

A comprehensive review of shorebird distribution in Malaysia: Identification of coastal Important Bird Areas (IBAs) and assessment of the IBAs qualifying shorebird species.

Normaisharah Mokhter¹, Nor Atiqah Norazlimi^{1*}

¹Department of Technology and Natural Resources, Faculty of Applied Sciences and Technology, Universiti Tun Hussein Onn Malaysia (Pagoh Campus), Pagoh Higher Education Hub, KM 1, Jalan Panchor, 84600 Muar, Johor, Malaysia.

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✉ * CORRESPONDING AUTHOR

Dr. Nor Atiqah Norazlimi
Department of Technology and Natural Resources, Faculty of Applied Sciences and Technology, Universiti Tun Hussein Onn Malaysia (Pagoh Campus), Pagoh Higher Education Hub, KM 1, Jalan Panchor, 84600 Muar, Johor,
Email: atiqah@uthm.edu.my

ABSTRACT

Although coastal habitats play a vital ecological role in supporting migratory shorebirds, comprehensive reviews of shorebird populations in Malaysia are still lacking. Existing studies are primarily focused on single Important Bird Areas (IBAs) and typically cover a broad range of avifauna across various ecosystems, including terrestrial, wetland, and coastal zones, due to the diverse habitats often present within a single IBA. Consequently, the current understanding of shorebird distribution, abundance, and habitat along Malaysia's coast remains fragmented and poorly characterized. This review aims to highlight the distribution patterns of shorebird species throughout Malaysia, drawing on previously published records from various online academic sources. It also provides an overview of the qualifying shorebird species identified by Birdlife International that are found across coastal zones in Malaysia. The review was intended to serve as a foundational reference for future shorebird conservation efforts in the country.

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1. INTRODUCTION

BirdLife International is a longstanding global partnership of non-governmental conservation organisations dedicated to the conservation of birds, their habitats, and wider biodiversity worldwide. It was originally founded in 1922 and now includes partners in more than 100 countries. BirdLife works to prevent bird extinctions, identify and safeguard Important Bird Areas (IBAs), restore critical habitats, and support local and international conservation action through science-based research and collaborative programs. It also serves as the official International Union for Conservation of Nature (IUCN) Red List Authority for birds, coordinating assessments of the global conservation status of all bird species.

According to BirdLife International (2025), Malaysia supports 725 avian species, including 31 seabirds and 237 migratory species. Within this migratory assemblage, shorebirds constitute one of the most prominent groups in terms of species representation and abundance along coastal habitats, particularly during migration seasons, highlighting their ecological significance in Malaysia's coastal ecosystems. Shorebirds, also referred to as waders, belong to the order of

Charadriiformes, which additionally comprises gulls, skuas, terns, and auks (Howes and Bakewell, 1989). This order encompasses 12 families and includes approximately 214 recognised shorebird species worldwide. The majority are concentrated in two families: Charadriidae, which includes lapwings and plovers (65 species), and Scolopacidae, comprising sandpipers, snipes, and related species (88 species). Other families such as Dromadidae, Ibidorhynchidae, and Pluvianellidae are more limited, each containing fewer than 10 species. In Asia, shorebirds are represented by 10 families, including jacanas Jacanidae, painted snipes Rostratulidae, crab plovers Dromadidae, oystercatchers Haematopodidae, ibis bills Ibidorhynchidae, stilts and avocets Recurvirostridae, stone-curlews or thick-knees Burhinidae, coursers and pratincoles Glareolidae, as well as the more species-rich Charadriidae and Scolopacidae (Howes and Bakewell, 1989).

Shorebirds exhibit various adaptations related to bill morphology, prey availability, and foraging strategies, which may involve either visual or tactile techniques (Zakaria and Rajpar, 2010). Many species undertake long-distance migrations, travelling thousands of kilometres from their

northern breeding grounds to southern regions during the winter months to escape harsh weather. Their migratory routes are closely linked to natural landscape features such as coastlines, river valleys, and inland water bodies (Jorgensen, 2004; Morrison et al., 2004). To maximise survival and minimise mortality during migration, shorebirds rely heavily on stopover sites along these routes, which provide essential opportunities for resting, feeding, and replenishing fat reserves required for successful onward movement (Jorgensen, 2004; Morrison et al., 2004).

Malaysia is situated along the East Asian–Australasian Flyway (EAAF), a major global migratory corridor extending across 22 countries and four continents. While the EAAF is widely acknowledged for its rich biodiversity, it is increasingly threatened by various conservation pressures (EAAFP, 2018). Geographically, Malaysia consists of two primary regions: Peninsular Malaysia and East Malaysia. According to the BirdLife Data Zone, all designated Important Bird Areas (IBAs) along the Peninsular Malaysian coastline are found on the west coast, namely the North Central Selangor Coast, Teluk Air Tawar–Kuala Muda Coast, Matang Coast, and the Southwest Johor Coast (BirdLife International, 2023). In contrast, East Malaysia, comprising the states of Sabah and Sarawak, has IBAs that are more widely distributed across the island. This region serves as an important stopover and temporary refuge for migratory birds travelling between northern Asia, Southeast Asia, and Australasia (McClure, 1974; Bamford et al., 2008; Mann, 2008; Lim et al., 2020). On the other hand, East Malaysia has been shown to support various migratory shorebird species, such as the Great Knot (*Calidris tenuirostris*), Red Knot (*Calidris canutus*), and Sanderling (*Calidris alba*). Satellite tracking studies demonstrate that its coastline serves as a critical stopover site during their long-distance migrations (van Eerbeek, 2013; Lisovski et al., 2016; Chan et al., 2019).

Despite this ecological importance, research specifically focused on shorebirds along the Malaysian coastline remains limited and fragmented. Most available studies have emphasised broad species inventories across multiple bird taxa and habitats, including terrestrial, forest, wetland, and coastal environments (Sheldon et al., 2014; Bili et al., 2015; Makbul and Wong, 2016; Teng et al., 2019; Mohd Azlan et al., 2022; Mohd-Azlan et al., 2023), with relatively little attention given to shorebird communities in particular. This lack of focused and standardised ecological data constrains the effectiveness of conservation planning within the East Asian–Australasian Flyway (EAAF), as protection measures depend on reliable information on species distribution, abundance, and site usage at key stopover habitats.

Comparative assessments among coastal IBAs are also scarce, with Effendi et al. (2024) representing one of the

few studies to directly compare shorebird diversity between the North-Central Selangor Coast and Teluk Air Tawar–Kuala Muda Coast IBAs. Furthermore, a noticeable geographical imbalance exists in research coverage, where studies in Peninsular Malaysia are relatively more frequent, while those in East Malaysia remain sparse and scattered. This disparity represents a critical knowledge gap that may hinder the development of a cohesive national conservation strategy that reflects the full importance of Malaysian sites within the flyway network.

Although BirdLife International is widely recognised as the global authority for identifying IBAs and their qualifying species, its database is primarily structured around overall bird diversity rather than tailored specifically to shorebird assemblages. Such broad classification may not sufficiently capture the specialised ecological requirements of shorebirds, which are strongly influenced by tidal cycles, intertidal mudflat availability, and seasonal habitat dynamics. These habitat dependencies differ markedly from those of many terrestrial bird species, indicating that generalised biodiversity-based assessments alone may be insufficient for guiding targeted shorebird conservation actions.

Given these limitations, a clearer synthesis of existing knowledge is needed. This review therefore aims not only to examine the current state of knowledge on the distribution and abundance of shorebirds across Malaysia's coastal IBAs, and to identify which species meet the qualifying criteria under BirdLife International standards, but also to provide recommendations for future research directions. In particular, it highlights the need for studies focusing on shorebird ecology, behavior, and conservation management to fill critical knowledge gaps, especially between Peninsular and East Malaysia, to guide more effective, evidence-based conservation strategies within the EAAF.

2. MATERIALS AND METHODS

The Important Bird and Biodiversity Areas (IBAs) recognised by BirdLife International encompass a wide range of ecosystem types. For the purpose of this review, the focus was specifically on IBAs that include coastal and shoreline zones, given that these areas provide critical habitats for migratory shorebirds. To better visualise the locations of all IBAs situated along the Malaysian coastline, a map was generated using QGIS software. The coordinates, aligned by latitude and longitude for each IBA, were first organised in Excel and then converted into a CSV file. This file was subsequently imported into QGIS to display the locations using the OpenStreetMap (OSM).

