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Diversity of Migratory Waterbirds along the Deli Serdang Coast, North Sumatra

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ABSTRACT

Migratory waterbirds rely strongly on wetland ecosystems as staging and refueling sites along their migration routes, including those situated within the East Asian–Australasian Flyway (EAAF) traversing Sumatra. This study aim to record the species diversity, evenness, and community similarity of migratory waterbirds along the Deli Serdang coast, North Sumatra. Field surveys were conducted from September to October 2025 at three intertidal mudflat sites: Paluh Getah, Muara Sei Tuan, and Bagan Serdang. Species identification was performed using binoculars, a monocular telescope, and photographic documentation. Waterbird assemblages were quantified using the concentration count and block methods, followed by calculation of the Shannon–Wiener diversity index (H′), species evenness (E), and inter-site similarity (IS). A total of 21 migratory waterbird species were recorded, with the Pacific Golden Plover (Pluvialis fulva) representing the most abundant species (582 individuals). Diversity (H') indices across all sites indicated moderate diversity, whereas E values were consistently high, reflecting relatively uniform species distributions. The most similar avian community was observed between Paluh Getah and Muara Sei Tuan (93.75%), likely attributable to similar habitat structure and levels of anthropogenic disturbance. These findings demonstrated that the mudflats of Deli Serdang constitute an ecologically important staging habitat for migratory waterbirds along the EAAF, including several species of conservation concern. Strengthened habitat protection and management are therefore essential to support the existence of migratory populations dependent on this coastal region.

Keyword: Deli Serdang, Diversity, Migratory Waterbirds, Mudflat, Wetland

1. Introduction

The eastern coast of North Sumatra extends for approximately 300 km and is characterized by extensive mangrove forests and diverse wetland habitats, including intertidal mudflats [1]. These mudflat ecosystems are highly productive and function as nutrient-rich substrates due to their capacity to accumulate organic matter, thereby supporting a wide range of aquatic organisms and providing essential foraging habitat for waterbirds [2]. Wetland-dependent bird assemblages in this region comprise both resident and migratory waterbirds. Migratory species undertake long-distance movements in response to seasonal shifts, climatic variation, and extreme conditions in their breeding or non-breeding ranges; these movements represent a fundamental ecological strategy for survival [3].

Coastal wetlands along major flyways have experienced dynamic environmental change. Modifications driven by sea-level variation, sedimentation processes, altered hydrology, and human-induced conservation or restoration activities have reshaped many coastal landscapes [4]-[7]. Such changes have generated ecological shifts that are particularly consequential for migratory species reliant on tidal habitats during staging and

refueling [8]. Widespread degradation and loss of coastal wetlands have been reported to exert significant pressure on waterbird populations along several migration routes [9], [10]. The Deli Serdang coast has been recognized as an Important Bird Area (IBA) within the East Asian–Australasian Flyway (EAAF). This coastline supports numerous migratory waterbird species, including several listed under threatened categories of the IUCN Red List [11]. Between 2012-2022, extensive conversion of mangrove forest along the Deli Serdang coast into aquaculture ponds, agricultural fields, and plantation, coupled with timber extraction, resulted in severe habitat loss. Deforestation rates reached 53.77% in Tanjung Rejo and 59,38% in Percut, accelerating natural habitat degradation and threatening the availability of critical stopover site for migratory waterbirds for forage and rest [12], [13]. Migratory waterbirds dependent on mudflat substrates may relocate if habitat conditions become unsuitable, posing risks to their overall migratory success and long-term population stability [14].

Ongoing ecological alteration along the Deli Serdang coast has been suggested to influence biodiversity patterns, including waterbird abundance and community composition. Recent concerns regarding habitat transformation have prompted multiple studies to highlight the need for strengthened conservation measures [15], [16]. Despite this, updated information on population structure, community diversity, and species presence along this section of the EAAF remains limited. Baseline data on migratory waterbird assemblages are crucial for evaluating habitat condition and informing conservation strategies at both local and flyway scales. This study aimed to characterize the migratory waterbird assemblages along the Deli Serdang coast by quantifying species diversity, evenness, and inter-site similarity across three mudflat locations, providing baseline ecological information to support conservation management within the EAAF.

