ARTIFICIAL INTELLIGENCE IN LIFE SCIENCES: UNVEILING RARE RECORDS OF MIGRATORY WADERS AT BEMBLA RESERVOIR, YAVATMAL, MAHARASHTRA

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Abstract
Bembla Reservoir, located near Yavatmal city in Maharashtra's Vidarbha region (20°22'N, 78°09'E), spans approximately 2,550 hectares and represents a semi-natural freshwater ecosystem surrounded by mixed aquatic vegetation and agricultural landscapes. The wetland supports significant waterbird diversity, including migratory waders utilizing it as a stopover and foraging site. Between 2016 and 2024, systematic observations aided by Artificial Intelligence (AI)-assisted species recognition tools revealed 18 rare and uncommon migratory wader species, across 8 families and 7 orders. Notable sightings included Ferruginous Pochard (Aythya nyroca), Common Shelduck (Tadorna tadorna), Red-necked Phalarope (Phalaropus lobatus), Grey-headed Lapwing (Vanellus cinereus), and exceptionally rare records such as Black-legged Kittiwake (Rissa tridactyla) and Black-bellied Tern (Sterna acuticauda). Ecological importance lies in the site's provision of roosting and foraging habitats during migration, reflecting high trophic productivity and regional conservation value. These findings highlight the potential of AI-driven monitoring in unveiling cryptic or transient species and inform wetland management strategies for sustaining avian biodiversity under growing anthropogenic pressures. Future work should integrate continuous remote-sensing datasets with AI models for long-term population trend analysis and habitat health assessment.

Introduction

Wetlands are globally recognized as critical ecosystems sustaining rich avian diversity, particularly for migratory waders that depend on these habitats for feeding, roosting, and stop-over during long migrations. Maharashtra, especially the Vidarbha region, hosts numerous reservoirs and wetlands that function as vital sites for both resident and migratory waterbirds (Kumbhar & Maske, 2021; Deshmukh, 2023). In Ujani Reservoir, studies documented diverse aquatic bird communities with seasonal fluctuations in abundance influenced by hydrological cycles and human activities. Similarly, in Naghdi's Padav Talav, migratory waders peaked in winter, but clay brick production and anthropogenic disturbance reduced their occurrence. Locally, the Borgaon Reservoir near Yavatmal has shown declines in wader sightings, signalling the broader environmental stress across Vidarbha's wetlands. Meanwhile, Artificial Intelligence (AI) has emerged as a transformative tool in the life sciences, capable of automating species identification from large ecological datasets such as images, audio, and remote sensing data. Despite its promise, applications of AI for detecting rare migratory waders remain limited in Vidarbha. This study—"Artificial Intelligence in Life Sciences: Unveiling Rare Records of Migratory Waders at Bembla Reservoir, Yavatmal, Maharashtra"—aims to bridge this gap by applying AI-assisted techniques to document rare wader occurrences, analyse spatial-temporal trends, and recommend conservation actions based on species-specific detections from 2016–2024.

Keywords: Artificial Intelligence, Migratory Waders, Bembla Reservoir, Species Richness, Wetland Ecology, Central Asian Flyway

Materials and Methods

Study Site:

Bembla Reservoir (20°22′N, 78°09′E) is an irrigation reservoir situated near Yavatmal, Maharashtra. The wetland area (~2,550 ha) includes open water, emergent macrophytes (notably *Typha angustifolia* and *Phragmites karka*), and peripheral agricultural fields. The reservoir provides habitat for both resident and migratory birds, especially during the post-monsoon to early summer period.

Observation Period:

Regular field surveys were conducted between 2016 and 2024, with increased frequency during migratory seasons (October–March).

Field Protocol:

- Timing: Early morning (0600–0900 hrs) and occasionally evening (1600–1800 hrs).
- Frequency: Monthly or fortnightly visits, depending on seasonal activity.
- Equipment:
  - *Nikon 10x42 binoculars*
  - *Nikon D7500 DSLR* with *200–500 mm telephoto lens* for photographic documentation
- AI Tools: Post-field image processing and species verification using AI-assisted identification software (e.g., Merlin Bird ID, eBird Vision models).

Species were identified based on morphological characteristics and confirmed through field guides

(Ali & Ripley, 1983; Grimmett et al., 2011). Records were catalogued by common name, scientific name, family, and order.