The BirdLife Data Zone was integrated, including information on qualifying shorebird species for each IBA. BirdLife data were structured in the Excel sheet, enabling direct comparison with the extracted literature data and

supporting cross-validation of species presence, habitat use, and conservation status.

In parallel, a systematic review of published scientific literature pertaining to shorebirds within the listed IBAs was conducted to complement the data retrieved from BirdLife Data Zone. The literature search was limited to English-language articles, journals, dissertations, and survey reports. Online academic platforms such as Google Scholar and ResearchGate, along with targeted web searches, were used to retrieve relevant studies. A combination of keywords was employed, including the names of all 17 identified coastal IBAs and additional terms, such as “avian,” “shorebird,” and “waterbird,” to capture studies that considered broader bird communities encompassing shorebirds.

For data extraction, relevant information from each publication was systematically recorded in an Excel sheet, including authorship, year of publication, publication type, survey methodology, survey duration, ecosystem classification, research scope, species presence and key findings. The extracted data were then analysed comparatively to identify patterns in shorebird distribution, survey coverage, and research gaps across IBAs.

The overall workflow, comprising IBA selection, integration of BirdLife datasets, literature retrieval, systematic data extraction and organisation, and comparative analysis, was designed to ensure transparency and reproducibility. The entire compilation and analysis process was completed over a month, providing a structured and comprehensive baseline of shorebird research within Malaysia's coastal IBAs.

3. RESULT AND DISCUSSION

3.1 IBAs along the Malaysian coastline

Based on the BirdLife Data Zone map, 17 IBAs have been identified, encompassing coastal zones. Of these, four are in Peninsular Malaysia, while the remaining 13 are situated in East Malaysia, with six in Sarawak and seven in Sabah. Figure 1 depicts the distribution of IBAs along Malaysia's shoreline.



Figure 1: Distribution of IBAs along the coast of Malaysia (map generated using QGIS).

3.2 IBAs qualifying shorebird species

BirdLife Partners have developed a standardized set of global criteria for the identification of Important Bird Areas (IBAs), emphasizing locations of international significance for bird conservation. These criteria are organized into four main categories, as presented in Table 1.

Table 1: IBAs Global criteria.

Category	Descriptions
A1	Species that are globally threatened
A2	Species with restricted ranges
A3	Species confined to specific bioregions
A4	Sites where large congregations of birds occur.

Table 2 presents the list of IBAs qualifying shorebird species along Malaysia's coastal zones. The majority of these species belong to the family of Scolopacidae ($n = 15$), followed by Laridae ($n = 7$) and Charadriidae ($n = 2$). Most of the listed species fall under the A4 category, as shorebirds occur in large congregations during seasonal visits, highlighting the importance of IBAs in providing specialised support for shorebird communities. In contrast, only two species, the Spoon-billed Sandpiper (*Calidris pygmaea*) and the Spotted Greenshank (*Tringa guttifer*) are classified under the A1 category, representing globally threatened species.

3.3 Paper reviews findings from open-source data

Among the 17 IBAs in Malaysia with coastal zones, this review identified 21 publications reporting data on shorebird species (Figure 2). The majority of the literature comprises journal articles ($n = 11$), followed by technical reports ($n = 4$) published by the Malaysian Nature Society (Yeap et al., 2004; Yeap et al., 2007; Bakewell, 2009; Nur Atiqah and Ng, 2015), conference proceedings ($n = 3$), books ($n = 2$) authored by the local institution from Universiti Malaysia Sarawak (Mohd Azlan et al., 2022; Mohd-Azlan et al., 2023), and one academic thesis/dissertation from the local institution by Universiti Putra Malaysia (Lomoljo, 2011).

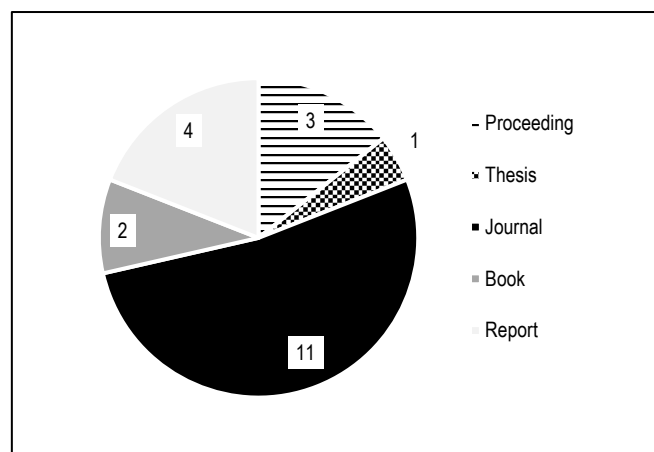


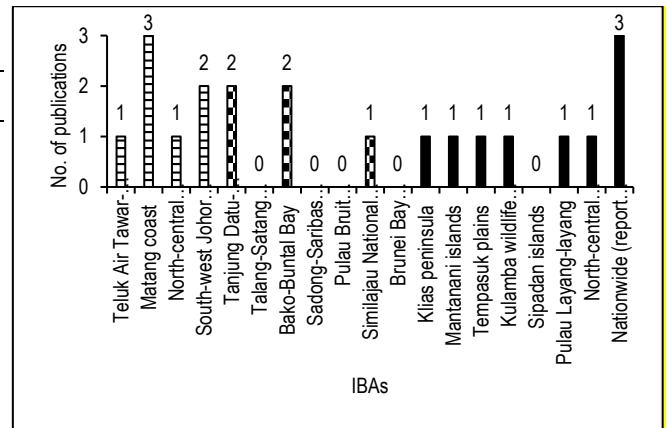
Figure 2: Type of publications compiled in the review.

Table 2: IBAs qualifying shorebird species listed in Malaysia from BirdLife Data Zone.

Family	Common Name	Scientific name	Region	IUCN	IBA
Charadriidae	Greater Sandplover	<i>Charadrius leschenaultii</i>	P, SR, S	LC	A4
	Pacific Golden Plover	<i>Pluvialis fulva</i>	SR	LC	A4
	Black-naped Tern	<i>Sterna sumatrana</i>	SR	LC	A4
Laridae	Common Tern	<i>Sterna Hirundo</i>	P, SR	LC	A4
	Greater Crested Tern	<i>Thalasseus bergii</i>	SS	LC	A4
	Lesser Crested Tern	<i>Thalasseus bengalensis</i>	P	LC	A4
	Little Tern	<i>Sterna albifrons</i>	SR	LC	A4
	Whiskered Tern	<i>Chlidonias hybrida</i>	SR	LC	A4
	White-winged Tern	<i>Chlidonias leucopterus</i>	P, SR	LC	A4
	Bar-tailed Godwit	<i>Limosa lapponica</i>	P	NT	A4
	Black-tailed Godwit	<i>Limosa limosa</i>	P, SR	NT	A4
	Broad-billed Sandpiper	<i>Calidris falcinellus</i>	SR	VU	A4
	Common Redshank	<i>Tringa tetanus</i>	P	LC	A4
	Curlew	<i>Calidris ferruginea</i>	P, SR	VU	A4
	Sandpiper	<i>Numenius Arqata</i>	P, SR	NT	A4
	Eurasian Curlew	<i>Numenius madagascariensis</i>	P, SR	NT	A4
	Far Eastern Curlew	<i>Calidris tenuirostris</i>	SR	EN	A4
	Great Knot	<i>Tringa stagnatilis</i>	SR	LC	A4
Scolopacidae	Marsh Sandpiper	<i>Calidris canutus</i>	SR	NT	A4
	Red Knot	<i>Numenius phaeopus</i>	SR	LC	A4
	Whimbrel	<i>Tringa nebularia</i>	P	LC	A4
	Common Greenshank	<i>Calidris pygmaea</i>	P	CR	A1
	Spoon-billed Sandpiper	<i>Tringa guttifer</i>	P, SR	EN	A1
	Spotted Greenshank	<i>Xenus cinereus</i>	P, SR	LC	A4
	Terek Sandpiper				

*Keywords: NT - Near Threatened; EN - Endangered; CR - Critically Endangered; VU – Vulnerable; LC – Least Concern; P - Peninsular; SR - Sarawak; SS -Sabah.

