Human Disturbance and Its Effects on Waterbird Populations at Atpadi Water Reservoir

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ABSTRACT

Human activities around wetlands alter habitat structure, resource availability, and disturbance regimes, often leading to changes in waterbird abundance, diversity, and behaviour. This study investigates the effects of human disturbance on waterbird populations at the Atpadi Water Reservoir (hereafter Atpadi Reservoir), Sangli district, Maharashtra. Field surveys were conducted monthly between January and December 2022 to 2024 at four fixed sampling sites around the tank. We quantified waterbird species richness, abundance, feeding and roosting behaviour, and disturbance events (fishing, livestock grazing, boating, bathing, fishing-net setting, and agricultural activities). Analyses combined descriptive statistics, diversity indices (Shannon–Wiener, Simpson), Generalized Linear Models (GLMs) linking disturbance intensity to bird abundance, and behavioural disturbance-response metrics. Results show a negative association between disturbance intensity and both waterbird abundance and richness, with the strongest impacts on large-bodied and easily flushed species (e.g., herons, storks, and some waterfowl). Areas with reduced human activity supported higher densities and nesting attempts. Management recommendations include delineating disturbance-free zones, seasonal restrictions on fishing and grazing, community awareness programs, and habitat enhancement measures. The study provides baseline data for local conservation planning and highlights the importance of managing human activities to conserve wetland-dependent birds in Atpadi.

Keywords: waterbirds, human disturbance, Atpadi Water Reservoir, wetland conservation, disturbance-sensitive species, avifauna

INTRODUCTION

Wetlands are among the most productive ecosystems, supporting high biodiversity and providing ecosystem services such as water purification, flood control, and habitat for migratory and resident waterbirds (Mitsch & Gosselink 2000). In India, small tanks and reservoirs contribute substantially to local biodiversity and livelihoods but face increasing pressure from anthropogenic activities (Kumar et al. 2014). Human disturbance—defined here as activities that alter normal bird behaviour through direct presence or habitat modification—can reduce carrying capacity for waterbird communities by causing habitat loss, lowering prey availability, and increasing energetic costs due to frequent flushes or displacement (Sutherland 1996; Carney & Sydeman 1999).

Atpadi Water Reservoir (Atpadi Tank) is a locally important wetland in Sangli district that supports diverse waterbird assemblages, including species of conservation concern. Rapid changes in land use, intensification of fishing and grazing, and increased recreational use have raised concerns among local stakeholders about declining waterbird numbers. Despite local interest, systematic studies quantifying disturbance impacts on avifauna at Atpadi are lacking. This study addresses that gap by (1) documenting waterbird species composition and temporal patterns, (2) quantifying the types and intensity of human disturbances, and (3) assessing the relationship between disturbance intensity and waterbird population metrics.

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STUDY AREA

Location and general description. Atpadi Water Reservoir is situated near Atpadi town in Sangli district, Maharashtra (approx. coordinates: 17.0°N, 74.5°E — *coordinate values indicative; replace with exact GPS when finalizing*). The tank covers an area of approximately 178 ha at full capacity and is surrounded by agricultural land, grazing fields, and small human settlements. Vegetation around the tank includes emergent reeds (e.g., Phragmites spp.), marginal grasses, scattered trees and exposed mudflats during the dry season.

Climatic and hydrological regime. The area experiences a tropical monsoon climate with most rainfall during June–September. Water levels in the tank fluctuate seasonally; low levels during March–May expose mudflats attractive to foraging waders, while post-monsoon months offer extensive surface water preferred by ducks and piscivorous species.

Human use. Local communities depend on the tank for irrigation, livestock watering, and small-scale fishing. Common activities include angling, set-net fishing, cattle grazing on exposed banks, washing and bathing, and occasional religious or social gatherings near the shoreline.

METHODS

3.1. Survey design

We established four fixed sampling sites (S1–S4) around the tank to capture variation in habitat type and human use intensity: two high-disturbance sites (near village access points and active fishing zones), one medium-disturbance site (adjacent grazing and agricultural interface), and one low-disturbance site (relatively sheltered bank with restricted access). Surveys were conducted monthly between January and December 2022 to 2024]. Each monthly visit included a standardized bird count during two observation sessions: early morning (sunrise to 09:30) and late afternoon (15:30 to sunset), timed to capture peak waterbird activity.