2. Method

2.1. Study Area and Sampling Period

Fieldwork was conducted from September to October 2025 along the eastern coast of Deli Serdang, North Sumatra (Figure 1). Three intertidal mudflat sites were selected based on their use by foraging waterbirds: Station 1, Paluh Getah mudflat (3°42′12.10″ N, 98°50′83″ E); Station 2, Sei Tuan Indah mudflat (3°42′19.98″ N, 98°50′24.47″ E); and Station 3, Bagan Serdang mudflat (3°42′10.31″ N, 98°50′57.97″ E). Sampling points were positioned within active foraging zones to ensure representative observations of migratory waterbird assemblages.

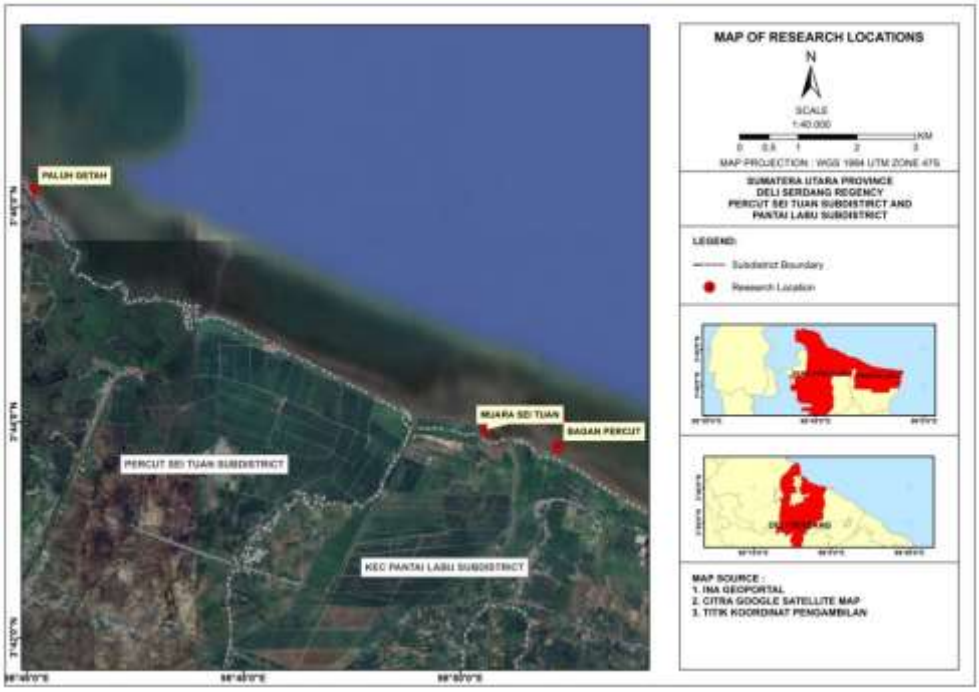

Figure 1. Map of the study area showing the three intertidal mudflat stations along the Deli Serdang coast, North Sumatra.

2.2. Field Survey

Migratory waterbirds were recorded using binoculars, a monocular telescope, and a Coolpix P900 camera to document species identity and assist with verification. All individuals encountered during surveys were treated as primary observational data. In addition to direct sightings, bird vocalizations and other field signs were noted to support identification. Species identification followed standard field guides for Indonesian avifauna. Observation on mudflat were replicated three times using the concentration count method (Figure 2). Surveys were conducted during low tide and terminated at high tide when the mudflats were inundanted and migratory waterbirds absent. The observation site represented a feeding ground with a 200-meter radius. When large congregations occurred, populations estimates were obtained using the block method by calculating the number of individuals within a block, multiplying by the total number of blocks and adding individuals outside of block. All species and individual numbers were recorded on standardized tally sheets to determine relative abundance. The conservation status of each species was compiled from the IUCN Red List (2025), which served as secondary reference information [17]. All collected data were used to evaluate species composition, diversity, and evenness across the three mudflat sites.

