Waterbird community in Pulau Rambut Wildlife Sanctuary, Jakarta Bay: Review on species composition and population size after thirty years

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Abstract. In the Jakarta Bay area, Pulau Rambut, a 25-ha island, has been known as an important breeding/nesting site for 15 waterbird species. Land-use change and habitat deterioration potentially have some impact on the waterbird population. The objective of this research was to compare species composition and population size of waterbirds nesting in Pulau Rambut after 30 years (1990-2020), and provide an analysis on the possible causes of the change. Secondary data on population size and species composition were used for analysis. Habitat changes in the foraging habitat were observed intermittently. Black-headed ibis and Little-pied cormorant were extirpated from the island, thus the species number was decreased to 13. Population size of all waterbirds was greatly decreased (from 10,180 to 4,950 individuals). However, the population of the endangered Milky stork has increased, from 24 (0.2%) to 78 (1.6%) individuals, possibly due to additional birds migrating from the eastern coast of Sumatra. There was a significant change in the species composition (paired t-test; t=0.488, P<0.01), with Cormorants still dominated the community. Possible causes of the population decrease were the shrinking wetlands in Java as waterbirds’ foraging habitat, and deterioration of mangroves as nest trees in Pulau Rambut due oil pollution.

1. Introduction
A small island off Jakarta Bay area named Pulau Rambut has been used as a roosting and breeding site by thousands of waterbirds from many species. Realizing the important value of the island in the bay area, the island was gazetted as a nature reserve since 1937 [1]. In 1999, the status of nature reserve was changed into a wildlife sanctuary to allow more intensive management of the island, especially to rehabilitate the deteriorated mangrove forest. Furthermore, considering the importance of the site for waterbird conservation, Pulau Rambut Wildlife Sanctuary was also listed as Ramsar Site in 2011.

Beside mangrove forest, there was also a secondary dryland forest, and a thin beach forest. The waterbird species that can be found nesting at the island were egrets, cormorants, herons, ibises, and storks, of which most of them prefer to use the mangrove trees as nest sites [1]. These waterbirds used the island as roosting and nesting site. As for foraging site, the waterbirds had to fly to the mainland of Java to seek for fishes and other food in wetland areas in the morning, and came back to the island in the evening.
The number of species and population of waterbirds nesting in Pulau Rambut has been observed from time to time. An intensive study was conducted in 1989-1991 [1] has collected many useful scientific knowledge on the species diversity and composition, monthly population fluctuation, habitat use, and competition for nest site. Several other research were also conducted at shorter time periods, mainly related to wildlife population survey. The last population survey was conducted in 2020 [2], allowing a comparison of the waterbird community at three decades apart.

There have been some concerns about the waterbird population roosting/nesting in Pulau Rambut. In addition to the deteriorated mangrove forest, the population number was also decreased. This study was conducted to compare species composition and population size of waterbirds nesting in Pulau Rambut after 30 years (1990-2020), and provide an analysis on the possible causes of the population change. Considering that the habitat of the waterbirds was also included the foraging areas outside the island, analysis was also extended to the coastal area of the entire Jakarta Bay.

2. Method

2.1. Study Area

The research was conducted in Pulau Rambut Wildlife Sanctuary (106.5°41’30”E, 5.5°58’30”S), a small island located in western part of Jakarta Bay area, Indonesia (figure 1). The size of the sanctuary was 45 ha, consists of 25 ha terrestrial island, and 20 ha surrounding seas. The distance between the island and the nearest coast (i.e., Java Island) is about 4 km.

![Figure 1. Location of Pulau Rambut Wildlife Sanctuary in the Jakarta Bay area; areas in bold were the potential foraging areas of the waterbirds. Source of map: GoogleMap](image)

As mentioned previously, this island plays an important role for the waterbird conservation in Jakarta Bay area, as it has been used by various species of waterbirds as roosting and nesting sites. During breeding season (usually starts in November and lasts to April or May), thousands of waterbirds from 15 species have been recorded to breed on this small island. The number of species and individuals that can be observed in Pulau Rambut is always dynamics, as some of them are visitors to this island that stay on the island for breeding only, while others are resident species or individuals, that stay both during breeding and non-breeding season [1].