There are seven publications pertaining to IBAs along Peninsular Malaysia (Bakewell, 2009; Lomoljo, 2011; Azimah and Tarmiji, 2018; Razak and Rahman, 2020; Fauzi and Norazlimi, 2021; Mohamad Safawi et al., 2023 and Fauzi et al., 2023). Nine studies are based in East Malaysia, including five from Sarawak (Duckworth et al., 1996; Teng et al., 2019; Teepol et al., 2021; Mohd Azlan et al., 2022 and Mohd-Azlan et al., 2023) and four from Sabah (Sheldon, 1983; Marzuki et al., 1997; Sheldon et al., 2014; Bili et al., 2015 and Makbul and Wong, 2016). Additionally, two publications by Effendi et al. (2024) compare shorebird diversity between the North-central Selangor Coast and the Teluk Air Tawar–Kuala Muda Coast IBAs. The remaining three sources are reports published by the Malaysian Nature Society, with one covering Peninsular Malaysia IBAs (Nur Atiqah and Ng, 2015) and two providing nationwide coverage (Yeap et al., 2004; Yeap et al., 2007). Figure 3 provides a detailed breakdown of the number of publications for the listed IBAs.

**Figure 3:** Publication count per IBA.

Of the 21 publications reviewed, two specifically focused on shorebird studies (see Table 3), all of which were conducted in Peninsular Malaysia. 10 additional publications addressed the broader category of waterbirds, recognising that they form a major component of migratory species. The remaining nine publications examined overall bird communities within the study areas, as some IBAs encompass a wide range of ecosystems. This is particularly evident in surveys conducted in East Malaysia (1 publication in Peninsular Malaysia; 8 publications in East Malaysia), where researchers often describe a single IBA as comprising diverse habitats, such as mangroves, swamps, kerangas, dipterocarp forests, and beach forests. The studies generally targeted a broader variety of bird species, often presented as checklists, whereas research specifically focusing on shorebirds remains limited. This pattern suggests that studies focusing on migratory bird communities, particularly waterbirds and shorebirds, are more widely conducted in Peninsular Malaysia than in East Malaysia.

Meanwhile, the Malaysian Nature Society (MNS) has conducted waterbird monitoring surveys on migratory species as part of broader international conservation initiatives. One survey concentrated on IBAs along the west coast of Peninsular Malaysia, while two additional nationwide surveys extended beyond the Peninsular region to include selected coastal sites in East Malaysia. These regular waterbird monitoring efforts were implemented to reduce spatial coverage gaps and improve the overall representation of shorebird populations across Malaysia.

Survey duration is largely determined by the specific objectives of a study. Research focusing on shorebird diversity generally involves extended observation periods, whereas shorter surveys are often sufficient for compiling general bird checklists. Some investigations have broadened their scope to include ecological components, such as assessing prey availability along shorelines and examining its quantitative relationship with shorebird presence. Others have incorporated a wider range of environmental factors to evaluate habitat suitability for shorebird communities. Notably,

these more integrative and ecology-focused studies have only been carried out in Peninsular Malaysia.

In contrast, publications from East Malaysia remain largely confined to general diversity surveys and species checklists, with limited ecological depth. This imbalance highlights a clear research gap and underscores the urgent need for targeted shorebird studies in East Malaysia. Future research in the region should incorporate ecological parameters, such as benthic prey assessment, tidal-cycle-based counts, and habitat suitability analyses, to provide a more comprehensive understanding of shorebird ecology. Expanding such studies to East Malaysia would allow for more balanced national data coverage and strengthen conservation planning across Malaysia's coastal IBAs.

3.4 Shorebird survey methodology

Repeated field surveys are essential for accurately capturing population fluctuation trends throughout the year, especially since shorebird abundance is closely linked to seasonal migratory patterns (Gregory et al., 2005; Conklin et al., 2014). The direct observation method remains the most widely applied approach for assessing shorebird diversity because it is particularly effective for detecting species that occupy open habitats and frequently fly at higher altitudes. Common survey procedures include shoreline transects and point-count surveys, both of which provide reliable estimates of species presence and relative abundance (Bibby et al., 2000). However, differences in survey methods can influence detection probability and contribute to data gaps, as detectability varies among species, habitats, and observer conditions (MacKenzie et al., 2002). Direct observation tends to favour conspicuous species in exposed coastal habitats, while cryptic, nocturnal, or less vocal species may be under-recorded, potentially estimates of species composition and limiting long-term comparability across sites and seasons (Ralph et al., 1995).

Although the mist-netting method is occasionally used to capture shorebirds, it is generally less effective for population censuses due to the birds' wariness, strong flight response, and preference for open foraging grounds, which reduce capture success. As a result, datasets derived from mist-netting often reflect only a subset of the community and may underrepresent larger or more mobile species (Remsen and Good, 1996). Nonetheless, mist nets play a valuable role in specialised studies that require the attachment of electronic tracking devices such as GPS loggers, geolocators, or satellite transmitters to document migratory routes, stopover use, and connectivity across flyways (Battley et al., 2012; Piersma et al., 2016). These data support broader monitoring objectives by revealing movement ecology, habitat use, and

site fidelity patterns that cannot be obtained through visual surveys alone (Bridge et al., 2011).

Table 3: Overview of the compiled studies.

Single IBA					
Site	Author	Duration	Ecosys tem	Avian group	Scope
Teluk Air Tawar - Kuala Muda Matang	Razak and Rahman, 2020	3 months	M	W	D
	Lomolji, 2011	12 months	M	W	D, HS
	Azimah and Tarmiji, 2018	10 months	M	S	GIS
	Mohd Safawi et al., 2023	-	M, SW	All	GIS
North Central Selangor	Bakewell, 2009	12 months	M	W	D
South West Johor	Fauzi and Norazlimi, 2021	2 months	M	W	D, P
	Fauzi et al., 2023	7 months		W	D, P
Similajau NP	Duckworth et al., 1996	3 months	Dip, SW	All	C
Tanjung Datu-Samunsan Protected Area	Mohd Azlan et al., 2022	19 days	M, H, Dip	All	C
	Teng et al., 2019	5 months	B	All	D
Bako Buntal Bay	Teepol et al., 2021	6 months	M	W	D
	Mohd Azlan et al., 2023	2 weeks	M, K, B, Dip, SW	All	C
Klias Peninsula	Sheldon et al., 2014	2 months	M, SW	All	C
Mantanani Island	Sheldon, 1983	3 days	B	W	C
Tempasuk plains	Makbul and Wong, 2016	6 months	M, SW	All	D
Kulamba Wildlife Reserve	Billi et al., 2015	5 days	M, Dip, SW, B	All	C
Pulau Layang-Layang	Marzuki et al., 1997	1 day	MMI	All	C
Multiple IBAs					
Teluk Air Tawar - Kuala Muda & North Central Selangor	Effendi et al., 2024	2 months	M	S	D
West Coast Peninsular IBAs	Nur Atiqah and Ng, 2015	2 weeks	M	W	C
West Coast Peninsular IBAs & East Malaysia	Yeap et al., 2004; 2007	2 weeks	M	W	C

*Keywords: M – Mangrove; SW – Swamp; Dip – Dipterocarp; H – Heath Forest; B – Beach Forest; K – Kerangas; MMI – Man made Island; W – Waterbird; S – Shorebird; All – All type of birds; D – Diversity; C – Checklist; HS -Habitat Suitability; GIS – Geographic Information System; P – Prey availability.

In recent years, Passive Acoustic Monitoring (PAM) has emerged as a non-invasive supplementary technique for detecting birds. PAM involves deploying autonomous sound recorders at targeted sites, enabling continuous documentation of species presence even in remote, dense, or otherwise inaccessible habitats. Its effectiveness has gained global recognition, with multiple studies showing that PAM-derived data correlate strongly with species records obtained through conventional direct observation methods (Darras et al., 2018; Sugai et al., 2019). Methodologically, PAM can help address detection gaps by capturing vocal activity during low-visibility periods such as night-time migration, poor weather, or tidal cycles when field access is limited (Blumstein et al., 2011). This makes it particularly suitable for remote coastal zones, offshore islands, and mangrove-fringed shorelines where repeated human surveys are logistically challenging and costly (Acevedo and Villanueva-Rivera, 2006). However, bird PAM still faces limitations, particularly the scarcity of comprehensive expert-validated call reference databases, which may reduce identification accuracy and limit species-level resolution across diverse tropical regions (Jamil et al., 2023).