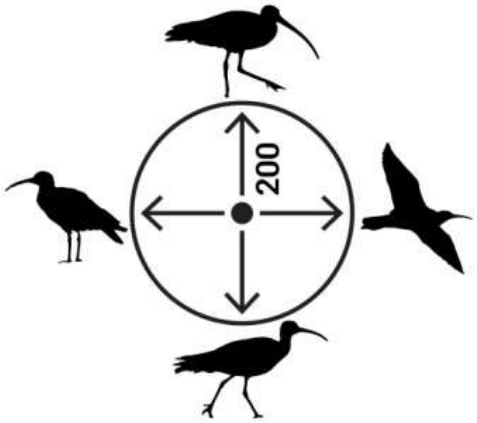

Figure 2. Illustration of the concentration count method used for assessing migratory waterbird abundance. Ilustrasion by author.

2.3. Data Analysis

Species diversity was calculated using the Shannon-Wiener index (*H'*):

$$H' = \sum P_i \ln P_i \quad (1)$$

Where, P_i denotes the proportion of individuals of species *i* relative to the total number of individuals recorded. Species evenness was calculated using:

$$E = \frac{H'}{\ln S} \quad (2)$$

Shannon-Wiener index (H'): H'≤ 1: low diversity

1< H'<3: moderate diversity

H' ≥ 3: high diversity

Where, S denotes the total number of species at a site. Values approaching 1 indicate highly even distribution of individuals among species. The similarity of community composition among sites, the species' index of similarity (IS) was calculated using:

$$IS = \frac{2C}{A+B} \times 100\% \quad (2)$$

Where, A is the number of species at site A, B the number at site B, and C the number shared between both sites. Number of unique species among survey sites was also visualized using InteractiVenn (https://www.interactivenn.net/).

Similarity Index criteria: 1-30%: low category

31-60%: medium category

60-90%: high category

>91%: very high category

3. Results and Discussion

3.1. Species Assemblage of Migratory Waterbirds along Deli Serdang Coast

A total of 21 migratory waterbird species belonging to three families were recorded across the three mudflat stations. The Pacific Golden Plover (*Pluvialis fulva*) was the most abundant species, with 582 individuals recorded across all sites. Its high presence and abudance were influenced by the suitability of mudflat habitat and the availability of food resources, particulary surface dwelling macrozoobenthos, which correspond to the species foraging morphology [19], [14]. The number of species recorded was lower than that reported by Putra et al. [20] yet exceeded that documented by Siregar and Jumilawaty [21], consistent with natural fluctuations commonly reported in migratory shorebird communities. Variability in species counts within coastal habitats can arise from several factors; however, migration season, timing of observation, prevailing environmental conditions, and site-specific ecological characteristics are regarded as the primary drivers of these differences [22].

Table 1. Checklist of migratory waterbird species surveyed in three survey sites of Deli Serdang Coast

No	Family	Species	Vernacular name	Number of individuals			IUCN
				Paluh Getah	Muara Sei Tuan	Bagan Serdang	
1.	Charadriidae	*Charadrius atriforns*	*Tibetan sandplover*	138	110	94	LC
		Pluvialis pulva	*Pacific golden plover*	220	174	188	LC
		Pluvialis squatarola	*Grey plover*	2	0	2	VU
		Vanellus cinereus	*Lapwing*	0	3	78	LC
2.	Sternidae	*Sterna hirundo*	*Common tern*	57	79	34	LC
		Sterna albifrons	*Little tern*	37	33	41	LC
		Clidonias leucepterus	*White winged tern*	29	36	39	LC
		Chlidonias hybrid	*Whiskerd tern*	73	68	67	LC
		Sterna nilotica	*Gull billed tern*	27	34	29	LC
3.	Scolopacidae	*Xenus cinereus*	*Terek sandpiper*	94	83	56	LC
		Tringa guttifer	*Nordman's greenshank*	8	0	0	EN
		Limossa lapponica	*Bar tailed godwit*	57	39	73	NT
		Limossa limosa	*Black tailed godwit*	21	13	15	NT
		Numenius arquata	*Eurasian curlew*	84	73	136	NT
		Numenius madagascariensis	*Far eastern curlew*	0	0	5	NT
		Numenius phaeopus	*Whimbrel*	139	110	128	LC
		Tringa tetanus	*Common redshank*	154	158	169	LC
		Tringa stagnatilis	*Marsh sandpiper*	0	0	57	LC
		Tringa nebularia	*Common greenshank*	0	0	12	LC
		Actitis hypoleucos	*Common sandpiper*	13	9	37	LC
		Calidris ferruginea	*Curlew sandpiper*	110	97	87	VU
		Total		1263	1119	1347	

Note: EN = Endangered, LC = Least concern, NT = Near-threatened, VU = Vulnerable.

