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Preliminary Observational Documentation of Shorebirds and Waterbirds along the Coastline of Kuala Juru and Port Klang, Malaysia

Mohamad Izzuddin Mohd Hadir[1], Mohamad Saupi Ismail[2], Yoshifumi Horie[3], Ahmad Dwi Setyawan[4,5], Krishnan Kumar[6] and Chee Kong Yap[1]*

[1]Department of Biology, Faculty of Science, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

[2]Fisheries Research Institute, Batu Maung, 11960 Pulau Pinang, Malaysia

[3]Graduate School of Maritime Sciences, Faculty of Maritime Sciences, Kobe University, Kobe 658-0022, Japan

[4]Department of Environmental Science, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret, Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia

[5]Biodiversity Research Group, Universitas Sebelas Maret, Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia

[6]Faculty of Health and Life Sciences, INTI International University, Persiaran Perdana BBN, 71800 Nilai, Negeri Sembilan, Malaysia

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Author : Chee Kong Yap

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***Correspondence:**

Chee Kong Yap, Department of Biology, Faculty of Science, Universiti Putra Malaysia, 43400 UPM Serdang, Malaysia,

E-mail: yapchee@upm.edu.my

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Abstract

Coastal wetlands and estuarine mudflats along the East Asian–Australasian Flyway (EAAF) are critical for migratory waders and resident waterbirds, yet many sites in Southeast Asia remain poorly documented despite intense anthropogenic pressure. This study presents opportunistic photographic observations of waterbirds, migratory waders, and predatory birds in two heavily industrialised estuarine systems along Malaysia's west coast: Kuala Juru, Penang, and Port Klang, Selangor. Surveys were conducted from small boats along intertidal mudflats and mangrove-fringed coastlines, with species identification verified using eBird and regional field guides. A total of nine waterbird and wader species were recorded, including the Near Threatened Lesser Adjutant (*Leptoptilos javanicus*), alongside four predatory and piscivorous species, including the Vulnerable Black-capped Kingfisher (*Halcyon pileata*). Observed behavioural patterns revealed partial overlap between resident waterbirds and migratory waders in flocking and foraging on exposed mudflats, while predatory species exhibited solitary perching and ambush strategies. Despite extensive industrialisation, shipping activity, and coastal modification, both estuaries continue to support foraging, roosting, and stopover functions for migratory and resident birds. These findings highlight the value of degraded estuarine habitats as secondary or opportunistic refuges within the EAAF and underscore their potential for ecological restoration. The study demonstrates the utility of opportunistic photographic surveys in data-limited regions and provides baseline information to support future monitoring, conservation prioritisation, and flyway-scale management of Malaysian estuarine wetlands.

Keywords: East Asian-Australasian Flyway; Waterbirds; Migratory Waders; Estuarine Wetlands; Industrialised Coasts; Opportunistic Observation; Habitat Restoration; Malaysia

Introduction

Coastal wetlands and estuarine mudflats are among the most productive ecosystems in the world, supporting a high diversity of waterbirds and waders that occupy key ecological roles across multiple trophic levels [14]. These habitats provide essential resources for foraging, roosting, and migration, particularly for shorebirds linked to the East Asian-Australasian Flyway (EAAF), one of the most species-rich and heavily threatened migratory routes globally. Many species migrating through the EAAF travel between Arctic breeding grounds and Southeast Asian or Australasian non-breeding sites, relying on a network of estuaries as sequential stopovers for refuelling [4, 7]. However, rapid coastal reclamation, industrial expansion, altered hydrology, and pollution have resulted in severe declines in suitable intertidal habitat throughout the flyway, causing widespread population reductions among migratory shorebirds. Southeast Asia remains one of the least monitored regions along the flyway, despite being a critical non-breeding and staging area, leaving

