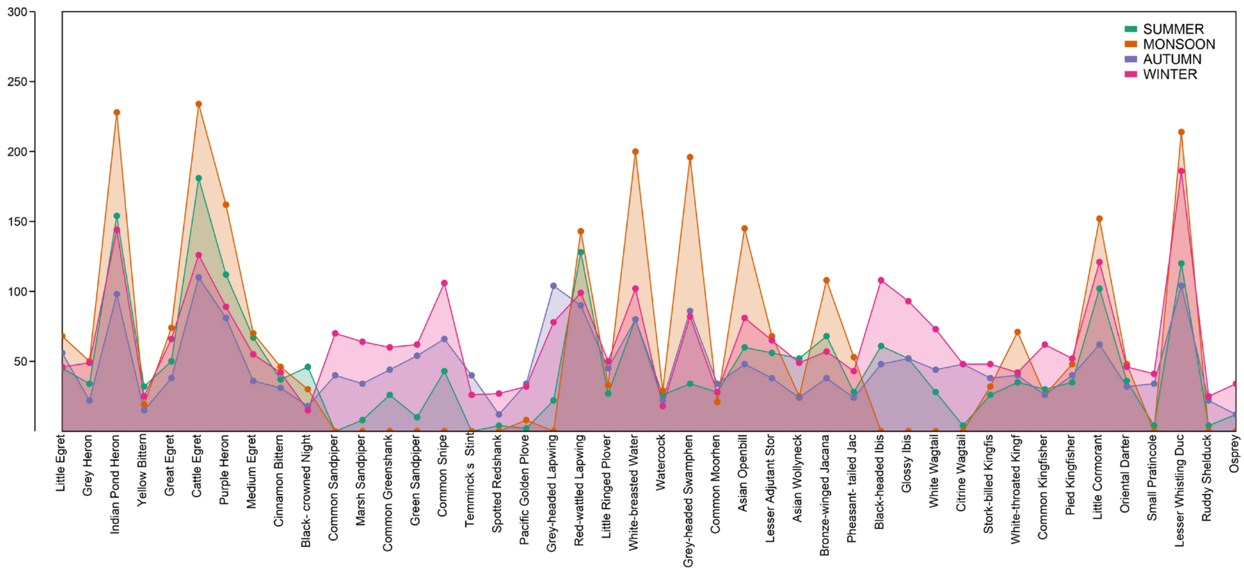

Image 3. Species-wise seasonal variation in the abundance of wetland associated birds recorded from Bajali District, Assam.

Table 3. Seasonal abundance of wetland-associated bird families and their relative diversity in the Bajali District, Assam.

Name of the family	Number of species observed	Relative diversity (%)	Seasons with no of individuals observed			
			Summer (pre-monsoon)	Monsoon	Autumn (post monsoon)	Winter
Ardeidae	10	22.72	758	981	505	657
Scolopacidae	7	15.90	91	0	290	415
Charadriidae	4	9.09	179	184	273	259
Rallidae	4	9.09	168	446	222	230
Ciconiidae	3	6.81	168	238	110	195
Jacanidae	2	4.54	96	161	62	100
Threskiornithidae	2	4.54	113	0	100	201
Motacillidae	2	4.54	32	0	92	121
Alcedinidae	4	9.09	126	177	144	204
Phalacrocoracidae	1	2.27	102	152	62	121
Anhingidae	1	2.27	36	48	32	46
Glareolidae	1	2.27	4	0	34	41
Anatidae	2	4.54	124	214	126	211
Pandionidae	1	2.27	12	0	12	34
Total	**44**		**2009**	**2601**	**2064**	**2835**

habitats for migratory shorebirds.

Rallidae reached its maximum abundance during the monsoon (446 individuals) and declined during autumn (222 individuals), winter (230 individuals), and summer (168 individuals). This seasonal pattern was largely driven by the White-breasted Waterhen *Amaurornis phoenicurus* (462 individuals) and Grey-headed Swamphen *Porphyrio poliocephalus* (398 individuals), whereas the Common Moorhen *Gallinula chloropus* (111 individuals), and Watercock *Gallicrex cinerea* (95 individuals) occurred less frequently. The predominance of these marsh-dependent species during the rainy season corresponds with the expansion of emergent vegetation and shallow inundated habitats, which provide suitable nesting, shelter, and feeding sites.