Species of scolopacidae family dominated the assemblage, a pattern frequently observed along the EAAF [23]. Members of this family possess morphological adaptations, such as long legs and elongated bills that support foraging efficiency in muddy substrates [24]. These traits enable individuals to exploit invertebrates such as crustaceans and mollusks at varying depths within soft sediments [25]. Their diverse foraging strategies and elevated metabolic requirements further explain their prolonged presence at feeding grounds during migration preparation [26]. In contrast, Species of charadriidae family were recorded in lower abundance. Their shorter bills limit access to prey within deeper mud layers, reducing foraging efficiency in soft-sediment habitats [27]. Additional factors likely influencing their reduced presence include short tidal exposure windows and competition with the more specialized Scolopacidae.

Conservation status assessments based on the IUCN Red List (2025) indicated that the recorded species included four Near Threatened (NT), two Vulnerable (VU), two Endangered (EN), and fourteen Least Concern (LC) species. Among these, Noordmann's Greenshank (*Tringa gutiffer*) as seen in (Figure 3) is of particular importance, being classified as endangered (EN) with an estimated global population of only 1.500-2.000 individuals [28]. Although, listed as an endangered species, previous research noted that tringa guttifer was identified appearing in the Tanjung Rejo coastal area from 2017 to 2019. Suprisingly, this species was not found again at the end 2019 to 2020 [29]. The rare appearance of *Tringa guttifer* is in line with minimal number of individuals found in this study, where the appearance of *Tringa guttifer* was only recorded in observation in the month of October. Furthermore, [30] reported the presence of the Far Eastern Curlew (*Numenius madagascariensis*) in the Banyuasin Penisula, noting a population decline of up to 60% over the past 35 years, which reflects the global downward trend of this species along the East Asian –Australian Flyway (EAAF). The occurance of these species highlight the conservation value of Deli Serdang mudflat as a critical stopover site. However, habitat degradation aquaculture expansion, coastal reclamation, and urbanization have been widely recognized as major driver of migratory shorebird population declines, including *Tringa gutiffer* [31]. Consequently, the use of this habitat by species that are endangered both locally and globally underscores the urgent need for habitat protection and careful management of the remaining mudflat area [32].

Figure 3. Field documentation Noordman's Greenshank (*Tringa gutifer*)

3.2. Diversity and Evenness of Migratory Waterbirds along Deli Serdang Coast

The Shannon-Wiener's diversity index (H′) for the three sites ranged from 2.49 to 2.70, indicating moderate diversity at all sites (Figure 4). The highest diversity was documented at Bagan Serdang, whereas Muara Sei Tuan showed the lowest, although the overall differences were small. Moderate diversity levels across the study area suggest that habitat conditions still support a relatively stable migratory bird community despite ongoing anthropogenic pressures. Coastal regions in North Sumatra, including Deli Serdang, have experienced considerable environmental change due to conversion of mangrove forests, increased human disturbance, and reduced vegetative cover. Such pressures reduce habitat quality and may influence both the abundance and distribution of migratory species. Previous studies have reported similar declines in bird diversity in rapidly developing coastal landscapes [33]. In contrast to diversity, species evenness (E) values across all sites were high, indicating that individuals were distributed relatively uniformly among species and that no species dominated the assemblage (Figure 4). High evenness typically reflects stable resource availability and low interspecific competition [34] Adequate food supply in mudflat ecosystems can promote balanced species distribution, as noted in other coastal habitats [35], [36].

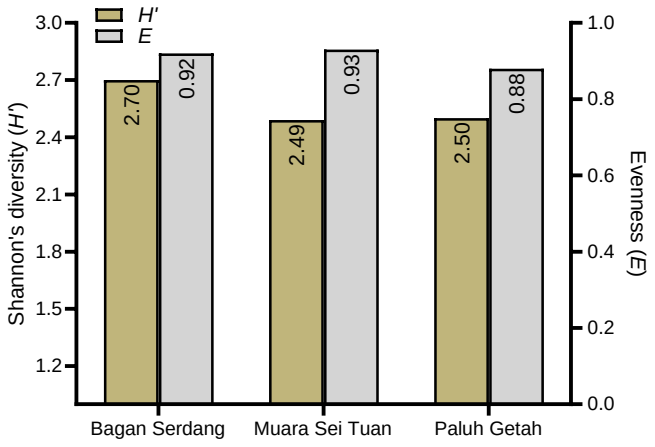

Figure 4. Diversity and evenness index of migratory waterbird communities among survey sites