To further enhance detection accuracy and improve spatial coverage, boat-based surveys are often incorporated, particularly in extensive mudflat areas, estuaries, or coastal wetlands that are difficult to access on foot. These surveys provide additional vantage points for detecting roosting and foraging shorebirds while complementing land-based census methods (Rogers et al., 2006). Boat-based approaches are beneficial for aligning monitoring objectives with habitat-specific challenges, such as surveying offshore sandbars, tidal flats, and protected coastal zones where terrestrial access is restricted, and have been shown to improve count accuracy and spatial coverage in large coastal systems (Komdeur et al., 1992). When combined with direct observation and emerging techniques such as PAM, multi-method approaches can reduce sampling bias, improve species detectability across habitat types, and provide more comprehensive data for long-term coastal bird monitoring (Thompson, 2002).

3.5 Year-round monthly survey frequency

Figure 4 illustrates the frequency of surveys conducted over the years, focusing only on studies related to waterbirds and shorebirds, as these are influenced by migratory seasons and researchers tend to align their sampling periods accordingly. Most surveys are conducted between November and January, coinciding with the peak migratory period. Malaysia supports the highest numbers of wintering shorebirds between October and December (Effendi et al., 2024), after which the birds gradually begin their return

migration to their original habitats starting in January (Razak & Rahman, 2020). However, concentrating surveys within this limited window introduces seasonal constraints that may underrepresent species that migrate earlier or later, as well as resident species present year-round (Minton et al., 2006; Hassell et al., 2017). Consequently, population estimates and diversity assessments for months outside the November–January period remain uncertain, highlighting a critical data gap that could affect long-term monitoring, habitat management, and conservation planning for shorebirds across Malaysian coastal wetlands.

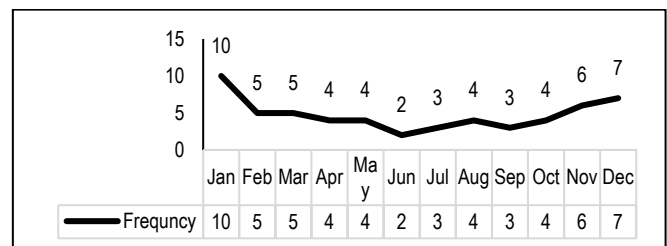


Figure 4: Frequency of surveys conducted monthly.

3.6 Species diversity

Based on Table 4, shorebirds from the Scolopacidae family are the predominant occupants along the Malaysian coastline, followed by the Charadriidae family. This pattern is consistently observed across several localities, including the Teluk Air Tawar–Kuala Muda coast (Nur Atiqah and Ng, 2015; Razak and Rahman, 2020; Effendi et al., 2024), the Southwest Johor coast (Fauzi et al., 2023), the North-central Selangor coast (Nur Atiqah and Ng, 2015; Effendi et al., 2024), and Bako Buntal Bay (Teepol et al., 2021).

Two of the most dominant species recorded from these families are the Common Redshank (*Tringa totanus*) and the Tibetan Sand Plover (*Charadrius atrifrons*), as reported in Teluk Air Tawar–Kuala Muda (Razak and Rahman, 2020) and along the North-central Selangor coast (Yeap et al., 2004; Bakewell, 2009). However, a different pattern is observed along the East Malaysia coast. Teepol et al. (2021) in Bako Buntal Bay reported that the Great Knot (*Calidris tenuirostris*) recorded the highest number of individuals, followed by the Greater Sand Plover (*Charadrius leschenaultii*) and the Tibetan Sand Plover (*Charadrius atrifrons*), indicating regional variation in species dominance. Nevertheless, surveys in East Malaysia are primarily conducted as checklists and do not provide detailed data on species diversity, making it difficult to determine the dominance of particular shorebird families or species and potentially biasing direct comparisons across regions.

Island records also highlight significant shorebird distributions, with dominance observed in species constituting the Laridae family. For example, Marzuki et al. (1997) reported that Pulau Layang-Layang comprised primarily of Brown

Noddies (*Anous stolidus*) (50%) and Lesser Crested Terns (*Thalasseus bengalensis*) (47%) from a total of 5,377 birds counted in a single-day survey. Mantanani Island, on the other hand, recorded several species of terns and plovers, including the Common Tern (*Sterna hirundo*), Great Crested Tern (*Thalasseus bergii*), Lesser Golden Plover (*Pluvialis dominica*), Malaysian Plover (*Charadrius peronii*), and Common Sandpiper (*Actitis hypoleucos*) (Sheldon, 1983).

Based on available records, certain areas in Malaysia support exceptionally high shorebird diversity. In Peninsular Malaysia, the Teluk Air Tawar–Kuala Muda coast hosted 20 shorebird species in 2015 (Nur Atiqah and Ng, 2015), increasing slightly to 21 species in 2020 (Razak and Rahman, 2020), and further rising to 25 species in 2024 (Effendi et al., 2024). The North-central Selangor coast was reported to support 32 shorebird species in 2009 (Bakewell, 2009), but this had decreased to 23 by 2024 (Effendi et al., 2024). Kapar Power Station, located on the North-central coast, supports a wide array of shorebirds (Yeap et al., 2004, 2007). The Southwest Johor coast reported relatively low shorebird diversity, with 2 species at Tanjong Laboh, Batu Pahat district (Fauzi & Norazlimi, 2021). However, a more extensive survey conducted in 2023, across Pontian and Muar districts, recorded 9 species in total (Fauzi et al., 2023).

In East Malaysia, Bako Buntal Bay has been the focus of several intensive surveys, during which 26 species were reported by Mohd Azlan et al. (2023). Additional surveys covering Bako Buntal Bay were conducted by Yeap et al. (2004, 2007) and Teepol et al. (2021). Other IBAs in East Malaysia were surveyed for shorter durations, often as checklists; nevertheless, shorebird counts remain significant. For example, Similajau National Park recorded 19 species (Duckworth et al., 1996), Tanjung Datu–Samunsan Protected Area with 9 species (Teng et al., 2019; Mohd Azlan et al., 2022), Klias Peninsula with 9 species (Sheldon et al., 2014), and Tempasuk Plain recorded 16 species (Makbul and Wong, 2016). Islands, being geographically smaller, recorded fewer species, such as five species on Mantanani Island (Sheldon, 1983) and Pulau Layang-Layang with Brown Noddies (50%) and Lesser Crested Terns (47%) (Marzuki et al., 1997).

For Peninsular Malaysia, MNS recorded a consistent shorebird count of 48 species in 2005 and 2006. In contrast, East Malaysia showed an increase from 25 species in 2005 to 46 species in 2006 (Yeap et al., 2007), highlighting both temporal variation and regional differences in shorebird diversity.

3.7 Spatial patterns of shorebird assemblages along the coastline

Table 5 presents the list of shorebird species recorded at each IBA based on published studies, with

species highlighted in grey indicating those recognised as qualifying species by the BirdLife Data Zone, as shown in the Table 2 previously. With the addition of 26 species documented from compiled publications to the 24 qualifying species listed by BirdLife, a total of 50 shorebird species have been recorded along the Malaysian coastline. These species belong to four families, with Scolopacidae dominating with 26 species, followed by Laridae (13), Charadriidae (10), and Recurvirostridae (1).

The Venn diagram in Figure 5 illustrates the distribution of 50 shorebird species compiled from published records and qualifying species recognised by the BirdLife Data Zone across three regions: Peninsular Malaysia, Sarawak, and Sabah. The diagram highlights region-specific and overlapping species among these biogeographic zones.