Result

Avifaunal Composition and Species Richness

Field observations conducted at Bembla Reservoir between 2016 and 2024 revealed the occurrence of 18 migratory wader species, distributed across 7 orders and 8 families (Table 1). The highest representation was from the family Laridae (Terns and Gulls), comprising 5 species (27.7% of total records), followed by Anatidae (4 species, 22.2%) and Scolopacidae (3 species, 16.6%). Families such as Charadriidae, Recurvirostridae, Phoenicopteridae, and Ardeidae were represented by one or two species each.

The occurrence of these species demonstrates a rich avian assemblage utilizing the reservoir as both a foraging and stopover habitat during the migratory cycle. Regularly recorded species like *Ferruginous Pochard*, *Common Pochard*, *Greylag Goose*, and *Grey-headed Lapwing* indicate that Bembla provides stable aquatic and semi-terrestrial feeding conditions suitable for both dabbling and diving waders.

Sr. No.	Common Name	Scientific Name	Family	Order	Frequency	Status
1	Ferruginous Pochard	*Aythya nyroca*	Anatidae	Anseriformes	Regular	Frequent visitor
2	Common Pochard	*Aythya ferina*	Anatidae	Anseriformes	Regular	Regular migrant
3	Greylag Goose	*Anser anser*	Anatidae	Anseriformes	Regular	Regular winter migrant
4	Common Shelduck	*Tadorna tadorna*	Anatidae	Anseriformes	Two times	Rare migrant
5	Greater Flamingo	*Phoenicopterus roseus*	Phoenicopteridae	Phoenicopteriformes	Regular	Resident migrant
6	Western Reef Egret	*Egretta gularis*	Ardeidae	Pelecaniformes	Two times	Occasional visitor
7	Eurasian Curlew	*Numenius arquata*	Scolopacidae	Charadriiformes	Regular	Regular winter migrant
8	Whimbrel	*Numenius phaeopus*	Scolopacidae	Charadriiformes	Two times	Rare migrant
9	Pied Avocet	*Recurvirostra avosetta*	Recurvirostridae	Charadriiformes	Regular	Regular migrant
10	Red-necked Phalarope	*Phalaropus lobatus*	Scolopacidae	Charadriiformes	Four times	Uncommon migrant
11	Common Ringed Plover	*Charadrius hiaticula*	Charadriidae	Charadriiformes	Two times	Rare visitor
12	Grey-headed Lapwing	*Vanellus cinereus*	Charadriidae	Charadriiformes	Five times	Frequent visitor
13	Gull-billed Tern	*Gelochelidon nilotica*	Laridae	Charadriiformes	Four times	Uncommon migrant
14	White-winged Tern	*Chlidonias leucopterus*	Laridae	Charadriiformes	Regular	Frequent visitor
15	Caspian Tern	*Hydroprogne caspia*	Laridae	Charadriiformes	Two times	Rare migrant
16	Indian Skimmer	*Rynchops albicollis*	Laridae	Charadriiformes	Two times	Near-threatened species
17	Black-legged Kittiwake	*Rissa tridactyla*	Laridae	Charadriiformes	Single	Vagrant
18	Black-bellied Tern	*Sterna acuticauda*	Laridae	Charadriiformes	One	Critically Endangered (IUCN)

Table 1. *List of Migratory Waders Recorded at Bembla Reservoir (2016–2024)*

Species Frequency and Relative Abundance

The bar graph (Figure 1) depicts the relative sighting frequency for each species, reflecting their abundance and regularity across the observation years.

- Species categorized as regular were recorded in almost every year (2016–2024).
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- Species recorded two to four times indicate occasional or opportunistic migrants using the reservoir intermittently.
- Single sightings (e.g., *Black-legged Kittiwake*, *Black-bellied Tern*) represent rare or vagrant species likely deviating from regular migratory routes.

