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HABITAT AND NEST-SITE CHARACTERISTICS OF WATERBIRDS IN PULAU RAMBUT NATURE RESERVE, JAKARTA BAY, INDONESIA

By

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ABSTRACT

HABITAT AND NEST-SITE CHARACTERISTICS OF WATERBIRDS IN PULAU RAMBUT NATURE RESERVE, JAKARTA BAY, INDONESIA

By

Ani Mardiastuti Pakpahan

Habitat and nest-site selection of waterbirds in Pulau Rambut was studied to reveal interspecific differences and to identify the important features of this island that allow for its large and diverse population of avifauna.

Pulau Rambut is a small island in Jakarta Bay, chosen as a study site due to its large population of waterbirds. Characteristics of nest-sites were studied as well as time partitioning for breeding seasons. Field observations were conducted in January 1990 through November 1991.

There were 15 species of waterbirds breeding in Pulau Rambut: Egrets (5 species), Day Herons (2 species), Night Heron (1 species), Ibises (2 species), Darter (1 species), Stork (1 species), and Cormorants (3 species). These species formed 5 colonies, and each colony had a distinct habitat structure and group of waterbirds nesting on it.

Most species preferred nesting during the rainy season. However, some temporal stratification was observed, probably due to the availability and variety of foods. The overall population of waterbirds in Pulau Rambut showed a continuous breeding season.

Vertical stratification of nest sites was lacking. Waterbirds tended to chose sites on top of the canopy and further from the tree trunks, suggesting that the ground-based predator, the Monitor Lizard (*Varanus salvator*) were more threatening than aerial predators, namely Brahminy Kite (*Haliastur indus*) and White-bellied Sea Eagle (*Haliaeetus leucogaster*).

Selection of vegetation type was influenced by social interaction and physiognomic features of the environment. Social factors include behavior and daily habit, and congeneric avoidance due to similarity in morphology, physiology, behavior, and ecology. Physiognomic aspects included body size, and location within the heronry (center vs. edge).

Factor analyses revealed that there were 5 components which described waterbird nest-sites: nest placement, tree size, inter-nest distance, nest support, and stability, as a result of differences in body size, choice of general vegetation type, and degree of predation.

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I. INTRODUCTION

A. Background

The Principle of Competitive Exclusion states that no two species can occupy exactly the same niche. In situations where two closely related species occupy similar niches there must be something preventing one species from competitively excluding the other. Resource partitioning is one mechanism by which closely related species can co-exist (Hulsman 1987).

Many bird species have rather specific nest-site requirements. This is true for colonial seabirds and freshwater birds (Burger and Gochfeld 1981), which in mixed colonies often have distinct species-specific preferences (Cody 1985). Many colonies of seabirds and Ciconiiformes are mixed species colonies (Pyrovetsi and Crivelli 1988, Beaver *et al*. 1980, McCrimmon 1978, Jenni 1969), in which the limited resources have to be shared by many individuals and many species. In small but crowded island, such as Pulau Rambut in Jakarta Bay, Indonesia, differential division of the nest-site resources may reduce competition among species.

The study of habitat and nest-site selection of colonial birds on Pulau Rambut was important to reveal social factors and physiognomic features of the environment, and to identify the important features of this island that allow for the large and diverse population of avifauna.

Pulau Rambut is a small island (45 ha) located about 2½ km off the north coast of West Java, Indonesia, gazetted as a Nature Reserve since 1937. The island is an important habitat for waterbirds (long-legged wading birds and seabirds), mostly belonging to the family Ardeidae, Anhingidae, Threskiornithidae, and Phalacrocoracidae. It was chosen as a study site due to its large heronry.

Previous studies (Mahmud 1991, Wiriosoepartho 1982) revealed that the mangrove forest of Pulau Rambut was very important waterbird habitat, especially for roosting and nesting sites. Unfortunately, the mangrove forest of Pulau Rambut was not in good condition. There has been a die-back of mangrove in the last decade (Hermana 1991), which could severely affect the survival of the waterbirds. Considering this situation, the overall condition and die-back of mangrove was also of special interest in this study.

In addition, Pulau Rambut also faces many problems and threats, which could influence the survival of the entire ecosystem due to the unfortunate location of the island in the Jakarta Bay area. Therefore, threats and problems were also identified.

B. Objectives

This study examined habitat and nest site selection in waterbirds in Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia. Field observations were conducted between January 1990 and November 1991.

Colonies using mangrove forests, and specifically 9 species (Purple Heron (*Ardea purpurea*), Grey Heron (*A. cinerea*), Great Egret (*Egretta alba*), Little Egret (*E. garzetta*), Cattle Egret (*Bubulcus ibis*), Black-crowned Night Heron (*Nycticorax nycticorax*), Glossy Ibis (*Plegadis falcinellus*), Little Black Cormorant (*Phalacrocorax sulcirostris*), and Pygmy Cormorant (*P. pygmaeus*) were examined in detail. Characteristics of nest placement and dispersion in relation to vegetation in the colony were also studied.

Since almost all waterbirds nested in the mangrove forest, this vegetation type was the primary focus of this study. Other forest types (i.e., mixed-dryland forest and beach forest) were also observed, but quantitative measurement was not conducted.

Time of breeding was recorded to reveal the temporal partitioning among species under study. Nesting association was also studied to obtain information on colony formation. Social interactions were not directly examined, but their possible role in spacing of nests and choice of nesting sites were discussed.

Since the waterbirds in the island were under heavy stresses, and since Pulau Rambut is the main breeding site in Jakarta Bay, problems and threats to the entire ecosystem were also examined. Some suggestions for managing the habitats and populations of birds are presented.

C. Definitions

The term 'habitat' in this study refers to a specific set of requirements needed by a species to exist. Habitat for each species includes areas for roosting, nesting, and conducting other activities related to breeding (e.g. display, pair formation, mating, incubating, feeding, etc.). Feeding sites were excluded from analysis since feeding grounds were located off the island.

Nest-site was defined as a certain place, more specifically a tree, where a waterbird chose to nest, including a specific site where a nest was placed. The characteristics of a certain species' nest were explained by variables described later (Chapter 3, Table 2).

Herons, ibises, and storks usually are categorized by some authors (Lack 1968, Wiese 1978, Faaborg 1988) as wading birds, while cormorants are categorized as seabirds (Ashmole 1971, Furness and Monaghan 1987, Hosking and Lockley 1983, Nelson 1978). The distinction between seabirds and freshwater birds is rather arbitrary since several groups of birds are found in both fresh and seawater. Terns, gulls and cormorants, which are generally considered as seabirds, often live in freshwater, while herons sometimes fish along the seashore (Burton 1985). In this study, 5 groups of birds, i.e., heron (family Ardeidae), ibis (family Threskiornithidae), stork (family Ciconiidae), darter (family Anhingidae), and cormorant (family Phalacrocoracidae) were categorized as waterbirds.

Other definitions of terms used in this study are as follows:

Group - two or more individuals of bird species which nest closely together; they might belong to the same species (conspecific group) or different species (mixed-group).

Colony - a geographically continuous group of breeding birds whose territorial boundaries are continuous (Travelpiece and Volkman 1979); a colony contains several groups of bird species.

Heronry - a geographical area that contains one or more colonies of breeding waterbirds; in this study, the heronry included the entire island of Pulau Rambut.

II. STUDY AREA DESCRIPTION

A. History and Location

It was long recognized that Pulau Rambut (which means 'hair island', and used to be called Middelburg Island) was a habitat for various waterbirds and some unique corals. Recognizing its highly valuable resources, Pulau Rambut was gazetted as a Nature Reserve on May 3, 1937 by Dutch Governor Decree No. 7/1937. Later, the Government of Indonesia reinstated its status by issuing a Government Decree No. 11/I/20 dated May 28, 1970. More recently, it has been identified as one of the most important waterbird breeding sites in Java (Silvius *et al*. 1987).

Pulau Rambut Nature Reserve (106°31'30"E, 5°57'S) was chosen as the study area because of its large heronry (Fig. 1). When gazetted as a Nature Reserve in 1937, the island had an area of 25 ha. Later, a more careful measurement revealed that the size of the island is about 45 ha. During the lowest tide the size of Pulau Rambut is 65.2 ha, while during the highest tide it covers an area of 44.0 ha. The island is one of the 'One Thousand

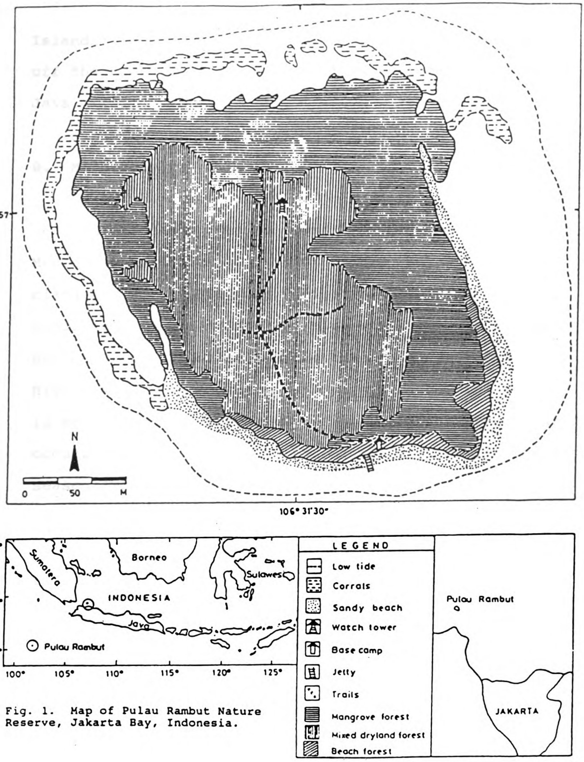


Fig. 1. Map of Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia.

Islands' in the Jakarta Bay area, Indonesia, about 2.5 km off the north coast of Tanjung Pasir, Tangerang, West Java.

B. Meteorology

In Indonesia, the monsoons (known as West and East Monsoons) have a strong impact on the weather and the climate. During the West Monsoon (December-March), the winds come from the west and blow eastward. This eastward motion of the winds is because the air masses move from high pressure in the Asian atmosphere. The West Monsoon is marked by high precipitation (the highest precipitation occurs in January) and is, therefore, also called the wet season (Nontji 1987). Average precipitation in Jakarta Bay reaches about 330 mm in January.

In the East Monsoon (May-September) the winds come from the east and move westward. The westward motion is caused by the movement of the air masses from high pressure areas in the Australian atmosphere to the lower pressure areas in the Asian atmosphere. Precipitation in this monsoon is low, and it is, therefore, called the dry season. Minimum precipitation occurs in July and August.

In between these two monsoons is a period called the Transition Period. March through May is called Transition Period I (transition from West to East Monsoon), whereas

September through November is called Transition Period II (transition from East to West monsoon). Winds in this period are irregular and wind speeds low. Average wind speed during the entire season varies between 3 and 30 km/hr. However, high wind speeds can reach 50 km/hr.

Total annual rainfall in this area is in accordance with the movements of the above winds (Table 1), with the higher rainfall (usually in January) during the West Monsoon period. During the East Monsoon period (usually in August), the lowest rainfall occurs.

The total rainfall starts increasing in the second Transitional Period, i.e., in September. Furthermore, the total annual rainfall in this area is only 1,700 mm although in the northern part of the area the total rainfall may reach up to 5,000 mm.

The monthly average temperature in the Jakarta Bay area ranges between 23°C - 32°C, and the temperature during the dry season is higher than during the rainy season. The relative humidity level is between 80% - 90%.

Table 1. Meteorological data for Jakarta observatory, Jakarta Bay, Indonesia, January 1990-June 1991.

Month	Mean Temperature (°C)	Total Rainfall (mm)	Relative Humidity (%)	Wind Direct-ion	Wind Velocity (m/sec)
Jan 90	26.1	425.8	86	W	1.7
Feb	27.3	98.0	82	N	1.8
Mar	27.5	103.4	80	W	2.0
Apr	28.5	134.9	77	N	1.9
May	28.3	63.3	75	E	1.8
Jun	27.9	95.7	73	E	1.8
Jul	27.6	31.9	71	E	2.1
Aug	27.2	303.8	76	N	1.7
Sep	28.1	5.4	68	N	2.2
Oct	28.4	62.6	68	N	2.1
Nov	28.3	49.1	71	N	1.8
Dec	26.7	225.5	80	W	1.8
Jan 91	26.6	293.9	80	W	1.9
Feb	26.3	257.8	82	W	2.1
Mar	*	286.1	*	*	*
Apr	*	252.2	*	*	*
May	*	4.3	*	*	*
Jun	*	1.4	*	*	*

* data not yet available

Source: Meteorological and Geophysical Agency, Department of Communication

C. Topography

The shape of Pulau Rambut is almost round and consists of dry lowland and inundated mangrove area. The whole island is more or less flat, with the altitude between 0-1.75 m from the sea surface. The highest site is at the southeast, the middle island is less than 1 m high, while the north is about 0.75-1 m high. The soil basically consists of decayed corals.

D. Terrestrial Flora and Fauna

Vegetation of the island can be categorized into 3 formations: coastal/beach forest, mixed-dryland forest, and mangrove forest (Fig. 1). The coastal/beach forest is covered with grasses, shrubs, and trees such as *Ipomoea pes-caprae, Sesuvium portulacastrum, Wedelia biflora, Acacia auriculiformis*, and *Leucaena glauca*.

The mixed-dryland forest located at the central part of the island, covers about 20 ha of land. The upper canopy is dominated by *Sterculia foetida* and the middle canopy is dominated by *Dyxoxylum caulostachyum*. Other tree species in the middle canopy are *Schleichera oleosa, Adenanthera pavonina, Ficus timorensis, Diospyros maritima, Guettarda speciosa*, and *Melia azedarach*. The lowest canopy is a thick layer of *Triphasia trifolia*.

The mangrove forest consists of a primary ('true') mangrove, which is always inundated by tides, and secondary ('back') mangrove, which is inundated only by high tides. Primary mangrove is dominated by *Rhizophora mucronata* and *R. stylosa*. Other species of mangroves are *Sonneratia alba, Bruguiera gymnorrhiza*, and *Avicennia alba*. The secondary mangrove mostly consists of *Ceriops tagal, Xylocarpus granatum, X. moluccensis, Scyphiphora hydrophyllacea* and *Excoecaria agallocha*.

Waterbirds are the main inhabitants of the island. The heronry during the study was inhabited by Grey Heron, Purple Heron, Black-crowned Night Heron, Great Egret, Plumed Egret (*E. intermedia*), Pacific Reef Egret (*E. sacra*), Little Egret, Little Black Cormorant, Pygmy Cormorant, Oriental Darter (*Anhinga melanogaster*), Milky stork (*Mycteria cinerea*), Black-headed Ibis (*Threskiornis melanocephallus*), and Glossy Ibis. All herons, egrets, cormorants, and ibises used either mixed-dryland forest or mangrove forest as their nesting site during the study.

Other birds (non-waterbirds) were also found in the island, e.g., Brahminy Kite (*Haliastur indus*), Whimbrel (*Numenius phaeopus*), Black-napped Oriole (*Oriolus chinensis*), Pied Imperial Pigeon (*Ducula bicolor*), Small Blue Kingfisher (*Alcedo caerulescens*), Magpie Robin (*Copsychus saularis*), and Brown-throated Sunbird (*Anthreptes malacensis*). In addition, the island also supports Monitor Lizards (*Varanus salvator*), Reticulated Phyton (*Phyton reticulata*), Mangrove Snakes (*Boiga dendrophila*), and Flying Foxes (*Pteropus vampyrus*). Complete lists of flora and fauna of the island are presented in Appendix 1 and 2.

III. METHODS

A. Population Size

The waterbirds of Pulau Rambut search food outside the island, mainly along the northern coast of western Java (i.e., south and southeast of Pulau Rambut). The estimates of the number of waterbirds in Pulau Rambut were based on counts of birds leaving the island in the morning (or coming back to the island in late afternoon) plus counts of the birds staying on the island (mostly incubating birds).

Morning counts were made between 5:15 and 7:00 am. Almost all diurnal waterbirds leave the island during that time. Waterbirds coming home were also counted between 5:15 pm until dark, usually about 6:30 pm. Counts were done by two observers on the southeast of the island, with one observer counting waterbirds flying south and the other counting waterbirds flying east and southeast. To minimize bias, the two observers were checked for consistency before counts. Counts were not conducted during the worst monsoons and whenever winds were too strong. During these times, most birds preferred to stay on the island. Countings were done about 60 times during the study.

Using this technique most waterbirds were counted except for those which stayed on the island or birds that left the island (or returned) outside the time of counting. To estimate the number of waterbirds staying on the island, five additional observation sites were established (two stations in the mixed-dryland forest, two others in the mangrove forest, and a fifth station at the watch tower). Smaller waterbirds, such as Cattle Egret, Little Egret, and Black-crowned Night Heron, were well hidden among the thick canopy. To count them, they were forced to fly away. In this way, almost all of the waterbirds were counted, but this technique created many accidents for eggs and small birds. Because of that, the flush technique was only conducted a few times, to estimate the percentage of the waterbirds remaining on the island.

However, it was still not possible to accurately record all waterbirds, since many of them might not have been observed during the morning/late afternoon counts or in the flush count. Therefore, the population of waterbirds was probably underestimated.

B. Nest Distribution

The distribution of birds' nests (or roosts) in the entire colony was observed directly every month or whenever the previous pattern of distribution changed. Selected plots of 20 x 20 were used to monitor the presence and absence of breeding groups. Maps were used to record the location of breeding groups. However, symbols used in the maps did not reflect the abundance of the waterbirds.

The mixed-dryland forest was covered with dense vegetation in 4 layers: upper canopy, middle canopy, lower canopy, and ground cover (Dinas Kehutanan 1988) and was difficult to walk through. To make checking easier, some fixed trails which reached all available Sterculia tree were established by clearing of the lower canopy (mostly Triphasia). The trails were marked by a bright-colored ribbons and were cleared whenever necessary. All areas in the mangrove forest, on the other hand, were accessible and therefore, no specific trails were established.

C. Breeding Season

Waterbird breeding periods were monitored throughout this study. A species was considered to be in a high breeding season when more than 25% of the population (i.e., more than 50% of breeding pairs) were nesting. A species was considered to be in a low breeding season when fewer than 10% of the population were nesting. In this study, breeding season was considered to be started when the majority of the waterbirds were building nests, and over when their young were not observed on the nests anymore.

The same trails for the distribution study were also used to check breeding status. The time when a waterbird species bred was noted and drawn in a simple graph. Rainfall might have a major impact on breeding herons (Lowe-McConnel 1976) and thus was of concern here. Rainfall patterns in the Jakarta area were analyzed using data collected monthly by the Meteorological and Geophysical Agency, Department of Communication. The Meteorological and Geophysical Agency has a number of rain gauges located throughout Jakarta and the Jakarta Bay area. Unfortunately, there was always some delay in data gathering. Therefore, the latest data available were up to June, 1991.

D. Nesting Association

Three representative locations were chosen within the heronry. These locations were: (a) mixed dryland forest, (b) primary mangrove forest (which were always inundated by tides), and (c) secondary mangrove forest (which were inundated only by a high tide). Using a nesting tree as a sample unit, species nesting in the tree were recorded. For the purposes of this study, it was assumed that any bird species occupying the same tree as another species was nesting in association with that species.

Because the parents always flew away upon human approach, identification of nests was based on its general appearance, its chicks, and/or its eggs. These observations were done during June-October 1990.

The associations between pairs of species were tested using a Chi-square (Pielou 1974) . The hypothesis was that there were no associations between species. A 2 x 2 table was set up in order to make the calculation. The calculated Chi-square was compared with the Chi-square distribution table with 1 degree of freedom (i.e., 3.48 for a 5% significant test and 6.63 for a 1% significant test).

E. Nest-Site Characteristics

Locations for the study of nest-site selection were in the mangrove area, since most (more than 80%) of the waterbirds were using this site. Oriental Darter was the only resident species which never used the mangrove forest for nesting sites. Therefore, this species was excluded from the nest-site characteristics study. Milky Stork and the Black-headed Ibis were seasonal resident species and their numbers were too limited to be included in the sample.

Availability of nest trees was examined through vegetation analysis. Selection for preferred tree genera was compared to availability of trees using Chi-square tests. Nests built or reoccupied were selected randomly and identified as to species. In almost all cases, nests could be identified to species. If necessary, nests were also re-examined and the species determined after the young hatched, based on the morphological characteristics of the young.

Fifteen nest-site characteristics (Table 2) were quantified in both years for 9 species of waterbirds nesting in Pulau Rambut during those years. Distances and mean diameter of nest tree crown were measured using a 20-m measuring tape. Measurements of diameter were conducted using a 1.5 m measuring tape.

Nest trees were marked by using bright-colored ribbons to avoid duplication. To reduce the number of dimensions for description and comparison of nest-sites of the 9 species, a factor analysis was performed using data (data for both years combined) of all species. VARIMAX rotation was used to aid in interpreting common factors. Mean vectors for each species of bird along each factor were calculated and plotted to reveal nest-site patterns for individual species of waterbirds. All statistical analyses were accomplished by using the SAS/PC package.

Table 2. Variables used to characterize the nest-site of waterbirds in Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia.

No.	Code	Meaning
1	HTREE	Height of nest tree (m)
2	HTRUNK	Height of rhizophore/pneumatophore roots(m)
3	DIATREE	Diameter of nest tree (cm)
4	DISTREE	Distance from nest tree to the nearest used tree (m)
5	DISEDG	Distance from the nest tree to the nearest island edge (m)
6	DISFORM	Distance from the nest to the nearest different vegetation type (m)
7	CROWN	Mean diameter of nest tree crown (m)
8	NNEST	Number of nests in a nest tree
9	HNEST	Height of nest (m)
10	DIANEST	Diameter of the largest support branch (cm)
11	DISIN	Distance from nest to tree trunk (m)
12	DISOUT	Distance from nest to canopy periphery (m)
13	NBR	Number of support branches
14	DISBNEST	Distance to the nearest nest at the same nest tree (m)
15	TOP	Distance to canopy top (m)

F. Analysis of Vegetation and Die-back Mapping

Vegetation analysis was conducted to reveal the structure and condition of the mangrove forest as the main vegetation type for the waterbirds. To do this, 13 strips (10 m wide), placed systematically from random starting points, were chosen as samples of the mangroves. The strips were 10 m wide, distributed throughout the mangrove areas, and were perpendicular to the seashore. Sampling plots were established within these strips. Plots were 20 m apart, and were nested for three size classes: trees (plot size 10 x 10 m), saplings (plot size 5 x 5 m), and seedlings (plot size 2 x 2 m).

Mature trees, saplings and seedlings were defined as follows:

Trees: woody vegetation having diameter at breast height of 10 cm or greater (measured at 1.30 m from the forest floor or 20 cm above rhizophore).

Saplings: young woody vegetation having diameter at breast height less than 10 cm but having height more than 1.5 m.

Seedlings: young woody vegetation with height less than 1.5 m.

The Importance Value was used to quantify occurrence of the vegetation, i.e., by adding up the relative density, relative frequency, and relative dominance. The calculation of these values were as follows (Kershaw 1966):

$$\text{Relative density} = \frac{\text{Number of individual of species}}{\text{Total number of individual of all species}} \times 100$$

$$\text{Relative frequency} = \frac{\text{Frequency of species x}}{\text{Sum of frequency values of all species}} \times 100$$

$$\text{Relative dominance} = \frac{\text{Dominance of species x}}{\text{Sum of dominance values of all species}} \times 100$$

Frequency was defined as the percentage occurrence of a species in a total sample, density was defined as the total number of individuals of a species relative to the total area examined, and dominance was expressed as basal area (Kershaw 1966).

In addition, colonies used by waterbirds were examined to reveal the profile diagram of vegetation. To do this, narrow strips (2 m width) were established in representative sites. Vegetation species, height, and diameter were measured and their locations from the starting point were recorded.

Height of tree species was measured using a Haga altimeter, and diameter was measured by a 1.5 m measuring tape, rounded to the nearest cm. Distances were measured using a-20 m measuring tape, rounded to the nearest m.

The die-back of mangrove forest was identified in the field and mapped by using a compass. Distances were measured using a-20 m measuring tape. The watch tower was used as a reference point. A tree was considered to be dead or dying if its remaining foliage was only 10% or less. The die-back coverage on the map was measured using a planimeter to reveal the total die-back coverage.

IV. RESULTS

A. Waterbird Species

There were 15 species of waterbirds nesting in Pulau Rambut during the study (Table 3), mostly belonging to the Heron family (Ardeidae) and Cormorant family (Phalacrocoracidae). Others were Darter (family Anhingidae), Stork (Ciconiidae), and Ibises (Threskiornithidae).

The highest abundance was obtained by the Black-crowned Night Heron, followed by both species of Cormorants and the mixed egret (5 species). Three species, namely Milky Stork, Glossy Ibis, and Black-headed Ibis, were considered seasonal resident birds. Among these three seasonal residents, Glossy Ibis had the highest abundance, followed by Milky Stork and Black-headed Ibis (Table 4). Reef Egret and Pied Cormorant were excluded from the table due to their very low number (maximum number was 4 and 1, respectively). Monthly number of these species is presented in Fig. 2 and Appendix 3.

