Spatial Biodiversity of Birds in Land Covers of Wetlands on Jakarta's North Coast

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Abstract

Wetlands are suitable habitats for the coastal bird community. One of the important wetlands is located on Jakarta's North Coast. Here, this study aims to assess the spatial biodiversity of birds in various land covers of wetlands on Jakarta's North Coast. In total, there were 23 species belonging to 12 bird families. Ardeidae, Rallidae, and Silviidae bird families have more species compared to other families. The biodiversity H' values in the wetlands dominated by mangrove cover were the highest, at 2.527, followed by the wetlands having less mangrove cover and more water bodies and fish ponds only having H' values equal to 1.811. The arboreal, small-to-medium-sized birds belong to Nectariniidae, Ploceidae, Silviidae, and Dicaeidae were widely distributed across all land cover. In contrast, the wetlands characterized by mangrove cover dominance combined with muddy substrate coasts were dominated by mid-large water birds belong to Anatidae, Scolopacidae, Ciconiidae, Rallidae, Ardeidae, Phalacrocoracidae, Anhingidae, and Alcedinidae. It is recommended to protect the mangroves and reforest the wetlands with mangroves to provide more habitats for the coastal bird community.

Keywords: Biodiversity, Bird, Coast, Cover wetland

Introduction

Coastal locations, with their wetland areas, are vital to the bird community (Rija *et al.*, 2015). The Indonesian archipelago's coastal ecosystems are noted for their tremendous biological variety and endemism. The Indonesian coast is a truly important habitat to an endemic bird species (Sodhi *et al.* 2011). Several of coastal bird species in Indonesia are only found in this region of the world, and those species are among the most important natural riches of this country, particularly when it comes to the numerous endangered species. There is a diverse range of inland and coastal wetland environments in Indonesia that support a diverse biological community including coastal bird community. The Ramsar Convention on Wetlands defines wetlands as areas of marsh, fen, peatland, or water, whether natural or man-made, permanent or temporary that contain water. Wetlands are among the world's most productive ecosystems, as well as in Indonesia.

Furthermore, for thousands of years, those wetlands have provided food, drinking water, building materials, and a plethora of other services to human populations. Wetlands also serve an important role in preserving global biodiversity, partly through their high production, which supports food chains, and partly by providing habitat for specially suited plant and animal species. Current research by Amarasekara *et al.* (2021) confirmed that a wetland is an important habitat for supporting 28 bird species from 22 families.

Wetlands in Indonesia are characterized by vast mangrove cover. Indonesia has 3 million ha, or 23% of the world's mangrove area. Those wetlands in Indonesia are important habitats for coastal bird communities. In the wetlands of Panjang Island's Coast, Jepara, Central Java, there were 27 bird species from 15 families, with the biodiversity rate of the bird species ranging from 1.15 to 2.20 (Utami *et al.*, 2017). In Maron Beach, Prasetyo & Wulandari (2021) reported that there were 42 bird species from

20 families, with a biodiversity rate of 2.915. Meanwhile, in the wetlands of Tegal's Coast, Central Java, there were 37 bird species from 18 families, with a biodiversity rate that ranged from 2.22 to 2.37 (Isworo & Oetari, 2020). In the same way that the other coasts on Java Island, Jakarta also has a wetlands. Despite the abundance of studies on the distribution and abundance of coastal bird communities along Jakarta's Coast, interactions between coastal birds, spatial distributions, and land cover were rarely investigated. This study is becoming more important recently since there has been a massive change in land cover of wetlands on Jakarta's Coast that led to the reduction of mangrove covers (Sasongko *et al*., 2014; Sofian *et al*., 2019) and the decline of the coastal bird community. Here, this study aims to assess the biodiversity and spatial distribution of bird communities in various land covers of wetlands on the north coast of Jakarta City.