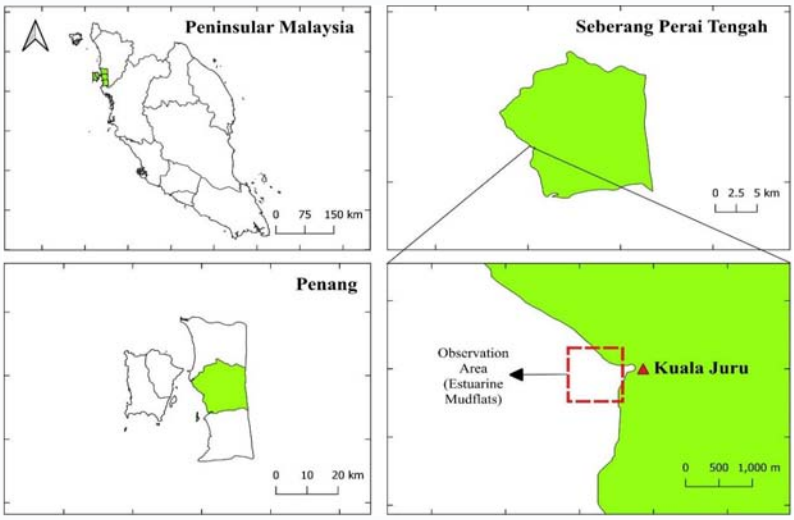

Figure 1: Observation location of waterbirds and migratory waders at Kuala Juru estuary, Penang, Malaysia.

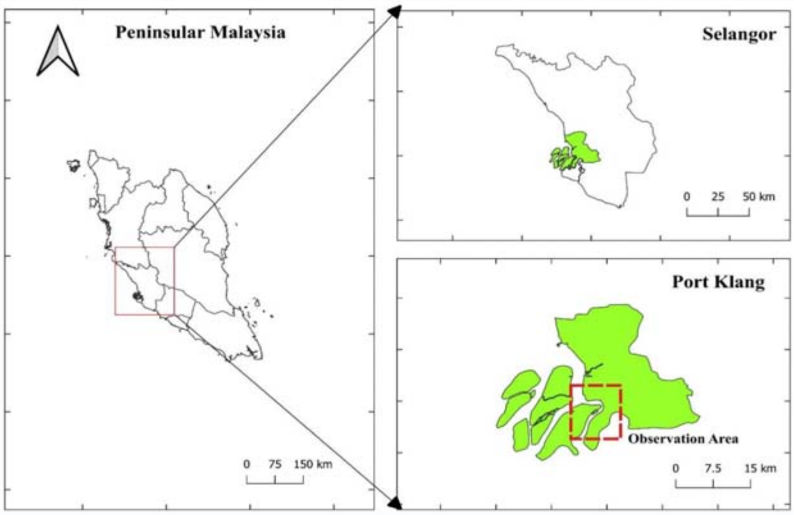

Figure 2: Observation location within the Port Klang estuarine channels and river inlets.

significant gaps in ecological knowledge and conservation planning [16].

Malaysia's west coast, particularly the estuarine systems of Penang and Selangor, is embedded within this migration corridor and holds ecological importance despite extensive anthropogenic pressure. Areas such as Kuala Juru and Port Klang are heavily industrialised, characterised by metal and electronics manufacturing zones, dense shipping lanes, port facilities, and near-continuous coastal urbanisation [8, 10]. These disturbances can directly affect prey availability, mudflat accessibility, sediment quality, and disturbance regimes, all of which are key determinants of wader and waterbird habitat suitability. Nevertheless, degraded or fragmented wetlands have been shown in other EAAF regions to function as micro-refuelling or opportunistic foraging sites when key resources persist or when alternative habitats elsewhere have been lost. Understanding species presence in such altered environments is therefore crucial for evaluating their ongoing ecological value and restoration potential [9].