3.2. Bird counts and behavioural observations

At each session, we used fixed-point counts and transect scanning with 8×42 binoculars and a 20–60× spotting scope when necessary. We recorded species identity, number of individuals, age-class when identifiable (juvenile/adult), primary activity (foraging, roosting, preening, flying), and any visible signs of breeding (nest building, courtship, active nests). For each disturbance event observed during a session, we recorded the type (e.g., fishing, grazing), proximity to birds (distance bin: <25 m, 25–100 m, >100 m), and bird responses (no response, alert, moved short distance, flushed).

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3.3. Disturbance index

To quantify anthropogenic pressure, we developed a site-level Disturbance Intensity Index (DII) combining the frequency of disturbance events, mean group size of human users, and mean proximity to waterbird concentrations. DII = (F_norm + G_norm + P_norm)/3 where F_norm is normalized monthly frequency of disturbance events (0–1), G_norm normalized mean human group size (0–1), and P_norm normalized proximity score (0–1; higher values for closer average proximity). Sites were then classified into low, medium, and high disturbance categories using tertiles of DII.

3.4. Data analysis

Species richness, abundance, and diversity indices (Shannon–Wiener H', Simpson's D) were calculated per site and month. We used Generalized Linear Models (GLMs; negative binomial family when overdispersion present) to model bird count response variables (total abundance, species richness, and abundance of disturbance-sensitive guilds) as a function of DII, water level, season (pre-monsoon, monsoon, post-monsoon), and habitat variables (percent emergent vegetation, open water area). Behavioural responses were summarized as percentages of disturbance events causing flushing.

All analyses were performed in R (R Core Team), and significance was assessed at $\alpha = 0.05$.

RESULTS

4.1. Species composition and overall patterns

During the study period, we recorded **N** waterbird species representing **M** families (Table 1). The assemblage included waders (Charadriiformes), herons and egrets (Ardeidae), storks (Ciconiidae), ducks and geese (Anatidae), rails (Rallidae), and other wetland-dependent taxa. The most frequently observed species were *Egretta garzetta* (Little Egret), *Ardea cinerea* (Grey Heron), *Anas platyrhynchos* (Mallard/Indian Duck complex where identification uncertain), *Himantopus himantopus* (Black-winged Stilt), and *Rallus* spp.

Table 1. Waterbird species recorded at Atpadi Water Reservoir.

Sr.No	Common Name	Scientific Name	Family	Habit
1	Little Cormorant	Phalacrocorax fuscicollis	Phalcrocoracidae	R
2	Grey Heron	Ardea cinerea	Ardeaidae	R
3	Large Egret	Casmerodius albus	Ardeaidae	R
4	White Bellied Heron	Ardea insignis	Ardeaidae	R
5	Little Green Heron	Butorides striatus	Ardeaidae	R
6	Median Egret	Mesophoyx intermedia	Ardeaidae	R
7	Little Egret	Egretta garzetta	Ardeaidae	R
8	Painted stork	Mycteria leucophalia	Ciconidae	RM
9	Asian Openbill Stork	Anastomous oscitans	Ciconidae	RM
10	White Necked Stork	Ciconia episcopus	Ciconidae	R
11	Eurasian spoon bill	Platelea leucorodia	Threskiornithidae	RM
12	White Ibis	Threskiornis melanocephalus	Threskiornithidae	RM
13	Black ibis	Pseudibis papillosa	Threskiornithidae	R
14	Glossy ibis	Plegadis falcinellus	Threskiornithidae	R
15	Greater Flamingo	Phoenicopterus rubber	Phonicoepteridae	M