Table 3. Waterbirds nesting in Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

Family	Species	Common Name
Anhingidae	*Anhinga melanogaster*	Oriental Darter
Ardeidae	*Ardea cinerea*	Grey Heron
	A. purpurea	Purple Heron
	Egretta alba	Great Egret
	E. garzetta	Little Egret
	E. intermedia	Plumed Egret
	E. sacra	Reef Egret
	Bubulcus ibis	Cattle Egret
	Nycticorax nycticorax	Black-crowned Night Heron
Ciconiidae	*Mycteria cinerea*	Milky Stork
Phalacro-coracidae	*Phalacrocorax pygmaeus*	Pygmy Cormorant
	P. sulcirostris	Little Black Cormorant
	P. melanoleucus	Pied Cormorant
Threskior-nithidae	*Plegadis falcinellus*	Glossy Ibis
	Threskiornis melanocephalus	Black-headed Ibis

Table 4. Species composition in Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

Species	Population Range (min-max)	Percentage[a]
Black-crowned Night Heron	1666-9122	38.23
Cormorants (2 species)	2222-6883	28.85
Mixed Egrets (4 species)	260-5267	22.07
Purple Heron	94-1136	4.76
Oriental Darter	131-328	1.37
Grey Heron	83-315	1.32
Glossy Ibis	0-729	3.06
Milky Stork	0-56	0.23
Black-headed Ibis	0-31	0.11
Total	4456-23822	

[a]calculated from the maximum abundance, when the peak breeding season occured

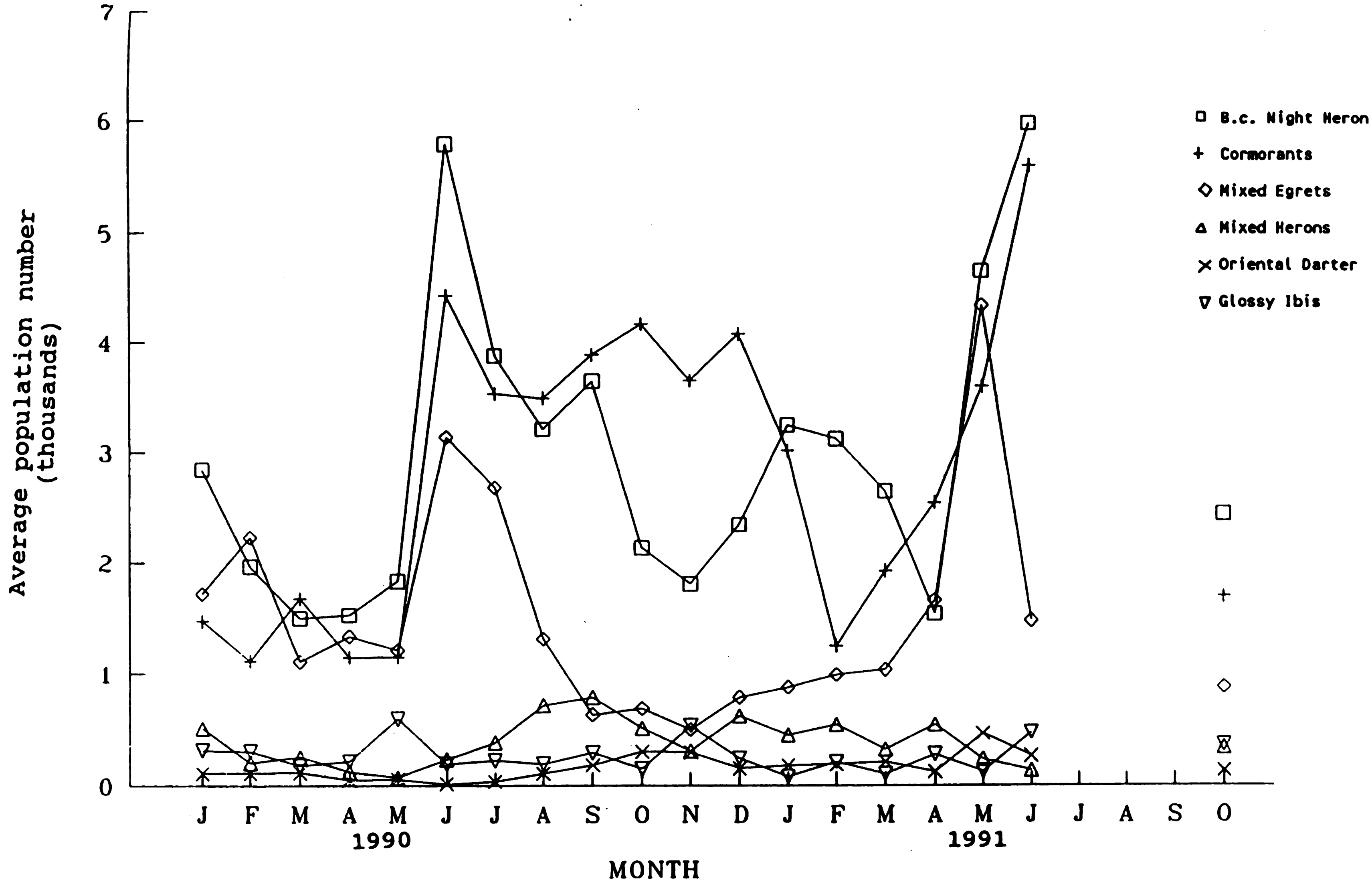


Fig. 2. Population trend of 6 group species of waterbirds in Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991 (data for July through September 1991 were not available).

B. Diurnal and Annual Rhythm

The number of waterbirds on the island varied greatly by time of day, with peak use from late evening through early morning. In daytime most of the birds were foraging either at sea or in wetlands in the northern coasts of the mainland (Java). In the evening they roosted on the island in large flocks. Early in the morning, before sunrise, they disappeared again to their foraging grounds.

There was also high variation of species and numbers throughout the year, with the greatest abundance usually occurring during June-July and the lowest abundance in November-December, coinciding with the worst West Monsoon season.

The seasonal resident species (Milky Stork, Glossy Ibis, and Black-headed Ibis), came to the island to breed, and soon after their young were able to fly, left the island. During 1990-1991, they arrived on the island in February and left in October-November.

Cattle Egret was probably also a seasonal resident. During its breeding season, this species was found breeding on the island. After the breeding season, its buff-colored feathers on the head and neck disappeared, making it difficult to distinguish from the other small-sized egret, i.e., the Little Egret. However, the low abundance of small-sized egrets during the non-breeding season suggested that the Cattle Egret was not on the island at that time.

C. Breeding Seasons

Birds in the tropics usually have breeding seasons coinciding with the onset of the rain. The relationship between the breeding season and rainfall in Pulau Rambut is shown in Fig. 3, in which the monthly rainfall and breeding season are plotted together. Among these waterbirds, the breeding seasons were considerably spread out. Although there were peaks of breeding activity in the rains, some species (i.e., Little Egret) started to nest just as the majority had almost finished rearing their young. There was also a good deal of variation from year to year, with 1990 being a "compact season" while in 1991 breeding activities were more spread out. This was probably due to the fact that the rainy season of 1990 was concentrated in January and December.

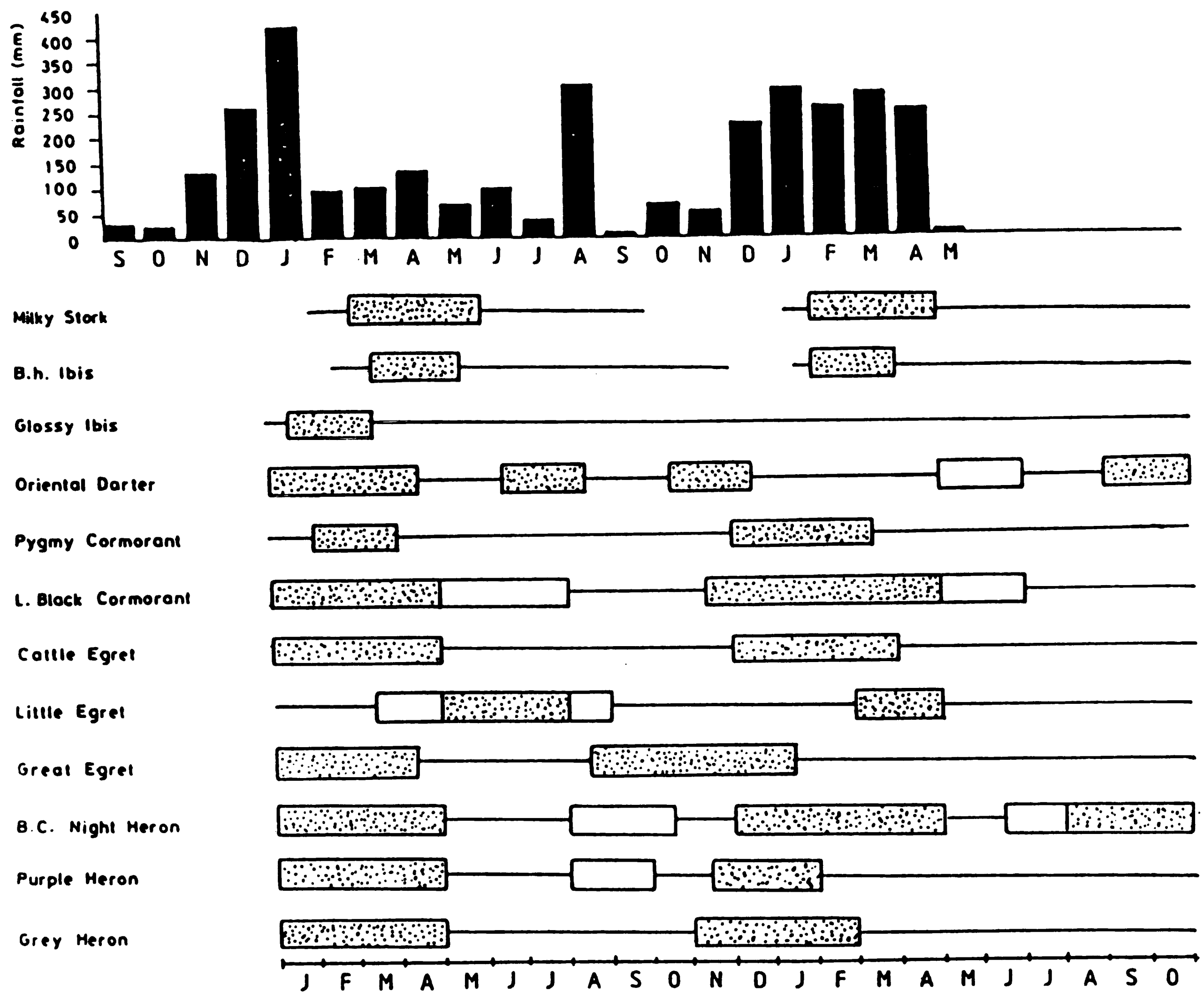


Fig. 3. Breeding season of waterbirds in Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991 (—— present, ▭ low breeding season, ▩ high breeding season).

In both years, Black-crowned Night Heron, Oriental Darter, and Little Black Cormorant had two peak nesting periods a year, in the main rains between December and April, and again during May-July (Oriental Darter and Little Black Cormorant) or August-September (Black-crowned Night Heron). Whether the same individuals bred in both seasons is not known since no marking or banding was done. Purple Herons had the same patterns of dual nesting periods in 1990, but in 1991 this species only had one nesting period.

Fig. 3 also shows that the time of nesting varied from year to year with the onset of the rains. However, when the observations started in January 1990, breeding was already in progress. Thus, direct comparisons with the 1991 breeding season were not possible.

D. Nest-Site Distributions

Distribution of nest-sites were not fixed. Rather, they were constantly changing. During the 2-year study, the overall distribution of nest-sites was changed 13 times (Appendix 4 through Appendix 16).

The dynamic change of the nest-site distribution can be summarized as follows:

(a) Based on location, there were 5 distinct colonies of waterbird in Pulau Rambut heronry: Colony A, Colony B (consisted of Colony B-1 and B-2), Colony C, Colony D, and Colony E; Fig. 4). Each colony had a distinct habitat structure and distinct group of waterbirds nesting on it.

(b) The waterbirds seldom used all these 5 colonies at the same time. Most of the time, they only used 3 or 4 colonies for nesting.

(c) There were two colonies used intensively all the time, i.e., Colony C and E, although within each colony the distribution of nest-sites also changed over time. The other 3 colonies (Colony A, B, and D) were used intermitently.

(d) There were some places which were never used as nesting sites, i.e., the beach forest in the south and west side of the island. Birds using this vegetation type were restricted to the smaller birds such as Brown-throated Sunbird, Magpie Robin, Black-napped Oriole, and Scarlet-headed Flowerpecker (*Dicaeum trochileum*).

(e) When comparing the same month for both years, nest-site distributions in 1990 were very different than in 1991. Colony A, for example, was never used until October 1990, after which it was used continuously until the end of the study. The east

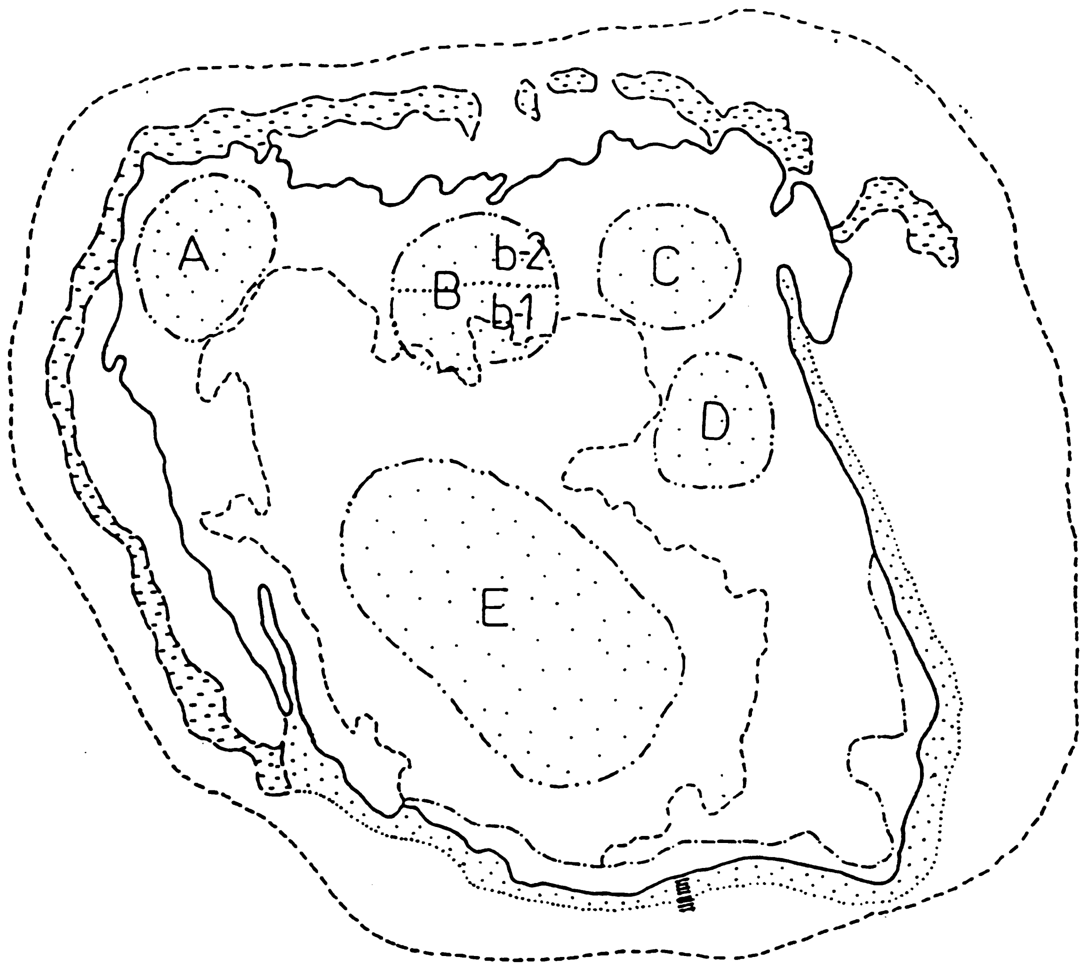


Fig. 4. Five colonies of waterbirds (A, B, C, D, and E) in Pulau Rambut heronry, Jakarta Bay, Indonesia, 1990-1991.

side of the heronry was used only in February 1990, and never used again after that.

E. Nesting Association

As expected, there were positive and negative associations between pairs of species. Table 5 and Appendix 17 show the results of a Chi-square test on the presence and absence of species in each of the occupied trees.

There was a highly positive significant association between (a) Purple Heron and Great Egret, (b) Grey Heron and Oriental Darter, (c) Grey Heron and Milky Stork, (d) Little Black Cormorant and Little Egret, and (e) Cormorant and Glossy Ibis. Negative and non-significant associations were found between congeneric species (i.e., Purple Heron-Grey Heron, Great Egret-Little Egret).

Table 5. Nesting association among pairs of waterbirds in Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

	Grey Heron	Great Egret	Little Egret	L. B. Cormorant	B.c. Night Heron	Oriental Darter	Milky Stork	Glossy Ibis
Purple Heron	0	**	*	0	ns	0	0	0
Grey Heron		ns	0	0	*	**	**	0
Great Egret			ns	0	ns	ns	0	0
Little Egret				**	ns	0	0	ns
L. B. Cormorant					*	0	0	**
Black-crowned Night Heron						ns	ns	ns
Oriental Darter							ns	0
Milky Stork								0
Glossy Ibis								

** : highly significant association ($P < 0.01$)
* : significant association ($P < 0.05$)
ns : there is no significant association
0 : negative association

F. Nest-Site Characteristics of Each Colony

1. Nest-Site Characteristics in Colony A

Habitat Structure. This area consisted of secondary mangrove, covered by a young stand of *Ceriops tagal* and *Rhizophora mucronata* (Table 6). *C. tagal* was dominant and in the process of rapid growth, where natural thinning was still in progress. The average density of *C. tagal* was very high, 1200 trees/ha. *R. mucronata* trees were scattered among *C. tagal* stands, with an average density of only 240 trees/ha. The canopy was low (average tree height was 5.85 m), uniform, continuous, and dense (Fig. 5).

Table 6. Importance Value (IV) of trees in Colony A, Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

Species	Density (trees/ha)	% Relative Density	Dominance (m^2/ha)	% Relative Dominance	Frequency	% Relative Frequency	IV
C. tagal	1200	83.33	0.1545	58.54	1.00	55.56	197.43
R. mucronata	240	16.67	0.1094	41.46	0.80	44.44	102.57

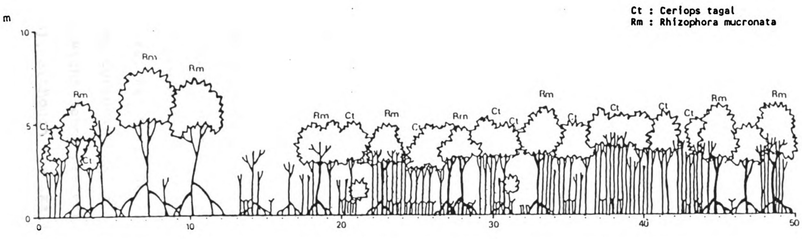


Fig. 5. Profile diagram of vegetation in Colony A, Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

Nesting Waterbirds. The colony was used by waterbirds from October 1990 until the end of field observation (November 1991). The colony consisted of Great Egret, Cattle Egret, Little Egret, Black-crowned Night Heron, Purple Heron, and Pygmy Cormorant.

The location was not occupied before October 1990, therefore, the sequence of nesting could be monitored. Purple Heron was the first arrival, followed by Great Egret. Both species occupied the upper canopy of *C. tagal-R. mucronata*. The Pygmy Cormorant was the next, filling up the middle canopy. Later on, Black-crowned Night Heron and Cattle Egret joined the colony, occupying the middle canopy, After most of the species completed their breeding season, Little Egrets arrived and began to nest. Nest-site characteristics of Little Egret in this colony were not measured since at the time of Little Egret nesting, the colony was not fully occupied.

Nest-Tree Selection. As mentioned, tree species present in this colony were *C. tagal* and *R. mucronata*. There was a strong preference for nest trees shown by Purple Heron (X^2=347.46, P<0.001), Great Egret (X^2=89.8613, P<0.001), and Pygmy Cormorant (X^2=60.39, P<0.001) (Table 7). Black-crowned Night Heron preferred *R. mucronata* (X^2=10.80, P<0.005), although the small sample size (n=6) made it

Table 7. Nest-tree preference by waterbirds in Colony A, Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

Bird species	Number of nests	Number of nests on	
		R. mucronata (%)	*C. tagal* (%)
Purple Heron	94	83 (88.30)	11 (11.70)
Great Egret	100	52 (52.00)	48 (48.00)
Pygmy Cormorant	56	31 (55.36)	25 (44.64)
Black-crowned Night Heron	6	4 (66.67)	2 (33.33)
Cattle Egret	20	4 (20.00)	16 (80.00)
Total	276	174 (63.04)	102 (36.96)

difficult to draw reliable conclusions, while Cattle Egrets showed no preference for nesting trees (X^2=0.16, P>0.05).

The tree architecture of *R. mucronata* and *C. tagal* were very different. *R. mucronata* had spreading branches and crown (mean crown diameter was 2.43 m), possessed tough twigs, and many crotches. This tree species was able to hold up to 16 nests (average 4.24 nests/tree). In contrast, the crown of *C. tagal* was slim, with pliable twigs. Basically there was only one main trunk, and therefore, crotches and forks of limbs were less available. As a result, *C. tagal* was able to hold significantly (P<0.001) fewer nests compared to *R. mucronata* (maximum 3 nests/tree, average 1.16 nests/tree).

Nest Placement. Nests were placed between 4.50 m to 5.54 m above the heronry floor (Table 8). *R. mucronata* trees (average height 6.19 m, SD 0.77 m) were significantly ($t=-7.05$, $P<0.0001$) higher than *C. tagal* (average height 5.14 m, SD 0.76 m). Nests built on *R. mucronata* were also significantly higher ($t=-9.79$, $P<0.0001$) than those on *C. tagal*, suggesting that the height of nests depended on the nest tree.

The distance from nests to the top of the canopy also showed significant differences ($F= 40.76$, $P<0.0001$), so did the distance from nests to the edge of crown ($F= 48.12$, $P<0.0001$). Purple Heron and Great Egret tended to choose high places, at the top of the canopy (less than 1 m under the tree canopy). The other three species chose the middle canopy (more than 1 m under the tree canopy of *R. mucronata*). All of these waterbirds selected sites from the mid- to outer regions of the tree canopy.

Table 8. Nest-site placement of waterbirds in Colony A, Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991. Values in brackets are SDs.

Bird species	Nest tree species	Nest height (m)	Distance from nest to		
			Tree trunk (m)	Canopy edge (m)	Top of crown (m)
Purple Heron	R. mucronata	5.54 (0.55)	1.13 (0.54)	0.92 (0.59)	0.75 (0.45)
	C. tagal	4.77 (0.48)	0.83 (1.37)	0.44 (0.19)	0.29 (0.14)
Great Egret	R. mucronata	5.34 (0.49)	1.11 (0.55)	1.00 (0.56)	0.84 (0.50)
	C. tagal	4.50 (0.50)	0.53 (0.60)	0.56 (0.70)	0.34 (0.23)
Pygmy Cormorant	R. mucronata	5.24 (0.64)	1.52 (0.73)	0.85 (0.46)	1.78 (0.85)
	C. tagal	4.86 (0.60)	0.54 (0.33)	0.37 (0.21)	0.55 (0.16)
Black-crowned Night Heron	R. mucronata	5.13 (1.14)	1.18 (0.54)	1.23 (0.59)	1.38 (0.22)
	C. tagal	4.75 (0.50)	0.40 (0.10)	0.38 (0.25)	0.50 (0.25)
Cattle Egret	R. mucronata	5.50 (0.92)	2.29 (1.17)	0.95 (0.48)	1.00 (0.59)
	C. tagal	4.90 (0.62)	0.60 (0.37)	0.39 (0.18)	1.10 (0.45)

2. Nest-Site Characteristics in Colony B-1

Habitat Structure. Colony B-1 consisted of secondary mangrove, inundated by seawater at high tides only. Tree species in this area were much more diverse than other parts of the mangrove forest, and consisted of: *C. tagal, S. hydrophyllacea, P. acidula, R. mucronata, E. agallocha, X. moluccensis, X. granatum*, and *H. littoralis*.

The most dominant tree was *C. tagal*, followed by *S. hydrophyllacea* and *P. acidula* (Table 9). *H. littoralis* was found only in some places along the ecotone between the mangrove forest and the mixed-dryland forest. Plot samples failed to include this species, so the quantitative measurement of its importance was not computed, although it obviously had a small importance value.

In contrast to Colony A, the canopy of Colony B-1 was less continuous (Fig. 6). Height of trees was highly variable. All strata but ground cover could be found in this colony. Ferns and epiphytes were also present.

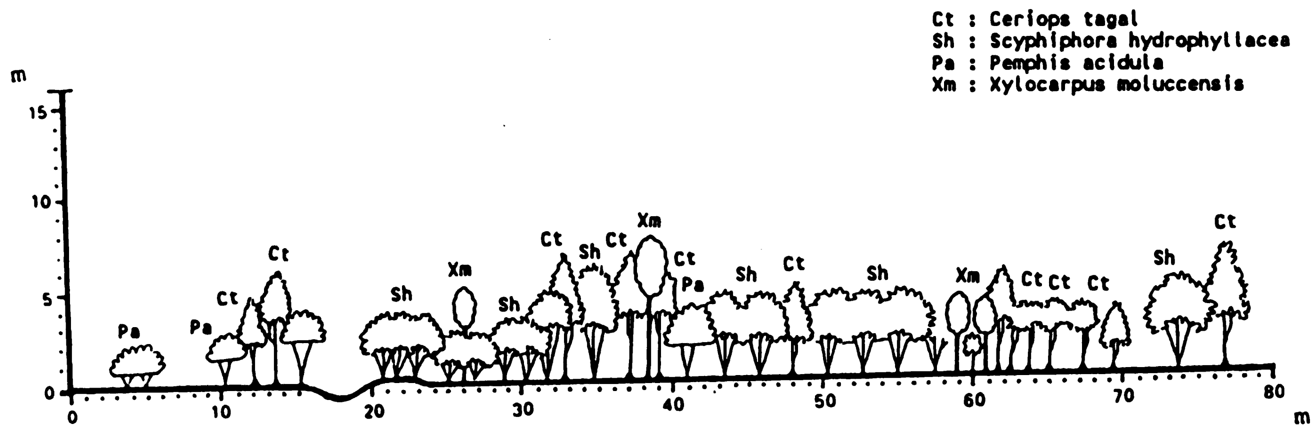


Fig. 6. Profile diagram of vegetation in Colony B-1, Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

Table 9. Importance Value (IV) of trees in Colony B-1, Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

Species	Density (trees/ha)	% Relative Density	Dominance (m^2/ha)	% Relative Dominance	Frequency	% Relative Frequency	IV
C. tagal	514	54.56	1.8571	31.57	0.7142	26.31	112.44
Scyphiphora hydrophyllacea	214	22.72	0.9871	16.78	0.5714	21.05	60.55
Pemphis acidula	85	9.03	1.4747	25.08	0.4286	15.79	49.90
R. mucronata	43	4.56	0.8229	13.99	0.2857	10.53	29.08
Excoecaria agallocha	43	4.56	0.3486	5.93	0.2857	10.53	21.02
Xylocarpus moluccensis	29	3.08	0.0714	1.21	0.2857	10.53	14.82
X. granatum	14	1.49	0.3200	5.44	0.1429	5.26	12.19

Nesting Waterbirds. Waterbird species utilizing this site were Great Egret, Little Egret, Black-crowned Night Heron, Purple Heron, and Pygmy Cormorant. The colony was used intensively during the 1990 breeding season.

Colony A, in contrast, was used intensively during the 1991 breeding season. Further, the species using Colony B-1 were the same as Colony A. This suggested that Colony A (in 1991) and Colony B-1 (in 1990) were functionally the same.

Nest-Tree Selection. Among the tree species present in this location, *P. acidula* was a small tree or shrub (3 m height), with tiny foliage and brittle twigs, lacking crotches and forked limbs. *R. mucronata* and *E. agallocha* were not used in this location because of their close location to human disturbance (i.e., watch tower). These two tree species were used for nesting in another colony, though.

As suspected, waterbirds in this colony also preferred certain tree species for nesting (X^2 tests, $P<0.001$ for all but Black-crowned Night Heron, which was excluded due to small sample size). More than half of the waterbirds in this colony used Xylocarpus trees for nesting (Table 10). Both Xylocarpus species were medium size (average height for *X. granatum* was 6.84 m and for *X. moluccensis* was 6.68 m), possessed many branches, crotches and forked limbs, but the canopies were thin. Nests placed on them (average was 4.01 nests on *X. granatum* and 3.52 nests on *X. moluccensis*) were highly visible from above and below the trees. The trunk of both Xylocarpus species were big enough (average diameter 14.09 cm) for Monitor Dragons to climb. Judging from scratches made by Monitor Dragons, it could be concluded that birds nesting on them suffered losses due to predation by this reptile.

S. hydrophyllacea was a medium-sized tree (average height was 7.03 m) possessing a thin canopy with no definite main trunk. Their twigs and branches were small but tough, able to hold large herons. However, its shrubby architecture in the canopy made it unsafe from winds.

Table 10. Nest-tree preference by waterbirds in Colony B-1, Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991. Values in brackets are SDs.