Charadriidae was recorded throughout the year, with abundance increasing from 179 individuals in summer to 273 individuals in autumn, followed by a slight decline

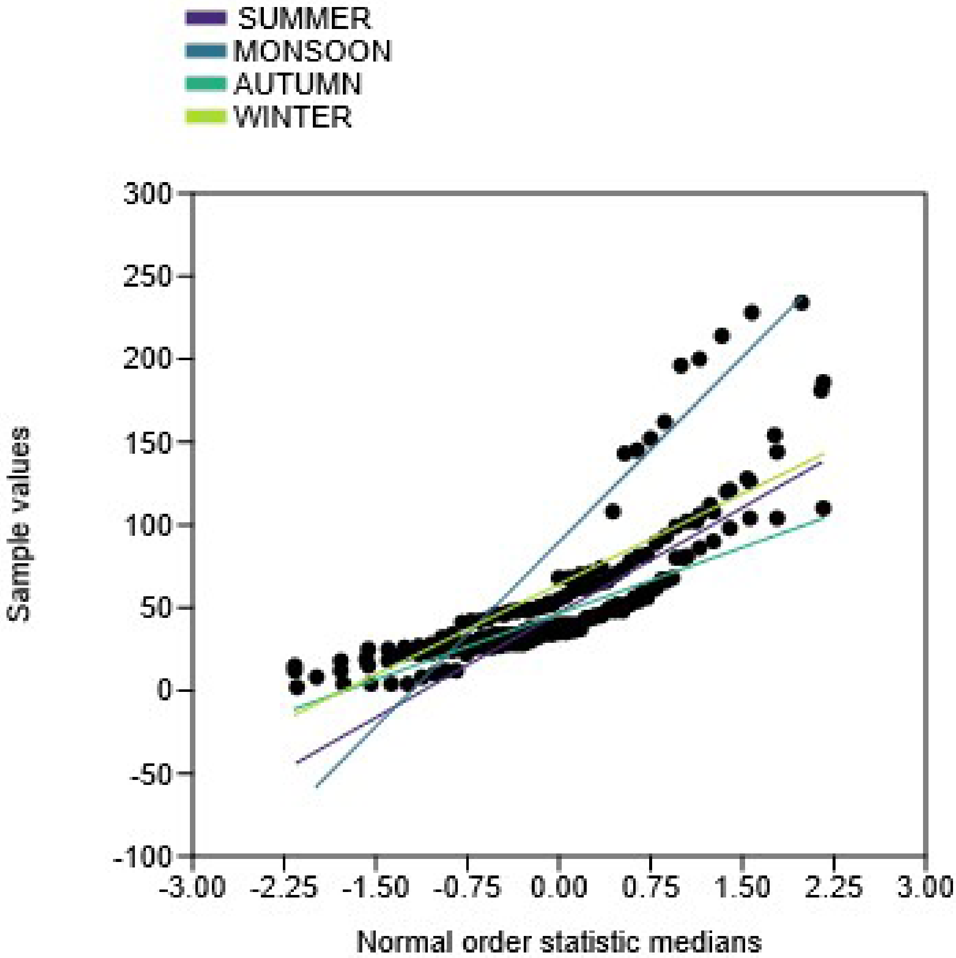

Image 4. Normal quantile–quantile (Q–Q) plot illustrating the distribution of seasonal abundances of wetland-associated bird species.

to 259 individuals in winter. Family abundance was dominated by the Red-wattled Lapwing *Vanellus indicus* (460 individuals), while the Grey-headed Lapwing *Vanellus cinereus* (204 individuals), Little Ringed Plover *Charadrius dubius* (155 individuals), and Pacific Golden Plover *Pluvialis fulva* (76 individuals) were comparatively less abundant. Similarly, Ciconiidae reached its highest abundance during the monsoon (238 individuals) and lowest abundance during autumn (110 individuals). The Asian Openbill *Anastomus oscitans* (334 individuals) was the dominant species within the family, followed by the Lesser Adjutant *Leptoptilos javanicus* (227 individuals) and Asian Woollyneck *Ciconia episcopus* (150 individuals). The seasonal occurrence of these large wading birds reflects fluctuations in water depth and prey availability across the wetlands.

Comparable species-level variation was also observed among the remaining families. Within Jacanidae, the Bronze-winged Jacana *Metopidius indicus* (271 individuals) was more abundant than the Pheasant-tailed Jacana *Hydrophasianus chirurgus* (148 individuals). In Threskiornithidae, the Black-headed Ibis *Threskiornis melanocephalus* (217 individuals) slightly outnumbered the Glossy Ibis *Plegadis falcinellus* (197 individuals). Motacillidae was represented predominantly by the White Wagtail *Motacilla alba* (145 individuals) compared with the Citrine Wagtail *Motacilla citreola* (100 individuals). Among Alcedinidae, the White-throated Kingfisher *Halcyon smyrnensis* (188 individuals) occurred more frequently than the Pied Kingfisher *Ceryle rudis* (175 individuals), Common Kingfisher *Alcedo atthis* 144 individuals), and Stork-billed Kingfisher *Pelargopsis capensis* (144 individuals). Likewise, Anatidae was overwhelmingly dominated by the Lesser Whistling Duck *Dendrocygna javanica* (624 individuals), whereas the Ruddy Shelduck *Tadorna ferruginea* (51 individuals) occurred only occasionally.