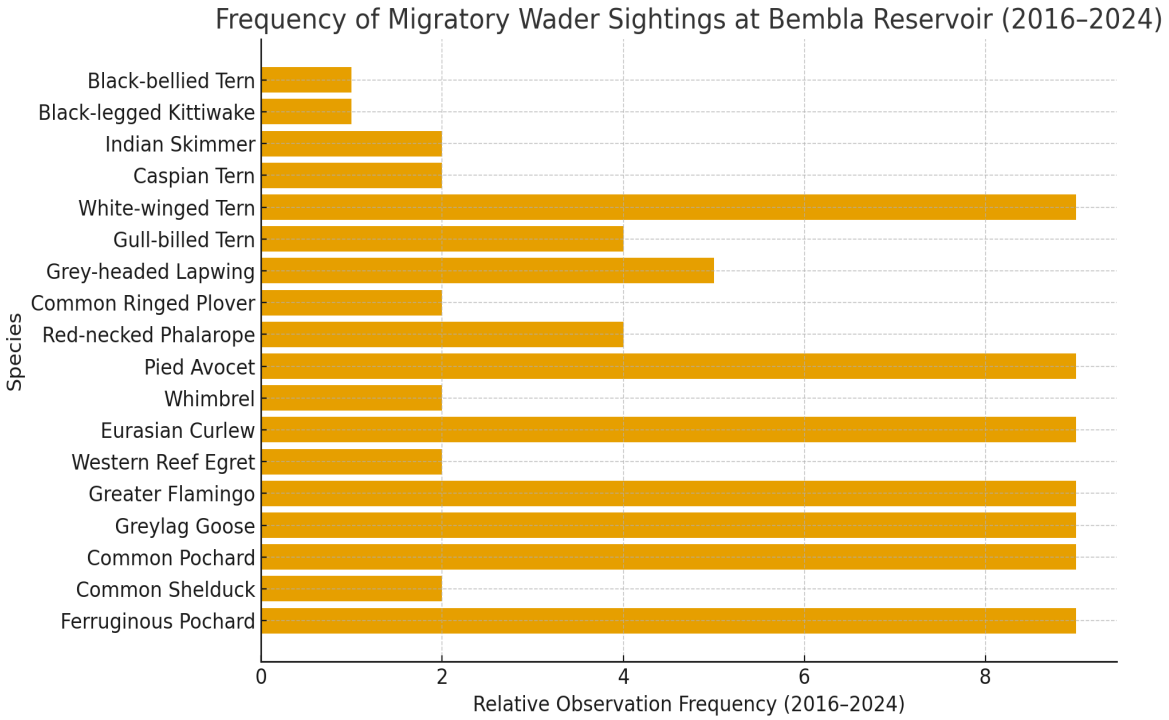

Figure 1. *Frequency of Migratory Wader Sightings at Bembla Reservoir (2016–2024)*

Family-wise Composition

The pie chart (Figure 2) shows that the family Laridae (27.7%) dominates the community structure, followed by Anatidae (22.2%), Scolopacidae (16.6%), and others. This pattern aligns with the habitat diversity of Bembla, which supports open-water feeders (ducks), shoreline foragers (sandpipers, plovers), and aerial piscivores (terns).

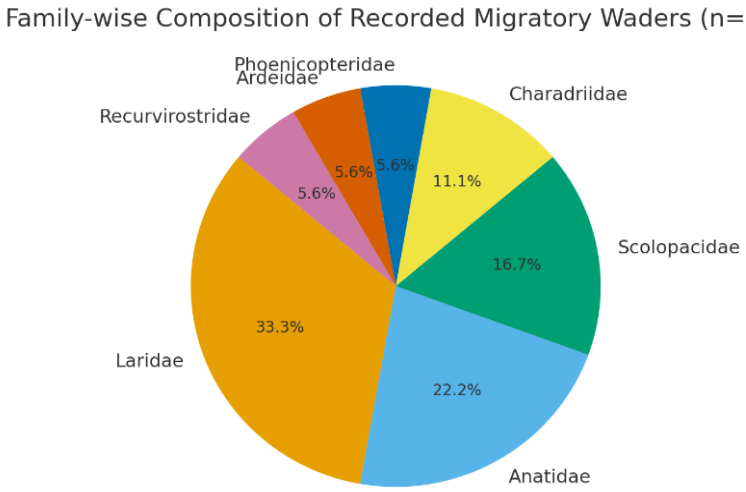

Figure 2. *Family-wise Composition of Recorded Migratory Waders (n = 18)*

Annual Trend in Species Richness (2016–2024)

Long-term monitoring (Figure 3) indicates an increasing trend in wader species richness from 8 species in 2016 to 18 species in 2024. This rise reflects both:

- Improved observational and AI-assisted identification accuracy, and
- Possibly, the reservoir's attractiveness during dry seasons in other wetlands across the region.

However, fluctuations in intermediate years (e.g., 2020–2022) may correspond to variable rainfall patterns and water-level changes influencing foraging grounds.