Bird species	Number of nests	Number of nest on				
		C. tagal (%)	S. hydro-hyllacea (%)	X. moluc-censis (%)	X. grana-tum (%)	H.litto-ralis(%)
Purple Heron	104	24(24.04)	24(23.08)	44(42.31)	11(10.57)	0(0.00)
Great Egret	75	3(4.00)	17(22.67)	29(38.67)	25(33.33)	1(1.33)
Pygmy Cormorant	7	1(14.28)	3(42.86)	0(0.00)	3(42.86)	0(0.00)
B.c.Night Heron	1	0(0.00)	0(0.00)	1(100.00)	0(0.00)	0(0.00)
Little Egret	14	0(0.00)	1(7.14)	7(50.00)	6(42.86)	0(0.00)
Total	201	29(14.43)	45(22.39)	81(40.29)	45(22.39)	1(0.50)

The use of *C. tagal* for a nesting tree was mostly restricted to those which occurred in large clumps. Single individuals of *C. tagal* were not an appropriate site for nesting due to its cone-shaped canopy and lack of crotches.

H. littoralis is a big tree (about 14 m tall), having a dense canopy with many available crotches and limbs, although its leaves were big and flexible. Its top canopy could have been used although it was not preferred, and the lower canopy appeared to be too dense to be used.

Nest Placement. Placement of nests was varied, depending on the nest tree species. Nest heights varied between 3.50 m to 6.13 m. The high range of nest heights allowed vertical stratification, but patterns of vertical stratification were not apparent. Most nests were placed far from sites abutting the tree trunk, and closer to the canopy edge (Table 11).

Table 11. Nest placement of waterbirds in Colony B-1, Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991. Values in brackets are SDs.

Bird species	Nest tree species	Nest height (m)	Distance from nest to		
			Tree trunk (m)	Canopy edge (m)	Top of crown (m)
Purple Heron	X. moluccensis	5.33 (1.17)	1.38 (0.75)	1.11 (0.81)	1.41 (0.91)
	X. granatum	4.70 (1.01)	1.51 (0.72)	0.73 (0.33)	2.20 (1.14)
	S. hydrophyllacea	5.39 (0.92)	2.31 (1.50)	1.07 (0.81)	2.38 (1.04)
	C. tagal	4.42 (0.53)	1.23 (0.71)	0.81 (0.51)	0.82 (0.52)
Great Egret	X. moluccensis	5.21 (1.18)	1.41 (0.81)	0.95 (0.35)	1.91 (1.03)
	X. granatum	5.59 (1.25)	1.46 (1.14)	1.23 (0.72)	2.15 (1.21)
	S. hydrophyllacea	5.14 (0.52)	1.42 (0.99)	0.66 (0.26)	1.84 (1.04)
	N. littoralis	4.00	2.50	1.00	2.00
	C. tagal	4.50 (0.35)	0.67 (0.24)	0.83 (0.24)	1.17 (0.43)
Pygmy Cormorant	X. granatum	4.00 (0.00)	0.47 (0.05)	0.83 (0.24)	1.00 (0.00)
	S. hydrophyllacea	5.33 (0.24)	1.60 (0.43)	0.83 (0.23)	2.67 (0.24)
	C. tagal	4.00	0.70	0.50	1.00
Black-crowned Night Heron	X. moluccensis	4.25	1.00	0.50	1.25
Little Egret	X. moluccensis	6.13 (1.19)	0.91 (0.72)	1.14 (0.35)	1.94 (1.02)
	X. granatum	5.58 (0.93)	1.06 (0.56)	0.92 (0.34)	2.25 (0.99)
	S. hydrophyllacea	3.50	4.00	1.00	4.00

3. Nest-Site Characteristics in Colony B-2

Habitat Structure. Although the vegetation in this site was different than in the previous location (B-1), both locations (B-1 and B-2) did not have an abrupt boundary. Changes in the vegetation community were gradual. For this reason, both were grouped in the same colony.

Primary mangroves covered this area, dominated by *R. stylosa* and *C. tagal* (Table 12). The southern part of the colony was covered by a mixture of *R. mucronata* - *C. tagal*, followed by stands of pure *R. mucronata*, and finally stands of *R. stylosa* in the northern part of the colony, adjacent to the island edge (Fig. 7). The central part of the colony was in a poor condition due to die-back of mangrove. Canopy coverage was good in some places. The die-back, however, created some gaps in some places.

Table 12. Importance Value (IV) of trees in Colony B-2, Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

Species	Density (trees/ha)	%Relative Density	Dominance (m^2/ha)	%Relative Dominance	Frequency	%Relative Frequency	IV
R. stylosa	133	27.54	3.6183	55.78	0.5000	37.50	120.82
C. tagal	250	51.76	1.1633	17.94	0.5000	37.50	107.20
R. mucronata	100	20.70	1.7050	26.28	0.3333	25.00	71.98

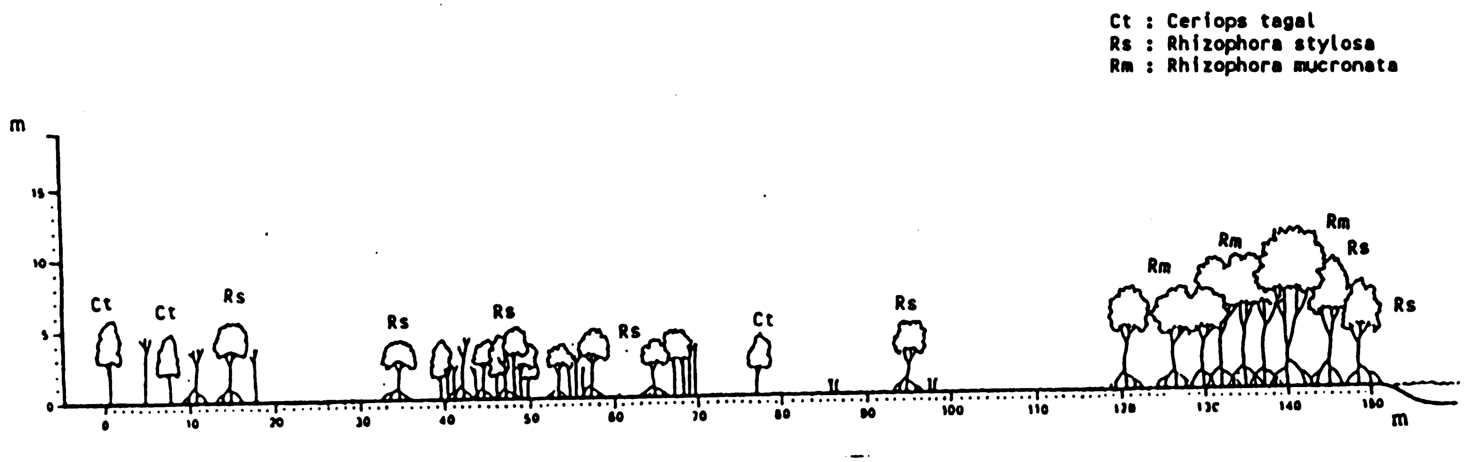


Fig. 7. Profile diagram of vegetation in Colony B-2, Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

Nesting Waterbirds. Seven waterbird species used this site for nesting: Little Black Cormorant, Little Egret, Grey Heron, Black-crowned Night Heron, Glossy Ibis, Black-headed Ibis, and Plumed Egret. The colony was used intensively in early 1990 and early 1991.

Nest Tree Selection. More than half of the waterbirds used *R. mucronata* for nesting (Table 13). Little Black Cormorant and Grey Heron chose only *R. mucronata* as their nesting trees. Little Egret used all three tree species in this site, but statistical tests showed a significant preference for *R. mucronata* (X^2=22.93, P<0.001). Black-crowned Night Heron also preferred *R. mucronata* (X^2=77.24, P<0.001).

Glossy Ibis, on the contrary, preferred *R. stylosa* for nesting (X^2=31.64, P<0.001). In fact, their nests were placed only in this tree species. Nest tree preference of Black-headed Ibis and Plumed Egret were not analyzed due to the small number of nests.

Table 13. Nest-tree preference by waterbirds in Colony B-2, Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

Bird Species	N	Number of nest on		
		R. stylosa (%)	*C. tagal* (%)	*R.mucronata* (%)
L.B. Cormorant	32	0 (0.00)	0 (0.00)	32 (100.00)
Little Egret	90	19 (21.00)	37 (41.11)	34 (37.78)
Grey Heron	27	0 (0.00)	0 (0.00)	27 (100.00)
Night Heron	27	3 (11.11)	0 (0.00)	24 (88.89)
Glossy ibis	12	12 (100.00)	0 (0.00)	0 (0.00)
Black-headed ibis	1	1 (100.00)	0 (0.00)	0 (0.00)
Plumed Egret	1	0 (0.00)	0 (0.00)	1 (100.00)
Total	190	35 (18.42)	37 (19.47)	118 (62.11)

Nest Placement. All nests were placed high above the ground (except Little Egrets' nests on *C. tagal* trees), therefore, vertical stratification was not observed in this colony. Most of these bird species built their nests on top of the tree canopy, although nests of Little Black Cormorant and Little Egret were placed slightly lower in the canopy (Table 14). Similar to previous locations, on the average, all nests were placed far from the trunk and closer to the canopy edge.

Table 14. Nest placement of waterbirds in Colony B-2, Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991. Values in brackets are SDs.

Bird species	Nest tree species	Nest height (m)	Distance from nest to		
			Tree trunk (m)	Canopy edge (m)	Top of crown (m)
L.B. Cormorant	R. mucronata	10.03 (1.53)	4.10 (1.34)	1.14 (0.48)	3.34 (1.56)
Little Egret	R. mucronata	7.39 (2.47)	1.94 (1.15)	0.78 (0.39)	2.84 (2.15)
	R. stylosa	10.39 (0.95)	3.54 (1.20)	0.89 (0.64)	2.13 (1.23)
	C. tagal	3.96 (0.37)	0.47 (0.40)	0.39 (0.23)	1.00 (0.55)
Grey Heron	R. mucronata	10.19 (3.37)	2.60 (1.59)	1.15 (0.39)	1.56 (1.48)
Black-crowned Night Heron	R. mucronata	9.94 (1.84)	2.96 (1.89)	0.82 (0.45)	1.47 (0.94)
	R. stylosa	11.53 (0.95)	2.17 (0.94)	1.92 (0.83)	1.47 (0.95)
Glossy Ibis	R. stylosa	11.35 (0.25)	3.26 (0.99)	1.50 (1.15)	1.28 (0.37)
Black-headed Ibis	R. stylosa	12.00	3.25	1.50	1.00
Plumed Egret	R. mucronata	8.25	2.00	0.75	0.75

4. Nest-site Characteristics in Colony C

Habitat Structure. The area was covered by primary mangrove, mostly by *R. stylosa* stands. Other tree species present in the colony were *R. mucronata, E. agallocha*, and *P. acidula* (Table 15). Some *R. apiculata* trees were also present, but this species was not included in the plot sample and thus its importance value was not quantified.

E. agallocha and *P. acidula* only occurred along the edge of the the stands, on the firmer substrate. As the substrate gradually became muddier, the vegetation present changed into *R. mucronata,* followed by *R. stylosa*.

Similar to Colony B-2, the tree canopy was good in some places only. Die-back of mangrove also occurred here, creating some bare areas in between *R. stylosa* stands (Fig. 8).

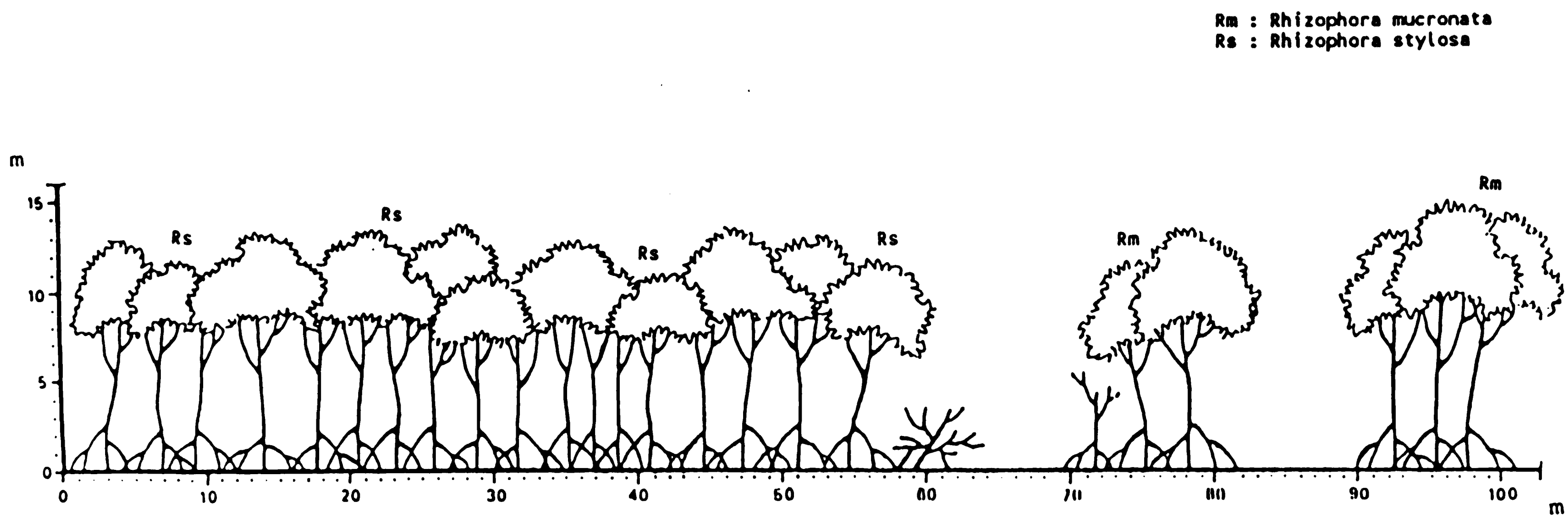


Fig. 8. Profile diagram of vegetation in Colony C, Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

Table 15. Importance Value (IV) of trees in Colony C, Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

Species	Density (trees/ha)	% Relative Density	Dominance (m^2/ha)	% Relative Dominance	Fequency	% Relative Frequency	IV
R. stylosa	137	64.63	2.4013	58.66	0.2500	40.00	163.29
R. mucronata	38	17.92	1.2938	31.60	0.1250	20.00	39.55
E. agallocha	25	11.79	0.3175	7.76	0.1250	20.00	39.55
P. acidula	12	5.66	0.0813	1.98	0.1250	20.00	27.64

Nesting Waterbirds. This colony was used all the time during the study, especially by Little Black Cormorants. During the breeding season, Little Egret, Black-crowned Night Heron, Glossy Ibis, and Pygmy Cormorant also utilized this site.

Nest-tree Selection. Selection of particular trees for nesting was observed here. *P. acidula* was never chosen, nor was *R. apiculata* because of its low height (5 m or less).

E. agallocha, which occurred in clumps along the colony edge, was used by the Black-crowned Night Heron only, probably because its foliage was too thin and flexible to hold larger waterbirds. All nests of Little Black Cormorant and Glossy Ibis were in the *R. stylosa* trees. Little Egret also preferred *R. stylosa*

(X^2= 32.19, P<0.001), although *R. mucronata* was also used. Black-crowned Night Heron preferred *R. stylosa* the most (X^2= 23.16, P<0.001), even though *R. mucronata* and *E. agallocha* were also used (Table 16).

It seemed that the choice of nest-trees depended on the condition of the stand of trees. The die-back of mangrove mostly occurred in the *R. mucronata* trees, making it less appropriate for nesting. Stands of *R. stylosa*, in contrast, were continuous but more susceptible to wind blow. Therefore, nests appeared to be carefully placed in certain sites safe from the wind.

Nest Placement. Nests placed in *R. stylosa* were higher than in *R. mucronata* because *R. stylosa* (average height 10.86 m) were significantly higher than *R. mucronata* (average height 7.47 m). Glossy Ibises placed their nests much higher than other species (Table 17). However, there was no clear stratification among the birds using this site. The waterbirds in this colony tended to nest closer to the canopy edge (further from sites abutting the trunk) as did birds in Colony B-2.

Table 16. Nest-tree preference by waterbirds in Colony C, Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

Bird Species	N	Number of nest on		
		R.stylosa (%)	*R.mucronata* (%)	*E.agallocha* (%)
L.B. Cormorant	18	18 (100.00)	0 (0.00)	0 (0.00)
Little Egret	99	68 (65.65)	34 (34.34)	0 (0.00)
B.c.Night Heron	57	24 (42.11)	19 (33.33)	14 (24.56)
Pygmy Cormorant	1	0 (00.00)	1(100.00)	0 (0.00)
Glossy Ibis	26	26 (100.00)	0 (0.00)	0 (0.00)
Total	201	133 (66.17)	54 (26.86)	14 (6.97)

Table 17. Nest placement of waterbirds in Colony C, Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991. Values in brackets are SDs.

Bird species	Nest tree species	Nest height (m)	Distance from nest to		
			Tree trunk (m)	Canopy edge (m)	Top of crown (m)
L.B. Cormorant	R. stylosa	9.56 (1.36)	1.84 (0.89)	0.82 (0.45)	1.19 (0.50)
Little Egret	R. mucronata	6.35 (1.63)	2.27 (1.76)	0.85 (0.48)	1.27 (0.75)
	R. stylosa	9.24 (1.30)	1.65 (0.84)	0.72 (0.41)	1.28 (0.75)
Black-crowned Night Heron	R. mucronata	6.62 (1.23)	2.08 (1.38)	1.12 (0.70)	1.80 (0.80)
	R. stylosa	9.50 (1.21)	1.60 (0.84)	0.89 (0.34)	1.26 (0.79)
	E. agallocha	6.95 (0.94)	0.96 (0.57)	0.79 (0.44)	1.19 (0.86)
Pygmy Cormorant	R. mucronata	6.50	3.50	1.00	1.26
Glossy Ibis	R. stylosa	11.56 (0.73)	1.64 (0.86)	0.58 (0.31)	1.24 (0.57)

5. Nest-site Characteristics in Colony D

Habitat Structure. Similar to Colony C, almost all of the colony was covered by *R. stylosa* stands (Table 18). Other species (*C. tagal, X. moluccensis*, and *H. littoralis*) were in low abundance.

Vegetation in the eastern part of Pulau Rambut, including this colony, was in a good condition. The canopy of pure *R. stylosa* was continuous, thick, and similar in height (average height 10.42 m, Fig. 9).

Nesting Waterbirds. Colony D was used very intensively during January through March 1990 only, and was never used after that. Waterbirds nesting in this site were small species: Little Black Cormorant, Little Egret, Cattle Egret, Black-crowned Night Heron, and Glossy Ibis.

Nest-tree Selection. Clearly, *R. stylosa* was the preferred nest-tree in this colony since all nests were found in this tree species (Table 19).

Nest Placement. Unlike other colonies, vertical stratification in this colony was evident (Table 20). Nest height among species differed significantly ($F=6.71$, $P<0.0001$). Little Egrets placed their nests the lowest, followed by Glossy Ibis, Black-crowned Night Heron, Cattle Egret, and Little Black Cormorant. Little Egret nests were significantly lower than those of Little Black Cormorant or Cattle Egret (Duncan's Multiple Range Test, $\alpha = 0.05$).

Table 18. Importance Value (IV) of trees in Colony D, Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

Species	Density (trees/ha)	% Relative Density	Dominance (m^2/ha)	% Relative Dominance	Frequency	% Relative Frequency	IV
R. stylosa	409	90.09	11.5254	94.46	0.8181	69.24	253.79
C. tagal	27	5.95	0.2882	2.36	0.1818	15.38	23.69
X. moluc-censis	9	1.98	0.2964	2.43	0.0909	7.69	12.10
Heritiera littoralis	9	1.98	0.0909	0.75	0.0909	7.69	10.42

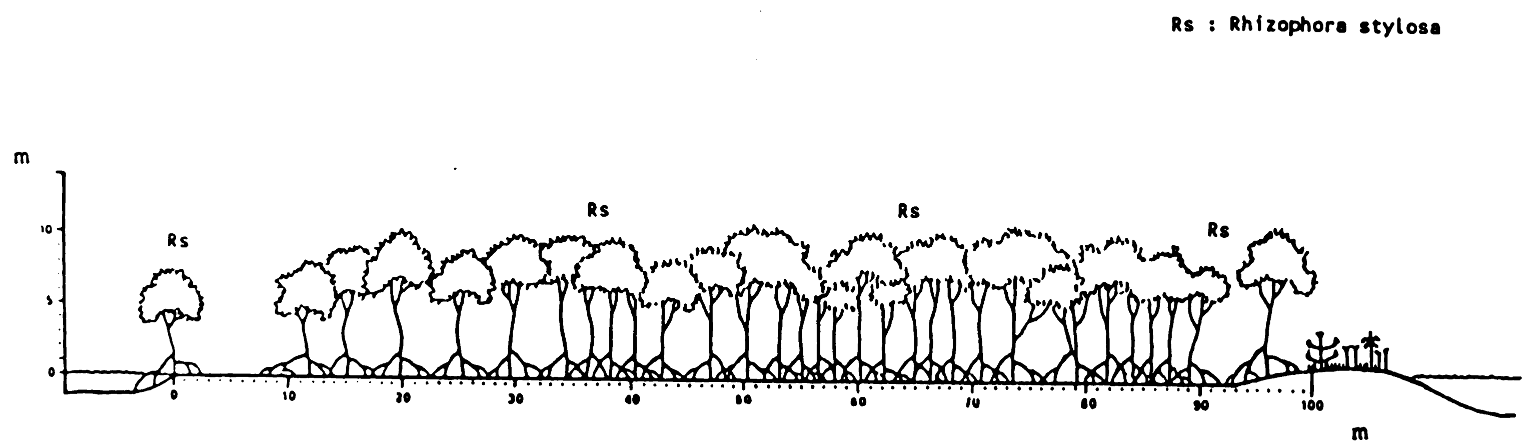


Fig. 9. Profile diagram of vegetation in Colony D, Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

Table 19. Nest-tree preference by waterbirds in Colony D, Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

Bird Species	Number of nest samples	Number of nests on *R. stylosa* (%)
L.B. Cormorant	132	132 (100)
Little Egret	20	20 (100)
Cattle Egret	19	19 (100)
B.c. Night Heron	35	35 (100)
Glossy Ibis	3	3 (100)
Total	209	209 (100)

Table 20. Nest placement of waterbirds in Colony D, Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991. Values in brackets are SDs.

Bird Species	Nest tree species	Nest height (m)	Distance from nest to		
			Tree trunk (m)	Canopy edge (m)	Top of crown (m)
L.B. Cormorant	R. stylosa	9.45 (1.59)	2.03 (1.30)	0.96 (0.71)	1.27 (0.95)
Little Egret	R. stylosa	7.70 (1.40)	1.44 (0.95)	0.81 (0.39)	2.75 (0.86)
Cattle Egret	R. stylosa	9.19 (0.79)	1.70 (0.86)	0.76 (0.31)	1.60 (1.19)
B.c. Night Heron	R. stylosa	8.79 (1.42)	1.45 (1.18)	1.05 (0.57)	1.62 (0.99)
Glossy Ibis	R. stylosa	8.33 (0.94)	1.83 (0.24)	1.00 (0.00)	1.67 (0.47)

6. Nest-site Characteristics in Colony E

Habitat Structure. Vegetation in this area consisted of mixed-dryland forest, where tides never reached. The entire vegetation created a complex vegetation structure with very dense coverage.

Forest canopy consisted of several layers (Fig. 10). The lower layer was densely covered by *Triphasia trifolia* shrub. The middle layer was a continuous tree of several species, while the top layer was scattered emergent *Sterculia foetida* trees, up to 30 m high.

S. foetida trees had the highest importance value due to their high relative dominance (Table 21), followed by *Dyxoxylum caulostachyum*. The rest of the site was covered by *Morinda citrifolia, Adenanthera pavonina, Ficus timorensis, Guettarda speciosa, Schleichera oleosa*, and *Diospyros maritima*.

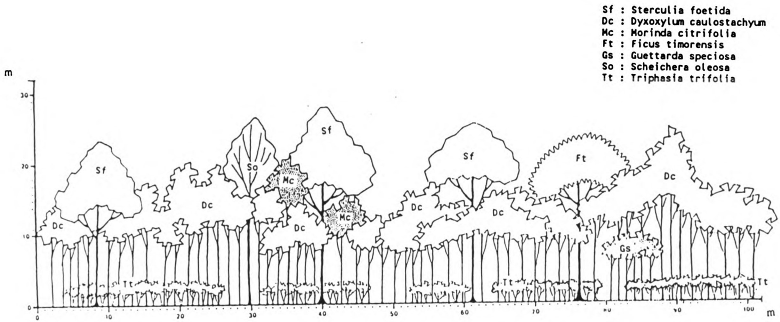


Fig. 10. Profile diagram of vegetation in Colony E, Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

Table 21. Importance Value (IV) of trees in Colony E, Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

Species	Density (trees/ha)	% Relative Density	Dominance (m^2/ha)	% Relative Dominance	Frequency	% Relative Frequency	IV
Sterculia foetida	78	14.97	12.1212	66.51	0.6667	24.00	105.48
Dyxoxylum caulostachyum	222	42.61	1.4629	8.03	0.6667	24.00	74.64
Morinda citrifolia	89	17.08	0.1515	0.83	0.4444	15.99	33.91
Adenanthera pavonina	44	8.45	0.7356	4.04	0.3333	11.99	24.84
Ficus timorensis	11	2.11	3.1384	17.22	0.1111	3.99	23.33
Guettarda speciosa	44	8.45	0.2784	1.53	0.2222	7.99	17.97
Schleichera oleosa	22	4.22	0.2729	1.49	0.2222	7.99	13.72
Diospyros maritima	11	2.11	0.0645	0.35	0.1111	3.99	6.46

Nesting Waterbirds. The permanent residents of this site were the Oriental Darter and Grey Heron. In fact, most of the sites were occupied by Oriental Darters all year long, making this species dominant here. Some species, i.e., Black-crowned Night Heron, Little Egret, Cattle Egret, and Milky Stork, also used this site on a temporary basis.

During October-November 1990, there was heavy grazing by loopers and caterpillars. They consumed almost all (more than 90%) of the upper and middle layer of the mixed-dryland forest, leaving an open canopy in the middle of the island. Most trees, especially the Dyxoxylum, were leafless and showing their twigs and branches.

The unexpected impact for the waterbirds was that waterbirds which were usually never found here were willing to use the bare trees for nesting and roosting sites. Great Egret and Little Black Cormorant were seen nesting successfully, while a big flock of Glossy Ibis was spotted roosting for several weeks.

Lighter insect outbreaks happened again in July 1991 and November 1991. However, in both occasions, the outbreaks destroyed less than 50% of the Dyxoxylum foliage and did not create good sites for nesting.

Nest-tree Selection. Although quantitative data were not gathered for this colony, it was obvious that *S. foetida* and *F. timorensis* were the preferred nest-trees, even though Black-crowned Night Heron exhibited a remarkable ability to use almost all trees in the forest.

Some trees were avoided by waterbirds either because of their flexible leaves and twigs or extremely dense foliage. Black-crowned Night Herons were still able to use them when these trees shed their leaves during drought seasons.

Nest Placement. Based solely on qualitative observations, it seemed that nests placed in this site were safe from predators and winds. Nest-trees chosen were emergent and high, preventing Reticulated Phyton and Monitor Dragons from reaching the nests.

Any place on the canopy of *S. foetida* and *F. timorensis* could be used safely. Nests were found scattered all over the canopy. Up to 30 nests could be found in a single tree.