Peninsular Malaysia supports seven region-specific species: Black-bellied Plover (*Pluvialis squatarola*), White-faced Plover (*Charadrius dealbatus*), Asian Dowitcher (*Limnodromus semipalmatus*), Dunlin (*Calidris alpina*), Little Stint (*Calidris minuta*), Sharp-tailed Sandpiper (*Calidris acuminata*), and Spoon-billed Sandpiper (*Calidris pygmaea*). Sarawak hosts four region-specific species: Common Ringed Plover (*Charadrius hiaticula*), Grey-tailed Tattler (*Tringa brevipes*), Red-necked Phalarope (*Phalaropus lobatus*), and Black-winged Stilt (*Himantopus himantopus*). Sabah, in contrast, records one region-specific species, the Greater Crested Tern (*Thalasseus bergii*).

Sarawak and Peninsular Malaysia exhibit the highest species overlap ($n = 16$), including Sanderling (*Calidris alba*), Common Tern (*Sterna hirundo*), Gull-billed Tern (*Gelochelidon nilotica*), Little Tern (*Sternula albifrons*), Whiskered Tern (*Chlidonias hybrida*), Bar-tailed Godwit (*Limosa lapponica*), Black-tailed Godwit (*Limosa limosa*), Broad-billed Sandpiper (*Calidris falcinellus*), Eurasian Curlew (*Numenius arquata*), Far Eastern Curlew (*Numenius madagascariensis*), Great Knot (*Calidris tenuirostris*), Nordmann's Greenshank (*Tringa guttifer*), Red Knot (*Calidris canutus*), Ruddy Turnstone (*Arenaria interpres*), Spotted Greenshank (*Tringa guttifer*), and Terek Sandpiper (*Xenus cinereus*).

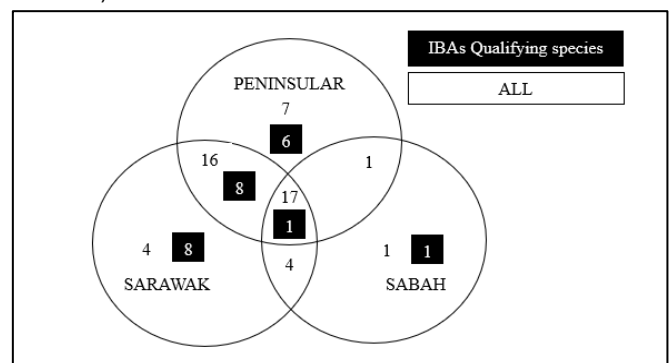


Figure 5: Venn diagram shows the number of species represented in each region.

Table 4: Summary of species diversity based on published records.

Site	Author	Findings
Teluk Air Tawar - Kuala Muda	Razak and Rahman, 2020	- Teluk Air Tawar- dominated by Scolopacidae 85% Charadriidae (5%) Laridae (1%). - Kuala Muda, Scolopacidae 61% Charadriidae (23%) Laridae 5% - Common Redshank records the highest count 21 species of shorebirds
Matang	Lomolji, 2011	Checklist data unavailable
	Azimah and Tarmiji, 2018	Checklist data unavailable
	Mohd Safawi et al., 2023	Data from eBird for shorebird checklists are excluded.
South West Johor	Fauzi and Norazlimi, 2021	2 species of shorebirds
	Fauzi et al., 2023	- The family Scolopacidae was the most diverse, with seven species recorded (41.18%), followed by the Charadriidae family. - The most abundant species recorded was the Tibetan Sand-plover followed by Common Redshank 9 species of shorebirds
Similajau NP	Duckworth et al., 1996	19 species of shorebirds
Tanjung Datu-Samunsan Protected Area	Mohd Azlan et al., 2022	7 species of shorebirds
	Teng et al., 2019	7 species of shorebirds
Bako Buntal Bay	Teepol et al., 2021	Dominant species - Great Knot was the most abundant - Greater Sand Plover: maximum 2,000 individuals - Tibetan Sand Plover: maximum: 1,800 individuals - Bar-tailed Godwit: maximum: 1,700 individuals - Black-tailed Godwit: maximum: 1,500 individuals
	Mohd Azlan et al., 2023	26 species of shorebirds
Klias Peninsula	Sheldon et al., 2014	9 species of shorebirds
Mantanani Island	Sheldon, 1983	5 species of shorebirds
Tempasuk plains	Makbul and Wong, 2016	16 species of shorebirds
Kulamba Wildlife Reserve	Billi et al., 2015	2 species of shorebirds
Pulau Layang-Layang	Marzuki et al., 1997	Brown noddy (50%) & Lesser crested tern (47%)
TATKMC & NCSC	Effendi et al., 2024	23 species recorded at NCSC and 25 at TATKMC.
West Coast Peninsular IBA	Nur Atiqah and Ng, 2015	Teluk Air Tawar recorded the highest number of shorebirds (13,326 individuals; 20 species), followed by sites along North–central coast of Selangor. - Common Redshank: 4,368 individuals - Tibetan Sandplover: 3,821 individuals - Pacific Golden Plover: 2,213 individuals - Eurasian Curlew: 2,084 individuals - Rufous-necked Stint: 1,873 individuals - Whimbrel: 1,339 individuals - Ruff at Sg. Balang rice fields, Johor (South West Johor Coast)
		Ruddy Turnstone at: - Kapar, North Central Selangor Coast: 3 individuals - Teluk Air Tawar: 5 individuals
		Total of 5,606 individuals from 10 species of gulls and terns were recorded nationwide. - Common Tern: 3,077 individuals - Whiskered Tern: 444 individuals - Brown-headed Gull: 353 individuals - Little Tern: 320 individuals - White-winged Tern: 310 individuals - Gull-billed Tern: 211 individuals
West Coast Peninsular IBAs & East Malaysia	Yeap et al., (2004; 2007)	A total of 36 wader species were recorded nationwide. Kapar Power Station (North–Central Selangor Coast) - Grey Plover: 491 individuals - Tibetan Plover: 1,940 individuals - Greater Sand-Plover: 470 individuals - Bar-tailed Godwit: 535 individuals - Eurasian Curlew: 750 individuals - Common Redshank: 1,053 individuals - Great Knot: 616 individuals - Rufous-necked Stint: 450 individuals - Nordmann's Greenshank: 6 individuals - White-winged Terns: 182 individuals - Gull-billed Terns: 167 individuals Bako–Buntal Bay (Sarawak) - Far Eastern Curlew: 20 individuals - Asian Dowitcher: 2 individuals - Black-headed Gull: 29 individuals - Over 100 Gull-billed Terns and Little Terns

Keywords: TATKMC - Teluk Air tawar – Kuala Muda Coast; NCSC – North Central Selangor Coast

Table 5: List of shorebird species documented at each IBA.