Both migratory and resident waterbirds also act as sensitive bioindicators of estuarine health. Migratory species integrate environmental conditions across broad geographic scales, while resident taxa reflect long-term, site-specific changes in habitat quality, hydrology, and pollution [11]. Their behavioural responses, such as changes in foraging patterns, flocking, vigilance, or roosting, provide real-time ecological signals that can guide habitat management decisions [15]. Despite their ecological importance, Malaysian estuaries remain poorly studied, with limited long-term monitoring and inconsistent documentation of bird species assemblages ever being conducted in highly industrialised zones. Opportunistic and photographic-based observational surveys offer an alternative practical approach for capturing species presence, distribution, and behaviour in such environments, particularly when systematic counts are not feasible. These methods provide useful baseline data that can support future monitoring, restoration planning, and integration into flyway-scale conservation frameworks.

This study documents waterbirds and migratory waders along the coastlines of Kuala Juru, Penang, and Port Klang, Selangor, using opportunistic photographic observations. The objective is to characterise species presence, behavioural patterns, and their

Table 1: Waterbird and wader species recorded *via* opportunistic photographic observations along the estuarine coastline of Kuala Juru, Penang and Klang, Selangor.

Order	Family	Species	Group	Common Name	Sites		IUCN status
					Kuala Juru	Klang	
Pelecaniformes	Ardeidae	*Ardea alba* (Linnaeus, 1758)	Waterbird	Great Egret	/	/	LC
		Ardea cinerea (Linnaeus, 1758)	Waterbird	Grey Heron	/	/	LC
		Egretta garzetta (Linnaeus, 1766)	Waterbird	Little Egret	/	/	LC
		Nycticorax nycticorax (Linnaeus, 1758)	Waterbird	Black-crowned Night Heron	x	/	LC
Ciconiiformes	Ciconiidae	*Leptoptilos javanicus* (Horsfield, 1821)	Waterbird	Lesser Adjutant	x	/	NT
Charadriiformes	Charadriidae	*Actitis hypoleucos* (Linnaeus, 1758)	Wader	Common Sandpiper	/	/	LC
		Anarhynchus sp.	Wader	Sand Plover	/	x	LC
		Numenius phaeopus (Linnaeus, 1758)	Wader	Whimbrel	/	x	LC
		Tringa tetanus (Linnaeus, 1758)	Wader	Common Redshank	/	x	LC

Note: Predatory raptors and piscivorous species were also observed at both estuaries (Table 2). These included White-bellied Sea Eagle (*Icthyophaga leucogaster*), Brahminy Kite (*Haliastur indus*), Collared Kingfisher (*Todiramphus chloris*), and Black-capped Kingfisher (*Halcyon pileata*), the latter listed as Vulnerable.

Table 2: Predatory and piscivorous birds observed alongside waterbirds and waders in Kuala Juru and Port Klang.

Order	Family	Species	Group	Common Name	Sites		IUCN status
					Kuala Juru	Klang	
Accipitriformes	Accipitridae	*Icthyophaga leucogaster* (Gmelin, 1788)	Predator	White-bellied Sea-Eagle	/	/	LC
		Haliastur indus (Boddaert, 1783)	Predator	Brahminy Kite	/	/	LC
Coraciiformes	Alcedinidae	*Todiramphus chloris* (Boddaert, 1783)	Predator	Collared Kingfisher	/	/	LC
		Halcyon pileata (Boddaert, 1783)	Predator (Migratory)	Black-capped Kingfisher	/	/	VU

ecological relevance within two disturbed estuarine systems; evaluate their potential as indicators of habitat condition and restoration suitability; and contribute to the limited body of data available for Malaysian EAAF sites. By establishing these baselines, the study aims to enhance understanding of how industrialised estuaries continue to support migratory and resident species and how these habitats may be prioritised within future coastal conservation and restoration efforts.