G. Nest-Site Characteristics of the Entire Heronry

Nest-site Measurements. Data from all five colonies were combined to reveal the general nest-site characteristics of each species under study (Table 22). Characteristics of waterbird nest-sites were significantly different (Wilk's lambda = 0.02614983, F = 103.96, P<0.001). In Colony A and B-1, the nest-site characteristics of Great Egrets seemed similar to those of Purple Heron. The MANOVA test revealed that in Colony A they were not significantly different (MANOVA, Wilk's lambda = 0.8571, F = 1.18, P>0.30), but in Colony B-1, both were significantly different (MANOVA, Wilk's lambda = 0.6214, F = 6.71, P<0.0001).

Table 22. Means and standard deviations of nest site variables for 9 species of waterbirds nesting in Pulau Rambut, Jakarta Bay, Indonesia, 1990-1991.

Variable[a]		Great Egret (n=175)	Cattle Egret (n=39)	Little Egret (n=223)	Grey Heron (n=27)	Purple Heron (n=198)	B.c.N. Heron (n=126)	Glossy Ibis (n=40)	L.B. Cormorant (n=182)	Pygmy Cormorant (n=64)	Overall species (n=1074)
HTREE	Mean	6.26	8.38	9.11	11.76	6.40	9.93	12.55	11.19	6.34	8.60
	SD	1.36	2.57	2.68	1.72	1.16	2.03	0.95	1.62	1.27	2.78
HTRUNK	Mean	1.32	2.56	1.43	1.73	1.03	1.97	2.04	2.29	1.35	1.60
	SD	0.93	1.27	0.82	0.93	0.71	0.94	0.43	0.74	0.86	0.95
DIATREE	Mean	10.71	9.41	14.02	23.43	12.76	15.93	15.00	20.54	9.49	14.41
	SD	6.72	4.43	5.88	5.81	7.06	5.25	2.24	7.11	5.10	7.24
DISTREE	Mean	2.46	2.19	2.13	3.57	2.69	2.12	1.29	2.34	1.93	2.32
	SD	1.40	2.21	1.59	2.71	1.48	2.38	0.55	2.02	1.51	1.79
DISEDG	Mean	118.71	36.92	71.31	74.26	148.33	69.67	14.50	30.74	65.16	82.51
	SD	93.33	9.97	59.02	28.51	101.90	52.90	3.72	17.04	53.28	79.91
DISFORM	Mean	44.50	69.87	37.77	17.52	45.88	42.70	97.00	58.03	53.70	48.19
	SD	22.81	8.31	37.31	21.36	21.60	37.12	16.00	37.06	17.03	32.67
NNEST	Mean	3.10	4.79	5.01	5.78	3.50	5.90	6.35	7.99	5.13	5.09
	SD	2.33	3.91	3.23	3.43	2.59	3.41	3.62	5.54	5.21	4.05
HNEST	Mean	5.08	7.05	7.38	10.19	5.25	8.46	11.27	9.56	5.04	7.17
	SD	0.89	2.25	2.51	1.90	0.88	2.06	1.08	1.58	0.74	2.55
DIANEST	Mean	2.03	2.25	2.36	4.56	2.20	2.97	2.41	2.69	1.85	2.43
	SD	0.64	0.66	0.93	1.43	0.81	1.30	0.61	0.64	0.50	0.97
DISIN	Mean	1.08	1.31	1.71	2.60	1.35	1.79	2.10	2.37	1.11	1.65
	SD	0.86	0.98	1.35	1.61	0.93	1.42	1.14	1.51	0.81	1.29
DISOUT	Mean	0.87	0.62	0.74	1.15	0.92	0.97	0.87	0.97	0.66	0.87
	SD	0.62	0.36	0.45	0.40	0.67	0.57	0.78	0.66	0.43	0.59
NBR	Mean	5.72	4.51	4.30	6.67	5.67	4.59	4.13	5.05	4.95	5.04
	SD	1.70	0.94	1.10	1.52	1.86	1.17	0.79	1.36	1.17	1.55
DISBNEST	Mean	1.29	0.53	0.78	1.15	1.39	0.93	0.68	0.89	0.84	1.00
	SD	0.73	0.33	0.51	0.56	0.52	0.66	0.54	0.64	0.47	0.64
CROWN	Mean	1.95	1.93	2.45	3.75	2.27	2.76	2.97	3.35	1.77	2.52
	SD	1.03	1.19	1.50	1.55	1.13	1.48	1.49	1.71	0.97	1.46
TOP	Mean	1.76	1.33	1.73	1.56	1.15	1.47	1.28	1.62	1.31	1.42
	SD	1.04	0.95	1.35	1.51	0.45	0.91	0.53	1.32	0.91	1.14

[a] HTREE (m): Height of nest tree, HTRUNK (m): Height of rhizophore/pneumatophore roots, DIATREE (cm) : Diameter of nest tree, DISTREE (m): Distance from nest tree to the nearest used tree, DISEDG (m) : Distance from the nest tree to the nearest island edge, DISFORM (m) : Distance from the nest to the nearest different vegetation type, CROWN (m): Mean diameter of nest tree crown, NNEST : Number of nests in a nest tree, HNEST (m): Height of nest, DIANEST (cm): Diameter of the largest support branch, DISIN (m): Distance from nest to tree trunk, DISOUT (m): Distance from nest to canopy periphery, NBR : Number of support branches, DISBNEST (m): Distance to the nearest nest at the same nest tree , TOP (m): Distance to canopy top

Selection of Vegetation Type and Nest Tree. Clearly, each species had a certain choice of vegetation type(s) for nesting. Little Black Cormorant and Glossy Ibis basically preferred primary mangroves, while Purple Heron, Great Egret, and Pygmy Cormorant selected secondary mangroves. For Grey Heron, it seemed that their population was separated into two distinct groups, each group having different nesting sites (i.e., primary mangrove and mixed-dryland forest). Oriental Darter nested exclusively in the mixed-dryland forest. Cattle Egret and Black-crowned Night Heron were considered generalists due to their ability to use all available vegetation types (Table 23, Fig. 11).

Table 23. Degree of habitat utilization by waterbirds in Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

Species	Primary Mangrove (Colony B-2, C, D)	Secondary Mangrove (Colony A, B-1)	Mixed-dryland Forest (Colony E)
Great Egret	never	intensive	almost never*
Little Egret	moderate	moderate	low
Cattle Egret	moderate	moderate	moderate
Purple Heron	never	intensive	never
Grey Heron	moderate	never	intensive
B.c. Night Heron	moderate	moderate	moderate
L.B. Cormorant	intensive	never	almost never*
Pygmy Cormorant	low	intensive	never
Milky Stork	intensive (in 1991)	never	intensive(1990)
Glossy Ibis	intensive	never	never
B.h. Ibis	intensive	never	never
Oriental Darter	never	never	intensive

* used during insect outbreak only

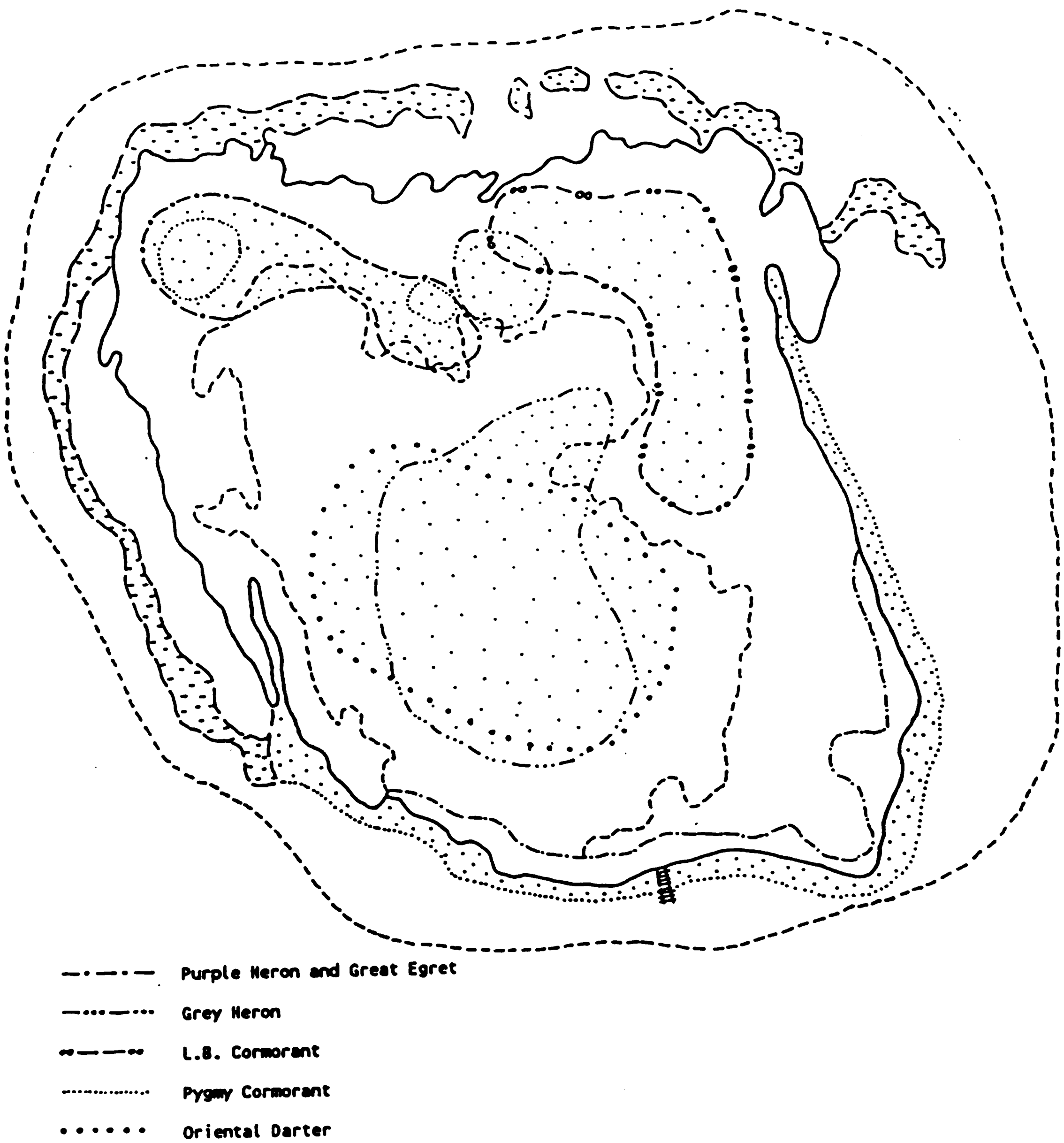


Fig. 11. General distribution of major resident waterbirds in Pulau Rambut Heronry, Jakarta Bay, Indonesia, 1990-1991.

The waterbirds also exhibited selection for certain nesting trees. *R. stylosa, R. mocronata* and *C. tagal* were preferred by most waterbirds. Among the 17 tree species available, only 8 species were used (Table 24).

The selection of nest tree by a certain waterbird obviously depended on the available tree in the chosen vegetation type. In the secondary mangrove, Great Egret and Purple Heron were able to utilize most tree species available. In the primary mangrove, both Rhizophora trees were intensively used (Table 25).

Table 24. Utilization of tree species for nesting waterbirds in Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

No.	Tree Species	Life Form, Average Height(m)[a]	Vegetation type[b]	Degree of abundance[c]	Percent of Utilization
1.	Rhizophora stylosa	tree, 10.95	PM	++++	34.92
2.	R. mucronata	tree, 8.48	PM, SM	+++	32.12
3.	Ceriops tagal	tree, 5.39	PM	+++	15.64
4.	X. moluccensis	tree, 6.92	SM	+	7.54
5.	Xylocarpus granatum	tree, 7.37	SM	+	4.19
6.	Scyphiphora hydrophyllacea	tree, 7.48	SM	+	4.19
7.	Excoecaria agallocha	tree, 8.14	SM	+	1.30
8.	Heritiera littoralis	tree, 6.00	SM	+	0.09
9.	Pemphis acidula	small tree	SM	+	0.00
10.	C. decandra	small tree	SM, BF	++	0.00
11.	Lumnitzeta racemosa	small tree	BF	±	0.00
12.	Bruguiera sexangula	tree	BF	+	0.00
13.	B. gymnorrhiza	tree	BF	±	0.00
14.	Sonneratia alba	tree	BF	+	0.00
15.	R. apiculata	tree	BF	++	0.00
16.	Thespesia populnea	tree	BF	+	0.00
17.	Avecennia alba	tree	BF	±	0.00

[a]the height of unused trees were not measured
[b]PM - primary mangroves, SM - secondary mangroves, BF - beach forest
[c]++++ : Importance Value (IV) more than 100; +++ : IV between 40 - 100; ++ : IV between 10 - 40; + : IV less than 10. Italic codes indicated that the species was not included in the sample plots

Table 25. Frequency of tree species chosen by nesting waterbirds in mangrove forest of Pulau Rambut, Jakarta Bay, Indonesia, 1990-1991.

Tree Species	Great Egret	Cattle Egret	Little Egret	Purple Heron	Grey Heron	Night Heron	L.B.Cor-morant	Pygmy Corm.	Glossy Ibis	Total
Ceriops tagal	51	16	37	36	0	2	0	26	0	168
Excoecaria agallocha	0	0	0	0	0	14	0	0	0	14
Heritiera littoralis	1	0	0	0	0	0	0	0	0	1
Scyphiphora hydro-phillacea	17	0	1	24	0	0	0	3	0	45
Xylocarpus granatum	25	0	6	11	0	0	0	3	0	45
X. moluccensis	29	0	7	44	0	1	0	0	0	81
Rhizophora mucronata	52	4	68	83	27	47	32	32	0	345
R. stylosa	0	19	104	0	0	62	150	0	40	375
Total	175	39	223	198	27	126	182	64	40	1074

H. Factor Analysis

The factor analysis defined 5 components which described waterbird nest sites: nest placement, tree size, inter-tree distance, nest support, and stability (Table 26). These five components represented 67.48% of the variation of the data. The other 10 components were omitted from the VARIMAX rotation because the individual eigenvalues were less than 1.0 (Chatfield and Collins 1989). They were also excluded in the final VARIMAX rotation.

The first factor was best termed nest placement because the variables with highest loadings were Distance from nest to tree trunk, Mean diameter of nest tree crown, Distance to canopy top, Diameter of nest tree, and Number of nests in a nest tree. The first three of these variables seemed to describe nest position in the canopy, which was slightly dependent on the last 2 variables, Diameter of nest tree and Number of nests in a nest tree. The factor could also have been termed nest safety since the Distance from nest to tree trunk and Distance to canopy top were closely related to safety from ground-based and aerial predators, respectively.

The second axis reflected tree size because of the high correlation of Height of nest tree, Height of rhizophore roots, and Height of nest. Distance from nest tree to the nearest used tree and Distance from the nest to the nearest island edge were loaded the highest on the third component, so it was termed inter-tree distance. The fourth component was termed nest support because the character Number of support branches dominated the loadings. In the fifth axis, only variable Distance from nest to canopy periphery loaded highly.

The mean scores for nest placement were close to each other (Table 27), indicating that there was little variation in nest placement. Tree size varied highly, so did the rest of the factors. Among species, Grey Heron had high values in all factors, while Pygmy Cormorant had low values in all factors.

Table 26. Variable loadings on the first five principal factors after VARIMAX rotation of the matrix for waterbirds nesting in Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

Variable[a]	Factors[b]				
	I	II	III	IV	V
HTREE	0.48	0.75	0.09	-0.26	-0.02
HTRUNK	0.01	0.71	-0.16	0.10	0.06
DIATREE	0.62	0.35	0.40	-0.01	0.11
DISTREE	0.10	-0.01	0.77	0.05	0.04
DISEDG	-0.04	-0.53	0.48	0.45	0.12
DISFORM	-0.03	0.18	-0.69	-0.31	-0.07
NNEST	0.57	0.19	0.14	-0.41	0.15
HNEST	0.19	0.89	-0.05	-0.19	0.08
DIANEST	-0.06	0.32	0.25	-0.03	0.48
DISIN	0.85	0.20	-0.12	0.24	0.00
DISOUT	0.19	-0.08	-0.00	-0.06	0.89
NBR	-0.03	0.05	0.11	0.70	0.00
DISBNEST	0.14	-0.19	0.17	0.59	-0.08
CROWN	0.85	0.15	-0.11	0.19	0.37
TOP	0.67	-0.22	0.30	-0.15	-0.22

[a] HTREE (m): Height of nest tree, HTRUNK (m): Height of rhizophore/pneumatophore roots, DIATREE (cm) : Diameter of nest tree, DISTREE (m): Distance from nest tree to the nearest used tree, DISEDG (m) : Distance from the nest tree to the nearest island edge, DISFORM (m) : Distance from the nest to the nearest different vegetation type, CROWN (m): Mean diameter of nest tree crown, NNEST : Number of nests in a nest tree, HNEST (m): Height of nest, DIANEST (cm): Diameter of the largest support branch, DISIN (m): Distance from nest to tree trunk, DISOUT (m): Distance from nest to canopy periphery, NBR : Number of support branches, DISBNEST (m): Distance to the nearest nest at the same nest tree , TOP (m): Distance to canopy top

[b]Factors were interpreted to be nest placement (I), tree size (II), inter-nest distance (III), nest support (IV), and stability (V)

Table 27. Mean component scores among species on each component for waterbird species nesting in Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

	Factors				
Bird species	Nest placement	Tree size	Inter-nest distance	Nest support	Stability
Great Egret	-0.26	-0.91	0.22	0.40	0.09
Cattle Egret	-0.32	0.42	-0.29	-0.54	-0.27
Little Egret	0.11	0.00	0.03	-0.43	-0.28
Grey Heron	0.24	1.35	1.06	0.87	0.88
Purple Heron	-0.30	-0.86	0.08	0.62	0.10
B.c. Night Heron	-0.03	0.47	0.09	-0.16	0.26
Glossy Ibis	0.08	1.02	-0.91	-0.63	-0.17
L.B. Cormorant	0.44	0.88	-0.09	-0.12	0.07
Pygmy Cormorant	-0.36	-0.81	-0.43	-0.25	-0.42

I. Vegetation Analysis and Die-Back

Vegetation analysis revealed that for all size classes (trees, poles, and seedlings), *R. stylosa* was the most dominant species, followed by *C. tagal* and *R. mucronata* (Table 28). Regeneration of most species was poor, indicated by low Importance Values for seedlings and poles.

In addition, the die-back of mangrove covered about 40% of the total available mangrove forest (19.04 ha) (Table 29), creating bare muddy areas. Most of the die-back area occurred in 3 colonies (B,C, and D; Fig. 12).

Table 28. Importance Value of vegetation in mangrove forest of Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

Species	Size class		
	Tree	Poles	Seedling
Rhizophora stylosa	109.71	115.74	58.26
Ceriops tagal	62.96	56.84	22.49
R. mucronata	44.02	46.94	78.29
R. apiculata	21.11	7.65	17.34
C. decandra	10.76	9.12	23.63
Scyphiphora hydrophyllacea	9.63	12.36	0.00
Pemphis acidula	9.22	4.94	0.00
Excoecaria agallocha	7.34	9.92	0.00
Sonneratia alba	6.62	0.00	0.00
Thespesia populnea	5.77	0.00	0.00
Bruguiera sp.	5.22	25.28	0.00
Xylocarpus moluccensis	3.88	3.85	0.00
Heritiera littoralis	1.94	0.00	0.00
X. granatum	1.83	7.58	0.00

Maximum Importance Value for tree and poles was 300, and for seedlings was 200.
For tree and poles: Importance Value = Relative Density + Relative Frequency + Relative Dominance.
For seedling: Importance Value = Relative Density + Relative Frequency.

Table 29. Die-back coverage of mangrove forest, Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

Location	Die-back coverage (ha)	Die-back species
1	4.775	*R. stylosa, R. mucronata, Avicennia alba*
2	0.375	*C. tagal, R. mucronata*
3	0.525	*X. moluccensis, X. granatum, C. tagal*
4	0.250	*C. tagal, R. mucronata*
5	0.300	*C. tagal, R. mucronata*
6	0.775	*C. tagal, P. acidula*
7	0.575	*C. tagal, R. mucronata*
Total	7.575	

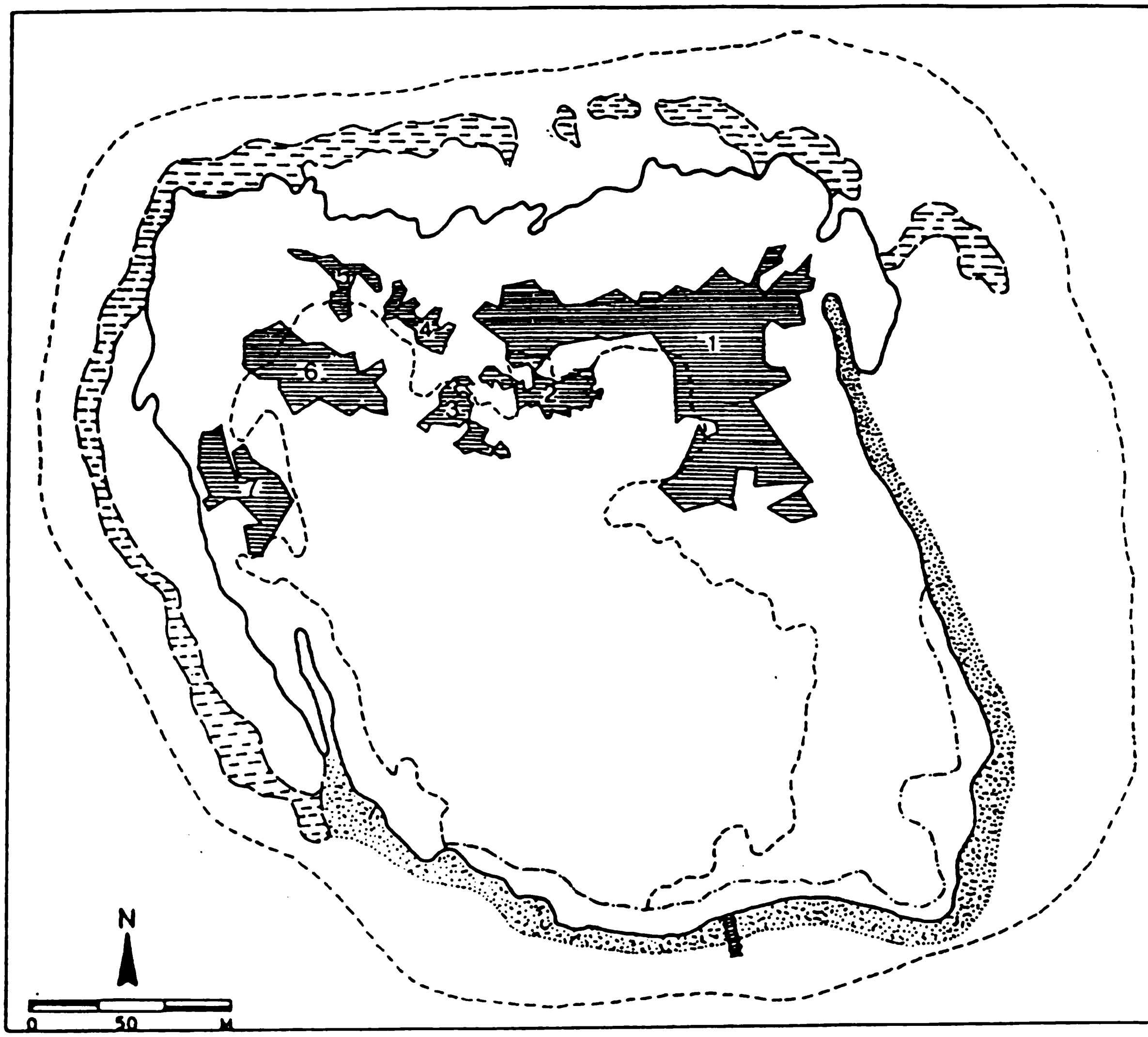


Fig. 12. Location of mangrove die-back in Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

V. DISCUSSION

A. Waterbird Species

The species of waterbirds reported to breed on Pulau Rambut have been listed by Mahmud (1991), Lambert and Erftemeijer (1988), Wiriosoepartho *et al.* (1986), Milton and Marhadi (1984), van Strien (1981), Lembaga Ekologi Universitas Nasional-PPA (1977), and Suwelo and Tobrani (1972). These observations show a lack of agreement. Lambert and Erftemeijer (1988) reported Little Green Herons (*Butorides striatus*), Milton and Marhadi (1984) also added Great-billed Heron (*Ardea sumatrana*), Suwelo and Tobrani (1972) listed Rufous Night Heron (*Nycticorax caledonicus*), while Wiriosoepartho *et al.* (1986) and Suwelo and Tobrani (1972) spotted many Javan Pond Heron (*Ardeola speciosa*).

These 4 species (Little Green Heron, Great-billed Heron, Rufous Night Heron, Javan Pond Heron) were not found during this study. With the intensive monitoring of birds in this study, the presence of these species should have been noted if they were present.

B. Breeding Season and Temporal Stratification

The breeding season of a species is defined as when it has eggs or young in the nest. More precisely, the timing of breeding of a species is usually based on the mean date on which each female laid the first egg of her clutch. Such a definition applies only to first clutches and excludes second or replacement clutches (laid after the first one is lost) (Perrins and Birkhead 1983).

In an evolutionary sense, birds should breed at the time when they can produce the most offspring that can survive to breed in the future (Faaborg 1988, Perrins and Birkhead 1983). Lack (1954) suggested that birds lay their eggs at a time of year which results in young in the nest when food is most abundant.

In the tropics, seasons are less well-defined and more elastic than in temperate zones. Seasons are governed by the advent of the rains which vary considerably from year to year. As a result, there is greater variation in the physiological state of individuals at any time of year (Lowe-McConnel 1976). Birds can be found breeding in all months of the year in the tropics (Perrins and Birkhead 1983), however, even within these areas most species have clearly defined breeding seasons (Miller 1955).

Most waterbirds in the Pulau Rambut heronry tended to breed in the rainy season, during November through April (Fig. 3). Breeding during the rainy seasons is perhaps related to aquatic feeding habits. Aquatic life in the wetlands of north Western Java is more abundant in the wet seasons. The bird's physical condition must be elastic enough for them to take advantage of variations in the onset of the rains from year to year (Lowe-McConnel 1976).

The dependency of nesting on rain was shown in the 1991 breeding season, an unusually dry year. As a result, most birds bred at the same time, thus being unable to avoid temporal competition for food. In addition, the number of breeding birds in 1991 was significantly lower than in the previous year. Glossy Ibis was not observed to breed in this year.

Cormorants searched for food mostly from the sea around the island (Hadi 1986). Rain seemed to have little effect on their breeding. The Little Black Cormorant tended to breed almost all year, except during the East Monsoon season (August-September) when fish apparently were less available.

For species which did not depend on aquatic organisms as their food, breeding seasons may be unrelated to the onset of the rain. The food of Black-crowned Night Heron in Java is listed as fish, frogs, water insects, small snakes, small mice, and shrews (MacKinnon 1988). Food ejected by young Black-crowned Night Heron under stress suggested that most of their diet consisted of mice, shrews, and lizards. It seems that the dry season gave an advantage to this species to find those kinds of food in the dried paddy fields. In addition, the Black-crowned Night Heron is a nocturnal species, which makes food searching easier due to lack of competitor. The lack of relatedness of the Black-crowned Night Heron's breeding season with rain was clearly observed during September-October 1991. These were the driest months during the past two years and yet it was the peak second breeding season for this species.