Research Methods
Study area

The study areas included 3 sampling locations (Table 1) with latitude coordinates of 6.099^0–6.117^0 South and a longitude of 106.737^0–106.762^0 East. The study areas include a protected forest in the center, a wildlife reserve in the east, and an ecotourism mangrove park in the west. The east location was bordered by the Angke River, a fishermen's village, and Jakarta Bay in the north. The central location was bordered by Jakarta Bay. The west location was bordered by fish ponds and also Jakarta Bay in the north. All locations were bordered by the built-up areas in the south part. The central location was dominated by dense mangroves. The east location had similar mangrove covers combined with water bodies. In contrast, a dominance of water bodies and fish ponds was observed in the west location (Figure 1).

Bird survey

The bird survey in the wetlands of Jakarta's North Coast was conducted for two months from July to August 2021. The survey techniques used included visual encounter surveys and multiple surveys through random visits. The survey was conducted during various time periods of the day using direct observations supported by binoculars and unaided eyes. Based on the bird activities, the survey was carried out at 05.30–7.00 am and continued at 04.00–06.15 pm. The coastal bird species richness of five distinct land covers, including *Rhizopora* sp., *Sonneratia* sp., and *Nypa* sp., covers, water and fish ponds, and built-up areas within the wetlands of Jakarta's North Coast, was recorded. The identification of birds was done using a bird identification book and field guide (MacKinnon & Phillipps, 1993). The presence of birds is then tabulated into a Geographical Information System (GIS) to be mapped into land cover thematic layers.

Mangrove survey

The mangrove survey was conducted using the purposive random sampling method following Hutabarat (2009) and Sofian *et al*. (2012) by making observation plots with the size of each plot being 10 x 10 m. Each individual mangrove was identified and its coordinates were recorded using a Global Positioning System (GPS) handheld device at the observation plot. Mangrove species identification was conducted using mangrove identification book and field guide (Chapman, 2016; Hirsch, 2016; Tomlinson, 2016). The recorded mangrove species were then tabulated for further land cover mapping.

Bird biodiversity index Shannon Wiener (H')

The biodiversity of bird community was assessed using Biodiversity index Shannon Wiener (H') with following equation: $H' = \Sigma[P_i \ln (P_i)]$, where P_i is the proportion of the species i bird in total individuals. The H' range is from 0 (low diversity) to 1 (high diversity).

Land cover mapping

Land cover classification and mapping of wetlands in Jakarta's North Coast were performed using remote sensing analysis and GIS analysis following Philiani et al. (2016), Kawamuna *et al*. (2017), and Sukojo & Arindi (2019). Landsat 8 satellite imagery of Jakarta's North Coast was retrieved and classified using supervised classification to determine the land cover types. The categories for land cover classifications were mangroves, including *Rhizopora* sp., *Sonneratia* sp., and *Nypa* sp., water and fish ponds, and built-up areas. The

result of land cover mapping is a thematic layer of land cover.

Result and Discussion

In this study, the compositions of the bird family (Figure 2) were varied. Central parts of Jakarta's North Coast or protected forest had the most diverse bird family compositions, followed by the wildlife reserve in the eastern parts. The least diverse compositions were observed in the western parts of the coast in the ecotourism park. These composition patterns influenced the biodiversity values (Figure 3). The H 'values in the central parts of the coast dominated by mangrove cover were the highest, at 2.527, followed by the less dense mangrove cover in the wildlife reserve in the east, at 2.184. The west parts of the coast with less mangrove cover and more water bodies and fish ponds only had a H' value equal to 1.811.

The bird community in this study includes 12 families, consisting of arboreal small-mid-sized birds sizing 15-17 cm in 4 families, and 8 families of mid-large water birds sizing 30-180 cm. The spatial distributions (Figure 4) of those bird families were varied. The arboreal small-to-medium-sized birds were widely distributed across all land cover, with a strong presence along the west coast, which was dominated by water bodies and fish ponds. In contrast, the central and eastern parts of the coasts characterized by mangrove cover dominance combined with muddy substrate coasts were dominated by mid-large water birds.