Materials and Methods

Observation Area and Condition

Bird observations were conducted at two estuarine sites: along the Juru River, Penang, and the Port Klang estuary, Selangor. At the Juru River, observations were carried out in the early morning (0800 - 0900H) and late afternoon (1300 - 1400H) on 23 February 2025. Morning conditions were slightly misty and sunny, while the late afternoon was cloudy with intermittent rain. The Juru estuary is located near the first Penang Bridge and is characterised by expansive intertidal mudflats fringed with coastal mangroves (*Rhizophora* spp.). The surrounding area is heavily industrialised, with infrastructures related to automotive, electronics, semiconductors, metals, rubber, pharmaceuticals, batteries, and food manufacturing industries. At Port Klang, bird observations were conducted on 23 November 2025, between 1200H and 1400H. The weather during the observation was cloudy, windy, and rainy. The Port Klang estuary is a major shipping hub, with numerous shipping ports, active shipping lanes, and clustered vessels, including cargo ships, tugboats, and fishing boats (Figure 1 and 2).

Field Observation

The opportunistic observation was performed while riding the fibreglass fishing boat along the estuary and mangrove-fringed coastline of Kuala Juru and Port Klang. A DSLR camera, Nikon 3400, with a telephoto lens AF-P DX NIKKOR 70-300mm f/4.5-6.3G ED VR was used to capture the presence and sightings of waterbirds or waders along the mangrove fringe and estuary. Observation was practised by scanning the exposed mudflats or sandy banks along the mangrove fringe to spot the perching or foraging birds using 10x42 Svbony and 10x8 Bushnell R-series binoculars at approximately 300-700 meters from the boat in Kuala Juru estuaries, while 20-100 meters in Port Klang. No bait-feeding or audio calling was being used. All the bird species were observed in situ without any interference or encroachment on their habitats and foraging activity.

Species Documentation and Identification

Each bird species observed was noted in the eBird app and verified by referring to the field guide, A Field Guide to the Birds of Malaysia and Singapore, and their updated taxonomy classification was described by following the information on the Avibase (https://avibase.bsc-eoc.org/avibase.jsp?lang=EN) and eBird from Cornell Lab of Ornithology, Cornell University, USA (https://ebird.org/home) website.

Results

Species Composition

A total of nine waterbird and wader species were recorded across both estuarine sites (Table 1). Seven species of estuarine birds were recorded in Kuala Juru, which are the Great Egret (*Ardea alba*), Grey Heron (*Ardea cinerea*), Little Egret (*Egretta garzetta*), Common Sandpiper (*Actitis hypoleucos*), Sand Plover (*Anarhynchus* sp.), Eurasian Whimbrel (*Numenius phaeopus*), and Common Redshank (*Tringa tetanus*). Meanwhile, five species were recorded in Port Klang, which are Great Egret (*Ardea alba*), Grey Heron (*Ardea*

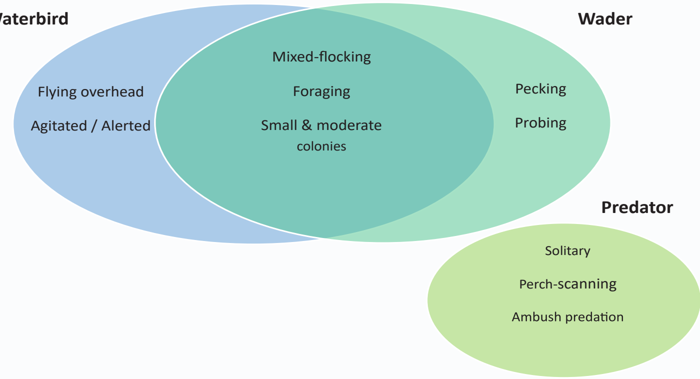

Figure 3: A Venn diagram to illustrate the observed behaviour of resident waterbird, migratory wader, and predatory bird in Kuala Juru and Port Klang.