Diet of Cattle Egrets was also different than most of the other waterbirds in Pulau Rambut. In Java, this species is known to eat grasshoppers, flies, wasps, dragonfly larvae, water insects, fish, and earthworms (MacKinnon 1988). The abundance of these insects depends heavily on rain and therefore, although Cattle Egret is mostly an insect-eater, its breeding season still depends on the onset of the rain.

The overall population of waterbirds in Pulau Rambut showed a continuous breeding season. The term 'continuous breeding' refers to the population as a whole. As mentioned previously, continuous breeding season in Pulau Rambut is possible because of the continuous food availability (i.e., for cormorants) and different varieties of food utilized. Breeding patterns of a heronry in Malaysia were found to be similar to that of Pulau Rambut, where there was no distinct breeding season and breeding probably occurred throughout the year with a definite seasonal peak (Jeyarajasingam 1983).

Some species were able to breed more than once a year. This phenomenon of a species' breeding more than once a year can be a result of two (or more) separate populations breeding at different times, but can also be due to a real double-broodedness of only one population with the same individuals nesting in both seasons (Immelmann 1971). Waterbirds were known to have a long fledgling period which makes it less likely to have double-broodedness. Breeding more than once a year was, therefore, likely a result of separate groups or individuals breeding at different times.

To summarize, although most species preferred nesting during the rainy season, temporal stratification for nesting did occur due to the availability and variety of food. As a result, the overall population of waterbirds in Pulau Rambut showed a continuous breeding season.

C. Selection of Vegetation Type for Nesting

Selecting a breeding site involves choosing a general vegetation type, then a specific territory within the vegetation type, and finally selecting a nest-site (Burger 1985). The selection, or choice, of the proper vegetation type, i.e., that area which provides optimum conditions for survival and reproduction, presumably provides a far more secure prospect for a long life than would a random choice (Klopfer and Gauzhorn 1985).

Most waterbird species of Pulau Rambut exhibited a preference for certain sites. As a result, there were clumpings of waterbirds based on the species. Vegetation differences obviously have been responsible for these results, as also reported elsewhere (McCrimmon 1978, Burger 1978, Ischak 1975, Jenni 1969, Beaver *et al*. 1980, Milton and Marhadi 1986).

Burger (1978) divided heronries into two broad categories depending on whether the structure of the vegetation was heterogenous or homogenous. A homogenous colony contained either one species of vegetation evenly distributed or more than one species evenly intermixed so that each area of the colony looked like every other area. A heterogenous colony contained subareas that differed with respect to the species and height of vegetation, and the number and percentage of open or edge areas.

The categorization by Burger (1978) was adapted for the heronry of Pulau Rambut, with colony A and B-1 being heterogenous colonies (i.e., secondary mangroves), and Colony B-2, C, and D being homogenous colonies (i.e., primary mangroves).

Great Egrets and Purple Herons selected heterogenous colonies only, although previous study (Burger 1978, McCrimmon 1978, Beaver *et al*. 1980) recorded that these species also utilized homogenous colonies. Morphology has been known to be associated with selection of vegetation type, and body size is one important feature that certainly determines the selection (Winkler and Leisler 1985). Being large-sized species, Great Egret and Purple Heron require trees which offer good supports for their nests. The heterogenous colonies of Pulau Rambut had 2 advantages over the homogenous colonies: (a) they were located in the middle of the heronry which was less susceptible to wind, and (b) they consisted of dense trees.

Little Black Cormorants selected homogenous colonies, closer to the island edge, which were more susceptible to wind. The ability to nest in this area was probably due to the fact that the nests of this species are a deep bowl shape, which provide security from wind.

Small-sized waterbirds (except Little Black Cormorants) did not have a specific site for nesting.

Little Egret, Cattle Egret, and especially Black-crowned Night Heron, showed a remarkable ability to use a wide variety of vegetation types. This was perhaps because (a) they were able to maneuver and to reach almost any place in the forest canopy, and (b) their nests were smaller compared to those of the large-sized waterbirds and required less support, so these small-size waterbirds had more choice in placing their nests.

Although many excellent studies of the breeding biology of waterbirds exist, none examined changes in nesting distribution. The changes in nest-site distribution in the heronry of Pulau Rambut could be due to avoiding the wind, abandonment of degraded vegetation, or both.

It was obvious that there were some sites disfavored for nesting. The island periphery, especially the western part, was never used due to strong winds. Ecotonal areas were utilized very little as well, due apparently to inappropriate vegetation for nest sites.

Most of the mangrove forest was preferred as nesting sites. However, the mangrove forest in the south-eastern island was not a preferred site, even though the condition of the mangrove forest was good. This was perhaps because the area was too close to the base-camp (Fig. 1), or because the site received a strong direct wind from the east.

Burger (1978) suggested that the nesting pattern observed in 16 colonies she studied might have been the result of arrival times, aggressive interactions, or both factors. Unfortunately, both factors could not be observed here, since most waterbirds in Pulau Rambut heronry were permanent residents and the intra- and inter-specific aggression was not examined.

Some waterbirds were able to nest together and some apparently were not. When two species occurred together in the same vegetation types, they might just coincidentally be together or there may be some kind of association. Association means some kind of partnership. The species are said to be positively associated if the presence of one species in any small place makes it more likely that the other will also be found. Conversely, they are negatively associated if the presence of one of the species makes that of the other less likely (Pielou 1974).

A species can have an association with other species if the association is beneficial for at least one of them, or if the association does not harm both of them. Investigating the cause of the association is difficult, because what we see in the field is the result of the association (Pielou 1974).

A study of nesting associations by Tomlinson (1979) in Rhodesia revealed that nesting associations have been found between large species and small species. The reason for this association was apparently that the smaller species obtained a degree of protection from the larger species. Furthermore, protection against predators was usually one of the reasons why birds lived in colonies (Wittenberger and Hunt 1985, Perrins and Birkhead 1983). The absence of large-small species associations in the Pulau Rambut heronry indicates that protection as the does not seem to hold as a primary reason in this location.

Negative associations were found between some congeneric species (i.e., Purple Heron-Grey Heron, Great Egret-Little Egret). A previous study revealed that closely related species, especially those in the same genus (congeneric species), are often quite similar morphologically, physiologically, behaviorally, and ecologically (Pianka 1983). These species of the same genus presumably require very similar habitat components (nesting/roosting site, nest materials, etc). Therefore, in order to decrease competition, they would rather avoid each other.

To summarize, the selection of vegetation type by waterbirds in Pulau Rambut heronry was affected by both social and physiognomic features of the environment as suggested by Burger (1985). Social factors included (i) congeneric avoidance due to similarity in morphology, physiology, behavior, and ecology, (ii) behavior in relation to daily habits. Physiognomic aspects of habitat selection include (i) body size, in relation to social domination and ability to maneuver and reach a certain site, and (ii) location within the heronry (center vs. edge) as suggested by Coulson (1968). Further, it was shown that some species appear to have strict habitat preferences, whereas others tolerate a wide variety of sites.

D. Selection of Nest Trees

Chi-square tests revealed that the waterbirds of Pulau Rambut did have a preference for specific tree species. Selection of tree species was important since the structure of the tree might offer safety during the breeding period, which in turn, could increase breeding success of the species concerned.

Vegetation analysis revealed that there were 17 species of trees in the mangrove forest (Colony A, B, C, and D). Of these, only 8 species were used by waterbirds for nesting (Table 24). The rest were never used either because of small size or because of their very close location to the island periphery.

Selection of nesting trees suggested that the waterbirds were able to use tree species as long as they were safe from wind (i.e., not too close to the island periphery). Most birds (67.04 % of all nests) preferred both species of Rhizophora tree for nesting. Ceriops and both species of Xylocarpus trees were also chosen for nest-sites. Scyphiphora, Excoecaria, and Heritiera trees were less preferred, probably due to their scarce foliage (i.e., Scyphiphora and Excoecaria) or extremely dense foliage (i.e., Heritiera).

R. mucronata was chosen by virtually all waterbird species, followed by *R. stylosa* (Table 25). Both Rhizophora trees have a very similar architecture and structure, suggesting that the difference in preference was due to location. *R. stylosa* was found in the outer part of the island, thus more vulnerable to wind, whereas *R. mucronata* was found further from the island periphery.

The condition of mangrove trees depends on their habitat (Tomlinson 1979). The height of *R. mucronata* trees in Colony B-2 reached as high as 14 m (average 11.66 m), although in Colony A their average height was only 6.10 m.

R. mucronata was found in the inner part of the island, where they were protected from the north wind. This tree species was chosen first by the early nesters. *R. stylosa* was the less preferred tree because it gave less safety from wind. The late nesters appeared to use it because the *R. mucronata* were already occupied by other waterbirds.

The cone-shaped canopy of *C. tagal* was also preferred by waterbirds nesting in the secondary mangrove. However, due to its canopy shape, this species was considered a good site for nesting only when it occurred in a clump of trees. Both species of Xylocarpus were good places for nesting, although these tree species were not safe from Monitor Dragons due to their big trunks and low height.

The waterbird's morphology, especially wing shape related to flying technique, also may have had some influence on the selection of nesting trees. This is shown by some waterbirds which preferred the mixed dryland forest (Colony E). Some birds in this location had to nest in a certain site due to the bird's difficulty of landing and take-off. Birds with slotted high-lift wings such as Milky Stork (Allport and Wilson 1986) and Oriental Darter, rely on static soaring to fly. A static soarer uses the lift provided by the deeply slotted, high-chamber wings, and the upward movement of air to almost effortlessly gain altitude, usually by circling within the rising air (Faaborg 1988). This type of bird needs an emergent canopy to land and take-off. Therefore, only the highest trees, namely *Sterculia foetida* and *Ficus timorensis*, were chosen.

In short, factors affecting selection of nest trees by waterbirds of Pulau Rambut were (i) safety from wind, especially from the destructive West Monsoon, (ii) structural stability as suggested by Coon *et al.* (1981) and McCrimmon (1978); smaller trees (less than 5 m) were avoided due to their inability to provide structural stability, (iii) foliage density, as also suggested by Furrer (1980); extremely dense or very scarce foliage was not suitable for nesting, and (iv) structure suitable for flying.

E. Selection of Nest-Site

1. Vertical Position

Previous study of House Finches (*Carpodacus mexicanus*) has proven that nests placed in tree tops might be visible to avian predators and more susceptible to destruction by strong winds. Nests placed low in trees could be vulnerable to detection from ground-based predators. Therefore, sites in the mid-to upper regions of nest trees would minimize the probability of detection by predators and provide greater nest stability (Graham 1988).

For most waterbirds, Burger (1978) noticed that the preferred nest-site seems to be the highest, tempered by adequate cover from predators, that the vegetation structure allows. Nesting high in the vegetation provided easy access to escape, better visibility of predators, greater distance from ground predators, and less vegetation to climb through in reaching and leaving the nest (Burger 1978). Waterbirds in the Pulau Rambut heronry tended to choose sites on top of the canopy, averaging 83% of the tree height (Table 22). This suggested that aerial predators were not a major threat, while ground-based predators may have been. The most threatening predator seemed to be the Monitor Lizard. The population of Monitor Lizard was not estimated during the study. Rough estimation based on regular encounters suggested that the population of the adult Monitor Lizard was about 60-80. Aerial predators included Brahminy Kite (*Haliastur indus*) and White-bellied Sea-eagle (*Heliaeetus leucogaster*). In addition, there were also arboreal predators, namely Mangrove Snake and Reticulated Phyton (which was considered to be a rare species).

The disadvantage of nest placement high in the canopy was that stability from wind was sacrificed. Therefore, in order to reduce the mortality of their eggs and young, the waterbirds employed some strategies:

(i) Select sites safe from the wind.

In the mangrove area, the secondary mangrove located in the north-central part of the island (i.e., Colony B-1) probably offered the safest site for nesting, either from East or West Monsoon. Taller trees of surrounding areas provided security from wind.

(ii) Nest further from the direction of the wind.

The monsoon had a strong impact on the nesting waterbirds. During the worst monsoon, the wind speed might reach 35 km/hr, able to destroy nests and throw out eggs and hatchlings. To avoid this, waterbirds chose nest sites in opposite directions of the wind: when wind blew from the east the waterbirds chose the middle or the west heronry, and vice versa.

(iii) Build a more sturdy nest which can resist the wind.

The Egrets and Day Herons were very mobile in placing their nest, while the cormorants (especially the Little Black Cormorant) tended to have a fixed site for nesting (see Appendix 4 through 16). Shape and the structure of the nest probably had some influence.

The nest of waterbirds consisted of dry sticks, arranged in a bowl-shape. A nest of a Little Egret in Pulau Rambut, for instance, consisted of 222 dry sticks collected from the surrounding area (Sulistiani 1991). Nests of Egrets (especially Great Egret) and Heron (especially Purple Heron) were very skimpy, shallow, and consisted of only few layers of sticks. Nest construction like this is very vulnerable. Wind or sudden movements by parents would throw the eggs/hatchlings out the nest.

Therefore, to overcome this problem, these waterbirds tried to find a safe place (i.e., safe from wind) by changing the distribution of nest-sites.

In contrast, nests of Little Black Cormorants were constructed of dry twigs, lined mostly with sea weed. The shape of the nest was a deep bowl, very compact. A nest like this will stand a strong wind, and this species did not need to locate the nest in a site safe from the wind.

2. Vertical Stratification

Vertical stratification has been reported elsewhere in mixed heronries (Pyrovetsi and Crivelly 1988, Milton and Marhadi 1986, Jenni 1969, Burger 1978). However, vertical stratification was not found in this study, although the height of vegetation would have allowed it to occur. Lack of vertical stratification was perhaps due to a potential predation by Monitor Lizards.

3. Horizontal Position

Graham (1988) noted that sites abutting the trunk provided better concealment than sites further from the trunk. In addition, sites abutting the trunk may receive maximum protection from the wind by being at the center of the foliage, and by being physically supported by the trunk and thick proximal end of branches.

In contrast to Graham (1988)'s results, all waterbirds in all colonies measured tended to nest further from the trunk and closer to canopy edges, with average deviation about 66% (Table 22).

By placing nests further from the central part of the nest tree, the waterbirds had gave up the advantages explained by Graham (1988). This means that these waterbirds were able to overcome problems due to weather and vegetation condition.

Sites further from the trunk were advantageous to avoid Monitor Lizards and Mangrove Snakes. Adult Monitor Lizards were big and heavy, capable of climbing up a tree, but not able to reach sites further from the tree trunk. Mangrove Snakes, on the other hand, were completely arboreal. Any sites within the tree canopy were reachable. But before reaching the site further from the tree trunk, the snakes presumably would sway the twigs which would in turn provide a warning for the nesting waterbirds.

Observations on the vertical and horizontal position within the canopy suggested that the waterbirds tried to avoid ground-based predators (i.e., Monitor Lizard), but not aerial predators (i.e., Brahminy Kite and White-bellied Sea Eagle). By placing nests high from the ground and further from sites abutting the tree trunk, ground-based predators had more difficulty in reaching the nests.

F. Factor Analysis

Three previous studies have examined nest-site characteristics for other waterbird species. McCrimmon (1978) used principal component analysis to describe and compare nest-site characteristics of five waterbirds in North Carolina (i.e., Great Egret, Snowy Egret (*Egretta thula*), Cattle Egret, Tricolored Heron (*E. tricolor*), and Little Blue Heron (*E. caerulea*)). He found that 4 components (vegetation structure, accessibility, protection, and shrub/tree center distance) accounted for 69% of the variation.

Beaver *et al*. (1980) used factor analysis to describe the nest sites of seven waterbirds (i.e., Great Egret, Snowy Egret, Cattle Egret, Tricolored Heron, Little Blue Heron, Black-crowned Night Heron, and Glossy Ibis) in different colonies along the Atlantic coast. They found that vegetation size and nest stability were two factors explaining most (55.2%) of the variation in data.

Nest-site characteristics of Yellow-crowned Night Heron (*Nycticorax violaceus*) was quantified and analyzed using factor analysis by Watts (1989). He found that 4 vegetative components (tree structure, stand density, nest position, and understory openness) accounted for 85% of the variation in the data.

Comparing nest-site characteristics of waterbird communities was difficult because species present, variables used, and habitat conditions were always different from site to site. Therefore, only a few compatible factors were able to be compared.

In all of the previous studies, the vegetation structure was always one of the most important factors. However, in this study, the first factor was nest placement, followed by tree size, suggesting that safety had the highest priority in selecting nest-sites. Nest position was the third factor in Watt's (1989) study and the fourth component in McCrimmon's (1978) study.

Stability was the second factor in Beaver *et al.* (1980)'s study, and the fifth factor in this study. The difference was probably due to the fact that study sites selected by Beaver *et al.* (1980) were primarily composed of shrubs and small trees, which offered less stability than the mangrove trees in this study.

Mean factor scores by species were plotted for each factor (Fig. 13). By examining how means were grouped it was possible to determine if the factor was important as a possible characteristic of the waterbird species or whether it was the result of a colony's physical characteristics.

Nest placement of waterbirds in Pulau Rambut seemed more or less similar, although some slight differences did exist for each species (Factor 1, Fig. 13), regardless of the location chosen within the heronry. Tree size, on the other hand, showed large differences. Tree height in secondary mangroves were significantly different than those of true mangrove. Birds nesting exclusively in the back mangrove (Great Egret, Purple Heron, and Pygmy Cormorant) had low values in Factor 2 (less than -0.60), while birds nesting exclusively in the primary mangrove (Grey Heron, Glossy Ibis, and Little Black Cormorant) had higher values (higher than 0.60). Waterbirds nesting in both vegetation types (Little Egret, Cattle Egret, Black-crowned Night Heron) had a moderate value.

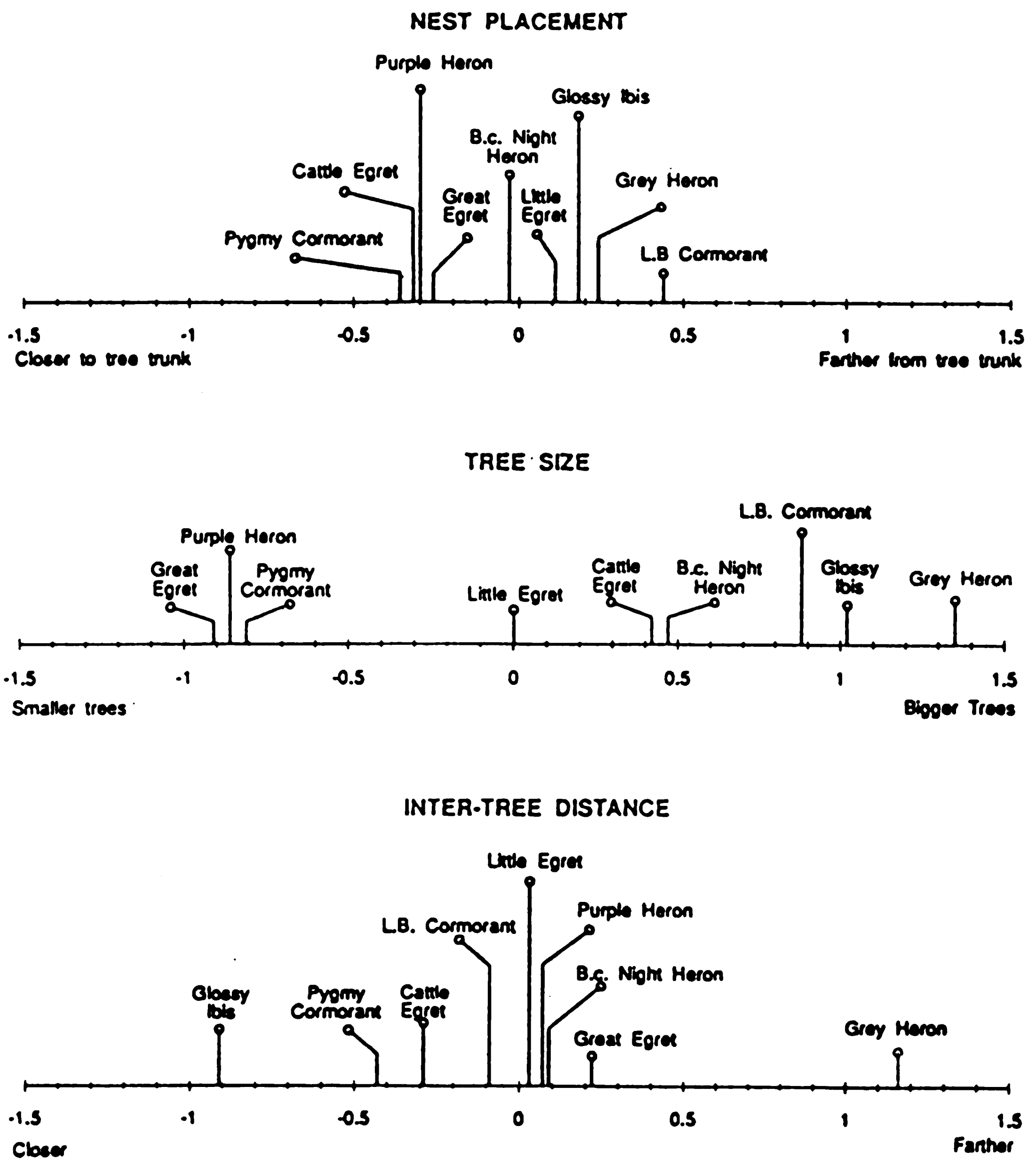
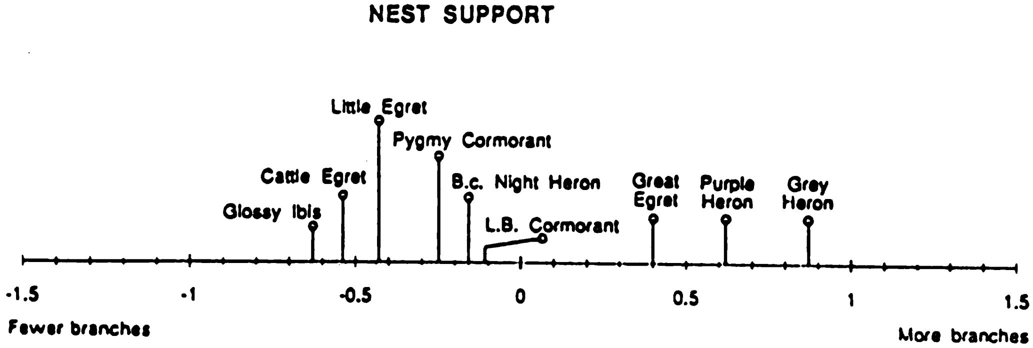
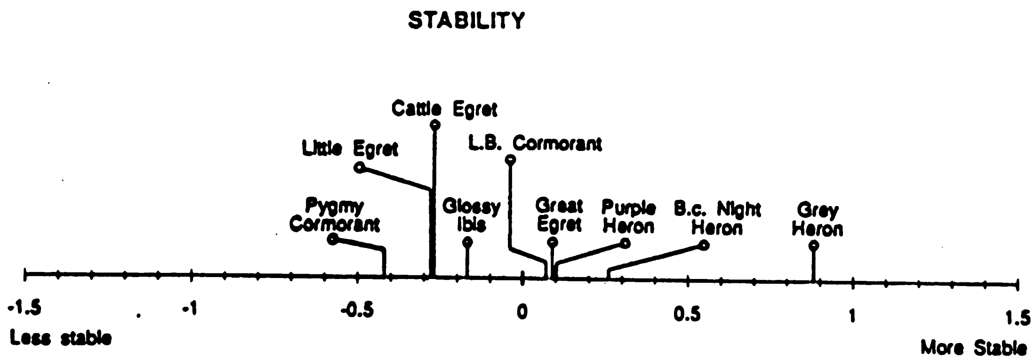


Fig. 13. Ordination of mean factor scores of nest-sites characteristics for waterbirds in Pulau Rambut heronry, Jakarta Bay, Indonesia, 1990-1991.

Fig. 13. (cont'd)


NEST SUPPORT
Little Egret
Pygmy Cormorant
Cattle Egret
B.c. Night Heron
Great Egret
Purple Heron
Grey Heron
Glossy Ibis
L.B. Cormorant
-1.5
-1
-0.5
0
0.5
1
1.5
Fewer branches
More branches


STABILITY
Cattle Egret
Little Egret
L.B. Cormorant
Pygmy Cormorant
Glossy Ibis
Great Egret
Purple Heron
B.c. Night Heron
Grey Heron
-1.5
-1
-0.5
0
0.5
1
1.5
Less stable
More Stable

With the exception of Grey Heron, the waterbirds tended to select clumped trees for their nest (Factor 3). Individual trees selected by Grey Herons were more susceptible to wind, and therefore, this species needed to have better nest support, as shown in Factor 4. Other large-sized birds (Purple Heron and Great Egret) also required large numbers of supporting branches.

Stability (Factor 5) was also affected by body size. All of these three large-size birds chose stable sites, farther from the canopy edge in order to get larger branches for nesting. Small-sized birds, except the Black-crowned Night Heron, were able to nest closer to canopy edges to avoid ground-based predators. Nest sites of Black-crowned Night Heron had a high stability, as also confirmed by Beaver *et al.* (1980).

In North Carolina, McCrimmon (1978) found that nest-sites of Great Egrets were significantly different from those of the other species. This species nested in larger trees, farther from the ground and closer to the edge of the heronry. In this study, in contrast, nests of Great Egrets were placed the lowest (Factor 2). In fact, it was the Grey Heron which showed some significant differences in choosing nest-sites, especially in trees size, inter-tree distance, nest support, and stability. Grey Heron selected the largest trees, highest inter-tree distance, largest number of nest support branches and highest stability.

Summarizing, there were 5 factors which distinguished the nest-site selection of waterbirds: nest placement, tree size, inter-nest distance, nest support, and stability, as a result of differences in body size, choice of general vegetation type, and degree of predation.

G. Nest-site Selection: Comparison Among Species

Although the nest-site selected by the waterbirds seems similar, measurements and observations showed that each species carefully selected timing and nest-site for breeding. Purple Heron and Great Egret had a very similar pattern, both spatially and temporally. These two species breed during the peak rainy season, in December to April. They also had a sympatric distribution, in Colony B-1 (1990) and Colony A (1991). MANOVA tests revealed that in selection of nest-sites in Colony B-1 was significantly different, but not in Colony A.

In Colony B-1 the Purple Heron chose larger trees, and were further from the island edge. Purple Heron preferred clumped trees, while the Great Egret showed a tendency to select large inter-distance trees (Factor 3). In addition, although both species had a similar body size, Purple Heron required more branches to support the nest. Vertical and horizontal placement, however, showed no significant differences.

Tree species chosen by both species varied, suggesting that it was the structure of the tree which was a more crucial factor. Protection from the wind seemed to be an important factor, especially for the Purple Heron. This was perhaps due to the fact that both species built large but skimpy flat nests, which were very vulnerable to wind.

Nest-site selection of the Grey Heron showed a distinct pattern compared to other species. This species nested either in the mixed-dryland forest (Colony E), overlapping with the Oriental Darter, or in primary mangrove of Colony B-2, overlapping with some smaller species (e.g., Black-crowned Night Heron, Little Egret). Factor Analysis revealed that this species had the highest value in Tree Size, Inter-nest Distance, Nest Support, and Stability. The high requirements of nest-sites for Grey Heron perhaps was one of the reasons why the population of this species was low on the island (Table 4).