Overall, the observed family-level patterns demonstrate that wetland bird assemblages in the Bajali landscape are strongly structured by seasonal

Table 4. Seasonal variation in diversity indices of the wetland-associated bird community in the study area.

Indices	Summer (pre-monsoon)	Monsoon	Autumn (post-monsoon)	Winter
Taxa_S	42	29	44	44
Individuals	2009	2601	2064	2835
Dominance_D	0.0405	0.05524	0.02905	0.0292
Simpson_ 1-D	0.9595	0.9448	0.971	0.9708
Shannon_H	3.426	3.08	3.655	3.654
Evenness_e H/S	0.732	0.7505	0.8791	0.8777
Menhinick	0.937	0.5686	0.9685	0.8264
Margalef	5.391	3.561	5.634	5.409
Fisher_alpha	7.509	4.57	7.9	7.393
Berger-Parker	0.09009	0.08997	0.05329	0.06561

hydrological changes and species-specific ecological requirements. Resident families such as Ardeidae, Rallidae, Jacanidae, Alcedinidae, and Anhingidae persisted throughout the year, whereas migratory families, particularly Scolopacidae, together with Threskiornithidae, Motacillidae, Glareolidae, and Pandionidae, exhibited marked seasonal occurrence, becoming most abundant during the post-monsoon and winter periods. These findings emphasize the complementary ecological roles of permanent wetlands and seasonally exposed mudflats in sustaining both resident and migratory wetland bird communities, supporting previous studies that identified seasonal habitat quality, hydrological variability, and migration dynamics as major drivers of shorebird and waterbird assemblages (Jagadeesan & Pandiyan 2021; Ma et al. 2021).

Community characteristics

The wetland-associated bird community of the Bajali landscape exhibited distinct patterns in species occurrence, migratory status, conservation status, and feeding guild composition (Table 2), reflecting the ecological heterogeneity and seasonal resource availability of the wetland ecosystem.

Based on the frequency of occurrence, the avifaunal community was dominated by common species, comprising 24 species (54.55%), followed by uncommon species (13 species; 29.55%), locally common species (6 species; 13.64%), and a single rare species (1 species; 2.27%). The predominance of common species suggests that the study wetlands provide relatively stable environmental conditions capable of supporting persistent populations of several wetland-associated birds throughout the annual cycle. Conversely, the limited representation of rare species may reflect species-specific habitat preferences, naturally low population densities, or seasonal occurrence within the study area.

Analysis of migratory status showed that resident species constituted the major component of the wetland bird assemblage, accounting for 65.91% (29 species) of the total recorded species, whereas winter visitors comprised the remaining 34.09% (15 species). The dominance of resident species indicates that the wetlands provide suitable breeding, nesting, and foraging habitats throughout the year. In contrast, the substantial contribution of winter migratory species demonstrates the seasonal importance of these wetlands as feeding and resting habitats along regional migratory routes. Similar dominance of resident species accompanied by a pronounced winter influx of migratory waterbirds has been documented from other wetland ecosystems across India (Verma 2008; Nair & Krishna 2013; Kar & Debata 2019), highlighting the importance of maintaining habitat quality for both resident and migratory populations.

Assessment of conservation status based on the IUCN Red List revealed that the majority of recorded species were classified as 'Least Concern' (42 species; 95.46%), whereas only two species (4.54%), namely the Lesser Adjutant *Leptoptilos javanicus* and the Asian Woollyneck *Ciconia episcopus*, were categorized as 'Near Threatened'. Although these threatened species represented only a small proportion of the recorded avifauna, their regular occurrence emphasizes the conservation value of the Bajali wetlands in supporting species of global conservation concern. The presence of Near Threatened waterbirds further highlights the need for continued monitoring and effective habitat management to ensure the long-term persistence of these vulnerable populations.