Sites/ Authors			TAT		NCS		SWJ		S	TDS		BAK	KLI	M	T	KW	P			
Family	Species name	Scientific name	IUCN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
Charadriidae	Black-bellied Plover	<i>Pluvialis squatarola</i>	VU		/	/														
	Common Ringed Plover	<i>Charadrius hiaticula</i>	LC										/							
	Greater Sandplover	<i>Charadrius leschenaultii</i>	LC	/	/	/	/		/	/			/	/						
	Kentish Plover	<i>Charadrius alexandrinus</i>	LC			/	/	/					/				/			
	Little Ringed Plover	<i>Thinornis dubius</i>	LC			/				/		/	/				/			
	Malaysian Plover	<i>Anarhynchus peronii</i>	NT							/			/			/				
	Pacific Golden Plover	<i>Pluvialis fulva</i>	LC	/	/	/							/	/	/	/	/			
	Sanderling	<i>Calidris alba</i>	LC			/				/			/							
	Tibetan Sandplover	<i>Anarhynchus atrifrons</i>	LC	/	/	/	/		/	/	/	/	/	/			/			
	White-faced Plover	<i>Anarhynchus dealbatus</i>	LC		/	/														
	Laridae	Black-headed Gull	<i>Chroicocephalus ridibundus</i>	LC			/				/			/	/			/		
		Black-naped Tern	<i>Sterna sumatrana</i>	LC		/		/					/	/			/			
		Bridled Tern	<i>Onychoprion anaethetus</i>	LC							/						/		/	
Brown Noddy		<i>Anous stolidus</i>	LC							/			/						/	
Brown-headed Gull		<i>Chroicocephalus brunnicephalus</i>	LC	/	/					/							/			
Caspian Tern		<i>Hydroprogne caspia</i>	LC			/				/			/				/			
Common Tern		<i>Sterna hirundo</i>	LC	/		/	/						/							
Greater Crested Tern		<i>Thalasseus bergii</i>	LC																	
Gull-billed Tern		<i>Gelochelidon nilotica</i>	LC		/	/	/			/			/							
Lesser Crested Tern		<i>Thalasseus bengalensis</i>	LC		/		/												/	
Little Tern		<i>Sternula albifrons</i>	LC	/	/	/	/						/							
Whiskered Tern		<i>Chlidonias hybrida</i>	LC	/	/		/													
White-winged Tern		<i>Chlidonias leucopterus</i>	LC	/	/	/	/										/			
Scolopacidae	Asian Dowitcher	<i>Limnodromus semipalmatus</i>	NT	/	/	/														
	Bar tailed Godwit	<i>Limosa lapponica</i>	NT	/	/		/						/							
	Black-tailed Godwit	<i>Limosa limosa</i>	NT			/	/						/							
	Broad-billed Sandpiper	<i>Calidris falcinellus</i>	VU	/	/	/	/													
	Common Greenshank	<i>Tringa nebularia</i>	LC	/	/	/			/				/	/			/			
	Common Redshank	<i>Tringa totanus</i>	LC	/	/	/	/	/	/	/			/	/			/	/		
	Common sandpiper	<i>Actitis hypoleucos</i>	LC	/	/		/		/	/	/	/	/	/	/	/	/			
	Curlew Sandpiper	<i>Calidris ferruginea</i>	VU	/	/	/	/							/						
	Dunlin	<i>Calidris alpina</i>	NT			/														
	Eurasian Curlew	<i>Numenius arquata</i>	NT	/	/	/	/		/				/	/						
	Far Eastern Curlew	<i>Numenius madagascariensis</i>	EN		/								/	/						
	Gray-tailed Tattler	<i>Tringa brevipes</i>	LC							/										
	Great Knot	<i>Calidris tenuirostris</i>	EN	/		/							/							
	Little Stint	<i>Calidris minuta</i>	LC			/														
	Marsh Sandpiper	<i>Tringa stagnatilis</i>	LC	/			/										/			
	Nordmann's Greenshank	<i>Tringa guttifer</i>	EN		/	/							/							

Red Knot	<i>Calidris canutus</i>	NT	/																	
Red-necked stint	<i>Calidris ruficollis</i>	NT	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
Red-necked Phalarope	<i>Phalaropus lobatus</i>	LC							/											
Ruddy Turnstone	<i>Arenaria interpres</i>	NT		/	/			/												
Sharp-tailed Sandpiper	<i>Calidris acuminata</i>	VU		/	/															
Spoon-billed Sandpiper	<i>Calidris pygmaea</i>	CE		/																
Spotted Greenshank	<i>Tringa guttifer</i>	EN																		
Terek Sandpiper	<i>Xenus cinereus</i>	LC	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
Whimbrel	<i>Numenius phaeopus</i>	LC	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
Wood Sandpiper	<i>Tringa glareola</i>	LC							/	/	/	/	/	/	/	/	/	/	/	/
Recurvirostridae	Black-winged Stilt	<i>Himantopus himantopus</i>	LC									/								
Total			21	25	32	23	2	9	19	7	7	8	26	9	5	16	2	2		

*Keywords: 1 - Razak and Rahman, 2020; 2- Effendi et al., 2024; 3 - Bakewell, 2009; 4 -Effendi et al., 2024; 5 - Fauzi and Norazlimi, 2021; 6- Fauzi et al., 2023; 7 - Duckworth et al., 1996; 8 - Teng et al., 2019; 9 - Mohd Azlan et al., 2022; 10 - Teepol et al., 2021; 11 - Mohd Azlan et al., 2023; 12- Sheldon et al., 2014; 13 – Sheldon, 1983; 14 - Makbul and Wong, 2016; 15- Billi et al., 2015; 16 - Marzuki et al., 1997; TAT - Teluk Air Tawar Kuala Muda Coast; NCS - North Central Selangor Coast; SWJ - South West Johor Coast; SM - Similajau NP; TDS - Tanjung Datu-Samunsan Protected Area; BAK - Bako NP; KLI - Klias Peninsula; MI - Mantanani Island; TP - Tempasuk plains; KWR - Kulamba Wildlife Reserve; PL - Pulau Layang-Layang; Highlight in Grey – IBAs qualifying species.

Sarawak and Sabah share four overlapping species ($n = 4$): Malaysian Plover (*Charadrius peronii*), Bridled Tern (*Onychoprion anaethetus*), Brown Noddy (*Anous stolidus*), and Wood Sandpiper (*Tringa glareola*). Meanwhile, only one species, the Lesser Crested Tern (*Thalasseus bengalensis*), overlaps between Peninsular Malaysia and Sabah. The remaining 17 species occur across all three regions, indicating substantial overlap in shorebird distribution among Malaysia's coastal biogeographic zones.

Although recognised by the BirdLife Data Zone, published records suggest that shorebird distributions exhibit substantially greater overlap among regions than reflected in the BirdLife listings. For instance, the Common Redshank (*Tringa totanus*) and Little Tern (*Sternula albifrons*) have been documented across all three regions of Malaysia, despite being listed in the BirdLife database for only selected IBAs. This discrepancy indicates that the BirdLife Data Zone may not comprehensively represent the full extent of shorebird occurrence at each locality, with certain species potentially underrepresented or omitted from the recognised records.

Figure 6 illustrates the number of shorebird species recorded at each IBA. The North-central Selangor Coast in Peninsular Malaysia supports the highest number of species, with 37 species documented in publications and 14 listed as IBA qualifying species. This is followed by Bako–Buntal Bay, which recorded 29 species in publications and three qualifying species, and Teluk Air Tawar–Kuala Muda Coast with 27 species in publications and two qualifying species.

Although no qualifying species were listed for

Similajau and the Tempasuk Plains, published records indicate that these locations support relatively high shorebird diversity, with 19 and 16 species recorded, respectively. In contrast, the Sadong–Saribas Coast, Matang Coast, and Pulau Bruit National Park lack published records on shorebird species; however, data from the BirdLife Data Zone show that these IBAs support notable numbers of qualifying species, with totals of 10, nine, and eight species, respectively.

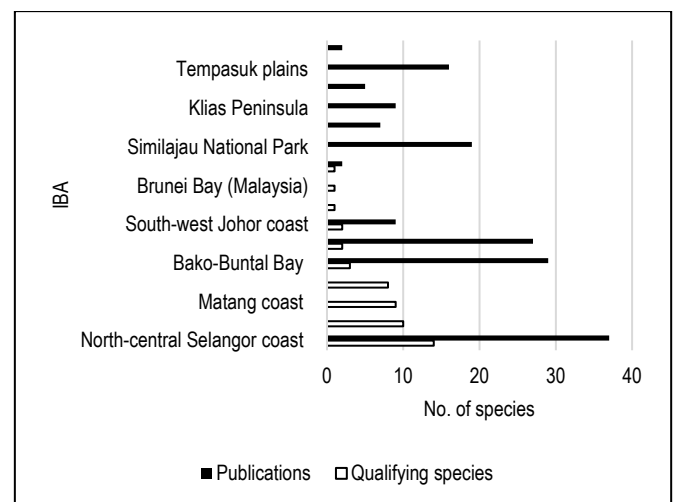


Figure 6: Qualifying species count versus total shorebird species recorded for each IBA.

3.8 Biogeographic variation and shorebird species assemblages

Malaysia's coastal ecosystems are predominantly characterised by extensive intertidal mudflats and mangrove forests, which function as critical habitats for shorebird populations. As most listed IBAs in this region (excluding island ecosystems) support intertidal mudflats, a notable overlap in species occurrence can be observed, with 17 species recorded across all three regions (Figure 5). Mangrove forests provide abundant and diverse food resources that support numerous shorebirds and some terrestrial bird species. Adjacent mudflats, composed of fine silts and clays rich in organic matter, harbour small fish, crustaceans, and molluscs (Dahdouh-Guebas et al., 2000; Robertson and Massenbauer, 2005). These invertebrates and aquatic organisms form the primary diet of both resident and migratory shorebirds, making mudflats essential feeding grounds.

