Uttar Pradesh Journal of Zoology

Volume 45, Issue 17, Page 176-185, 2024; Article no.UPJOZ.3936
ISSN: 0256-971X (P)

Shorebirds: Threats and Strategies for Conservation

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

Article Information

DOI: https://doi.org/10.56557/upjoz/2024/v45i174360

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://prh.mbimph.com/review-history/3936

Review Article

Received: 05/06/2024
Accepted: 08/08/2024
Published: 13/08/2024

ABSTRACT

Shorebirds or waders inhabit in the coastal littoral zone and play critical role in the marine ecosystems and environmental monitoring. Ecological services provided by shorebirds include facilitating energy and nutrient transfer; enrich soils to increase biodiversity along with primary and secondary production. Shorebirds are used as indicators of pollution, environmental change, food chain, and climate change. These birds are vulnerable to hunting pressure, habitat changes, disturbance and other threats. Disturbance to roosting or feeding shorebirds is a major concern along coastlines. Shorebirds can adapt to regular disturbances at predictable distances; but some loud, unpredictable disturbances such as shouting, people running, jet skis, helicopters, kite boards, fast and noisy boats, and dogs are the most threatening to them. Anthropogenic stressors such as chemical pollution, fishing, habitat loss, invasive alien species/introduced species, marine debris, oil spills, poaching, and shipping pose threats to the shorebirds. Human activities can affect the shorebirds, either directly or by producing behavioural or physiological impacts. Present review attempts to provide an illustrative and updated account of shorebirds relevant to current status; natural, anthropogenic, and emerging and under-studied threats; and strategies to be adopted for

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Cite as: *Mhatre, Manda Anil. 2024. "Shorebirds: Threats and Strategies for Conservation". UTTAR PRADESH JOURNAL OF ZOOLOGY 45 (17):176-85. https://doi.org/10.56557/upjoz/2024/v45i174360.*

better conservation and restoration of shorebirds. This study suggests that about threats to shorebirds, future research priorities should be given to assess the cumulative effects of anthropogenic stressors on shorebirds and to recommend effective preventive measures.

Keywords: Conservation; cumulative pressures; invasive alien; shorebirds; species; threats.

1. INTRODUCTION

Shorebirds or waders are the birds that feed by wading in shallow water or saturated sand and mud on the shores of lakes, rivers and the sea. They are ground-nesting birds, and lay eggs in shallow scrapes in sand, or in grass and other vegetation. Shorebirds prefer beaches, sand flats and tidal estuaries for breeding and feeding [1]. They feed on small crustaceans, molluscs, insects and other small invertebrates. Examples of shorebirds include sandpipers, curlews, plovers, stilts, snipe, terns, gulls, godwits and oystercatchers [2].

Commonwealth of Australia [3] documented that; shorebirds inhabit the shorelines of coasts and inland water bodies during most of their life cycles. Most of these birds are from two taxonomic families, Scolopacidae (sandpipers) and Charadriidae (plovers). Shorebirds mostly prefer the coastal and inland habitats such as coastal wetlands, ephemeral water sources, estuaries, floodplains, grassland areas, inland wetlands, mangroves, mudflats, reefs, rocky inlets, and sandy beaches [4].

Sauvageau [5] noted that; shorebirds nest individually, or in very loose aggregations. They often nest on flat, gravel rooftops, or hidden behind dunes, vegetation, or other protected areas. These birds provide many ecosystems services including their role as potential indicators of marine conditions [6]. Shorebirds forage within a few miles of land, and feed in the marine/coastal zone in marshes and along brackish creeks. Shorebirds breed in salt marshes, rocky coastline, gravelly or sandy beaches, and offshore islands, provide critical habitat for nesting [7].

Good et al [8] stated that; shorebirds face threats from loss of habitat, degradation of habitat, human disturbance, alien species, oil and other marine pollution, contaminants, fisheries interactions and the introduction of debris into the marine environment [9]. Their population are also affected by the lost or abandoned commercial and recreational fishing nets, lines, pots and traps that sit or float underwater. Other threats include avian predation, extreme weather and inundation, fox/feral dog predation, and human disturbance (domestic dogs) [2].

United Nation (UN) [10] revealed that; species of shorebirds with small range or population are of more concern due to the threat of decline. For conservation of shorebird population, it is necessary to minimize the visitor impacts on shorebirds along with restricting the beach access, dogs, fishing, and issuing fines to the visitors and intruders [11]. Invasive species threaten the shorebirds through direct predation, including interactive effects among multiple introduced predators. Shorebirds are impacted indirectly by habitat degradation by invasive herbivores and competition with a variety of invasive and problematic native species [12].