The wetland-associated bird assemblage was also differentiated according to feeding guilds. Carnivorous species predominated, accounting for 29 species (65.91%), followed by omnivorous species (10 species; 22.72%), insectivorous species (4 species; 9.09%), and a single piscivorous species (1 species; 2.27%). The predominance of carnivorous birds reflects the high availability of aquatic prey, including fishes, amphibians, molluscs, crustaceans, and aquatic invertebrates, within the wetland ecosystem. Such trophic composition is characteristic of productive freshwater wetlands, where abundant food resources support a diverse assemblage of higher trophic-level waterbirds.

Collectively, these community characteristics demonstrate that the wetlands of the Bajali landscape support a structurally diverse avian assemblage composed predominantly of resident and common species, while simultaneously functioning as important seasonal habitats for migratory waterbirds and species of conservation concern. The coexistence of multiple feeding guilds further indicates that these wetlands provide a wide range of ecological resources capable of sustaining diverse functional groups throughout the year, thereby emphasizing their ecological significance within the regional wetland network.

Seasonal variation in diversity indices

The diversity indices revealed pronounced seasonal variation in the structure, composition, and stability of the wetland-associated bird community (Table 4). Observed species richness (Taxa_S) was highest during autumn and winter (44 species each), followed by summer (42 species), whereas the monsoon recorded the lowest richness (29 species). The higher richness during autumn and winter coincided with the arrival of migratory waterbirds and the availability of favourable habitat conditions following the monsoon. In contrast, the reduced richness during the monsoon is likely attributable to extensive flooding, increased water depth, breeding-related behavioural changes, and lower detectability of birds within dense emergent vegetation. Similar seasonal fluctuations have been widely reported in freshwater wetlands, where hydrological regimes strongly regulate habitat availability and bird community composition (Saygili et al. 2011; Kumar & Sharma 2019).

Patterns of species diversity further supported these seasonal differences. The Shannon–Wiener diversity index (H’) reached its highest value during autumn (3.655), followed closely by winter (3.654) and summer (3.426), while the lowest value was recorded during the monsoon (3.080). Likewise, Simpson’s diversity index (1−D) was highest during autumn (0.971), followed by winter (0.9708) and summer (0.9595), whereas the monsoon exhibited the lowest diversity (0.9448). Conversely, Simpson’s dominance index (D) showed an inverse trend, attaining its highest value during the monsoon (0.05524) and lowest value during autumn (0.02905). The concurrence of high Shannon and Simpson diversity together with low dominance during autumn and winter indicates a comparatively balanced community in which individuals were more evenly distributed among species. Conversely, increased dominance during the monsoon suggests that only a few species contributed disproportionately to total abundance, resulting in a comparatively simplified community structure under seasonally constrained environmental conditions. Similar seasonal responses of diversity indices have been reported in wetland bird communities where hydrological fluctuations influence habitat quality and resource availability (Azizoglu et al. 2023).

Species evenness also varied considerably among seasons. Pielou’s evenness (J’) was highest during autumn (0.8791), followed by winter (0.8777) and monsoon (0.7505), while the lowest value occurred during summer (0.7320). Greater evenness during autumn and winter indicates a more equitable distribution of individuals among species, suggesting relatively balanced resource utilization and reduced numerical dominance. In contrast, the lower evenness observed during summer and the monsoon reflects greater dominance by a limited number of abundant species, likely resulting from seasonal variation in habitat conditions and resource availability.

The richness estimators showed remarkable consistency in describing seasonal community structure. Menhinick’s index reached its highest value during autumn (0.9685), while Margalef’s richness index was also greatest during autumn (5.634), followed by winter (5.409). Similarly, Fisher’s alpha attained its maximum value during autumn (7.900) and remained comparatively high during winter (7.393). The agreement among these independent richness estimators provides robust evidence that post-monsoon and winter conditions supported the greatest true species richness within the study wetlands. These periods are characterized by stabilized hydrological conditions, increased habitat heterogeneity, and enhanced availability of aquatic food resources, thereby creating favourable conditions for both resident and migratory waterbirds.

The Berger–Parker dominance index further reinforced these seasonal patterns. The lowest dominance was recorded during autumn (0.05329), whereas comparatively higher values were observed during summer (0.09009) and the monsoon (0.08997). Lower Berger-Parker values indicate that no single species overwhelmingly dominated the assemblage, reflecting a more heterogeneous and balanced bird community during the post-monsoon period. In contrast, increased dominance during summer and the monsoon suggests that environmental conditions favoured relatively few adaptable species, thereby reducing overall community heterogeneity.