The west coast of Peninsular Malaysia has consistently been described as being dominated by intertidal mangrove–mudflat ecosystems. In contrast, East Malaysia exhibits greater habitat heterogeneity. Although mangroves and mudflats remain important, IBAs along the coasts of Sarawak and Sabah encompass a wider range of ecosystems. These include sandy beaches exposed to the South China Sea, open marine environments, rocky intertidal zones, beach forests, swamp forests, dipterocarp forests, and heath (kerangas) forests. Many IBAs integrate multiple ecosystem types within a single site, such as Similajau National Park, Bako–Buntal Bay, Klias Peninsula, Tempasuk Plains, Kulamba Wildlife Reserve, and Tanjung Datu–Samunsam Protected Area. This diversity of habitats contributes to varied shorebird assemblages and supports different ecological guilds.

Despite this ecological richness, research on mangrove ecosystems and coastal bird populations in Sarawak remains comparatively limited (Wilson, 2002), even as these habitats face increasing anthropogenic pressures. Nevertheless, IBAs along the Sarawak coastal lane are recognised as important stopover, staging, or wintering sites for migratory birds. For example, the Tempasuk Plains have long been identified as a key wintering ground for shorebirds (DWNP, 1987).

Marine island ecosystems also play a significant role in Malaysia's avifaunal diversity. Sites such as Pulau Layang-Layang, Sipadan Island, Talang Satang National Park, and Mantanani Island are designated as IBAs due to their importance for island-dependent and pelagic bird species. Talang Satang National Park supports substantial populations of Black-naped Tern (*Sterna sumatrana*), benefiting from offshore rocky islets suitable for breeding and roosting.

Mantanani Island is notable for hosting both migratory and resident seabirds, including frigatebirds such as the Christmas Island Frigatebird (*Fregata andrewsi*), Lesser Frigatebird (*Fregata minor*), and Great Frigatebird (*Fregata magnificens*), with large numbers of Christmas Island Frigatebirds also recorded on Sipadan Island (BirdLife International, 2025).

Overall, while intertidal mudflat–mangrove systems form the ecological backbone of shorebird habitats in Malaysia, regional variation in ecosystem composition, particularly in East Malaysia, contributes to broader habitat heterogeneity and influences species distribution patterns across the country.

3.9 Species under conservation status

Figure 7 presents the IUCN Red List conservation status of shorebird species recorded across all listed IBAs. In total, 18 species are classified as threatened, comprising nine Near Threatened, four Vulnerable, four Endangered, and one Critically Endangered species. Near Threatened species indicate populations under increasing pressure and potentially at risk in the near future, while Vulnerable species face a high risk of becoming endangered in the medium term. Endangered species are considered to have a very high probability of extinction in the wild. In addition, the Spoon-billed Sandpiper (*Calidris pygmaea*) is listed as Critically Endangered, reflecting an extremely high and immediate risk of extinction (threatened species are presented in Table 6).

According to Nur Atiqah and Ng (2015), in Peninsular Malaysia, Teluk Air Tawar recorded a significant number of Near Threatened Eurasian Curlew (*Numenius arquata*), totaling 2,084 individuals. The Near Threatened Ruddy Turnstone (*Arenaria interpres*) was also documented, with five individuals recorded at Teluk Air Tawar and three at the Kapar Power Station on the North Central Coast of Selangor. In addition, the Kapar Power Station area supported the Endangered Nordmann's Greenshank (*Tringa guttifer*), with six individuals observed, along with a notable count of Great Knot (*Calidris tenuirostris*), totalling 616 individuals. Two other Near Threatened species, the Bar-tailed Godwit (*Limosa lapponica*) with 535 individuals and the Eurasian Curlew (*Numenius arquata*) with 750 individuals, were also recorded at Kapar.

In contrast, findings from East Malaysia demonstrate similarly significant records of species of conservation concern. Teepol et al. (2021) reported notable single-day counts, including 600 individuals of the Endangered Far Eastern Curlew (*Numenius madagascariensis*), 2,000 individuals of the Endangered Great Knot (*Calidris tenuirostris*), and seven individuals of the Endangered Nordmann's Greenshank (*Tringa guttifer*) in Bako Buntal Bay IBA. Additionally, Mantanani Island has been documented to

support a considerable population of the Near Threatened Malaysian Plover (*Charadrius peronii*) (Sheldon, 1983).

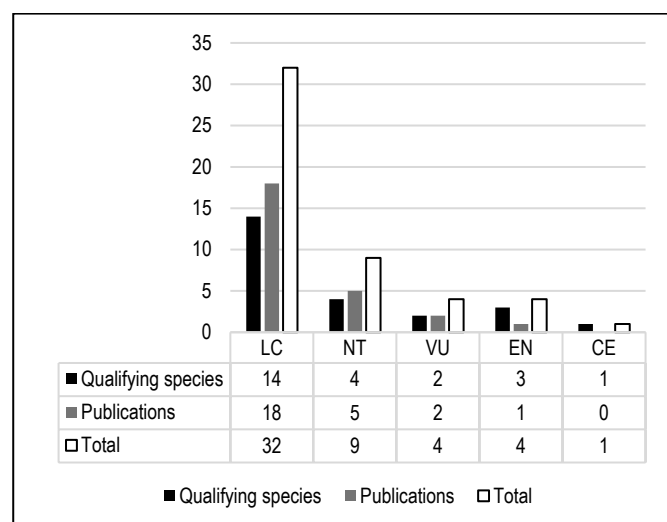


Figure 7: IUCN Redlist status for shorebird in coastal Malaysia IBAs.

Table 6: List of Threatened species according to the IUCN Red List.

Common name	Scientific name	IUCN Status
Spoon-billed Sandpiper	<i>Calidris pygmaea</i>	CE
Far Eastern Curlew	<i>Numenius madagascariensis</i>	EN
Great Knot	<i>Calidris tenuirostris</i>	EN
Nordmann's Greenshank	<i>Tringa guttifer</i>	EN
Spotted Greenshank	<i>Tringa guttifer</i>	EN
Broad-billed Sandpiper	<i>Calidris falcinellus</i>	VU
Curlew Sandpiper	<i>Calidris ferruginea</i>	VU
Sharp-tailed Sandpiper	<i>Calidris acuminata</i>	VU
Black-bellied Plover	<i>Pluvialis squatarola</i>	VU
Malaysian Plover	<i>Anarhynchus peronii</i>	NT
Asian Dowitcher	<i>Limnodromus semipalmatus</i>	NT
Bar tailed Godwit	<i>Limosa lapponica</i>	NT
Black-tailed Godwit	<i>Limosa limosa</i>	NT
Dunlin	<i>Calidris alpina</i>	NT
Eurasian Curlew	<i>Numenius arquata</i>	NT
Red Knot	<i>Calidris canutus</i>	NT
Red-necked stint	<i>Calidris ruficollis</i>	NT
Ruddy Turnstone	<i>Arenaria interpres</i>	NT

*Keywords: Highlight in grey – IBAs/ KBAs Qualifying species; CE – Critically Endangered; EN – Endangered; VU –Vulnerable; NT – Near Threatened.

3.10 Harnessing eBird for community-driven bird monitoring and conservation

eBird, managed by the Cornell Lab of Ornithology, is a global platform for collecting citizen-science bird observation checklists. It was developed to gather information from birdwatchers, with the data freely shared to support research, conservation, and education. Today, eBird is the world's largest biodiversity-related citizen science project, receiving over 100 million bird sightings annually from contributors

around the globe (eBird, n.d). As such, it serves as an important alternative and supplementary platform for monitoring bird distribution, particularly in areas where formal field surveys are limited, seasonal, or logistically challenging. This is especially valuable for monitoring shorebird distributions, as many shorebird species are migratory and occur only during specific seasons. Due to the temporal nature of their presence and the limitations of conducting frequent, site-specific surveys, eBird provides continuous observations contributed by birdwatchers that help fill data gaps, capture seasonal movements, and improve understanding of shorebird occurrence and distribution patterns.