Croxall et al [13] reported that; seabirds are more threatened than other related birds and that their status has deteriorated faster over recent decades. At present, shorebirds were threatened by commercial fisheries, pollution, alien invasive predators, habitat degradation and human disturbance. Shorebirds depend upon the wetlands and they are threatened by pressures from the increasing human use of land and resources. They have a limited ability to respond to environmental changes, but are in the need of health coasts and wetlands for breeding, migration, and survival [14].

Melville and Schuckard [15] recorded that; shorebirds require good quality feeding grounds, unpolluted areas, low nutrient levels and a rich benthos in the intertidal substrate. At high tide, these birds require an undisturbed area for roosting, and relatively undisturbed beaches for breeding [16]. The most crucial habitats for shorebirds are tidal flats, which are being degraded and sometimes removed altogether. For shorebirds, loss or degradation of habitat in feeding, breeding or staging areas can result in failure to breed or death from starvation or predation [17].

According to American Bird Conservancy [18], the current threats to the shorebirds are agriculture, deforestation/timber extraction, fire

suppression, forest management, global warming, invasive species/disease, livestock grazing, pesticides/pollution, urban/suburban development, water diversion projects, wetland drainage, and other (forest succession, coastal engineering, deer, fisheries, recreation, fire). Threats to shorebirds have biological impacts ranging from indirect loss of habitat and reduced fitness resulting from disrupted foraging to direct mortality and loss of habitat [19].

UNEP and NCS [20] noted that; birds are a vital part of the world's biodiversity, and conserving their habitats will help in protecting many other species and the wider ecosystem. Shorebirds have a function in regulation of aquatic, benthic and infaunal communities; cycling of nutrients; and transporting nutrients from foraging grounds to roosting and nesting localities [17]. In light of these observations, present review attempts to provide an illustrative and updated account of threats, and strategies for conservation and restoration of shorebirds.

2. LITERATURE SEARCH METHODS

The existing literature shows that on the topic, threats and conservation of shorebirds, in-depth research has been conducted. For present review the searched literature contains research papers, reviews, reports, and conference papers with the help of internet search engines like Google, Google Scholar, PubMed, ScienceDirect, and ResearchGate. According to the content relevancy, 12 papers were eliminated, and 32 papers were selected. The purpose of this review was to summarize current status, threats to the population, and strategies to be adopted for sustainable conservation of shorebirds.

3. MAJOR THREATS TO SHOREBIRDS

Croxall et al [13] noted that; threats acting at the breeding sites of shorebirds include human disturbance, infrastructure/commercial/residential development, invasive species, and problematic native species. Other threats acting on the foraging, moulting or migration areas/aggregations of shorebirds were bycatch, climate change and severe weather (sea level rise), hunting and trapping, overfishing or inappropriate spatial management of fisheries, and pollution (Table 1).

Whitehead et al [21] stated that; threats to shorebirds are grouped under various categories such as climate change, direct human impacts, disease, fisheries, invasive alien species (includes biosecurity), and pollution. It is important that, none of these threats work in isolation. Species may face multiple threats, and the combination of multiple threats to a population can be vastly more damaging than anyone would alone (Table 2).

According to Martinez-Curci et al [22], climate change is a major threat to shorebird species inhabiting estuaries and breeding in high latitudes. Various land-based threats to shorebirds were bycatch (in gillnet, trawl, and other fisheries), changes in land use and land cover, commercial and residential development, habitat deterioration, human disturbance, hunting, invasive alien species, noise (busy shipping lanes, seismic surveys, and sonar), pollution (oil spills, chemical contaminants, plastic and marine debris), prey depletion caused by overfishing, energy production, and mining; and problematic native species [23].