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16	Northern Pintail	Anas acuta	Anitidae	M
17	Common Pochard	Aethya ferina	Anitidae	M
18	Bar Headed Goose	Anser indicus	Anitidae	M
19	Brahminy Shelduck	Tadorna ferruginea	Anitidae	M
20	Spot Billed Duck	Anas poecilorhyncha	Anitidae	RM
21	Wigeon	Aethya penelope	Anatidae	M
22	Common Teal	Nettapus coromandelianus	Anatidae	M
23	Common coot	Fulica atra	Rallidae	RM
24	Little Ringed Plover	Charadrius dubius	Charadrinnae	RM
25	Spotted Red Shank	Tringa erythropus	Scolopacinae	M
26	Marsh Sandpiper	Tringa stragnatilis	Scolopacinae	M
27	Common Green Shank	Tringa nebularia	Scolopacinae	M
28	Little Stint	Calidris minuta	Scolopacinae	M
29	Dunlin	Calidris alpine	Scolopacinae	M
30	Curlew Sandpiper	Calidris ferruginea	Scolopacinae	M
31	Black Tailed Godvit	Limosa limosa	Scolopacinae	M
32	Common Sandpiper	Actitis hypolecos	Scolopacinae	M
33	Purple Moorhen	Porphyrio porphyrio	Phasianidae	RM
34	White Breasted Waterhen	Amaurornis phoenicurus	Phasianidae	R
35	Black Winged Stilt	Himantopus himantopus	Recurvirostridae	RM
36	Great Stone Plover	Esacus recurvirostris	Burhinidae	M
37	Small Pratincole	Glareola lactea	Glariolidae	RM
38	River Tern	Sterna aurantica	Laridae	RM
39	Lessar Pied Kingfisher	Ceryle rudis	Alcedinidae	R
40	White Breasted Kingfisher	Halcyon smyrnensis	Alcedinidae	R
41	Small Blue Kingfisher	Alcedo Attis	Alcedinidae	R
42	Yellow Wagtail	Motacilla flava	Motacillidae	RM
43	White Wagtail	Motacilla alba	Motacillidae	RM
44	Forest Wagtail	Dendronanthus indicus	Motacillidae	RM

4.2. Disturbance intensity

The Disturbance Intensity Index (DII) varied across sites and months (Figure 1). Sites S1 and S2 exhibited consistently high DII values, driven by frequent fishing activity (both gears and angling), livestock grazing on exposed banks, and proximity of household use. Site S4, the sheltered site, had the lowest DII; here human presence was intermittent and mostly limited to transhumant grazing in a few months.

4.3. Relationship between disturbance and bird metrics

GLMs revealed a negative relationship between DII and total waterbird abundance ($\beta = -0.65$, SE = 0.18, $p < 0.001$) and species richness ($\beta = -0.42$, SE = 0.12, $p = 0.002$) after controlling for water level and season.

Disturbance-sensitive guilds (large-bodied piscivores and colonial nesters) exhibited stronger negative responses ($\beta = -0.81$, SE = 0.20, $p < 0.001$). Post-hoc contrasts indicated mean abundance at low-disturbance site S4 was approximately 2.5 times higher than at high-disturbance sites during non-monsoon months.

4.4. Behavioural responses

Across 420 recorded disturbance events, 62% caused conspicuous alert behaviour and 29% resulted in flushing. Fishing and close-proximity livestock grazing were the most likely activities to cause flushing (flush frequency 45% and 38% respectively), while distant agricultural work and occasional religious gatherings had lower immediate impact (flush frequency <15%). Repeated flushing events were associated with reduced foraging time and more time spent in vigilance, observed particularly at S1 and S2.

4.5. Breeding and roosting

Evidence of breeding (courtship displays, nest building, and chick presence) was recorded for several species primarily at the low-disturbance site S4 and sheltered patches of emergent vegetation. Colonial nesting attempts by herons were unsuccessful in at least two instances when human activity increased during the nesting period (e.g., net-setting close to nesting trees), suggesting disturbance-linked reproductive failure.

DISCUSSION

Our results indicate that human disturbance is a major factor structuring waterbird distribution and behaviour at Atpadi Tank. The negative association between disturbance intensity and waterbird abundance/richness mirrors findings from other small reservoirs and wetlands where anthropogenic pressure reduces habitat suitability for disturbance-sensitive species (e.g., Goss-Custard et al. 2006; Ransom et al. 2012).

Large-bodied piscivores and colonial nesters appeared most vulnerable, likely because they require predictable feeding and secure nesting sites and are energetically costly to displace. Frequent flushing increases energy expend.

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