The eBird database contains valuable information on bird distribution, abundance, migration patterns, and habitat use. Participants record when, where, and how they conducted their birdwatching activities, and then submit a checklist of all species seen or heard during each outing. These continuously updated records allow researchers to track long-term population trends, detect range expansions or declines, and identify important habitats that require protection. In this way, eBird has become a key tool for strengthening biodiversity monitoring and supporting evidence-based conservation planning.

To ensure data reliability, eBird maintains strict quality control. Each submission is filtered and reviewed by assigned experts, particularly when unusual species sightings or exceptionally high counts are reported (eBird, n.d). This verification process improves data accuracy while still allowing broad public participation.

In Malaysia, eBird has become increasingly important as a complementary data source for understanding bird distribution across the country. Researchers and local bird groups use eBird records to map species occurrence, monitor migratory shorebirds, and document changes in bird presence across coastal, mangrove, and inland habitats. The platform is used in collaboration with NGOs and institutions such as Universiti Putra Malaysia (UPM), the Kuching Birdwatching Club, Wild Bird Club Malaysia, Nature Sustainable Ecosystem Society (NEST), and Malaysia Bird Report (eBird, n.d). Data from eBird have supported local checklists, distribution mapping, student research projects, and conservation assessments, making it a valuable resource for reporting and understanding bird diversity in Malaysia.

3.11 Conservation and policy implications

Among the 17 IBAs identified as supporting shorebird communities in Malaysia, seven IBAs are recognised as protected areas. One of these is the Kuala Selangor Hill Wildlife Reserve, which forms part of the North Central Selangor Coast IBA. Gazetted under Malaysia's

wildlife conservation framework, the reserve functions to protect forest and coastal ecosystems, regulate human activities, prevent hunting and habitat degradation, and conserve resident and migratory fauna. Its protected status helps maintain ecological integrity and provides refuge for migratory shorebirds utilising adjacent mudflats and mangroves for roosting and foraging (Department of Wildlife and National Parks of Peninsular Malaysia (PERHILITAN, 2017).

Within the South-West Johor Coast IBA, both Pulau Kukup and Tanjung Piai have been listed as Ramsar Sites under the Ramsar Convention on Wetlands of International Importance due to their critical role as habitats for migratory shorebirds. The high abundance and diversity of shorebirds recorded at these sites, including several species of international conservation concern, underscore their importance in sustaining migratory populations along the flyway.

In East Malaysia, Pulau Layang-Layang has been designated as a Marine Park. Marine Parks in Malaysia are established under the Fisheries Act 1985 to conserve marine, such as coral reefs, seagrass beds, and associated biodiversity, through zoning, prohibitions on of extractive activities, and regulated tourism. Although primarily aimed protecting marine biodiversity, such designation indirectly supports shorebird conservation by safeguarding surrounding coastal and island ecosystems that serve as resting and feeding grounds (Fisheries Act, 1985; Department of Fisheries Malaysia, 2020).

Several other IBAs in East Malaysia are also encompassed within legally protected areas, including Similajau National Park, Tanjung Datu National Park – Samunsam Wildlife Sanctuary, Bako National Park, and Kulamba Wildlife Reserve. These protected areas conserve coastal forests, mangroves, intertidal flats, and adjacent marine habitats that are essential for migratory shorebirds.

Bako–Buntal Bay, which is also recognised as a National Park by the Sarawak State Government, has been designated as Malaysia's representative site under the East Asian–Australasian Flyway Partnership (EAAFP). This recognition highlights its role as a key stopover and wintering area, where substantial shorebird congregations depend on intertidal habitats for feeding and energy replenishment, thereby, contributing significantly to the survival of migratory populations within the East Asian–Australasian Flyway (Howes and Bakewell, 1989).

Despite these designations, major congregation sites that meet the A4 criterion remain highly vulnerable. A4 sites regularly support $\geq 1\%$ of a biogeographic population, meaning that any habitat loss or disturbance at a single site

can have disproportionate consequences for population viability at the flyway scale. For migratory shorebirds within the East Asian–Australasian Flyway (EAAF), the loss or degradation of staging and wintering grounds can reduce survival rates, body condition, and subsequent breeding success, ultimately contributing to long-term population declines (Murray et al., 2014; Studds et al., 2017). Thus, the vulnerability of Malaysia's A4 congregation sites is directly linked to the stability of EAAF populations.

In Peninsular Malaysia, IBAs such as Teluk Air Tawar–Kuala Muda Coast and parts of the North Central Selangor Coast are increasingly exposed to coastal reclamation, port expansion, industrial development, and aquaculture activities, including shrimp farming. These activities lead to the conversion of mudflats and mangroves, alteration of hydrological regimes, and increased human disturbance, thereby reducing the availability and quality of foraging and roosting habitats (MacKinnon et al., 2012; Murray et al., 2014). Similarly, sections of the South-west Johor Coast have experienced rapid coastal modification associated with infrastructure development and land reclamation, placing additional pressure on critical shorebird habitats (Studds et al., 2017).

In East Malaysia, although some IBAs fall within gazetted protected areas, the surrounding coastal zones remain susceptible to aquaculture expansion, oil palm development near estuarine systems, and infrastructure growth. Even when core areas are legally protected, ecological connectivity between intertidal flats, mangroves, and adjacent feeding grounds may be compromised by external land-use change (MacKinnon et al., 2012; IPCC, 2022).

In light of the review findings, there is a strong justification for more IBAs to be formally gazetted as protected areas by the relevant local and state authorities. For instance, Teluk Air Tawar–Kuala Muda Coast clearly meets the A4 and A1 criterion, as it regularly supports large congregations of shorebirds annually (Nur Atiqah and Ng, 2015). Sites qualifying under the A4 category are internationally significant because they hold substantial proportions of migratory populations during staging or wintering periods. The concurrent fulfilment of both A1 and A4 criteria further strengthens the argument for legal protection.

Collectively, these findings indicate that several IBAs, particularly major A4 congregation sites, are not only ecologically significant but also vulnerable to accelerating coastal transformation. Strengthening gazettelement, enhancing enforcement, and integrating sustainable coastal zone planning are therefore critical to safeguarding Malaysia's contribution to the conservation of migratory shorebirds along the East Asian–Australasian Flyway.

4. CONCLUSION

Research on shorebirds along Malaysia's coastline has been concentrated mainly in Peninsular Malaysia, focusing not only on species diversity and assemblages but also on habitat characteristics and anthropogenic factors affecting shorebird distribution. In contrast, East Malaysia, despite supporting a broader range of habitats within individual IBAs, has received relatively little attention in shorebird-specific studies, with most publications limited to species checklists rather than in-depth ecological analyses. Both regions host several shorebird species of conservation concern, including the Critically Endangered Spoon-billed Sandpiper (*Calidris pygmaea*), Endangered Nordmann's Greenshank (*Tringa guttifer*), Far Eastern Curlew (*Numenius madagascariensis*), Great Knot (*Calidris tenuirostris*), and Spotted Greenshank (*Tringa guttifer*), as well as Vulnerable species such as Broad-billed Sandpiper (*Calidris falcinellus*), Curlew Sandpiper (*Calidris ferruginea*), Sharp-tailed Sandpiper (*Calidris acuminata*), and Black-bellied Plover (*Pluvialis squatarola*), highlighting the high conservation value of Malaysia's coastal habitats. The findings highlight that IBA criteria "A1" (presence of globally threatened species) and "A4" (supporting large congregations) are key indicators of conservation value in areas such as the North–Central Selangor Coast and Teluk Air Tawar–Kuala Muda Coast in Peninsular Malaysia, as well as Bako–Buntal Bay in Sarawak's coastal zones. Major congregation sites remain vulnerable to habitat loss and disturbance from coastal development, reclamation, and aquaculture, which directly affect shorebird populations along the East Asian–Australasian Flyway. Data gaps in East Malaysia, including seasonal variation and prey availability, hinder comprehensive management, emphasising the need for standardised survey methodologies and centralised databases coordinated by the local authorities. Conservation efforts should integrate species protection with the safeguarding of "Blue Carbon" habitats, such as mangroves and intertidal mudflats, ensuring both the survival of migratory shorebirds and the resilience of Malaysia's coastal ecosystems against climate change and anthropogenic pressures.

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