Table 1. Major threat to shorebirds (Source: Kristyn and Menezes [28])

Natural Threats	Anthropogenic Threats	Emerging & Under-Studied Threats
Disease, Predators, Weather	Chemical pollution, Climate change Temperature changes at sea & on land, Fisheries, Habitat changes, Human disturbance, Hunting pressure, Invasive Alien Species & Biosecurity, Loss of subsurface predators, Risks to the health & survival, Shorebird & egg harvesting,	Discarding, Hybridization, Offshore wind farms

Table 2. Natural threats to shorebirds

Threats	Examples	Impacts on shorebirds
Disease	Avian cholera, avian malaria, avian pox, avian influenza, Newcastle disease, Aspergillosis	Infections by viruses, bacteria, fungi, protozoa, gastrointestinal parasites, and ectoparasites. Sub-lethal effects on adults. Periodic threat to dense colonial shorebirds. Stress and weakening of immune capabilities. Mass mortality of adults and chicks. Steep population declines.
Predators	Mammalian predators (dogs, cats, rats, pigs, mustelids & hedgehogs)	Decline in populations & local extinction. Impact breeding success. Kill the adults, smaller shorebirds, and chicks. Predation of both adults and chicks. Preying upon adults, eggs & chicks. Reduction in number of eggs.
Weather	Extreme weather	Landslips and erosion of burrow habitat. Pose problems for visual foragers. Washout of adults, eggs, or chicks.

(Source: Woehler [24])

Table 3. Anthropogenic threats to shorebirds

Threats	Examples	Impacts on Shorebirds
Invasive alien species & Island Biosecurity	Avian predation (Australasian harrier, Black-backed gull)	Prey on the eggs, chicks and adult birds. Decline in the populations.
	Island Biosecurity (Prevention, detection & response to incursions)	Invasion of islands, including poisons, traps, passive detection devices and trained dogs.
	Weeds (Boxthorn, Kikuyu grass)	Detrimental to colonies. Death due to wings tangled in fibrous growth.
Fisheries	Commercial Fisheries: Long-line, gillnet, & trawl fisheries. (Bottom longline, Surface longline,	Adult mortality & declines in populations. Birds can be hauled in, or collide with net cables in trawl fisheries. Birds can be hooked during the haul.

Threats	Examples	Impacts on Shorebirds
	Set net, & Trawl)	Birds may become entangled in the net. Diving species can be caught in set or drifting gillnets and drowns. Notorious for pelagic shorebirds by-catch and exploiting fish stocks.
	Indirect impacts	Reduce available prey species. Natural decline in population. Reduce food available to shorebirds.
	Recreational fisheries	Impact shorebirds through by-catch. Diving after baited hooks or entangled in fishing lines or in set nets. Birds were snagged on their tree roosts, entangled by the line and hanged, or strangled by the line itself. Mortality of birds.
	Set nets	Catch diving shorebirds with shearwaters, diving petrels, penguins and shags. Discarded fishing gear causes marine plastic pollution. Entanglement mortalities of young birds. Mortalities of birds due to 'ghost fishing'.
Pollution	Artificial light at night	Severely impact the behaviour. Disorientation by light. Cause confusion leading to crash landing in residential areas. Injury or vulnerable to death.
	Coastal development	Sedimentation and runoff reduce area of foraging for near shore feeding bird species. Runoff impact nutrient flows from terrestrial to marine environments. Cause eutrophication and deteriorate aquatic ecosystems. Sewerage overflow cause faecal contamination. Runoff causes heavy metal contamination.
	Oil spills	Impacts for long term breeding success. Cause persistent sub-lethal physiological stress. Reduce the availability of prey species. Devastate population. Mortality.
	Plastics	Accidental ingestion of plastics. Direct consumption by misdirected feeding behaviours. Gradual starvation by filling the digestive tract. Impact the reproduction of prey species. Reduction in seabird foraging success. Increase their exposure to toxic contaminants. Ingested plastic may cause internal blockages or perforations. Inhibit reproductive systems and cause developmental problems. Physical injury. Plastic ingestion & accumulation in gizzards. Potential toxicological effects.
Climate change	Ability of shorebirds to adapt to changing conditions	Struggle to adapt to rapidly changing environmental conditions. Adapt to changes in resource distribution or thermal tolerance.
	Increase in toxic algal blooms	Accumulation of biotoxins in coastal waters. Mortality due to toxic condition and anoxia.
	Increased frequency of storm events	Cause mass mortality of birds.

Threats	Examples	Impacts on Shorebirds
		Destroy nesting and roosting habitat.
	Large scale events	Alter in breeding and foraging capacity. Change population trends. Increase erosion of coastal habitats. Loss of egg or chicks.Reduce habitat for breeding and roosting. Flooding and washouts of burrow sites.
	Prey-shifting	Unavailability of normal prey-sources. Decline in prey species affect breeding cycles.
Direct Human Impacts	Disturbance on land	Breeding sites are critically endangered. Reduce the feeding, roosting and breeding habitats. Loss of nesting sites. Use of beaches and estuaries as recreational areas for people and their pets.
	Disturbance on water	Boats approaching too close can disturb birds. Risk of predation to the chicks. Greater risk of injury or death to diving birds.
	Fire	Pose a risk to shorebird populations. Destroy habitat. Mortality of adult birds or fledglings. Damage to breeding sites.
	Harvesting	Hunting of seabirds for feathers and flesh. Harvesting of eggs. Prevent populations from increasing. Decline in population. Illegal mutton-birding by destruction of burrows Expose islands to introduction of pests and predators.
	Persecution	Competition with human interests. Birds are harassed, injured, and even killed. Harm or killing of birds by recreational fishers.
	Researcher disturbance	Observation or handling of birds for research. Impact on dense colonies for survival and breeding.