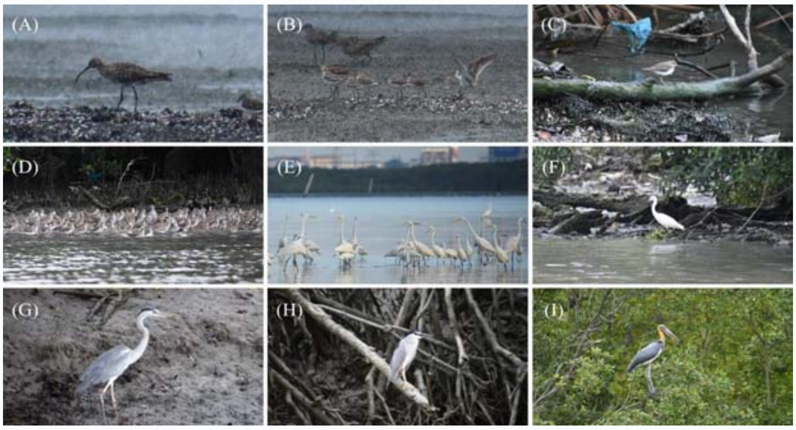

Figure 4: Compilation of nine species of waders and waterbirds observed in Kuala Juru and Port Klang: **(A)** Eurasian Whimbrel (*N. phaeopus*), **(B)** Sand Plovers (*Anarhynchus* sp.), **(C)** Common Sandpiper (*A. hypoleucos*), **(D)** Common Redshank (*T. tetanus*), **(E)** Great Egret (*A. alba*), **(F)** Little Egret (*E. garzetta*), **(G)** Grey Heron (*A. cinerea*), **(H)** Black-crowned Night Heron (*N. nycticorax*), **(I)** Lesser Adjutant (*L. javanicus*).

Figure 5: Common sightings of predatory raptors and coastal passerine birds among waterbirds and waders in Kuala Juru and Port Klang: **(A)** White- bellied Sea-eagle (*I. leucogaster*), **(B)** Juvenile Brahminy Kite (*H. indus*), **(C)** Black-capped Kingfisher (*H. pileata*), **(D)** Collared Kingfisher (*T. chloris*).

cinerea), Common Sandpiper (*Actitis hypoleucos*), Black-crowned Night Heron (*Nycticorax nycticorax*) and Lesser Adjutant (*Leptoptilos javanicus*), the latter being listed as Near Threatened by the IUCN (Table 2).

A brief observation of behavioural patterns revealed that they differed among waders, resident waterbirds and predatory birds within the estuarine habitat. Waterbirds and migratory waders exhibited partial behavioural overlap, particularly in their tendency to form mixed or conspecific flocks and to aggregate in small to moderate colonies while foraging on exposed intertidal mudflats or near mangrove fringe. However, waders displayed distinct specialised foraging strategies characterised by continuous probing and rapid pecking on mudflats; while waterbirds demonstrated overhead flight, heightened alert or agitation responses to disturbance, and intermittent foraging along shallow-water edges. Predatory species, including raptors and predatory passerines, showed no overlap with either waders or waterbirds, instead exhibiting solitary behaviour dominated by extended perching, scanning, and occasional ambush

Figure 6: (A & B) Expansive intertidal mudflats fringed by mangroves and human infrastructures in the background of Kuala Juru estuaries. These mudflats are swarmed with waders and waterbirds during low tide. **(C & D)** Exposed muddy sandbanks by mangrove fringes along the estuarine canals of Port Klang, where most waterbirds tend to congregate and forage during the receding tide.

Figure 7: (A) Large industrial hubs within the mudflats and mangrove fringe near the first Penang Bridge, **(B)** Rapid urbanisation occurring near coastal areas of Penang Island, just opposite Kuala Juru estuaries, **(C)** Large ship harbours in Port Klang, **(D)** Active shipping ports being operated along the estuaries of Port Klang.

predation attempts (Figures 3-7).