Bird habitat in Pulau Rambut consisted of secondary dryland forest (in the middle of the island), mangroves (in the east, north, and west-side of the island), and beach forest (mostly in the southern part of the island). Most waterbirds use the mangrove forest as their roosting and breeding trees. Mangroves in the island basically consisted of primary mangrove (i.e., always inundated by seawater) and secondary...
mangroves (i.e., temporary inundated by seawater, only during high tide). Primary mangroves mostly consisted of *Rhizophora apiculata*, *R. mucronata*, and *R. stylosa*, basically located at the outer part of the island. Meanwhile, secondary mangrove consisted of various species, including *Xylocarpus mollucensis*, *Ceriops tagal*, *Ceriops decandra*, *Excoecaria agallocha*, *Scyphiphora hydrophyllacea*, and *Pemphis acidula*, located more inward, adjacent to the secondary dryland forest [3].

### 2.2. Method
Data on waterbird species composition and population were gathered from previous research that were conducted in the past 30 years. The basis data were intensive and continuous population studies in 1989-1991 [1] and a waterbird survey in 2020 [2]. In both studies, population were estimated through direct total counting during flight when the birds fly out from the island in the morning (5-7am) to their foraging sites in the nearest coast of the mainland Java, and when the birds flying back to the island in the late evening (4-6pm). Counting was done at least for 15 days or 30 replications. The maximum counting number was used as the population estimation. Comparisons were conducted for the waterbird population number and composition during early breeding seasons. Additional information on the latest situation of Pulau Rambut and the coastal area of Jakarta Bay was obtained through opportunistic field visit in the last five years.

Population changes and its probable causes were analysed based on habitat requirement of the waterbirds and other related ecological factors, both in the roost/nest site in Pulau Rambut Wildlife Reserve (internal factors), and in the potential foraging sites in surrounding areas (external factors). Condition and trend in the land-use and other related environmental factors were assessed based on literature reviews. Map was generated by using GoogleMap.

### 3. Result and discussion

#### 3.1. Species presence and their foraging habitat
In 1990s there were 15 waterbird species recorded in Pulau Rambut (table 1). Unfortunately, two species, namely Black-headed ibis and Little-pied cormorant could not be found in the study area anymore, and thus the current number of waterbird species were only 13. In 1990s, the number of Black-headed ibis was reported up to 31 individuals during breeding season [1]. The species has become a rare species in its main distribution area (i.e., Java and Sumatra), and has been categorized as Near Threatened by IUCN. In Java, the population has been reported to be decreased sharply, most likely due to anthropogenic disturbance [4]. The Little-pied cormorant was only seen one individual bird in 1990s, clearly noticeable due to its white plumage on its neck and upper breast [1]. The very small number of population clearly is vulnerable to local extinction.

Of the 13 current existing waterbird species, two species of cormorants (i.e., Little-black cormorant and Little cormorant) are able to forage for fish in surrounding seawater (easily observed in the southern part of Pulau Rambut) and in the wetlands in the mainland Java. The remaining 11 species have to rely on wetlands in Java, and thus have to travel farther.
Table 1. Waterbird species found in Pulau Rambut Wildlife Sanctuary, with some information on their foraging habitat; common names in bold were not found anymore in 2020.