The current study provides insights into the bird assemblages of this coastal area in Jakarta. The results of this study thus serve as a baseline for monitoring future trends in the coastal bird communities and for evaluating conservation and management efforts over time. Bird species' relative abundance was in overall high in the surveyed area, with some species occurring more locally abundant and widespread than others, particularly those feeding on grains, fruits, and/or insects. The Ploceidae and Dicaeidae families are responsible for some of the species found along the west, central, and east coasts of Jakarta. This could be attributable to the local differences in species' ecological adaptation that have enabled some species to occupy a wide habitat range. *Dicaeum trochileum, Lonchura punctulata,* and *Nectarinia jugularis* depict such an example (Amzah *et al*., 2021; Partasasmita *et al*., 2017). *Lonchura punctulata* feeds on both grains and fruits and was recorded in the mangrove bush land habitat throughout the surveyed area, suggesting an abundance of seeds and fruits. Although bird abundance and diversity have been found to strongly correlate with habitat quality in terms of food availability, we do not yet have quantitative data on seed abundance. However, the abundant feeding and ecological guilds observed in our study suggest that the surveyed area may well constitute diverse microhabitats that support different bird species.

The most important findings of this study were that most water bird species belonging to the Anatidae, Ardeidae, Phalacrocoridae, Rallidae, Scolopacidae, and Anhingadae families were widely distributed along the Jakarta Coast's central and eastern parts. Those locations are characterized by diverse mangrove species and muddy substrates. Dense mangrove covers, as seen in the central protected forest, provide suitable habitats for coastal bird species with nesting sites, protected forest. At least five species of Ardeidae inhabited this forest. This finding is in agreement with Gonzales *et al*. (2009) and Firdausy *et al*. (2021). The Ardeidae species were known to have preferences for occupying the *Rhizophora mucronota* covers used as a nest and perch located on the mangrove forest's edge (Canales-Delgadillo et al. 2019; Roshnath & Sinu, 2017). Besides the central and eastern parts of Jakarta providing mangrove covers suitable for nesting places for coastal birds, the muddy substrates in those locations were suitable habitats for molluscs and fish that were the prey are for water birds. Water birds in coastal areas were generally dominated by zoophagous species with up to 93% of which consume invertebrates as their first choice, while just five zoophagous species preferred to consume vertebrates, and the rest, about 22%, were omnivorous species. Wetlands in the central and east parts of Jakarta's North Coast, attracted waterfowl, waders, birds of prey, and several other wetland-dependent birds year-round due to abundant food availability such as insects, crabs, shrimp, molluscs, and indigenous fish (Mukhopadhyay & Mazumdar,

2019). Intact forest patches, protected areas, and wetlands as available in the central part of Jakarta's Coast are characterized by an adequate food base and resources were species rich while the patchy landscapes were species scarce, as can be observed in the ecotourism park in the west of the coast (Sohil & Sharma, 2020).

The abundance of water bird prey was also related to the abundance of food resources for those preys. In wetland ecosystems, water bird prey ranging from insects, crabs, shrimp, molluscs, and indigenous fish that depend on and consume mangrove litter (Kabir *et al*., 2014; Kaharudin & Wahidin, 2020). On Jakarta's Coast, mangrove litter was only available in the protected forest and wildlife reserve where the mangrove covers and trees were still available. The preferences of the kingfisher birds on particular land covers, besides food availability, are related to the perching ecology or environmental variables include food and vegetation required when kingfisher birds forage in a high position or in a position near the edge of water bodies (Peinado & Ortega, 2020). In this study, kingfisher species belonging to the Alcedinidae preferred the central and east parts of the Jakarta's Coast, in spite of the fact that there were plenty of fish available in fish ponds in the west parts due to the availability of trees for perching. Only the protected forest in the central and wildlife reserve in the east parts of the coast that still had mangrove stands required by kingfisher species to perch while foraging (Peinado & Ortega, 2020).

Water bird species were scarce in the west of the Jakarta's Coast, but abundant and concentrated in the north and east, based on this study. In tropical coastal areas, where productivity is generally low, coastal water birds tend to concentrate on productive areas where prey is more abundant and/or easier to catch (Jaquemet *et al*. 2004). The distribution of those water bird species depended on physical parameters like thermal fronts, upwellings, currents, or salinity gradients. On the Jakarta's Coast, the central sampling locations or the protected forest were located near the sea and more saline, so this location was appropriate for the coastal bird species.