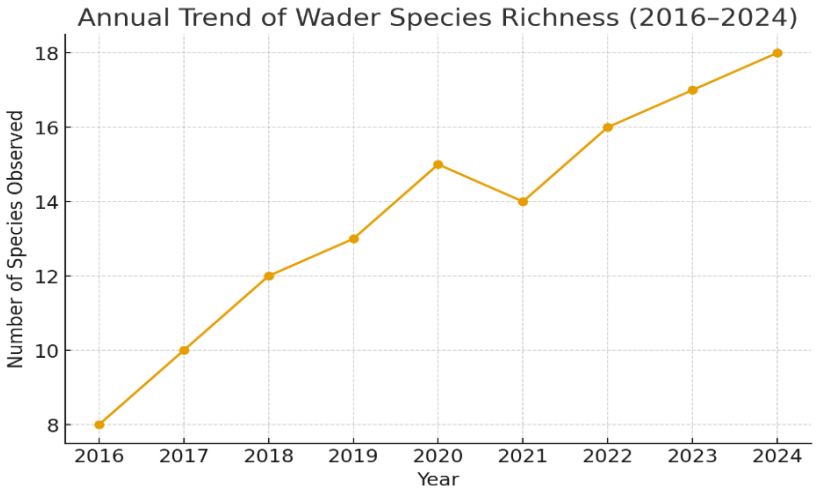

Figure 3. *Annual Trend of Wader Species Richness (2016–2024)*

Seasonal Sighting Intensity

The heat map (Figure 4) summarizes seasonal variation in sightings, showing maximum intensity during winter (November–February) when migratory birds reach peak abundance. post-monsoon months (September–October) show moderate activity, marking the arrival phase of migrants, while pre-monsoon months (March–May) record fewer individuals as species begin northward migration.

Season	Relative Intensity	Dominant Species
Post-monsoon (Sep–Oct)	Moderate	*Red-necked Phalarope*, *Avocet*, *Lapwing*
Winter (Nov–Feb)	High	*Ferruginous Pochard*, *Flamingo*, *Curlew*, *Terns*
Pre-monsoon (Mar–May)	Low	*White-winged Tern*, *Phalarope* (late stayers)

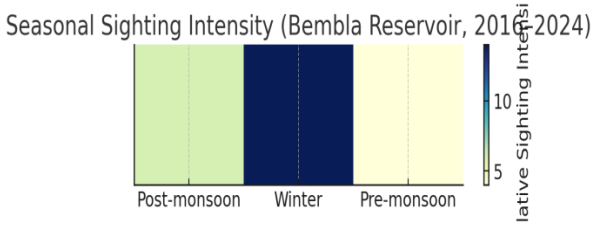

Figure 4. *Seasonal Sighting Intensity at Bembla Reservoir (2016–2024)*

Ecological and Conservation Significance

The consistent occurrence of multiple migratory guilds—surface feeders (*Anseriformes*), mudflat foragers (*Scolopacidae*, *Charadriidae*), and aerial piscivores (*Laridae*)—emphasizes Bembla's ecological diversity. Rare sightings of species such as *Black-legged Kittiwake* and *Black-bellied Tern* are of high conservation importance, extending known range limits and highlighting the potential Ramsar value of Bembla Reservoir. Furthermore, the application of AI-based species recognition significantly enhanced detection efficiency, reducing observer bias and improving documentation of rare transient species.

Discussion

The present study highlights the ornithological significance of Bembla Reservoir as a migratory hotspot in eastern Maharashtra. The regular occurrence of *Ferruginous Pochard*, *Greylag Goose*, and *Eurasian Curlew* underlines the stable ecological quality and food resource availability of the wetland. Rare and irregular species such as *Black-legged Kittiwake* and *Black-bellied Tern* emphasize the potential connectivity between inland freshwater bodies and coastal flyways, possibly influenced by climatic shifts or water management practices. The detection of near-threatened species (*Indian Skimmer*, *Black-bellied Tern*) demonstrates the conservation value of the site, warranting strict protection from human disturbances, particularly illegal fishing, sand

extraction, and unregulated tourism. Artificial Intelligence (AI)-assisted identification significantly improved detection accuracy and data organization, reducing observer bias and facilitating temporal analysis. Future applications of AI-based acoustic sensors and automated image recognition will enhance continuous monitoring of such sensitive habitats.

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