| No | Family Name | Latin Name | Common Name | Foraging Habit |
|----|-------------|------------|-------------|----------------|
| 1  | Phalacrocoracidae | Phalacrocorax sulcirostris | Little-black cormorants | All members of this family are able to swim and dive; need a relatively deep water to fish |
|    |             |            |             | Difficult to differentiate with the Little cormorant during flight; both are able to forage at sea and in freshwater wetlands in the mainland of Java |
| 2  |             | Phalacrocorax melanoleucos | Little-pied cormorant | Only very few individuals, visitor to the island, no record whether this species actually breed at the island |
| 3  |             | Phalacrocorax niger | Little cormorant | Difficult to differentiate with the Little-black cormorant during flight; both are able to forage at sea and in freshwater wetlands in the mainland of Java |
| 4  | Anhingidae | Anhinga melanogaster | Oriental darter | Able to swim and dive; need a relatively deep water to fish |
|    | Ardeidae | Ardea cinerea | Grey heron | All members of this family fish at shallow water and muddy area |
| 5  | Ardeidae | Ardea purpurea | Purple heron | |
| 6  | Ardeidae | Bubulcus ibis | Cattle egret | Have orange breast feather during breeding season, but fly together with other small-sized egret, making them difficult to survey by specific species |
| 7  |            | Egretta sacra | Pacific reef-egret | Very few individuals, foraging near the shore of the island |
| 8  |            | Egretta [Ardea] alba | Great egret | |
| 9  |            | Egretta intermedia | Intermediate egret | |
| 10 |            | Egretta garzetta | Little egret | |
| 11 |            | Nycticorax nycticorax | Black-crowned night-heron | The only nocturnal species in the island; leave the island at early evening and return at early morning |
| 12 | Ciconiidae | Mycteria cinerea | Milky stork | Visitor to the island; arrive to nest during breeding season only |
| 13 | Threskiornithidae | Threskiornis melanocephalus | Black-headed ibis | Visitor to the island; arrive to nest during breeding season only |
| 14 |            | Plegadis falcinellus | Glossy ibis | Visitor to the island; arrive to nest during breeding season only |

*reference of sequence number was based on field guide [5]

The depth of wetlands is also important for the birds. Most birds need shallow wetlands to seek for food by wading and pecking. However, Oriental darter and cormorants need deep wetlands, as they search for food by diving and actively chasing for fish food [5]. Meanwhile, the Black-crowned night heron was the only nocturnal species found in Pulau Rambut, utilizing the same wetlands in Java as foraging areas, but only at nights.

The most recent data on bird population in 2020 was 4,950 individuals [2], less than half of the population three decades ago, as much as 10,180 individuals [1] (table 2). As for the bird composition, both time periods were significantly differed (paired t-test; t=0.488, P<0.01). Cormorants (two species...
combined) that were constituted almost half of the population in 1990s were decreased to 32%, but still dominated the waterbird community. The co-dominant species was also the same, the Black-crowned night heron. The egret group (small-sized egrets and Great egrets combined) showed a dramatic increase in the composition, from around 9% in 1990 jumped to 30% in 2020, indicating that egrets were better in utilizing depleted resources, both within Pulau Rambut and outside the island. Milky stork also increased in the number (24 to 79 individuals) and composition (0.2% to 1.6%), so did the Glossy ibis, replacing the decreased composition of day herons.

Table 2. Composition (in percentage, %) and number of waterbirds observed in Pulau Rambut in 1990 and 2020; cormorants and small-sized egrets could not be differentiated during the surveys and thus were lumped together during surveys.

| No | Species/Group of Species | 1990 [1] | 2020 [2] | Remarks |
|----|--------------------------|----------|----------|---------|
|    |                          | %        | Number   | %       | Number  |                      |
| 1  | Cormorants               | 42.6     | 4,332    | 32.2    | 1,592   | Two cormorant species were combined |
| 2  | Oriental darter          | 4.0      | 409      | 4.4     | 218     |
| 3  | Grey heron               | 1.0      | 102      | 2.7     | 133     |
| 4  | Purple heron             | 11.1     | 1,132    | 3.2     | 158     |
| 5  | Great egret              | 3.8      | 390      | 2.3     | 115     |
| 6  | Mixed egrets             | 5.7      | 581      | 28.1    | 1,391   | A mix of small-sized egrets (3 species of *Egretta* and *Bubulcus ibis*) |
| 7  | Night heron              | 27.3     | 2,780    | 22.8    | 1,129   |
| 8  | Milky stork              | 0.2      | 24       | 1.6     | 79      |
| 9  | Glossy ibis              | 4.1      | 417      | 2.7     | 135     |
| 10 | Black-headed ibis        | 0.1      | 13       | 0       | 0       |
|    | Total number of birds    | 100      | 10,180   | 100     | 4,950   |