Fewer coastal bird species and lower biodiversity values as observed in the west in ecotourism park and wildlife reserve in the east are also in line with results from Graells et al. (2022). Based on the previous study, water bird species were more abundant inland and on rocky shores of Chile's coast than on the beach. The causes of these conditions were related to anthropogenic factors and the distance to the sea. Anthropogenic influences in the form of urbanization had affected birds, reducing species richness and, in contrast, increasing species richness in areas with intermediate levels of disturbance.

Urbanization changed coastal bird species assemblages depending on urban characteristics and resources available. Urbanization on the coast led to high percentages of paved surfaces such as roads and buildings. Urban areas could also generate ecological traps for bird nesting, mortality by collisions with moving vehicles (Erritzoe *et al*., 2003), and increased competition for good quality food, and native trees for nesting (Seress & Liker, 2015). In this study, the western parts of the Jakarta's Coast, where the coastal bird biodiversity was lower in comparison to other coastal locations, were actually designated as ecotourism parks, involving massive anthropogenic influences and activities. Those activities included the development of tourism infrastructure combined with tourism activities themselves. Besides that, the ecotourism park in the west was bordered directly by the fish ponds that have deforested the mangrove forest, reduced the coastal bird habitat, and this led to the decline of the coastal bird community. As reported by Priosambodo *et al*. (2020), since most of the coastal area has been converted into fish ponds, rice fields, and built up areas, many coastal bird species are seriously threatened by land cover conversion. Similar to the expansion of fish ponds, fisheries have yield significant threats to coastal bird community. Related to this, annual adult survival of the Galapagos Waved Albastross (*Phoebastria irrorata*) declined between 1999 and 2005, likely due to high mortality caused by fisheries and now this water bird species is endangered with extinction.

Table 1. Locations and descriptions of study areas.

Study area	Remarks	Latitude	Longitude
West	Ecotourism park, bordered by fish ponds in the west	$6.099^0 – 6.117^0$	106.737^0
Central	Angke Kapuk protected forest, bordered by Jakarta Bay in the north	$6.099^0 – 6.117^0$	$106.737^0 \cdot 106.762^0$
East	Muara Angke wildlife reserve, bordered by Angke River in the east	$6.099^0 – 6.117^0$	106.762^0
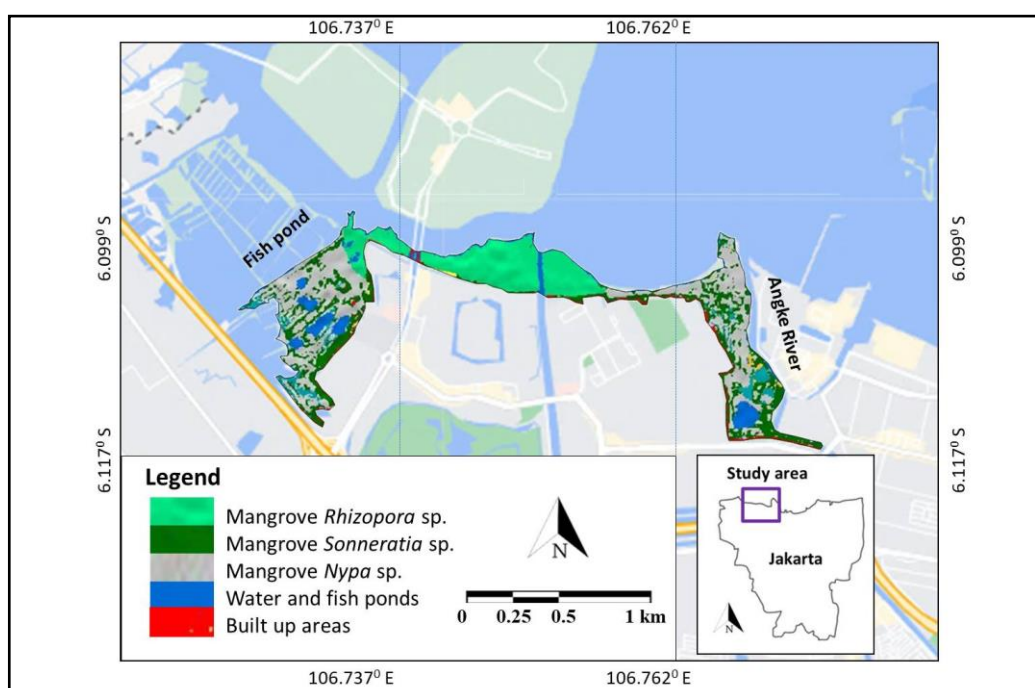
Figure 1. Study area and land covers including mangrove covers *Rhizopora* sp., *Sonneratia* sp., and *Nypa* sp., water and fish ponds, and built up areas in the wetlands of Jakarta's North Coast.
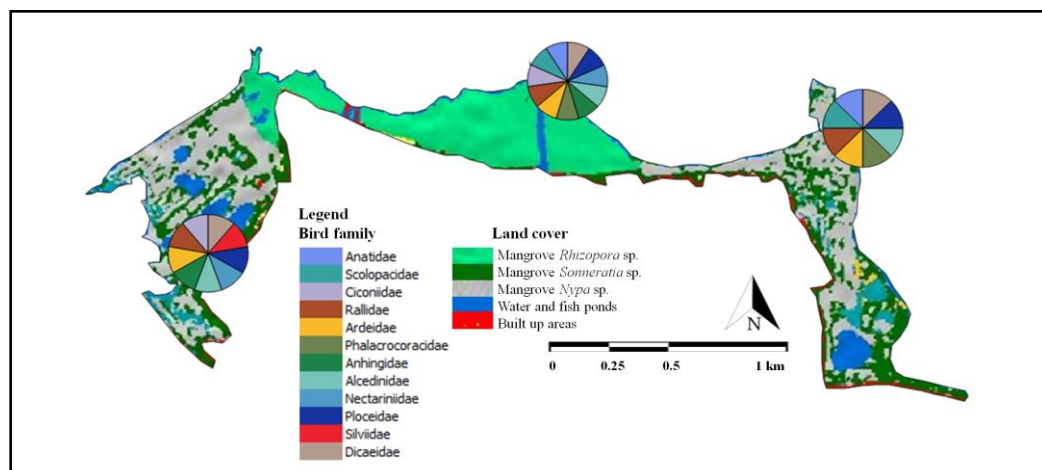