The Little Black Cormorant used the primary mangrove intensively. Wind seemed do not have a big influence for this species, considering that they were able to nest very close to the island edge (18 m from the island edge). This species also placed their nest furthest from the tree trunk (Factor 1), but had medium nest support and stability, suggesting that their nests were able to withstand the wind. Although this species used the primary mangrove, during the insect outbreak (October-November 1990) it was able to nest in the mixed-dryland forest, suggesting that its nest location did not depend on the mangrove forest. The population of the Little Black Cormorant was high during the study (Table 4), probably because of: (i) wide requirements for nest-site, (ii) long breeding period, from November to July, and (iii) available food resources, since this species foraged in the surrounding sea, while other species had to go farther.

In contrast, the population of Pygmy Cormorant was low during the study, although this species was also able to search for food at sea. Breeding season occurred from January to March. Factor analysis showed that the nests of Pygmy Cormorant were very close to the tree trunks (Factor 1), and very unstable (Factor 5). It seemed that this species was not able to compete as well with other species. Black-crowned Night Heron, Little Egret, and Cattle Egret were generalists in the heronry. They were able to use almost all available sites, and nested in association with any other waterbirds. The high population of the Black-crowned Night Heron could be also as a result of its extended breeding season.

The Glossy Ibis was a temporary resident species on the island, breeding in February-April 1990. During that time, it nested in the primary mangrove, selecting tall, clumped trees. The high variety of nest-site placement in colonies chosen (Colony B-2, Colony C, and Colony D) indicated that this species probably had wide requirements for nest-sites. Lack of samples (N=40, from 1990 breeding season only) created difficulties in drawing reliable conclusions.

Summarizing, each species had a certain breeding season and nest-site selection, in terms of location within the heronry, and vertical and horizontal position within the nest tree. Combined with other factors, such as ability to compete for space and food, the temporal and spatial specialization affected the population number on the heronry.

H. Vegetation Condition

Previous study (Telfair 1983, Wiese 1978) revealed that large numbers of waterbirds might cause defoliation and destruction of their habitat through guano deposition. However, in this study, the die-back of mangroves occurred mostly in the primary mangroves, which were always inundated by water, so guano was washed away. In other words, the guano deposition was unlikely to be the cause of the mangrove die-back.

With the existing mangrove, Pulau Rambut can apparently support up to 24,000 waterbirds (12,000 pairs). The die-back of mangrove occurred primarily in Colony C and B-2. Waterbirds of both colonies (mostly Little Black Cormorant, Little Egret, Glossy Ibis, and Grey Heron) still nested on the existing trees, within the die-back area. Obviously, as the trees fall down they will no longer be available.

The cause of the die-back has already been investigated, and it was shown that the average level of oil deposits in the soil was quite high, 11,267 ppm (Hermana 1991). Thus, oil was probably the cause of the mangrove die-back.

Jakarta Bay is polluted (Ongkosongo *et al.* 1987). It was suspected oil spilled from off-shore mining operations north of Pulau Rambut, and/or from boats and ships sailing nearby, polluted the soils on Pulau Rambut.

There were some indications that the size of the die-back areas is increasing. If there is no action taken, it is possible that the die-back will lead to the destruction of the entire mangrove forest.

VI. THREATS AND PROBLEMS

A. Threats and Problems from Outside the Island

1. Deteriorating Condition of Jakarta Bay

Pulau Rambut is one of 108 islands scattered in Jakarta Bay. Situated facing the Java Sea, Jakarta Bay is the most recognized bay in Indonesia because Jakarta (the capital of the country) is also the main focus of almost all activities in the region (Ongkosongo *et al.* 1987). At present, the condition of Jakarta Bay is deteriorating rapidly. It is estimated that in the long run, unless necessary measures are taken, the quality of the environment may be reduced so much that it will pose a threat to the lives of the people and wildlife living in its surrounding area (Study team of JBMS 1987, Pusat Studi Ilmu Kelautan Fakultas Perikanan IPB-KLH 1989).

The deteriorating condition of the Jakarta Bay waters is mainly caused by (i) polluted bay waters (ii) polluted sediment (iii) polluted marine biota (iv) excessive exploitation of natural resources (v) unorganized management of Jakarta Bay by various government offices (Study team of JBMS 1987).

In the waters of Jakarta Bay, the concentration of Hg increased from 1974 to 1979 (Ongkosongo *et al.* 1987). The concentration of other heavy metals in the sediments can still be considered normal, although Pb, Cu, and Zn, at some stations, were considered in high concentrations. Some pesticides, i.e. PCB and DDT, were 9 ppb and 13 ppb, respectively, and have surpassed the acceptable limits of 0.5 ppb. The water was also very polluted with bacteria. Some consumed, biota fish and mollusca, have been bacterially contaminated (Ongkosongo *et al.* 1987). Research has shown that PCB and DDT had a serious effect on birds, causing death, eggshell thinning, decreases in fertility and hatching capacity of the eggs (Nandika 1986).

Oil discharge from ships can also create worse conditions. Pollution from oil slicks are frequently encountered on the waters and mangroves of Pulau Rambut, as are tar balls along the coasts. However, without evidence that these potential threats are having an effect on breeding birds on the island, no conclusions can be drawn concerning how serious such threats are.

2. Decreasing Size of Feeding Ground

A major threat to the waterbirds of Pulau Rambut is in the feeding grounds, outside the reserve boundaries. Feeding grounds are decreasing with the increase in the numbers of people. In addition, poisoning from pesticides and killing of waterbirds occurs.

Land use of the northern coast of western Java has been changing very rapidly during the last decade. Wetlands and mangrove forests have been converted into purposes less favorable for waterbirds, such as Soekarno-Hatta International Airport, extension of Tanjung Priok harbor, housing, fish ponds, shrimp hatcheries, and recreation areas (Widodo and Hadi 1990, Study Team of JBMS 1987).

The waterbirds from Pulau Rambut have been seen fishing in Tanjung Pasir and Teluk Naga (Prawiradilaga and Widodo 1991, Widodo and Hadi 1990), Muara Angke (Avenzora 1988), along the highway of Soekarno-Hatta International Airport (Prawoto 1990), and Tanjung Kerawang (Sajudin *et al*. 1982). However, the exact locations of the waterbirds' feeding grounds are not known. It is suspected that the waterbirds search for food in paddy fields (especially when the paddy fields are ploughed), fish ponds, shrimp hatcheries, and wetlands along the northern coast of western Java (Fig. 14).

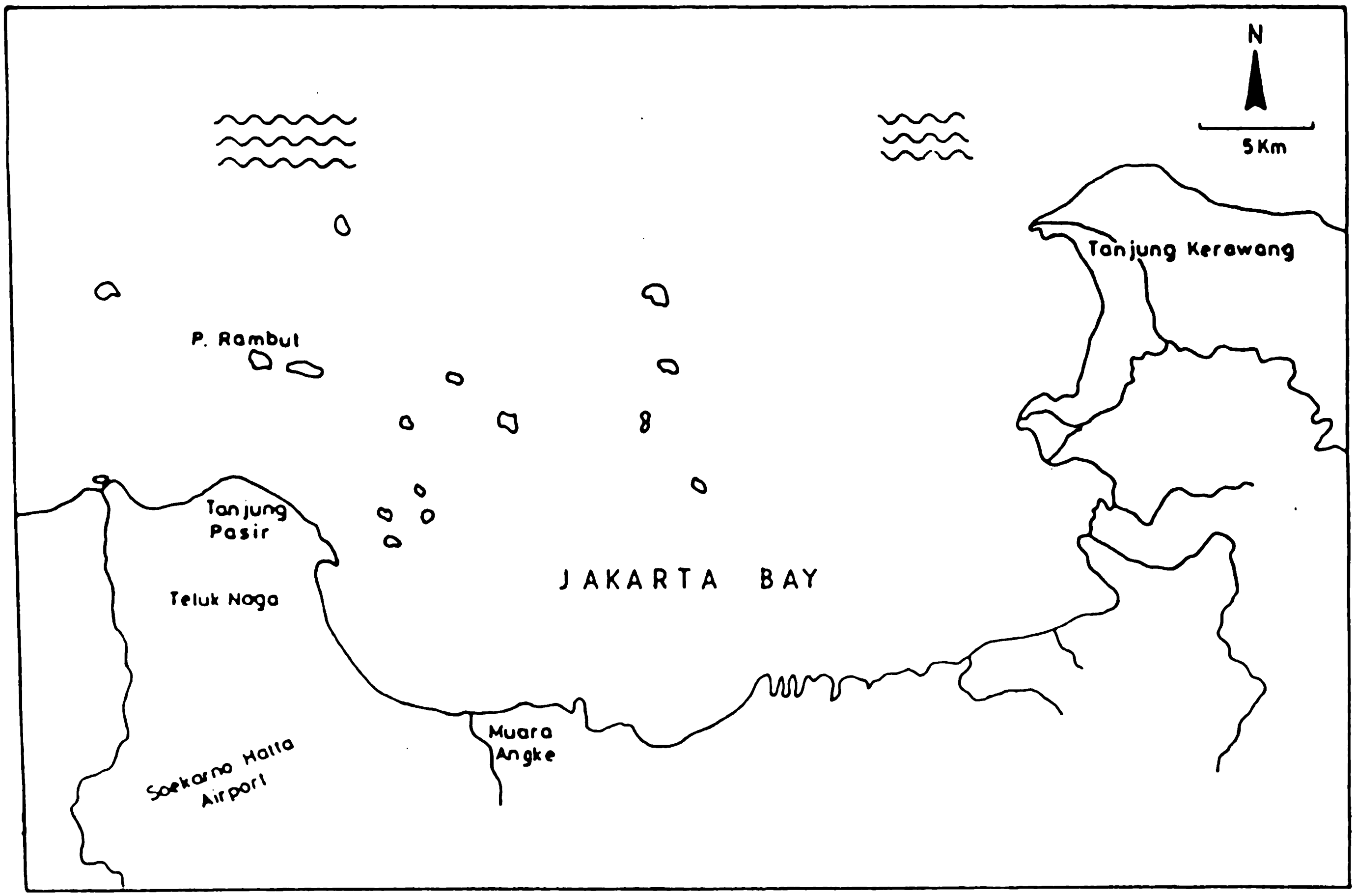


Fig. 14. Some known feeding ground of Pulau Rambut's waterbirds: Tanjung Pasir, Soekarno-Hatta Airport, Muara Angke, and Tanjung Kerawang (Jakarta Bay, Indonesia).

The decreasing size of the waterbirds' feeding grounds has forced the waterbirds to search for food closer to human proximity such as fish ponds and shrimp hatcheries. As a result, people consider the waterbirds as pests, which need to be eliminated. By capturing the waterbirds (usually by using a net), people not only can get rid of the pests, but also obtain additional sources of meat.

3. Waste

The city of Jakarta had a population of 8,222,515 people in 1990[1]. With an area of 659 km^2, it means that the average density is 12,460 people/km^2. The rate of increase is 2.41% per year, thus there are an additional 198,000 people per year. In 1987, when the population of Jakarta was about 7.5 million, the amount of garbage disposal reached about 17,900 m^3/day while only 13,300 m^3/day could be accommodated by the temporary dumping area. This meant that 4,600 m^3 of garbage was disposed by either dumping in the rivers or remaining scattered in the markets (Ongkosongo *et al.* 1987).

The distance between Tanjung Pasir (the nearest village in Java) and Pulau Rambut is about 3.75 km, while the distance between Pulau Untung Jawa (nearest island) and Pulau Rambut is only 0.5 km. It is unfortunate that

[1]National Census of 1990

coastal water and beaches are traditionally used by local people for all kinds of waste disposal, and therefore along coastal settlements the beaches are aesthetically polluted.

Currents easily carry the garbage from these two locations and deposit them along the south and east coast of Pulau Rambut, creating an unpleasant sight. If the garbage enters the mangrove forest and accumulates at that site, it might create a problem by preventing natural regeneration.

Study of Pulau Rambut's waste revealed that there was an extremely wide variety of waste stranded along the coast and within the mangrove in the north area. Types of waste were as follow : (1) wood, including remnants of boards and unused house building material, (2) pieces of cloth, (3) paper, especially paper wrap, (4) bamboo, (5) cork, including bottle cork, float, and fishing net cork, (6) rubber, including shoes, foam, (7) plastics, including children's toys, plastic wrap, plastic jerry can, plastic bottles and containers, plastic sacks, fishing nets, seat covers, etc., (8) glass, including light bulbs, glass bottles, broken windows, (9) styrofoam, including food and fruit wrap, (10) various types of cans, (11) synthetic leather such as shoes, handbags, and belts (Hartawan, 1992, Lembaga Ekologi Universitas Nasional-PPA 1977).

4. Sandmining

Sandmining for building and road constructions at the bay has been conducted for several years. The small strait between Tanjung Pasir and Pulau Rambut was also explored for possible sandmining. The exploration revealed that there were high deposits of sand in that site (Fig. 15).

An Environmental Impact Assessment (EIA) for sandmining was done in 1989 (Husin *et al.* 1989). It was known that there were 3.15 million cubic meters of sand, ready to be mined in a 5 year period. The location of mining activity was planned to occur as close as 1.5 km from Tanjung Pasir and 0.5 km from Pulau Rambut. Based on the EIA, the benefit of the mining exceeded the operational cost and environmental cost due to the impact of mining activity, and therefore, the mining project was approved.

The mining activity was conducted in mid-May 1990 until the end of June 1990, 0.5 km south of Pulau Rambut, using a barge equipped with a clamp shell. The mining activity did not last longer because people from Tanjung Pasir were strongly opposed.

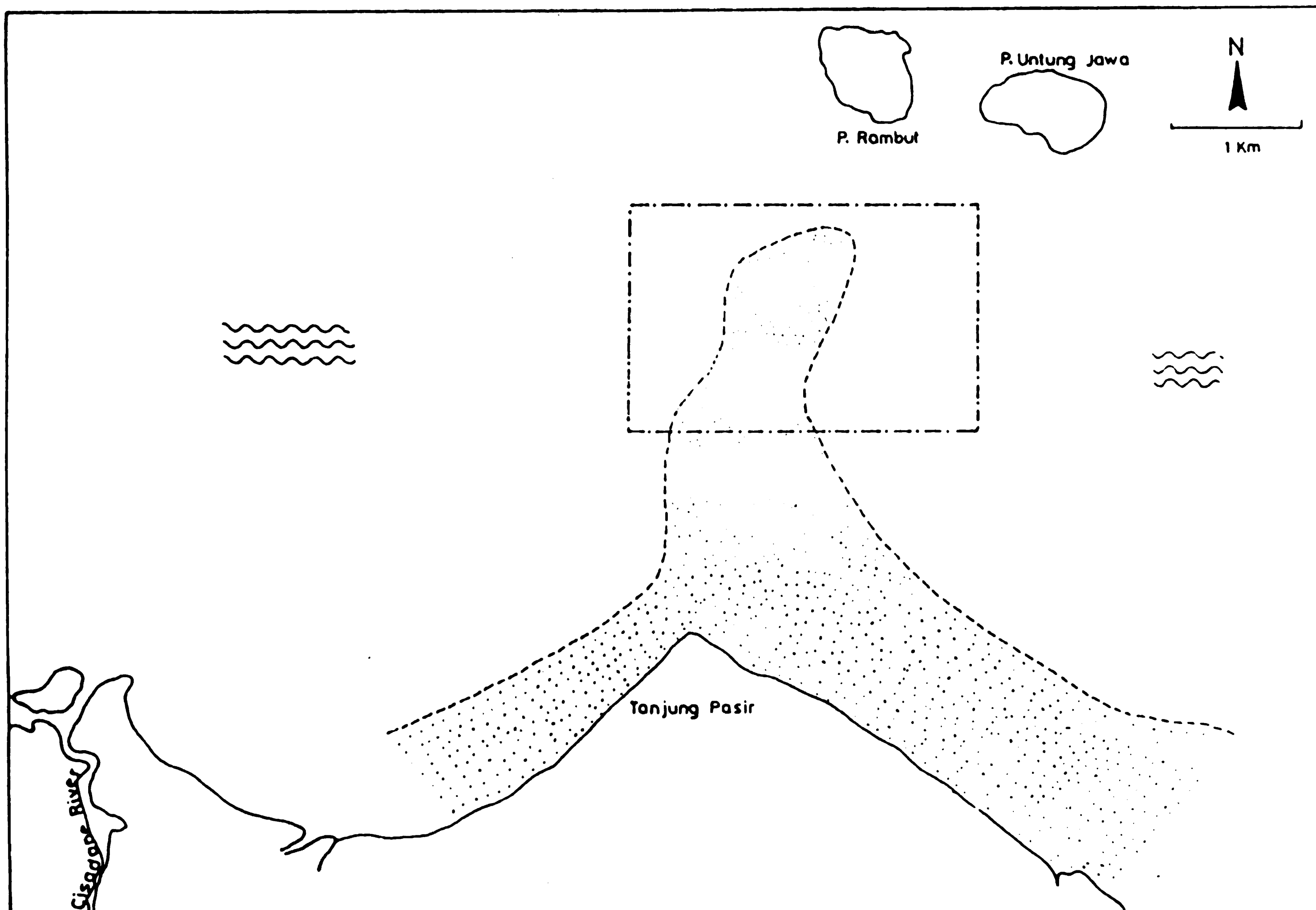


Fig. 15. Sand deposit in southern part of Pulau Rambut Nature Reserve , Jakarta Bay, Indonesia, 1989.

5. Disturbance from Local People

People are prohibited from living on the island but do some fishing near Pulau Rambut. However, the neighboring island, Pulau Untung Jawa, is crowded with people. People from Untung Jawa often visit Pulau Rambut. Their activities fall into two categories: (1) gathering firewood, usable waste, mollusks, and seaweeds stranded along the coast (mostly done by women and children), (2) fishing (using nets and/or fishing rods) within the boundaries of the reserve. In addition, fishermen from far away places often land on Pulau Rambut during bad weather.

It is rather difficult to ask them to stay away from the Nature Reserve, since the distance between these two island is only about 0.5 km. Every day there are fishermen who set their nets nearby, although according to PHPA's[2] rule, they must be at least 0.5 km off-shore from the nature reserve.

A guard, stationed at Pulau Rambut, has chosen to let fishing and collecting of mollusks occur, because these people are poor and only use the fish and mollusks for their own consumption. Besides, the local people from the neighboring island sometimes help him in guarding the island. Based on informal interviews, all of them

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[2]Perlindungan Hutan dan Pelestarian Alam (Directorate General of Forest Protection and Nature Conservation),

understand the presence and importance of the island as a Nature Reserve for waterbirds.

6. Disturbance from Visitors

The density of nesting waterbirds is low in the areas where peak human activity is encountered. This is particularly evident within a 50 m radius of the guard post/base camp and near the observation tower at the center of the island. However, waterbirds still nest along the walking trail because they select high nest trees (more than 20 m) which are numerous along the trail, reducing the disturbance by visitors.

The mangrove forest receives fewer visits due to its wet and unpleasant mud. Unfortunately, the island is sometimes used for students from local universities for practicing vegetation/mangrove inventory by establishing transects or plots all over the area. During such activity, many nestlings and eggs were ejected from the nests during the parents' panic flight.

7. Possible Disturbance from Airport Activities

The development of Soekarno-Hatta International Airport has also influenced the life of waterbirds in Pulau Rambut. The airport itself has taken up a large amount of waterbird feeding ground. Since the beginning of the airport development (1984/1985), there has been no study on its impact to waterbirds in Pulau Rambut.

Sound louder than 95 dBA created by highway traffic near the airport has been found to change the behavior of some species of Egrets and Day-herons (Prawoto 1990). The impact of sound created by airplanes on waterbirds in Pulau Rambut is still unknown.

B. Threats and Problems from Inside the Island

1. Reduction of Mangrove Forest

The greatest threat to waterbirds in Pulau Rambut was the reduction of mangrove forest. It was evident that the mangrove forest is very important for the survival of the waterbirds. Unfortunately, ground measurement revealed that almost half (39.78%, 7.575 ha) of the mangroves (19.04 ha) was dying-back and in very poor condition.

2. Poor Natural Regeneration

Vegetation analysis also revealed that the overall natural regeneration in the mangrove forest was poor. The Importance Values for seedlings of most species was zero, indicating that none of them were included in the plot samples. A few species had a few seedlings, but the number is still lower than needed for sustainable forest regeneration (i.e., 1000 seedlings/ha).

3. Possible Competition with the Flying Foxes

Milton and Marhadi (1984) concluded that Flying Foxes on the island did not constitute an important threat to birds on the island, through competition for nesting or roosting sites. Wiriosoepartho *et al.* (1986) suspected that these bats were responsible for their observed reduction in bird numbers between two surveys, five months apart. However, no evidence to support this hypothesis was provided. Dharmawan (1987) studied the competition between waterbirds and Flying Foxes and concluded that there was indeed an intense competition for roosting and nesting trees between them.

In January 1988, Lambert and Erftemeijer (1988) noted that the Flying Fox population was estimated to be less than 3000 individuals, and these all roosted in an area which did not appear to be particularly important for nesting and roosting waterbirds.

During this study, no count was made to estimate the population of Flying Foxes. However, it was apparent that the number and the distribution of this bat changed from time to time. The number of Flying Fox was estimated at 500 to 3000, and they roosted only in the mixed-dryland forest. Dharmawan (1987) reported that the bats also used the mangrove forest.

Most of the Flying Foxes used either Dyxoxylum or Sterculia trees for their roosting sites. Dyxoxylum was almost never used by nesting waterbirds. When the bats roosted in Sterculia trees, certain waterbird species, i.e., Grey Heron and Oriental Darter, were able to roost and/or nest together with the bats on the same tree without showing any intense competition.

The only cause for concern arising from the occurrence of the Flying Fox population is that their accumulating feces could alter the soil pH to a degree that trees are killed. Flying Foxes may be rare in the Jakarta area, and it would seem that the protection of the bat colony on Pulau Rambut is also an important function of the reserve (Lambert and Erftemeijer 1988).

4. Decrease in Biodiversity

It is believed that Pulau Rambut a long time ago was a habitat for numerous wildlife. The list of wildlife once living in Pulau Rambut is written and sculptured on a wall near base camp. The wildlife species listed on this wall which cannot be found in Pulau Rambut at present are presented in Table 30.

Table 30. List of wildlife previously found in Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia.

No.	Common Name	Latin Name
1.	Clouded Leopard	*Panthera bengalensis*
2.	Leopard Panther	*P. pardus*
3.	Lesser Adjutant	*Leptoptilus javanicus*
4.	Rufous Night Heron	*Nycticorax caledonicus*
5.	Greater Painted Snipe	*Rostratula benghalensis*
6.	Whistling Tree-duck	*Dendrocygna arcuata*
7.	Lesser Tree-duck	*Dendrocygna javanica*
8.	Great Thick-knee	*Esacus magnirostris*

Island life has unique characteristics. One of the characteristics is the lack or absence of mammalia (Williamson 1981). Leopards were once present in Pulau Rambut and when they became extinct, their extinction probably was unavoidable and considered as part of natural phenomena due to the small size of the island. Feral cats were also present in a large numbers a few years ago but the PHPA took action by capturing all the cats and placing them the mainland. The only existing mammal on that island at present is the Flying Fox.

Large size waterbirds such as the Javan Stork are not found on the island anymore. Its absence is presumably due to the decreasing number in the western part of Indonesia in general. Large size waterbirds face difficult survival because (i) they need more food compared to smaller waterbirds, and food is getting more difficult to obtain along the northern coast of Java, and (ii) they also are very susceptible to illegal hunting by local people.

The presence of Rufous Night Heron was reported by Suwelo and Tobrani (1972). In Java this bird is very rare and there is no recent record of its presence (MacKinnon 1988). Duck-like birds were no longer present in Pulau Rambut. Perhaps there is no suitable habitat for them.

The existing non-waterbird species are also vulnerable. Both species of snakes (Mangrove Snake and Reticulated Phyton) have become increasingly rare in Pulau Rambut. The cause of the decline is unknown. Perhaps they are hunted by local people, either live-captured as pets or killed for their beautiful skin. Monitor Dragon is also sometimes trapped illegally. Its meat is believed to be an excellent remedy for various skin problems. Also, its skin is precious for belts, shoes, and women's handbags.

5. Stealing of Sand, Coral, and Triphasia

Seashore sand is valuable for building material and especially for bunkers at golf courses. Coral is also used as decorations accessories for aquariums, as well as tough building material. The high price of this sand and coral causes it to be stolen. Sand and coral of Pulau

Rambut have been stolen many times. Lack of personnel and facilities creates a problem in guarding the entire coastline. If coral and especially sand stealing is still happening, it can reduce the size of Pulau Rambut.

Triphasia trifolia is a small tree which dominated the lower layer of the mixed-dryland forest. This species is easy to take care of, very tolerant in low light, possesses an artistic shape, and has tiny foliage and bright red fruits. All of these characteristics make the Triphasia as a favorite 'bonsai' plant. Triphasia as bonsai has a high price, causing many to be stolen.

Triphasia has little use for the waterbirds. Its canopy is too low for the waterbirds. In addition, its twigs are thorned, so birds are unable to use them for nest material. However, the thickness of this species offers a good cover for other wildlife species such as Monitor Dragon, Mangrove Snake, and many Passerine birds. It also prevents visitors from walking outside the available trails.

6. Exotic Plants

There are 3 species of trees planted around the guest house and base camps, namely *Acacia auriculiformis, Casuarina equisetifolia*, and *Leucaena glauca*. The man-made plantation was done by Dinas Kehutanan[3] in order

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[3]Provincial Forestry Sector

to prevent the beach from destructive erosion and to enlarge the seashore (Dinas Kehutanan 1988).

The exotic plants are not used for nesting by the waterbird. Their close location to visitor's activity center discourages bird use, as does the weak twigs on the trees, although these plant species can still be used for nest material. However, dangers of plant introductions include the possible alteration of canopy dynamics and forest community dynamics, elimination of some species (Mooney and Drake 1987), modification of wildlife habitat, and habitat destruction and establishment of exotic plants (Courtenay 1987).

C. Institutional Problem

1. Dual Management

The island is managed under two separate institutions namely the PHPA and Dinas Kehutanan. As a result, there are also two policies regarding the use of the island. PHPA is more conservation oriented, letting only researchers and birdwatchers enter the island. Dinas Kehutanan, in contrast, is more recreation oriented and gives permission to virtually anybody who wants to do some recreation on the island.

The question of who supposedly manages the island does not have a simple answer. A Nature Reserve in

Indonesia is managed under PHPA. In addition, PHPA, as a major agent of conservation, obviously wants the island under its full control. Unfortunately, PHPA is a poor institution, with a very limited budget allocated to Pulau Rambut. The only thing PHPA owns in Pulau Rambut is a small, poor conditioned base camp, guarded by one person.

Dinas Kehutanan has a far higher budget for the island. This institution owns one good base camp (2 bedrooms, 1 bathroom, 1 kitchen), one cottage (with 2 bedrooms, 2 bathrooms, 1 conference room) equipped with a generator, a well with hand-pump, a watch tower (17 m high), a new jetty, and a small boat. There are three people (from Dinas Kehutanan) guarding Pulau Rambut.

Conflicts arise when Dinas Kehutanan gives permission to large numbers of people to enter the island. PHPA itself, taking consideration of the small size of the island and the disturbance caused by visitors, only gives permission for up to 25 people on the island at one time. PHPA has chosen the neighboring island, Pulau Untung Jawa, as a buffer of the Nature Reserve by building a camping ground on the island.

Although the dual management faces conflict, PHPA still needs the Dinas Kehutanan for its facilities and personnel. Perhaps if PHPA had a larger budget for Pulau Rambut, it might have full control of this precious island.