3.2. Causes of population decreased

The cause of Pulau Rambut’s waterbird population decreased was hypothesized due to multiple causes, both internal (i.e., inside Pulau Rambut) and external factors (i.e., outside Pulau Rambut; figure 2). Within Pulau Rambut, there has been a severe die-back of mangroves as the waterbirds’ nesting trees in 1990, possibly due to oil pollution, covering an area of 7.575 ha [1]. Estimation of the die-back area by using the recent GoogleMap in June 2021 showed that the die-back area was greatly reduced to 1.984 ha, indicating a successful mangrove recovery program conducted by the Wildlife Sanctuary Authority (i.e., Balai Konservasi Sumberdaya Alam DKI Jakarta). Unfortunately, in July 2019 there was a crude oil spill incident, which could hinder the mangrove recovery process [3].

Mangrove forest was the main nesting habitat for the waterbirds in Pulau Rambut [1,2]. Decreasing in size and quality of the mangrove would have a significant negative impact for the waterbirds, as the limited nesting sites would trigger more intense competition for space and nest materials. In addition to the oil contamination, the island also has receiving a huge amount of marine litter originated from domestic wastes in Java [6], capable of hampering regeneration of important mangrove species [7].

External factor also greatly contributed to the population decline, namely the decrease of many wetland areas as waterbirds’ foraging/fishing areas, including marshes (deep and shallow), mudflats, open-muddy areas in mangrove forest, rice fields, fish/shrimp ponds, estuaries, lake and dams. Each species has its own preference of the wetland types for foraging (table 3). There were many reports (e.g., [8], [9], [10]) on the rapid changes in the land-use of the Jakarta Greater Area (also known as Jabodetabek or Jakarta, Bogor, Depok, Tangerang, Bekasi), which converting wetlands for other purposes. Rice fields as important foraging areas for the waterbirds also have been decreased in Java [11], including in the northern coastal area of Jakarta Bay and surrounding inland areas.
Figure 2. Internal and external factors that might cause the decrease of Pulau Rambut waterbird population.

Table 3. Preferred waterbirds’ foraging habitat outside Pulau Rambut Wildlife Sanctuary.

| No | Species/Group of Species | Main Food | Preferred Foraging Habitat |
|----|--------------------------|-----------|-----------------------------|
| 1  | Cormorants (Little-black, Little) | Fish (small to medium size) | Seawater surrounding Pulau Rambut, deep marshes in the mainland of Java |
| 2  | Darter | Fish (small to medium size) | Deep marshes in the mainland of Java |
| 3  | Herons (Grey, Purple, Night), Egrets (Great, Intermediate, Little), Ibis (Glossy, Black-headed) | Fish (small size), eel, shrimp, crustaceans, molluscs, earthworms, crabs, amphibians, macrozoobenthos | Shallow marshes, mudflats, open-muddy areas in mangrove forest, rice fields, fish/shrimp ponds, shallow parts of a lake/dam/estuaries |
| 4  | Cattle egret | Insects, grasshoppers, crickets, flies, moths, spiders, amphibians, lizards, earthworms | Shallow marshes, mudflats, open-muddy areas in mangrove forest, rice fields; fish/shrimp ponds, shallow parts of a lake/dam/estuaries |
| 5  | Milky stork | Fish (medium size), eels, amphibians | Shallow marshes, mudflats, open-muddy areas in mangrove forest, rice fields; fish/shrimp ponds; shallow parts of a lake/dam/estuaries |