Figure 2. The compositions of bird families in various land covers in the wetlands of Jakarta's North Coast.
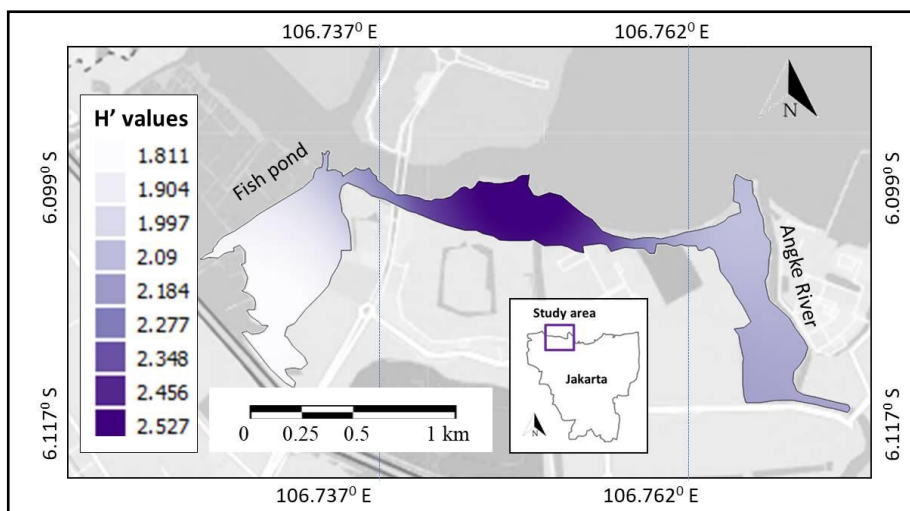
Figure 3. Biodiversity index (H') of bird community in the wetlands of Jakarta's North Coast.
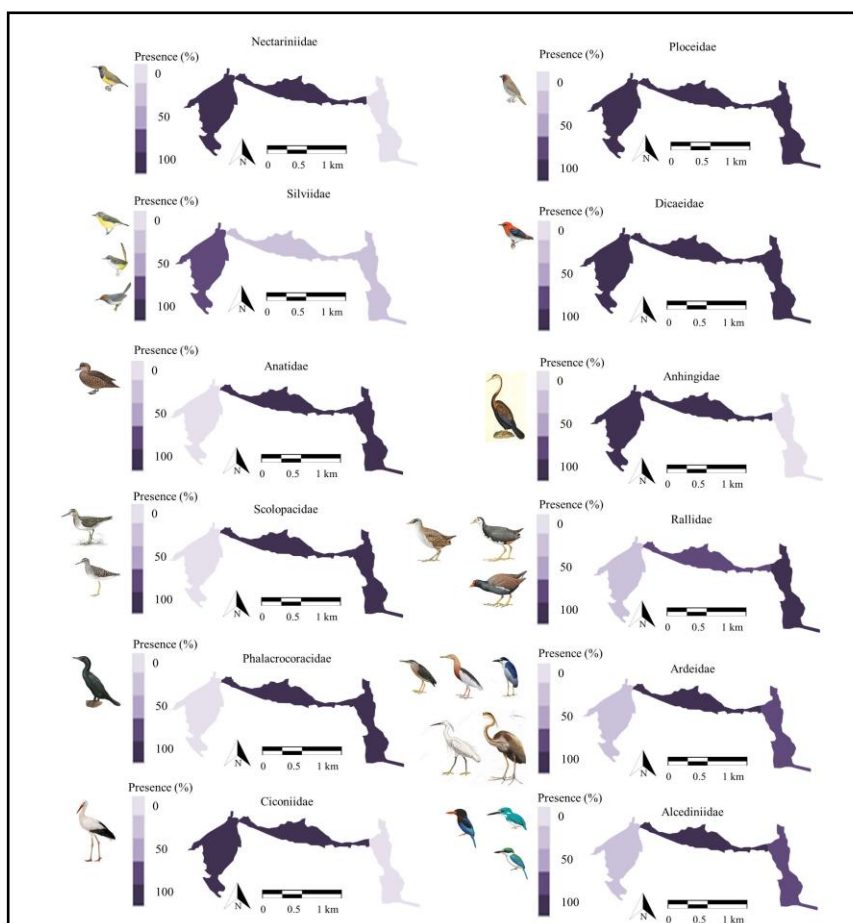