(Source: Whitehead et al [21])

Table 4. Emerging and under-studied threats to shorebirds

Threats	Examples	Impacts on Shorebirds
Discarding	Unwanted catch, spent bait, and offal	Negative impact on populations. Affects food web and community structure. Lower growth rates of chicks. Increases in abundance of predator-scavengers.
Hybridization	Pairing of mixed-species and production of hybrid offspring	Threat to conservation concern. Degrades the gene pool.
Offshore wind farms	Turbines of wind farms	Turbines affect shorebirds via collision. Displacement from good-quality habitats. Impacts on sea ducks, terns, and shags.

(Source: Richard et al [25])

Woehler [24] reported that; major threats to resident and migratory shorebirds in Tasmania include beach-walking, bicycle riding, coastal and near-shore resource harvesting, dogs, drones and unmanned aerial vehicles UAVs, entanglement, horse riding, invasive plants, light spill, livestock, native and introduced vertebrate predators, off-road vehicles, projected sea-level rise, and urban sprawl, coastal infrastructure and development (Table 3).

Richard et al [25] reported that; of the shorebirds, almost 29% species are globally threatened with extinction or as near threatened by the International Union for Conservation of Nature (IUCN) Red List. Overfishing, climate change, pollution, and coastal development threaten the health of the ocean, and communities that depend on the ocean, by disrupting ecosystems, degrading coastal habitats, threatening marine biodiversity, and undermining human welfare [23].

Collard [26] stated that; shorebirds have suffered sharp declines because of wetlands destruction, agricultural conversion of prairie potholes, and long-term climate-related drought. According to Marine Management Organization [27], commercial fishing has hazardous effects of population of shorebirds. Various types of fishing gear (bottom towed gear, mid-water gear, anchored nets and lines, traps) and the fishing vessels have direct and indirect impacts on shorebirds [28].

Kristyn and Menezes [29] documented that; impacts caused by natural, anthropogenic, or emerging and under-studied threats on shorebirds include anaemia, collisions with the light source/nearby structures, disrupts hepatic function, hypothermia, impacts osmoregulation and reproduction, increased risk of predation, increases metabolic rate, liver damage, loss of foraging time, oxidative damage to red blood cells, reduced breeding time, and reduced viability of eggs [30,31] (Table 4).

4. STRATEGIES FOR CONSERVATION OF SHOREBIRDS

For protection, conservation and restoration of shorebirds, Whitehead et al [21], The David and Lucile Packard Foundation [23], and Commonwealth of Australia [32] have suggested various strategies such as:

- Build conservation and monitoring policy for protection of shorebird sites.
- Bycatch reduction by improvements and fishery gear modifications.
- Enforcement of restrictions for pets and vehicles on the beaches.
- Habitat conservation by protection of critical habitats.
- Identification of potential disease risks in shorebirds for proper management.
- Island restoration for sustainable conservation.
- Legal protection for the natural coastal zones.
- Prevention of pests and predators incursions on breeding sites.
- Protection of breeding colonies of all shorebirds.
- Public awareness on seabirds and threats to them.
- Reduce plastic pollution at the hotspot areas of breeding sites.
- Reduction of bycatch to minimize the mortality.
- Removal of invasive species to increase breeding success and survival.

5. CONCLUSION

The results of the study reveals that; in recent years, anthropogenic stressors have impacted the feeding, roosting, and breeding sites of shorebirds as a result of human activities in coastal areas. Outcomes mentioned in this study contribute to the scientific knowledge on current status of shorebirds, natural and human induced threats faced by shorebirds, and strategies to be adopted for better conservation and restoration of shorebirds. Since most of the shorebirds are of conservation concern, future research need to be focussed on cumulative effects of anthropogenic impacts on shorebirds for more effective coastal planning and protection of shorebird populations.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://prh.mbimph.com/review-history/3936