3.3. Similarity of Migratory Waterbirds' Assemblage among Sites

The species similarity index (IS) revealed the greatest overlap between Paluh Getah and Muara Sei Tuan, with a similarity of 93.75%, classified as very high (Figure 5). These two sites share similar habitat structure, tidal exposure patterns, and anthropogenic activity, which likely contribute to the near-identical species composition. Both areas are frequently used by local fishers for shellfish collection, creating comparable disturbance regimes. Similarity between the other site pairs Paluh Getah and Bagan Serdang (86.48%), and Muara Sei Tuan and Bagan Serdang (88.88%), was also high. According to theory and earlier studies [37], habitats with comparable vegetation, substrate type, and disturbance intensity tend to support similar bird communities. The high similarity across all sites suggests that the Deli Serdang coast functions as a unified ecological corridor for migratory waterbirds, with each mudflat providing complementary foraging opportunities. Several species of migratory bird waterbirds were not found at three research sites due to global population decline and a high level of sensitivity to environmental changes. This consistent with the findings [38] who started that migratory waterbirds tend to select habitat that meet their ecological requirements, however environmental disturbances may cause intolerant species to abandon such habitats even though those habitats support their survival.

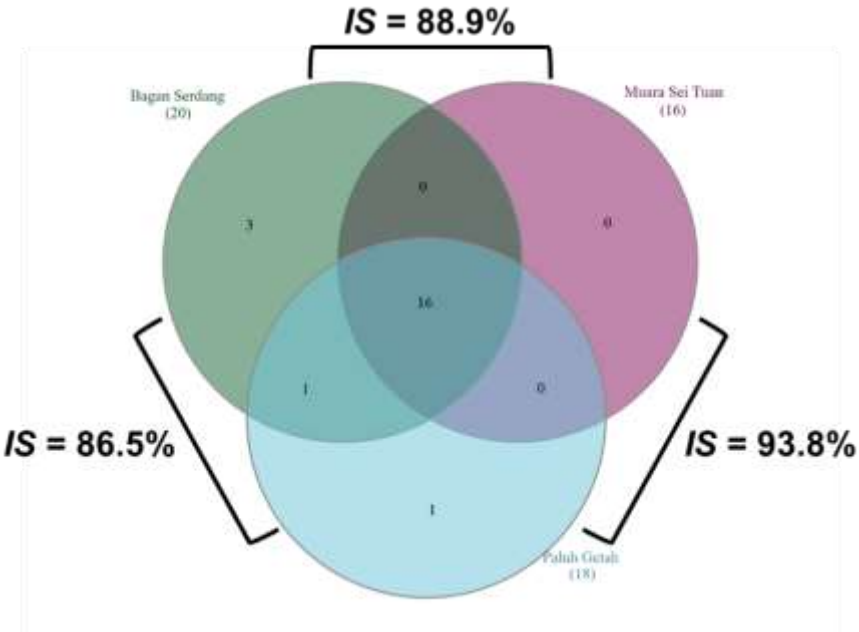

Figure 5. Venn diagram showing shared migratory waterbird species among Paluh Getah, Muara Sei Tuan, and Bagan Serdang with similarity indices (*IS*).

4. Conclusion

This study documented 21 migratory waterbird species across three mudflat sites along the Deli Serdang coast, with *Pluvialis fulva* as the most abundant species. The presence of threatened taxa, including *Tringa guttifer* (EN), *Numenius madagascariensis* (EN) and *Calidris ferruginea* (VU), confirmed the on-going ecological importance of these mudflats as staging areas within the East Asian–Australasian Flyway. Diversity values across sites were moderate, while evenness was consistently high, indicating balanced species distributions despite ongoing habitat pressures. High inter-site similarity further highlights the functional connectivity of these coastal wetlands. These findings reinforced the need for sustained habitat protection and management to support migratory waterbird populations in this region.

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Conflict of Interest

The authors declare that there are no conflicts of interest associated with this study.

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