Figure 4. The presences and spatial distributions of bird families in the wetlands of Jakarta's North Coast. Nectariniidae (*Nectarinia jugularis*), Ploceidae (*Lonchura punctulata*), Silviidae (*Gerygone sulphurea*, *Orthotomus ruficeps*, *Prinia familiaris*), Dicaeidae (*Dicaeum trochileum*), Anatidae (*Anas gibberifrons*), Scolopacidae (*Actitis hypoleucos*, *Tringa glareola*), Ciconiidae (*Mycteria cinerea*), Rallidae (*Amaurornis phoenicurus*, *Gallinula chlorop*, *Porzana cinerea*), Ardeidae (*Ardeola speciosa*, *Ardea purpurea, Egretta garzetta*, *Butorides striata*, *Nycticorax nycticorax*), Phalacrocoracidae (*Phalacrocorax sulcirostris*), Anhingidae (*Anhinga melanogaster*), Alcedinidae (*Alcedo coerulescens*, *Halcyon cyanoventris*, *Todirhamphus chloris*). Bird illustrations: Birds of the World - Cornell Lab of Ornithology.

Conclusion and Suggestion

The land covers in the wetlands of Jakarta's North Coast were very diverse. This diverse land cover has influenced the spatial distributions of bird communities that inhabit wetlands. Water birds of medium to large size were common in wetlands with mangrove and muddy substrate covers. In contrast, small-to-mid-sized arboreal birds were widely distributed in the wetlands characterized by combinations of mangrove covers with water bodies and fish ponds.

Based on the result, it is recommended to first protect the remaining mangroves in the central and east parts of Jakarta's North Coast. And second, it is also urged to reforest the west parts of the coast with mangroves to provide more habitats for the coastal bird community.

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