Discussion

Waterbird and Wader Presence as Indicators of Coastal Condition and Restoration Potential

The presence of diverse waterbirds and migratory waders along the coastlines of Kuala Juru and Port Klang indicates that these estuaries continue to provide essential ecological functions despite extensive anthropogenic disturbance. Migratory species along the East Asian - Australasian Flyway (EAAF) depend on many productive stopover sites that support resting, refuelling, and pre-migratory fattening [6]. Because many EAAF populations are undergoing steep declines driven by habitat loss, altered hydrology, and reduced prey availability, even small or previously degraded estuarine habitats can significantly impact their conservation value. Bird surveys on the Yellow Sea coast showed that the shorebird population plummeted steeply in reduced and altered tidal flats. As coastal specialists, most shorebirds are the most vulnerable and sensitive groups of birds to any habitat changes and disturbances [5]. Locally, the sightings of sandpipers, plovers, egrets, herons, and other coastal birds at both industrialised coastal sites suggest that these wetlands still retain a baseline of ecological integrity suitable for recovery under targeted restoration.

This pattern is akin to observations from other flyway regions where remnant tidal flats, deltaic wetlands, and semi-enclosed bays continue to host large bird aggregations despite surrounding urbanisation. The case of Deep Bay in the Pearl River Delta demonstrates that highly urbanised estuaries can still support globally significant bird populations, even though intense reclamation, altered circulation, declining benthic biomass, and mangrove encroachment have pushed the system toward its carrying capacity [9]. Similarly, coastal zones in China, Korea, Vietnam, and South Asia show that shorebirds consistently transit in remnant patches of suitable habitat, which implies the sensitivity of migratory species to wetland quality and the potential for restoration success when prey availability and hydrological conditions are improved [9]. Their population responses could signify chronic environmental pressures such as heavy metal pollution, water quality degradation and destructive wetland habitat disturbance [3]. Thus, a combined aggregation of migratory and resident species provides an overview for assessing ecological change and restoration outcomes across different temporal scales.

During surveys, the observation of predatory birds such as Brahminy Kites and White-bellied Sea Eagles provides crucial insight into the trophic structure of these estuaries. Predatory species occupy top or near-top positions in coastal food webs and act as important regulators of waterbird behaviour, patch occupancy, and foraging efficiency. Even non-lethal predator presence can modify wader flock structure, vigilance levels, and microhabitat selection, thus shape energy expenditure and feeding success. For migratory birds whose survival depends on rapid fat accumulation during short stopovers, such interruptions can reduce refuelling rates and compromise migration success.

However, predator presence also signals that the food web remains functional, with sufficient prey biomass to support higher trophic levels. In many restored or recovering wetlands, the return of raptors is considered evidence of improved prey abundance and ecosystem health. Yet anthropogenic changes can distort natural predator-prey dynamics. For example, urban-associated predators such as free-roaming cats disproportionately target small-bodied species like plovers and sandpipers, creating an artificial predation pressure that does not reflect natural trophic interactions. In contrast, natural raptors respond to fluctuations in fish, crab, and waterbird abundance, able to improve ecosystem productivity across trophic levels.

Case studies from Deep Bay show how changes in hydrology and benthic productivity influence predatory bird abundance and hunting behaviour. Years with increased rainfall triggered higher benthic biomass, which led to increased waterbird aggregations and subsequently drew in predatory species. Conversely, reclamation-driven reductions in infauna depressed both prey availability and predator presence. Such linkages highlight that predator occurrence and foraging behaviour can serve as indirect metrics of ecosystem function and restoration success, an observation directly applicable to the Malaysian estuaries studied here.

Migratory Connectivity, Flyway-Scale Stressors, and Local Impacts

Migratory species are inherently challenging to conserve because their life stages unfold across geographically distant regions. A decline detected at one site may originate from threats experienced thousands of kilometres away. Along the EAAF, the conversion of tidal flats, aquaculture expansion, pollution, climate-driven habitat shifts, and overexploitation of biological resources collectively drive widespread population drops. The flyway holds the world's highest proportion of threatened or near-threatened shorebird species, and Southeast Asia represents a critical non-breeding concentration zone where pressures are particularly acute [7].