The decrease of the wetlands would decrease the opportunity for the waterbirds to find fishes, macrozoobenthos, and other food in the wetlands, which would decrease the breeding capacity of the waterbirds. When chicks were born, both parents had to fly back and forth, from Pulau Rambut to the foraging areas to feed their chicks. When the wetland areas had decreased or disappeared, the waterbirds had to fly farther to find alternate foraging areas, increasing the energy use for the extra flight.
The food limitation due to the decrease of food would have various unwanted impact to the birds, ranging from flying farther from Pulau Rambut, skipping the breeding season (i.e., not breeding at all), decreased the number of brood size (i.e., number of eggs per nest), and starvation of the parents and chicks. During the period of weaning the chicks, both parents had to provide fish food taken from the mainland of Java. When the fish food is not sufficient due to various reasons (e.g., wetlands dried-up due to climate change, decreased the size and quality of the wetlands), the population certainly would decrease.

There were also many reports (e.g., [12], [13]) saying that the seawater in Jakarta Bay area has been heavily polluted with heavy metals. Marine fishes that were consumed by the waterbirds most likely also exposed to the pollution and impacted the waterbirds that fish on seawater, such as cormorants. The rivers that flowing to the Jakarta Bay were also not in a good condition. Ciliwung River, one of 13 rivers that flows from the Greater Jakarta area to the Jakarta Bay, was already polluted with organic matters [14] and even microplastics [15], which in turn would also endanger freshwater fishes and other aquatic organism consumed by most waterbirds.

Options for foraging areas became limited as the natural habitats were converted into other uses. Seven feeding areas were identified within the Jakarta Bay area (excluding the seawater; table 4, see also figure 1). The farthest feeding area was Muara Gembong wetlands, located about 18 km from Pulau Rambut, which still has relatively vast natural wetlands. Research in Hong Kong on the flight speed of egrets and night heron revealed that the flight speed of the waterbirds ranged between 31.2 km/h for the Black-crowned night heron and 41.1 km/h for the Cattle egret [16]. Assuming that the most waterbirds in Pulau Rambut would travel at 35 km/h, it would take about one hour from Pulau Rambut to Muara Gembong, and another hour to go back, which was timely and energetically high cost during breeding season. Therefore, during breeding seasons, its is crucial to have sufficient and productive wetlands near the nesting site of Pulau Rambut, for example in Tanjung Pasir, Cisadane Estuary, Teluk Naga, and Tanjung Kait.

Although the foraging areas for the waterbirds have been experiencing a great shrinkage, there was an unexpected population increased for the Milky stork nesting in Pulau Rambut. This rare waterbird species recently was also recorded re-nesting in Pulau Dua, another small island about 60 km to the west of Pulau Rambut, after 45 years of absence [17]. Meanwhile, population survey in the eastern coast of South Sumatra and Jambi revealed that the population of Milky stork was decreased [18]. There was a possibility that some of them were migrated to the northern coast of Java, looking for alternative safe breeding sites. Further research surely was needed to confirm this hypothesis.

**Table 4.** List of potential waterbirds’ foraging areas in the Jakarta Bay, arranged based on the distance to Pulau Rambut Wildlife Sanctuary.

| No | Foraging Site                  | Direction | Main Type of Foraging Habitat                           | Distance from Pulau Rambut (km)* | Flying Time 1-Way (min)** |
|----|--------------------------------|-----------|--------------------------------------------------------|----------------------------------|---------------------------|
| 1  | Surrounding seawater            | South     | Seawater                                               | 0.1-0.2                          | <1                        |
| 2  | Tanjung Pasir                   | South     | Rice fields, fish/shrimp ponds                         | 5.5                              | 9                         |
| 3  | Cisadane Estuary                | South-west| Mudflats, fish/shrimp ponds, shallow parts of estuary  | 6.7                              | 11                        |
| 4  | Teluk Naga                      | South     | Rice fields, fish/shrimp ponds                         | 7.0                              | 12                        |
| 5  | Tanjung Kait, Mauk              | South-west| Mudflats, open-muddy areas in mangrove forest, rice    | 7.5                              | 13                        |
|    |                                |           | fields, fish/shrimp ponds                              |                                  |                           |
| 6  | Cengkareng                      | South     | Shallow marshes, mudflats, open-muddy areas in mangrove| 16.0                             | 27                        |
| 7  | Tanjung Anom, Mauk              | South-west| Shallow marshes, mudflats, open-muddy areas in mangrove| 18.0                             | 31                        |
| No | Foraging Site   | Direction | Main Type of Foraging Habitat                                                                 | Distance from Pulau Rambut (km)* | Flying Time 1-Way (min)** |
|----|----------------|-----------|-----------------------------------------------------------------------------------------------|----------------------------------|--------------------------|
| 8  | Muara Gembong  | East      | forest, rice fields, fish/shrimp ponds, Shallow marshes, mudflats, open-muddy areas in mangrove forest, rice fields, fish/shrimp ponds, shallow parts of estuary | 34.0                             | 58                       |