2. Status as a Nature Reserve

The status of Pulau Rambut since 1937 has been as a Nature Reserve. There are four types of reserves currently defined under the Basic Forestry Law No. 5, 1967 of Indonesia (Sumardja *et al.* 1984):

1. Nature Reserve (IUCN Category I) in which no management or human interference with the environment is permitted.
2. Game Reserve (IUCN Category IV: Managed Nature Reserve) in which the natural balance of the environment must not be disturbed but a low level of management, visitor use, and utilization are permitted.
3. Hunting Reserve (IUCN Category VIII: Multiple Use Managed Area) are managed specifically for hunting and fishing
4. Recreation Park (IUCN Category V: Protected Landscape) which are maintained for outdoor recreation purposes.

The general criteria for a Natural Reserve is generally "small undisturbed fragile habitats of high conservation importance, unique natural sites, homes of particular rare species, etc; areas requiring strict protection" (Sumardja *et al.* 1984). Activities permitted in a Nature Reserve are guarding by PHPA personnel and limited research.

Pulau Rambut fits the criteria for Nature Reserve. However, activities on the island are more or less similar to a Recreation Park, where visitors are allowed to do some recreation, fishing, etc.

VII. MANAGEMENT IMPLICATION

There is no doubt that Pulau Rambut Nature Reserve is the most important breeding site for waterbirds in the Jakarta Bay area. In the future, the vast development of the Jabotabek area (Jakarta, Bogor, Tangerang, and Bekasi, that is, Jakarta and its surrounding towns) would require more land, which will probably reduce any other areas for breeding waterbirds. If this happens, Pulau Rambut Nature Reserve will become even more important.

Management should be directed to overcome problems and threats mentioned previously. Since there are so many problems and threats to this island, the following section will discuss the most important management recommendations for this reserve.

A. Management Outside the Nature Reserve

1. Set aside some important feeding sites

Knowledge obtained from this study is still far from sufficient. Pulau Rambut Nature Reserve is only part of a waterbird's home range. It serves as roosting and breeding sites, including any activities related to breeding (pair formation, mating, rearing young, etc). Other important parts of their home range, namely feeding sites, are somewhere along the northern coast of West Java, especially along Jakarta Bay.

The exact location of feeding sites and their quality is crucial for management of these birds. This information would allow for recommendations about locations which may need to be set aside for these waterbirds. An expensive but accurate way is by using radio tracking. A less expensive but time consuming method is by banding. Bands (presumably a bright-color) can be attached around nestling's tarsus. Its movement can be monitored when the nestling is able to feed by itself, in the following year.

2. Campaign

Problems and threats outside the island need political action. A campaign to make people realize that there is an invaluable Nature Reserve close by is needed.

The campaign could also include proper attitudes towards conservation, in general, such as hunting and pollution. In addition, a campaign about Nature Reserves and other types of conservation areas is still needed to educate people.

B. Management Inside the Nature Reserve

1. Predator Monitoring

Placement of waterbirds' nests has suggested that predation by Monitor Lizard was the biggest threat for survival of eggs and youngs. Predation by others (Mangrove Snakes, White-bellied Sea Eagle, and Brahminy Kite), and kleiptoparatism by Lesser Frigatebirds, *Fregata ariel*, were not considered to be important.

The Monitor Lizard is the top predator in the Pulau Rambut ecosystem. This species has no natural enemy, although sometimes they are illegally hunted for their skin. Their population in Pulau Rambut is still unknown and it is difficult to obtain an accurate estimate.

An adult Monitor Lizard presumably requires a lot of eggs and/or youngs for their daily meal. Unfortunately, mortality due to predation by this reptile is still unknown.

Activities in predator monitoring should include:

(a) population number of Monitor Lizard, including age class, sex ratio, birth rate, and death rate

(b) distribution of the Monitor Lizard on the entire island in relation to the distribution of the five colonies of waterbirds

(c) feeding behavior and degree of predation.

2. Monitoring of Waterbird Species and Population

Regular monitoring of species of waterbirds present in Pulau Rambut should be conducted. The heronry used to support more species. Local extinction of waterbirds (or other wildlife species) should be treated seriously and its cause should be determined.

The increase of species number could be an indicator of habitat conditions outside the island. Considering its status, Pulau Rambut is the safest breeding and roosting site in Jakarta Bay area. If other locations are gone or decrease in size, it is possible that more waterbirds might move to reside in Pulau Rambut.

Population size is also an indicator of habitat condition, especially feeding ground availability. It the feeding ground is decreasing, the waterbird numbers might decrease, or they might search for other further feeding grounds (which means more energy required to seek food).

3. Man-made Regeneration for Mangrove Forest

Of the 15 waterbird species found in Pulau Rambut, 14 of them depend on the mangrove forest for their roosting and breeding sites. If the condition of the mangrove is left alone like this, it is possible that in the future the mangroves will be extirpated.

Vegetation analysis revealed that the natural regeneration is not in good condition. In addition, the die back of mangrove has created a worse situation. Unfortunately, experiments on man-made regeneration are not promising. The germination time (time between planting and germination) of Ceriops and Rhizophora were very long, averaging 43 days and 47 days, respectively. For the first three months, the average percent of germination is only about 5-9% for Rhizophora and 70% for Ceriops (Hermana 1991).

In addition to the high level of oil in the soil (11,267 ppm), germination failure was also due to herbivory by mollusc *Terebralia palustris*, and destruction by solid wastes (e.g., plastics, lumber, bamboo, etc) entering the site during high tides.

Considering the low percentage of germination using a direct planting method, it is worthwhile to try another planting method, for example, sapling planting. To do this, seedlings are germinated *ex-situ* in poly bags, then planted in the field when they are strong enough to withstand factors mentioned previously.

4. Control of Visitors

The overall distribution of nesting sites also showed that sites close to visitor's activities were not used. During the study, it was also known that all waterbird species (with the exception of Milky Stork) were very susceptible to human approach. Therefore, it is important to :

(a) prohibit visitors from entering the heronry during the peak breeding season

(b) limit the visitor number to fewer than 25

(c) recommend only daily visits, not overnight. Overnight visitors can use the camping ground on Pulau Untung Jawa. Researchers could still spend the night on the island without turning on the noisy electric generator.

5. Improvement of Facilities and Budget

Lack of facilities and low salaries for the guardians can jeopardize the safety of the Nature Reserve. As an illustration, the Nature Reserve is often left unguarded during the night, which makes it easily accessible and disturbed. The absence of sea transportation also prohibits regular visits by the guardians or by other researchers.

A considerable amount of budget should also be allowed, especially for man-made regeneration activities. If the activities is not started promptly, the cost of mangrove restoration could be increased due to the increasing damaged areas.

VIII. SUMMARY AND CONCLUSIONS

Pulau Rambut Nature Reserve is an important nesting areas for the colonial birds of the families Ardeidae, Phalacrocoracidae, Threskiornithidae, and Ciconiidae. There were 15 species of waterbirds breeding in Pulau Rambut during the 1990-1991 breeding seasons: Great Egret, Plumed Egret, Little Egret, Pacific Reef Egret, Cattle Egret, Grey Heron, Purple Heron, Black-crowned Night Heron, Glossy Ibis, Black-headed Ibis, Oriental Darter, Milky Stork, Little Black Cormorant, Pygmy Cormorant, and Pied Cormorant. Among these, Milky Stork, Glossy Ibis, and Black-headed Ibis were seasonal resident species.

Rain played a significant role in breeding season. Although the high breeding season occurred during December and April, coinciding with the high rainfall, the overall population showed a continuous breeding season.

Distribution of nest-sites was always changing. However, it was obvious that the nesting waterbirds formed 5 colonies in the mangrove forest and in the mixed-dryland forest. The beach forest was never used due to the strong wind. In addition, the waterbirds never used sites near the base camp, sites surrounding the watch tower, ecotonal areas, and sites along the island periphery.

Some species appear to have strict habitat preferences, whereas others tolerate a wide variety of sites. The primary mangrove was used intensively by Little Black Cormorant, Glossy Ibis, Black-headed Ibis, and Milky Stork. The secondary mangrove was used intensively by Great Egret, Purple Heron, and Pygmy Cormorant, while mixed-dryland forest was used primarily by Oriental Darter and Grey Heron. Other smaller species under study (i.e., Little Egret, Cattle Egret, and Black-crowned Night Heron) used all of these vegetation types.

Selection of vegetation type by waterbirds in Pulau Rambut heronry was influenced by both social and physiognomic features of the environment. Social factors included (i) congeneric avoidance due to similarity in morphology, physiology, behavior, and ecology, (ii) behavior in relation to daily habit. Physiognomic aspects of habitat selection include (i) body size, in relation to social domination and ability to maneuver and reach a certain site, (ii) location within the heronry (center vs. edge).

The waterbirds also showed preferences for certain nesting trees. Nesting trees selected were safe from the winds (especially from the destructive West Monsoon), structurally stable, and possessed a proper foliage density (extremely dense or very scarce foliage was not suitable for nesting). Further, some birds with soaring ability required a tall and emergent trees to land and take-off.

In three colonies (of four colonies measured), vertical stratification was either absent or unclear. In fact, there was a tendency to nest as high as possible. This suggested that the heronry suffered from ground-based predators (i.e., Monitor Dragon), but not from aerial predators (i.e., Brahminy Kite and White-bellied Sea Eagle). Lack of nest concealment and nest location further from the trunk also support this conclusion. However, nests on high sites were unsafe from the winds. In order to overcome this problem, the waterbirds developed some strategies: selecting sites safe from winds all year long (i.e, in middle heronry), or nesting further from the direction of the wind (which resulted in constantly changing their distribution), or building a more sturdy nest which could resist the strong wind, as shown by Little Black Cormorants.

Factor analyses revealed that there were 5 components which described waterbird nest-sites: nest placement, tree size, inter-nest distance, nest support, and stability. These factors were results of differences in body size, choice of general vegetation type, and degree of predation.

Results of this study have shown that the mangrove forests were very important for waterbirds. It should be emphasized here that the mangrove forests have suffered a 40% decrease in area during the last twenty years, due to the die-back of mangrove trees caused by oil spills.

The unfortunate location of Pulau Rambut also creates some problems and threats to the entire ecosystem. Its location in Jakarta Bay area makes it exposed to pollution. Humans disturb the ecosystem and steal some of its valuable resources.

Finally, it is important to identify the feeding grounds of these waterbirds outside Pulau Rambut and to set aside some locations in order to maintain a successful breeding population of these species in Java, and in Indonesia as a whole.

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Appendix 1. List of birds reported present in Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia.

No.	Family	Latin Name	Common Name
Waterbird and shorebird			
1	Anhingidae	*Anhinga melanogaster*	Oriental Darter
2	Ardeidae	*Ardea cinerea*	Grey Heron
3	Ardeidae	*A. purpurea*	Purple Heron
4	Ardeidae	*Ardeola speciosa*	Javan Pond Heron
5	Ardeidae	*Bubulcus ibis*	Cattle Egret
6	Ardeidae	*Butorides striatus*	Little Green Heron
7	Ardeidae	*Egretta alba*	Great Egret
8	Ardeidae	*E. garzetta*	Little Egret
9	Ardeidae	*E. intermedia*	Plumed Egret
10	Ardeidae	*E. sacra*	Pacific Reef Egret
11	Ardeidae	*Nycticorax nycticorax*	Black-crowned Night Heron
12	Ciconiidae	*Mycteria cinerea*	Milky Stork
13	Phalacrocoracidae	*Phalacrocorax melanoleucus*	Pied Cormorant
14	Phalacrocoracidae	*P. pygmaeus*	Pygmy Cormorant
15	Phalacrocoracidae	*P. sulcirostris*	Little Black Cormorant
16	Threskiornithidae	*Plegadis falcinellus*	Glossy Ibis
17	Threskiornithidae	*Threskiornis melanocephalus*	Black Headed Ibis
18	Laridae	*Sterna hirundo*	Common Tern
19	Scolopacidae	*Numenius phaeopus*	Whimbrel
20	Scolopacidae	*Actitis hypoleucos*	Common Sandpiper
Non-Waterbird			
21	Accipitridae	*Haliastur indus*	Brahminy Kite
22	Accipitridae	*Haliaeetus leucogaster*	White-bellied Sea-eagle
23	Alcedinidae	*Alcedo caerulescens*	Small Blue Kingfisher
24	Alcedinidae	*Halcyon chloris*	White-collared Kingfisher
25	Alcedinidae	*H. sancta*	Sacred Kingfisher
26	Anatidae	*Dendrocygna arcuata*	Whistling Tree-duck

(cont'd)

Appendix 1. (cont'd)

No	Family	Latin Name	Common Name
27	Apodidae	*Collocalia esculenta*	White-bellied Swiftlet
28	Artamidae	*Artamus leucorhynchus*	White-breasted Wood Swallow
29	Caprimulgidae	*Caprimulgus macrurus*	Large-tailed Nightjar
30	Columbidae	*Ducula bicolor*	Pied Imperial Pigeon
31	Columbidae	*Streptopelia chinensis*	Spotted Dove
32	Columbidae	*Treron olax*	Little Green Pigeon
33	Corvidae	*Corvus enca*	Slender-billed Crow
34	Cuculidae	*Centropus bengalensis*	Lesser Coucal
35	Cuculidae	*Clamator coromandus*	Chestnut-winged Cuckoo
36	Cuculidae	*Eudynamis scolopacea*	Common Koel
37	Dicaeidae	*Dicaeum trochileun*	Scarlet-headed Flowerpecker
38	Dicruridae	*Dicrurus macrocercus*	Black Drongo
39	Fregatidae	*Fregata ariel*	Lesser Frigatebird
40	Hirundinidae	*Hirundo rustica*	Barn Swallow
41	Hirundinidae	*H. tahitica*	Pacific Swallow
42	Meropidae	*Merops superciliosus*	Blue-tailed Bee-eater
43	Muscicapidae	*Rhipidura javanica*	Pied Fantail
44	Nectarinidae	*Anthreptes malacensis*	Brown-throated Sunbird
45	Nectarinidae	*Nectarinia jugularis*	Olive-backed Sunbird
46	Oriolidae	*Oriolus chinensis*	Black-naped Oriole
47	Ralidae	*Amaurornis phoenicurus*	White-breasted Waterhen
48	Sturnidae	*Sturnus melanopterus*	Black-winged Starling
49	Sylvidae	*Prinia familiaris*	Bar-winged Prinia
50	Turdidae	*Copsychus malabaricus*	White-rumped Shama
51	Turdidae	*C. saularis*	Magpie Robin

Appendix 2. List of plants in Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia.

No.	Family	Latin Name
Found in Mangrove Forest		
1	Euphorbiaceae	*Excoecaria agallocha*
2	Lythraceae	*Pemphis acidula*
3	Meliaceae	*Xylocarpus granatum*
4	Meliaceae	*X. moluccensis*
5	Polypodiaceae	*Acrostichum aureum*
6	Rhizophoraceae	*Rhizophora apiculata*
7	Rhizophoraceae	*R. mucronata*
8	Rhizophoraceae	*R. stylosa*
9	Rhizophoraceae	*Bruguiera exaristata*
10	Rhizophoraceae	*B. gymnorrhiza*
11	Rhizophoraceae	*Ceriops decandra*
12	Rhizophoraceae	*C. tagal*
13	Rubiaceae	*Scyphiphora hydrophyllacea*
14	Sonneratiacea	*Sonneratia alba*
15	Sterculiaceae	*Heritiera littoralis*
16	Verbenaceae	*Avicennia alba*
Mostly Found in Mixed Dryland Forest		
17	Apocynaceae	*Cerbera manghas*
18	Caesalpiniaceae	*Bauhinia sp.*
19	Caesalpiniaceae	*Erythrina variegata*
20	Caesalpiniaceae	*Tamarindus indica*
21	Caricaceae	*Borerea laevis*
22	Caricaceae	*Carica papaya*
23	Compositae	*Elaphanthopus scaber*
24	Compositae	*Pluchea indica*
25	Dioscoreaceae	*Dioscorea bulbifera*
26	Dioscoreaceae	*Pleomella elliptica*
27	Ebenaceae	*Diospyros maritima*
28	Guttiferae	*Calophyllum inophyllum*
29	Meliaceae	*Dyxoxylum caulostachyum*
30	Meliaceae	*Melia azedarach*
31	Mimosaceae	*Albizia procera*
32	Moraceae	*Ficus timorensis*
33	Papilionaceae	*Adenanthera pavonina*
34	Papilionaceae	*Pongamia pinnata*
35	Passifloraceae	*Passiflora foetida*
36	Piperaceae	*Piper betle*
37	Polypodiaceae	*Asplenium nidus*
38	Rubiaceae	*Ixora timorensis*

(cont'd)

Appendix 2. (cont'd)

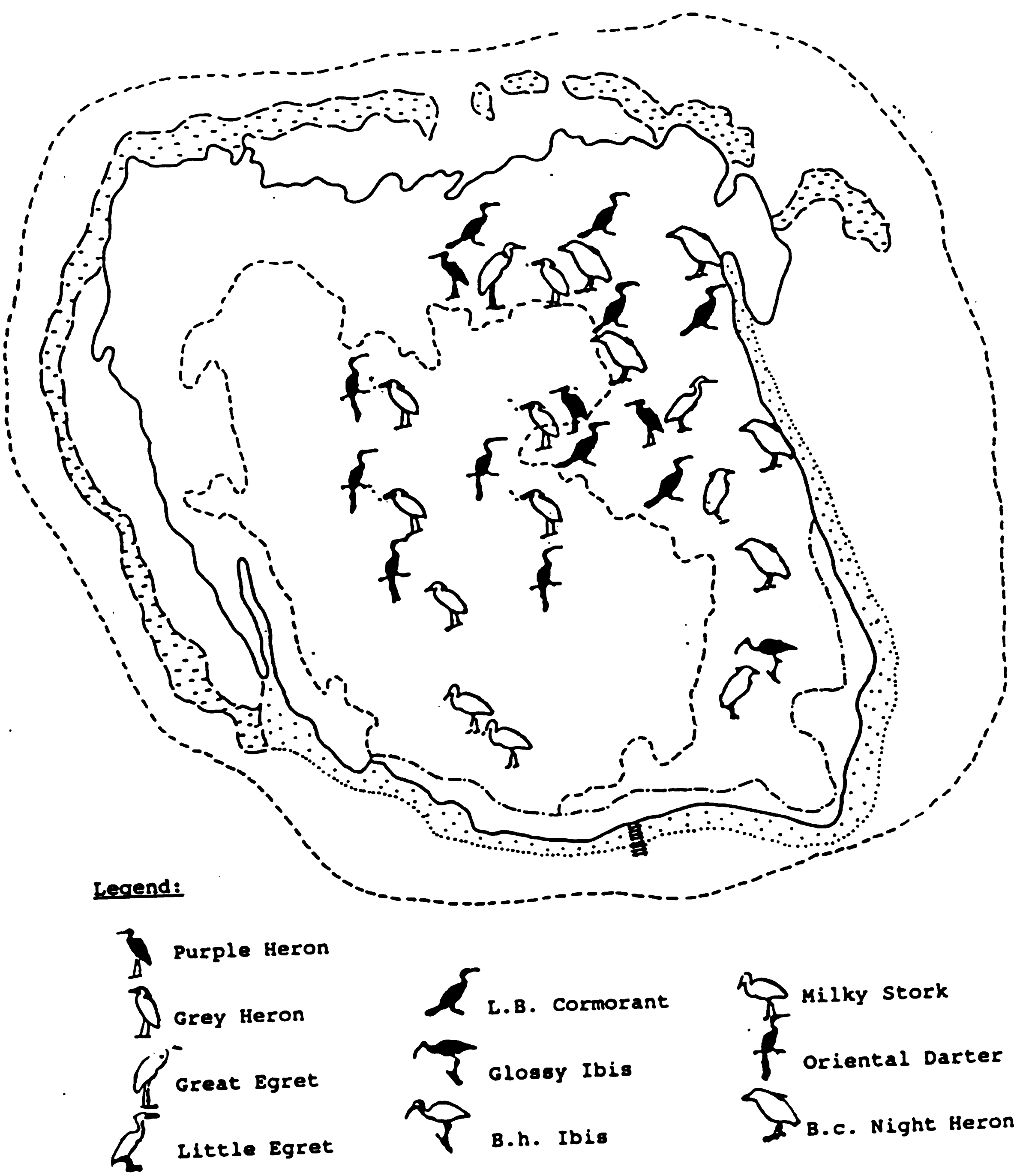
No.	Family	Latin Name
39	Rubiaceae	*Morinda citrifolia*
40	Rubiaceae	*Guettarda speciosa*
41	Rutaceae	*Triphasia trifolia*
42	Sapotaceae	*Manilkara kauki*
43	Sterculiaceae	*Sterculia foetida*
44	Sapindaceae	*Schleichera oleosa*
45	Solanaceae	*Physalis angulata*
46	Taccaceae	*Tacca pinnatifida*
Mostly Found in Shore/Beach Forest		
47	Aizoaceae	*Sesuvium portulacastum*
48	Amaryllidaceae	*Crinum asiaticum*
49	Asteraceae	*Wedelia biflora*
50	Boraginaceae	*Tournefortia argentea*
51	Cactaceae	*Opuntia vulgaris*
52	Casuarinaceae	*Casuarina equisetifolia*
53	Combretaceae	*Lumnitzera racemosa*
54	Combretaceae	*Terminalia catappa*
55	Compositae	*Sophora tomentosa*
56	Convolvulaceae	*Ipomea pes-caprae*
57	Cyperaceae	*Remirea maritima*
58	Cyperceae	*Thouarea involuta*
59	Euphorbiaceae	*Euphorbia atoto*
60	Goodeniaceae	*Scaevola frutescens*
61	Malvaceae	*Hibiscus tiliaceus*
62	Malvaceae	*Thespesia populnea*
63	Mimosaceae	*Leucaena leucocephala*
64	Mimosaceae	*Acacia auriculiformis*
65	Olacaceae	*Ximenia americana*
66	Pandanaceae	*Pandanus tectorius*
67	Papilionaceae	*Canavalia marina*
68	Papilionacaea	*Desmodium umbellatum*
69	Poaceae	*Ischaemum muticum*
70	Poaceae	*Spinifex littoreus*
71	Verbenaceae	*Clerodendron inerme*
72	Verbenaceae	*Lantana camara*

Appendix 3. Monthly number of waterbirds in Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

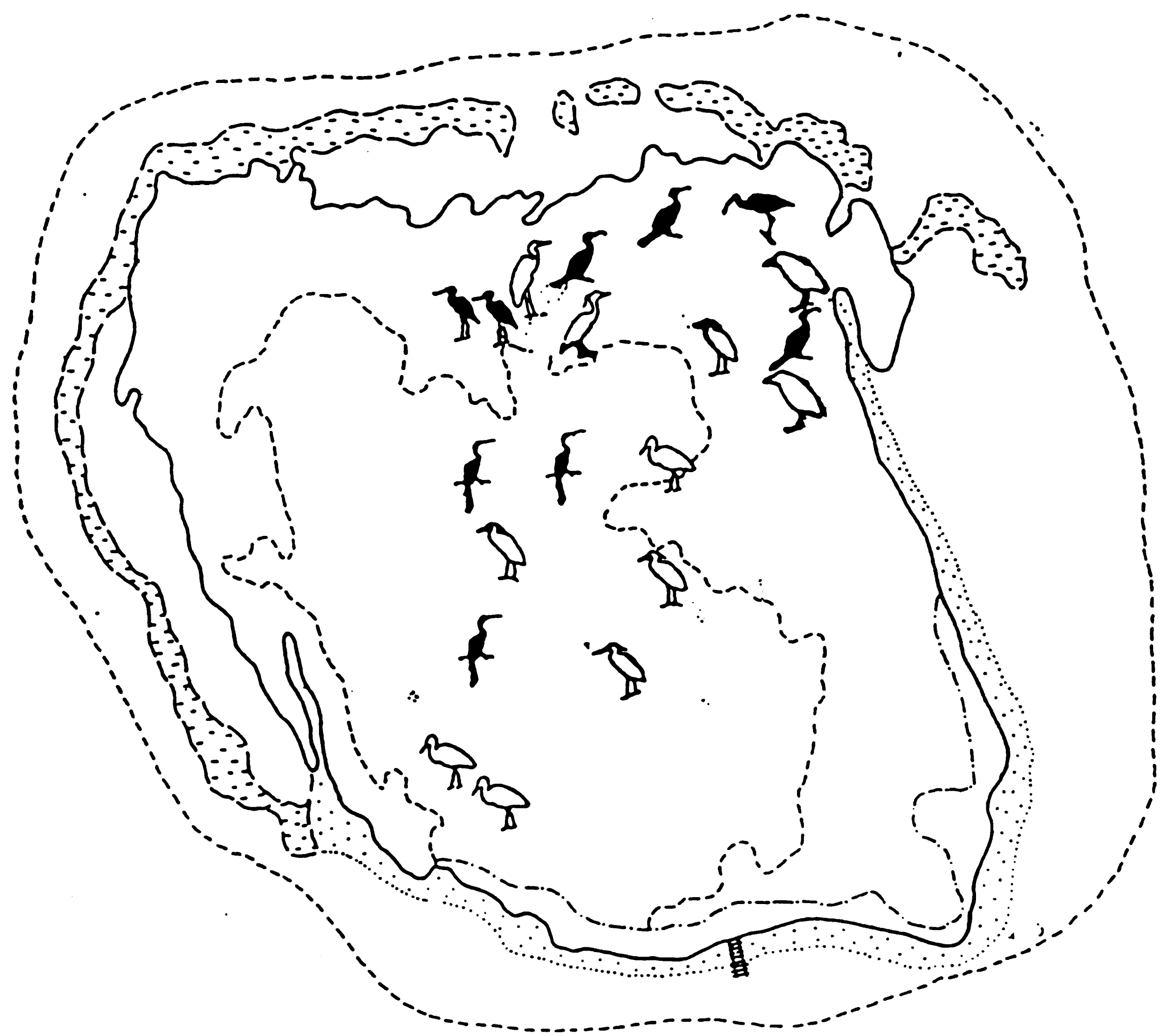
	Black-crowned Night Heron	Cormorants	Mixed Egrets	Mixed Herons	Oriental Darter	Glossy Ibis	Milky Stork	Black-Headed Ibis
January 1990	2848	1472	1717	515	112	317	0	0
February	1962	1118	2229	205	112	308	1	0
March	1497	1678	1109	258	115	180	0	1
April	1526	1150	1337	124	54	216	2	3
May	1836	1154	1213	75	57	598	2	5
June	5791	4427	3142	235	19	196	4	6
July	3880	3534	2679	387	37	222	6	8
August	3210	3495	1312	718	109	193	3	11
September	3646	3890	635	788	181	296	1	4
October	2133	4165	687	514	303	149	0	8
November	1804	3650	503	311	297	535	0	16
December	2341	4076	789	623	154	245	0	7
January 1991	3243	3012	876	453	178	78	0	0
February	3121	1243	989	545	189	212	2	0
March	2645	1920	1032	324	213	102	5	0
April	1535	2538	1654	542	124	280	2	0
May	4646	3597	4332	237	464	129	24	8
June	5970	5593	1474	139	266	471	39	10
July	*	*	*	*	*	*	*	*
August	*	*	*	*	*	*	*	*
September	*	*	*	*	*	*	*	*
October	2432	1689	876	342	132	360	0	31

* data for July, August, and September 1991 were not available.