Observations from Kuala Juru and Port Klang serve as vital stepping stones, supporting migratory connectivity and aligning with regional patterns that show birds are increasingly relying on secondary or marginal wetlands due to the rapid loss of large tidal flats elsewhere. For instance, the Yangtze River and Yellow Sea estuaries continue to support immense wintering populations but are experiencing severe habitat degradation [4]. In South China, mangrove restoration has enhanced coastal habitat area, but the encroachment of mangroves onto mudflats has reduced feeding grounds for shorebirds [13]. Because many migratory species rely on a sequence of interconnected sites, conservation actions at one location must align with broader flyway-scale strategies. The study areas in Malaysia represent not only local conservation priorities but also integral components of a continental migration network. Their ability to support foraging and roosting functions directly influences the survival prospects of species migrating between Arctic breeding grounds and Australasian wintering areas.

Anthropogenic Disturbances, Habitat Loss, and Their Impacts on Waterbirds

The observation-based results from Kuala Juru and Port Klang clearly reflect the pressures associated with rapid urbanisation, industrial activity, and coastal modification. Both sites exhibit characteristics typical of Southeast Asian estuaries where population growth and development have resulted in wetland loss, declining water quality, increased sedimentation, hydrological alteration, and fragmentation of intertidal habitats [9]. These patterns are similar to well-documented cases such as Deep Bay, where land reclamation reduced mangrove and mudflat areas, altered salinity, disrupted estuarine circulation, and caused a substantial decline in benthic infauna biomass. Reduced prey availability is consistently identified as the primary driver of waterbird population change, reinforcing the need to protect benthic-rich mudflats from further degradation [9].

Pollution, including nutrient enrichment, agricultural runoff, and industrial contaminants, also poses major threats. In several flyway regions, agricultural intensification has increased exposure to pesticides and fertilisers that disrupt food chains and reduce the health of waterbirds [9]. Heavy metals and other pollutants accumulate in tissues, lowering reproductive success and impairing foraging and flight performance [4]. Resident waterbirds provide continuous, locally relevant indicators of pollutant exposure, while migratory species integrate environmental signals across broader spatial scales [4]. Together, their responses offer a powerful assessment of multidimensional environmental stressors in Malaysian estuaries.

Implications for Habitat Restoration, Management, and Conservation Planning

The results of this study emphasise that small and degraded wetlands can still function as critical refuges when larger or historically important sites have been lost. Effective restoration and management must therefore prioritise habitat features that directly support waterbird foraging and roosting: open mudflat availability, healthy benthic infauna communities, hydrological connectivity, and minimal disturbance. As seen in the Pearl River Delta and other urbanised coasts, restoration must balance mangrove planting with the protection of open mudflats, avoiding excessive encroachment that reduces shorebird feeding areas [4].

Conservation strategies should incorporate both local management actions and flyway-scale coordination. Locally, this includes limiting reclamation, regulating pollution sources, mitigating disturbance from fisheries and coastal traffic, and incorporating community-based stewardship approaches proven effective in Vietnam, Indonesia, and other regions of the EAAF. At the flyway level, maintaining transboundary monitoring networks, data-sharing systems, and collaborative habitat protection agreements is essential for addressing threats experienced at multiple migratory stages [5, 16].

Resident waterbird species, often overlooked in migration-focused conservation, must also remain central to management strategies. Their sensitivity to long-term habitat degradation provides early warnings of declining ecosystem health even before migratory populations show visible declines [6]. Protecting both resident and migratory bird species will therefore enhance ecological resilience and support a more comprehensive coastal restoration framework.