*the shortest distance, measured using GoogleMap

**assuming average flying speed was 35 km/h, see text for explanation

4. Conclusion
Within the duration of thirty years, the waterbird community in Pulau Rambut has been changed in population and in the species composition. The population was decreased about half, while two species disappeared from the island. Egrets apparently had the higher adaptation compared to other Ardeid species.

Management intervention to conserve the waterbirds of Pulau Rambut has to involve the roosting/nesting habitat in Pulau Rambut, as well as the foraging areas in the freshwater wetlands of Jakarta Bay area. As the Greater Jakarta Area is constantly developing to accommodate the live of the people inhabited the megacity, management intervention should encompass holistic approach, including management of land-use system, reducing domestic waste that potentially littering the seawater, as well as improving habitat quality within the island and in freshwater wetlands as foraging sites.

References
[1] Mardiastuti A 1992 *Habitat and Nest-site Characteristics of Waterbirds in Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia* Dissertation (East Lansing: Michigan State University)
[2] Firdausy M S, Mardiastuti A and Mulyani Y A 2021 *IOP Conf. Series: Earth and Environmental Science* **771**
[3] Mardiastuti A, Mulyani Y A, Susanti N K Y, Ivronnie R N and Oktavia A C 2020 *IOP Conf. Series: Earth and Environmental Science* **528**
[4] Noor Y S and Hasudungan F 2000 *Kukila* **11** 128
[5] MacKinnon J, Phillips K and van Ballen B 2010 *Burung-Burung di Sumatera, Jawa, Bali, dan Kalimantan* (Bogor: Burung Indonesia-LIPI)
[6] Ivronie R N and Mardiastuti A 2020 *E3S Web of Conferences* **211**
[7] Debrot A O, Meesters H W G, Bron P S and de León R 2013 *Marine Poll Bull* **72** 1
[8] Steinberg F 2007 *Habitat International* **31** 354–365
[9] Rudianto and Tantu A G 2013 *J Coast Conserv*
[10] Rachmat F B and Muhammad H 2018 *E3S Web of Conferences* **73**
[11] Rustiadi E, Mulya A P, Pravitasari A E, Setiawan Y, Tsutsushima N and Pribadi D O 2021 *Cities* **111** 103000
[12] Kunzmann A, Arifin Z and Baum G 2018 *Mar Res Indonesia* **43** 37-51
[13] Riani E, Cordova M R and Arifin Z 2018 *Marine Poll Bull* **133** 664-670
[14] Dsikowitzky L, Schwarzbauer J, van der Wulp S A, Dwiyitno, Ariyani F, Hesse K J and Damar 2018 *Estuarine, Coastal and Shelf Sci* **215** 219-228
[15] Cordova M R, Riani E and Shiomoto A 2020 *Marine Poll Bull* **161** 111763
[16] Wong L C, Corlett R T, Young L and Lee J S Y 1999 *Waterbirds* **22** 424-434
[17] Noor Y S, Umar, Mardiastuti A, Iqbal M and Gumilang R S 2020 *SIS Conservation* **2** 29-32
[18] Danielsen F, Purwoko A, Silvius M J, Skov H and Verheugt W 1991 *Kukila* **5** 133-135