The seasonal patterns observed in the diversity indices were further supported by the **Q–Q plot (Image**

Image 5. Photographs of selected wetland-associated bird species recorded in Bajali District, Assam, India. 1—Little Egret | 2—Grey Heron | 3A—Indian Pond Heron (non-breeding plumage) | 3B—Indian Pond Heron (breeding plumage) | 4—Yellow Bittern | 5—Great Egret | 6—Cattle Egret | 7—Purple Heron | 8—Medium Egret | 9—Common Sandpiper | 10—Green Sandpiper | 11—Common Snipe | 12—Spotted Redshank | 13—Temminck's Stint | 14—Pacific Golden Plover | 15—Grey-headed Lapwing | 16—Red-wattled Lapwing | 17—Little Ringed Plover | 18—White-breasted Waterhen | 19—Grey-headed Swamphen | 20—Common Moorhen | 21—Asian Openbill | 22—Lesser Adjutant Stork | 23—Asian Woollyneck. © Bidyut Kumar Das.

Image 5 cont.. Photographs of selected wetland-associated bird species recorded in Bajali District, Assam, India. 24—Bronze-winged Jacana | 25—Black-headed Ibis | 26—Glossy Ibis | 27A—White Wagtail (Hodgson's) | 27B—White Wagtail (Chinese) | 28—Citrine Wagtail | 29—Stork-billed Kingfisher | 30—White-throated Kingfisher | 31—Common Kingfisher | 32—Pied Kingfisher | 33—Little Cormorant | 34—Oriental Darter| 35—Small Pratincole | 36—Lesser Whistling Duck | 37—Ruddy Shelduck. © Bidyut Kumar Das.

4), which demonstrated that bird abundance data generally conformed to normality assumptions across seasons, with only minor deviations at the lower and upper quantiles. Winter and autumn communities exhibited comparatively stable distributional patterns, whereas the steeper gradient observed during the monsoon reflected greater variability in abundance and the influence of a few highly dominant species. These results indicate that seasonal hydrological conditions not only influence species richness and diversity but also affect the overall distributional characteristics of wetland bird assemblages.

Collectively, the diversity analyses demonstrate that the wetland bird community of the Bajali landscape undergoes substantial seasonal reorganization in response to hydrological fluctuations and habitat dynamics. The post-monsoon and winter seasons supported the highest levels of species richness, diversity, and community evenness, primarily owing to improved habitat conditions, greater habitat heterogeneity, enhanced food availability, and the seasonal influx of migratory waterbirds. In contrast, extensive monsoonal inundation reduced habitat suitability for several species, resulting in lower species richness, increased dominance, and a comparatively simplified community structure. These findings are consistent with previous studies demonstrating that seasonal hydrology, water-level fluctuations, habitat quality and heterogeneity, prey availability, and migration dynamics are the principal ecological drivers shaping the diversity, abundance, and community organization of wetland-associated birds across freshwater and coastal wetland ecosystems (Colwell & Dodd 2017; Kumar & Sharma 2018, 2019; Kumar 2019; Ellis et al. 2021; Jagadeesan & Pandiyan 2021; Kularatne 2021; Ma et al. 2021; Rashiba et al. 2022; Byju et al. 2025a,b). Overall, these findings highlight the ecological importance of maintaining natural hydrological regimes, habitat heterogeneity, and wetland integrity to sustain diverse resident and migratory wetland bird communities.

CONCLUSION

This study provides the first comprehensive baseline assessment of the diversity, seasonal dynamics, and community structure of wetland-associated birds in the wetlands of Bajali District, Assam, thereby addressing an important knowledge gap for the lower Brahmaputra floodplain. The documented assemblage of resident and migratory species demonstrates that these wetlands function as ecologically important habitats that support breeding, foraging, and seasonal refuge for a diverse avifaunal community. The marked seasonal variation in species richness, abundance, and community composition confirms that hydrological regimes, habitat heterogeneity, and seasonal resource availability are the principal ecological drivers shaping wetland bird assemblages in the region.

The regular occurrence of the 'Near Threatened' Lesser Adjutant and Asian Woollyneck further highlights the conservation significance of these wetlands and underscores the need to maintain habitat quality amid increasing anthropogenic pressures. Protecting shallow wetlands, marshes, seasonally exposed mudflats, and riparian habitats will be essential for sustaining both resident populations and winter migratory birds that depend on these ecosystems.

Beyond providing the first checklist for Bajali District, this study establishes an important ecological benchmark against which future changes in wetland bird communities can be evaluated. Continued long-term monitoring, combined with habitat restoration, regulation of wetland degradation, and community-based conservation initiatives, will be crucial for safeguarding the ecological integrity of these wetlands under ongoing land-use change and climate variability. The findings presented here provide a scientific foundation for future biodiversity assessments, conservation planning, and sustainable wetland management in the lower Brahmaputra valley.

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