Study Limitations and Suggested Future Bird Observation Approaches

Monitoring coastal birds to estimate their population size, distribution, or temporal trends requires robust and unbiased estimators of abundance. However, this study's brief and opportunistic survey design inherently limits the reliability of the observation and monitoring. A major challenge in avian field surveys is imperfect detection, which can lead to biased population estimates and misinterpretation of conservation status or management effectiveness. Numerous methodological frameworks exist to adjust for incomplete detection, including distance sampling, repeated counts, mark-recapture, double-observer protocols, time-removal models, and hybrid approaches, yet their applicability varies depending on species behaviour, habitat structure, survey logistics, and temporal constraints. These components fluctuate with weather, time of day, season, species-specific cue rates, distance from the observer, and observer skill [2].

Because this survey covered only a small proportion of the study area, lacked repeated visits, and was not designed to measure detection distances or cue production rates, many species were likely overlooked, resulting in a biased representation of the bird community. Some waders and waterbirds known to occur at the site were missed entirely, while others were observed only briefly, which dismisses the possibility of modelling detection probability or estimating density. The absence of multiple observers or repeated sampling also prevented the use of more advanced hierarchical models that jointly estimate occupancy and detectability. As a result, any behavioural patterns described, such as mixed-flock formation in waterbirds, probing foraging in waders, or solitary ambush strategies in predatory birds, must be interpreted cautiously, as the true behavioural diversity and species richness were likely under-detected.

The reliance solely on human observers introduces additional sources of uncertainty. Traditional point-count or transect-style visual surveys are known to suffer from observer bias, dependence on surveyor skill, and inconsistent detection rates across species with different behaviours or vocalisation patterns. Short-term, infrequent visits tend to underrepresent both rare species with low detectability and highly mobile species that move rapidly across the landscape [1, 12]. Environmental conditions such as wind, rain, and unpredictable weather also compromise detection accuracy, contributing to further uncertainty.

More advanced monitoring tools, such as passive acoustic monitoring (PAM) or automated recording units (ARUs) were not employed in this study, representing a missed opportunity for improved detectability and temporal coverage. PAM generates long-duration, standardised datasets that allow repeated analysis, independent verification, and modelling of species occupancy and detectability, which are particularly useful for species that vocalise reliably [1]. However, PAM also has practical limitations, including equipment cost, expertise required for sound processing, and reduced performance for visually cryptic but quiet species [1].

Other widely used methods, such as distance sampling, were also not feasible in this study despite their capacity to yield unbiased density estimates when carefully implemented. These approaches require well-trained observers, precise distance measurements, and repeated sampling under favourable conditions, criteria not met during the opportunistic nature of this fieldwork. Moreover, surveying highly disturbed and industrialised estuarine landscapes is inherently logistically challenging, both due to safety constraints and the difficulty of accessing sites with boat traffic, mudflats, or restricted industrial zones [12].

Future research in Kuala Juru and Port Klang would benefit from transitioning from opportunistic observation to a structured and repeated monitoring framework with standardised effort. The integration of visual surveys, PAM, and remote sensing would substantially improve detection probability and reduce bias. Incorporating multi-seasonal or long-term surveys is especially necessary to capture migratory turnover, seasonal habitat use, and population trends in accordance with international monitoring standards. Ultimately, such methodological improvements are essential for generating robust ecological baselines that can guide conservation planning for waterbirds and migratory waders in Malaysia's rapidly developing estuarine systems.

Conclusion

By documenting waterbird and wader presence in these two heavily industrialised coastal zones, including their predators, this study contributes essential data to understudied Malaysian sectors of the EAAF. The results highlight the intertwined ecological roles of shorebirds, resident waterbirds, and top predators in maintaining trophic balance, and they underscore the urgent need for integrated conservation strategies capable of addressing both local habitat degradation and large-scale migratory dynamics. These findings affirm that Malaysian estuaries and coastal areas, though heavily modified, could still retain significant restoration potential and should be prioritised within broader flyway conservation planning.

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