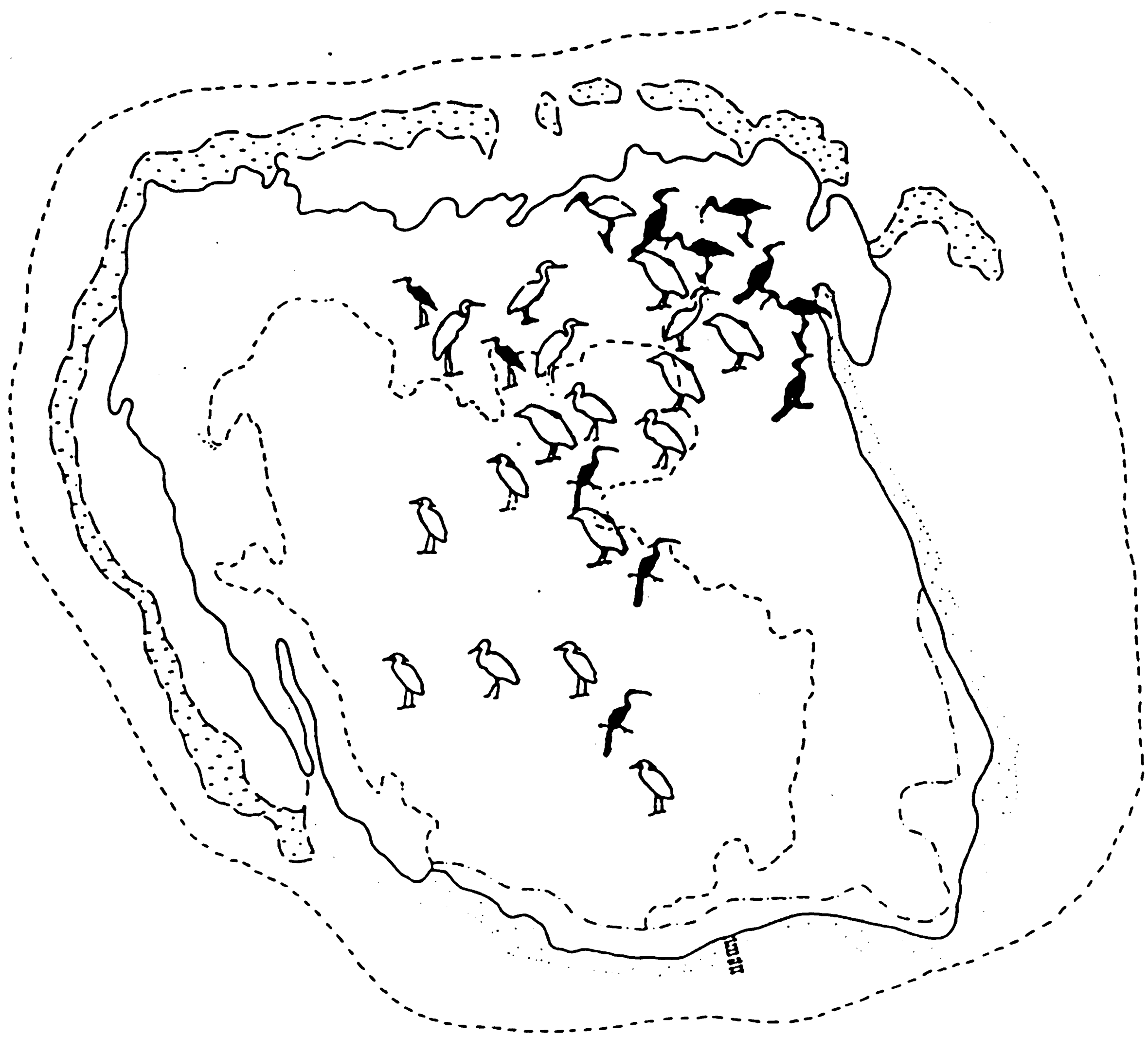
Appendix 4. Distribution of nesting waterbirds in Pulau Rambut heronry, Jakarta Bay, Indonesia, January 1990-March 1990.



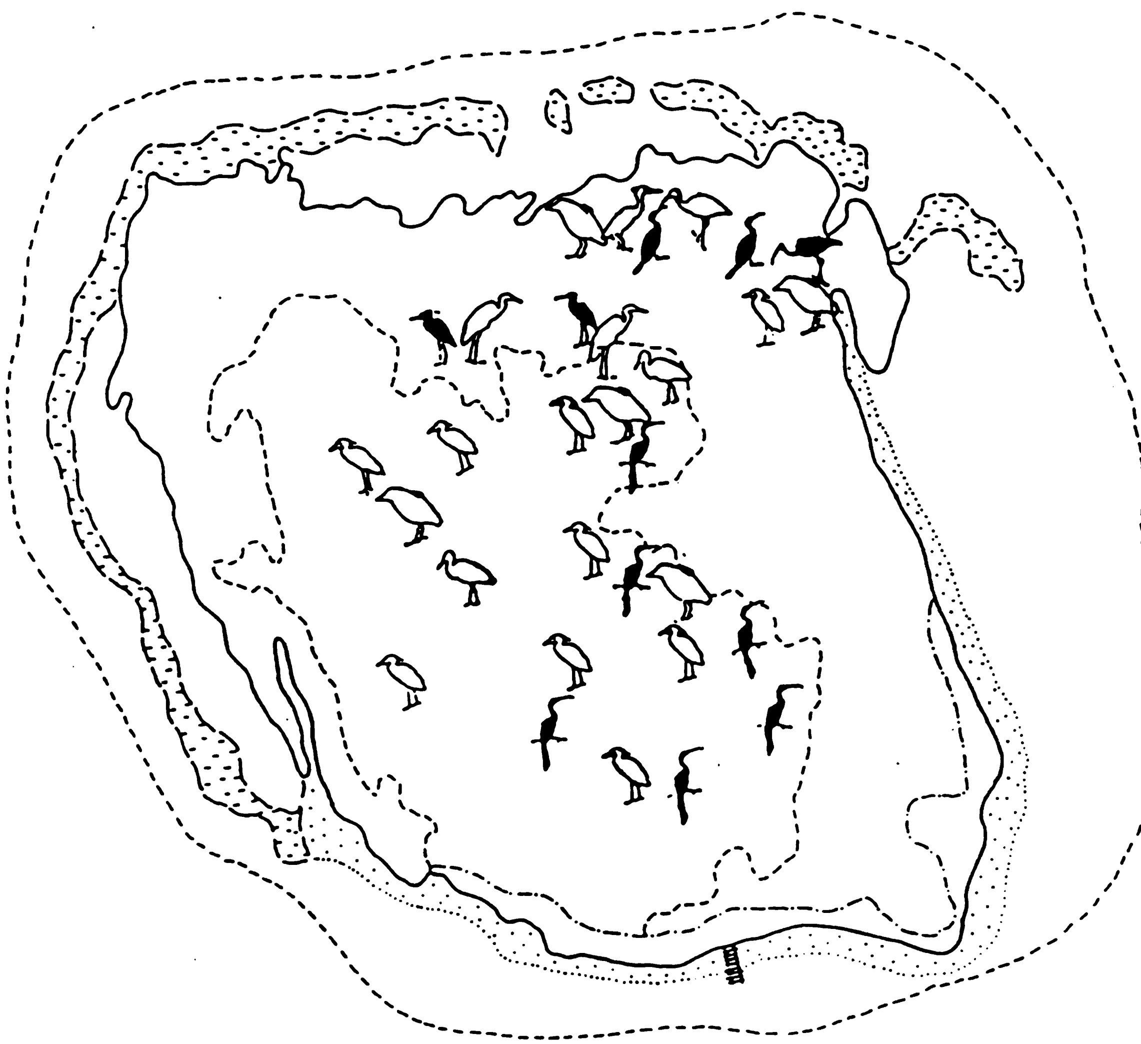
Appendix 5. Distribution of nesting waterbirds in Pulau Rambut heronry, Jakarta Bay, Indonesia, April 1990-May 1990.



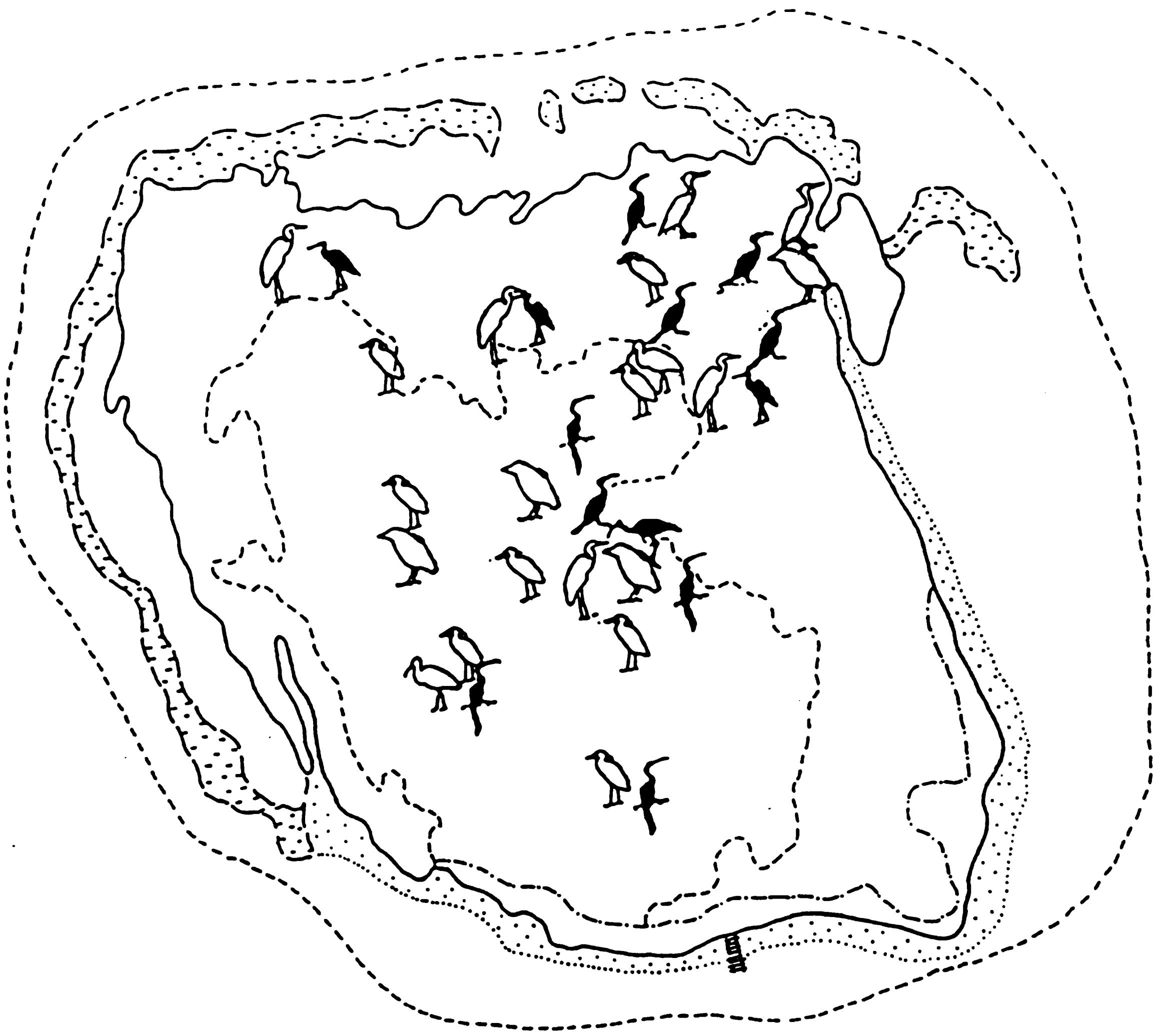
Appendix 6. Distribution of nesting waterbirds in Pulau Rambut heronry, Jakarta Bay, Indonesia, June 1990-July 1990.



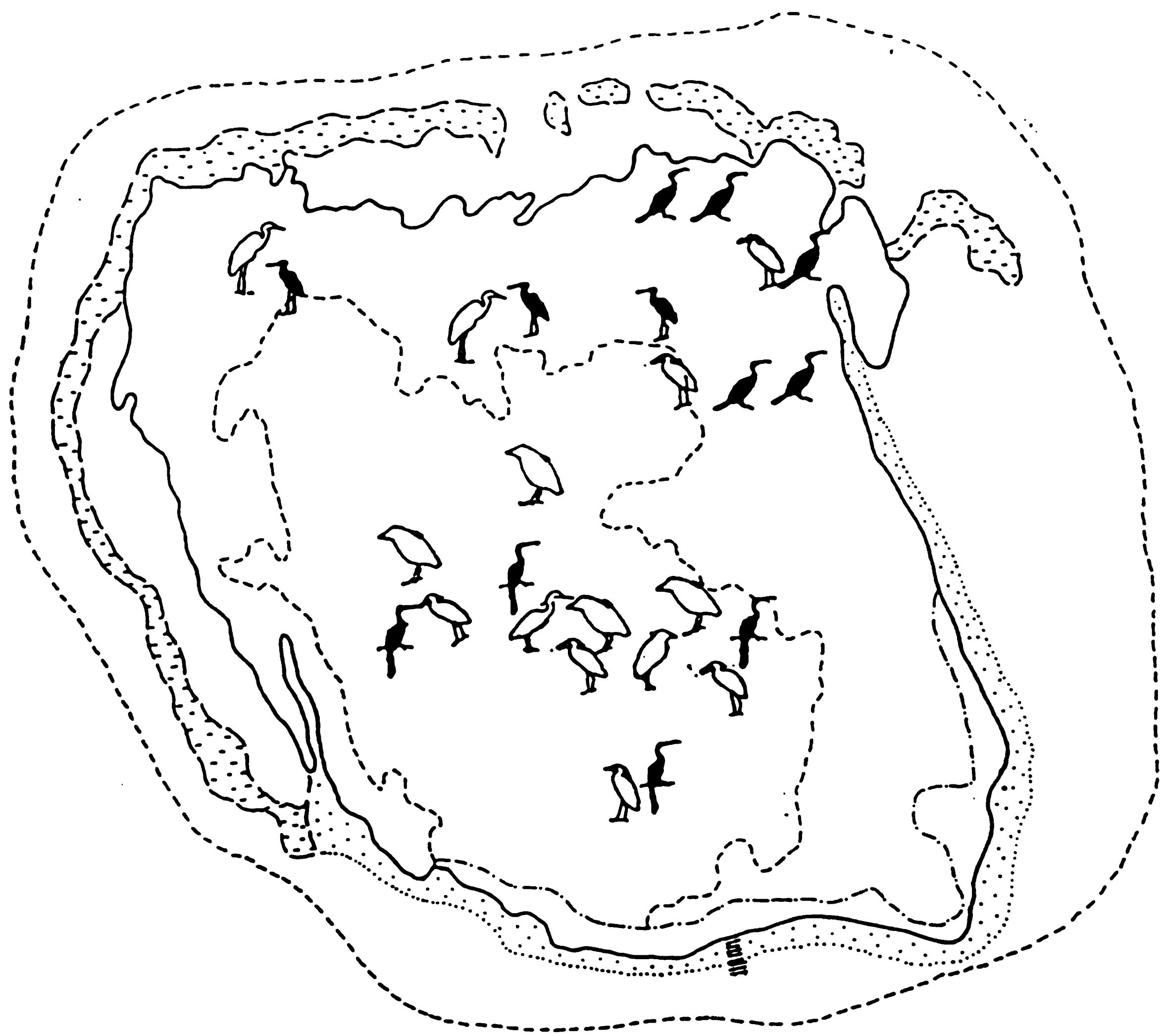
Appendix 7. Distribution of nesting waterbirds in Pulau Rambut heronry, Jakarta Bay, Indonesia, August 1990-September 1990.



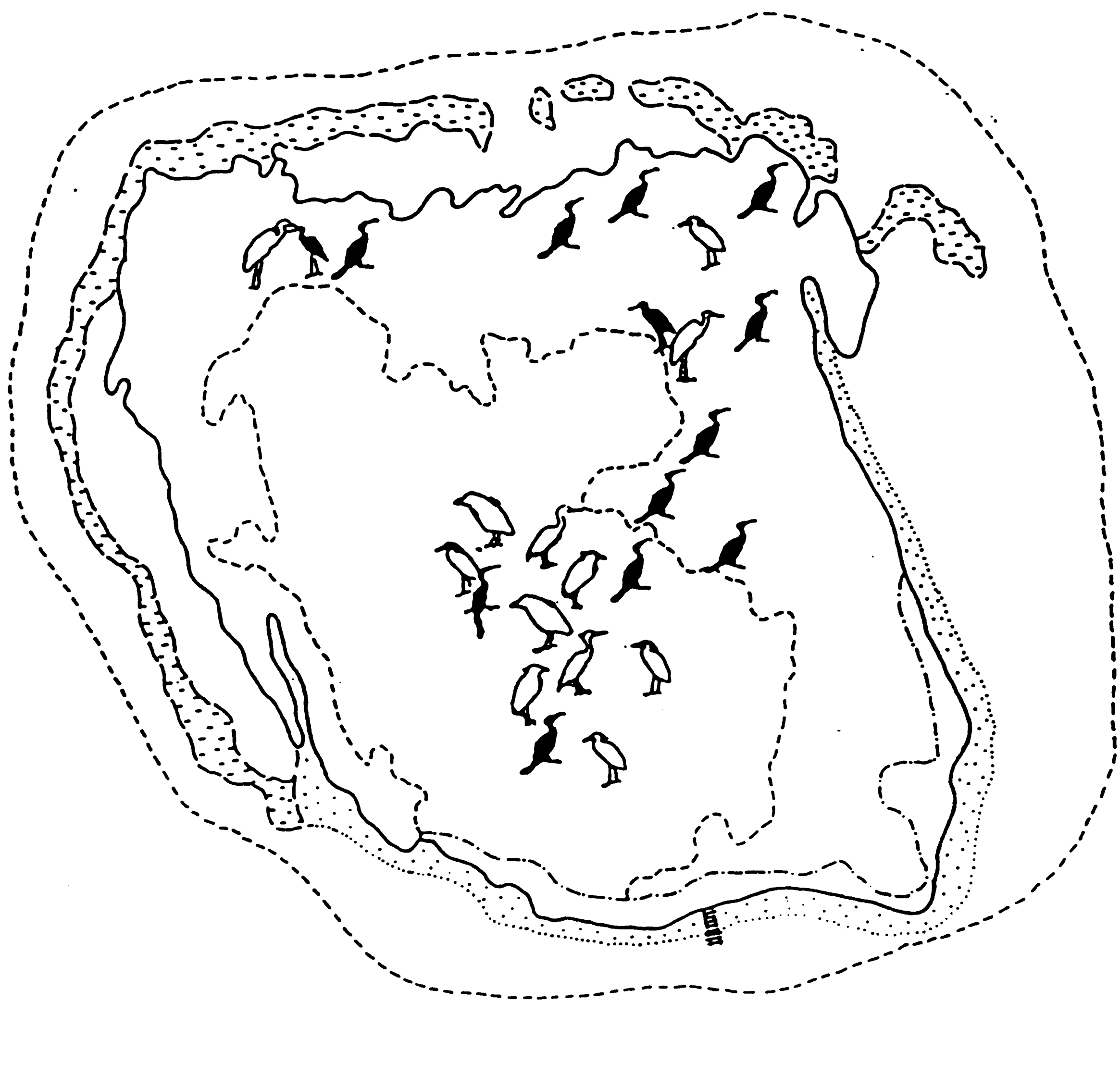
Appendix 8. Distribution of nesting waterbirds in Pulau Rambut heronry, Jakarta Bay, Indonesia, October 1990-November 1990.



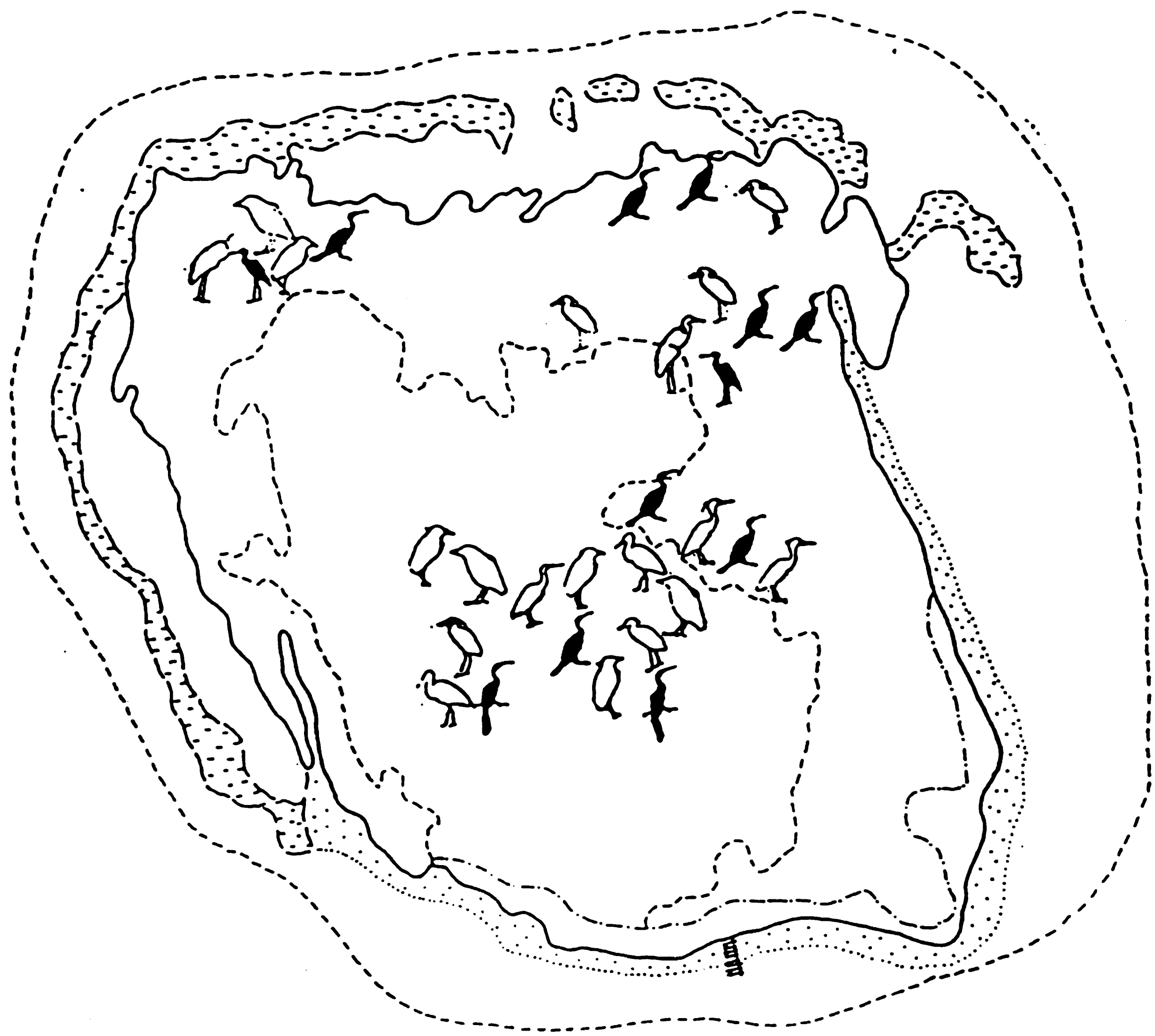
Appendix 9. Distribution of nesting waterbirds in Pulau Rambut heronry, Jakarta Bay, Indonesia, December 1990.



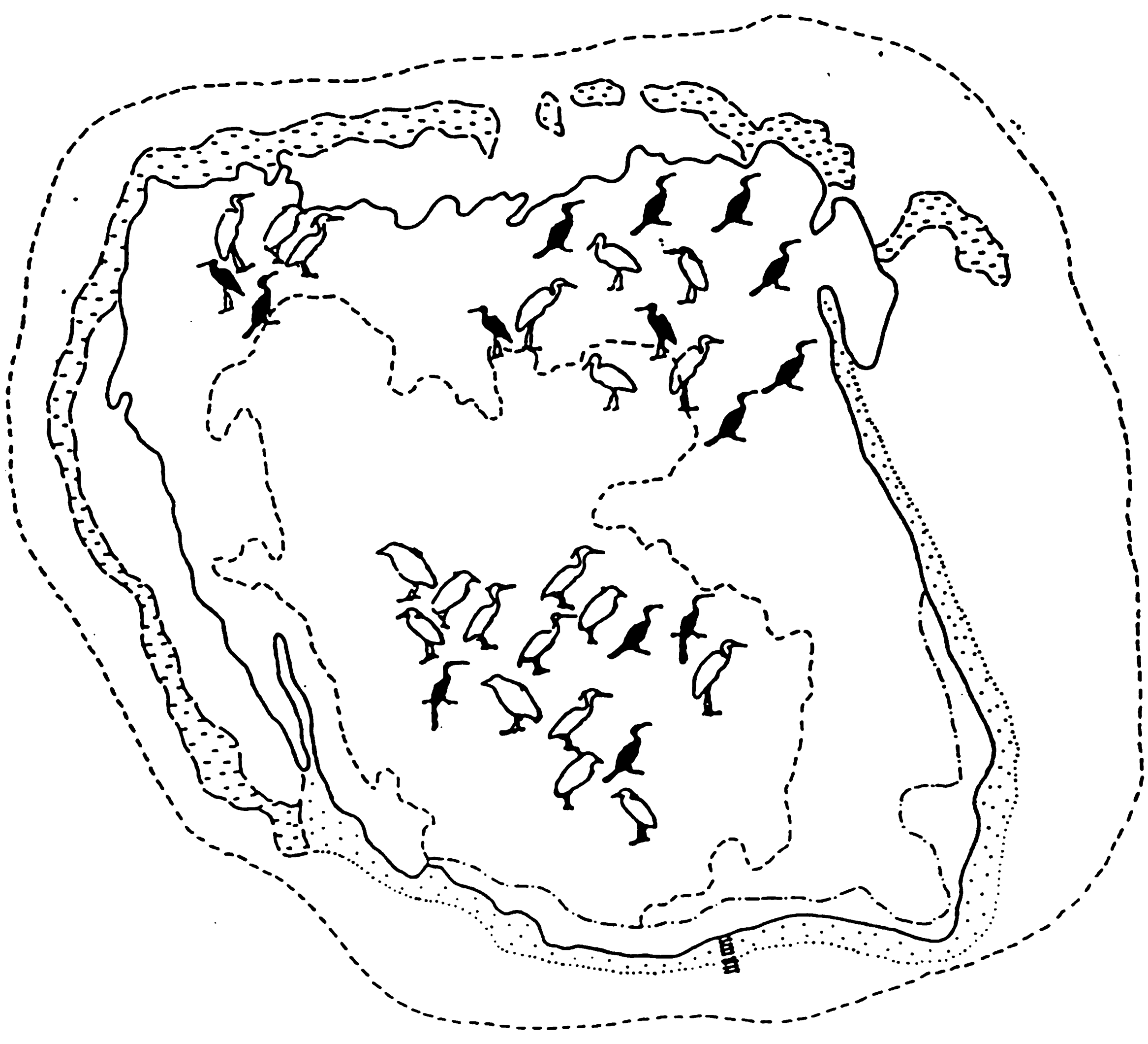
Appendix 10. Distribution of nesting waterbirds in Pulau Rambut heronry, Jakarta Bay, Indonesia, January 1991.



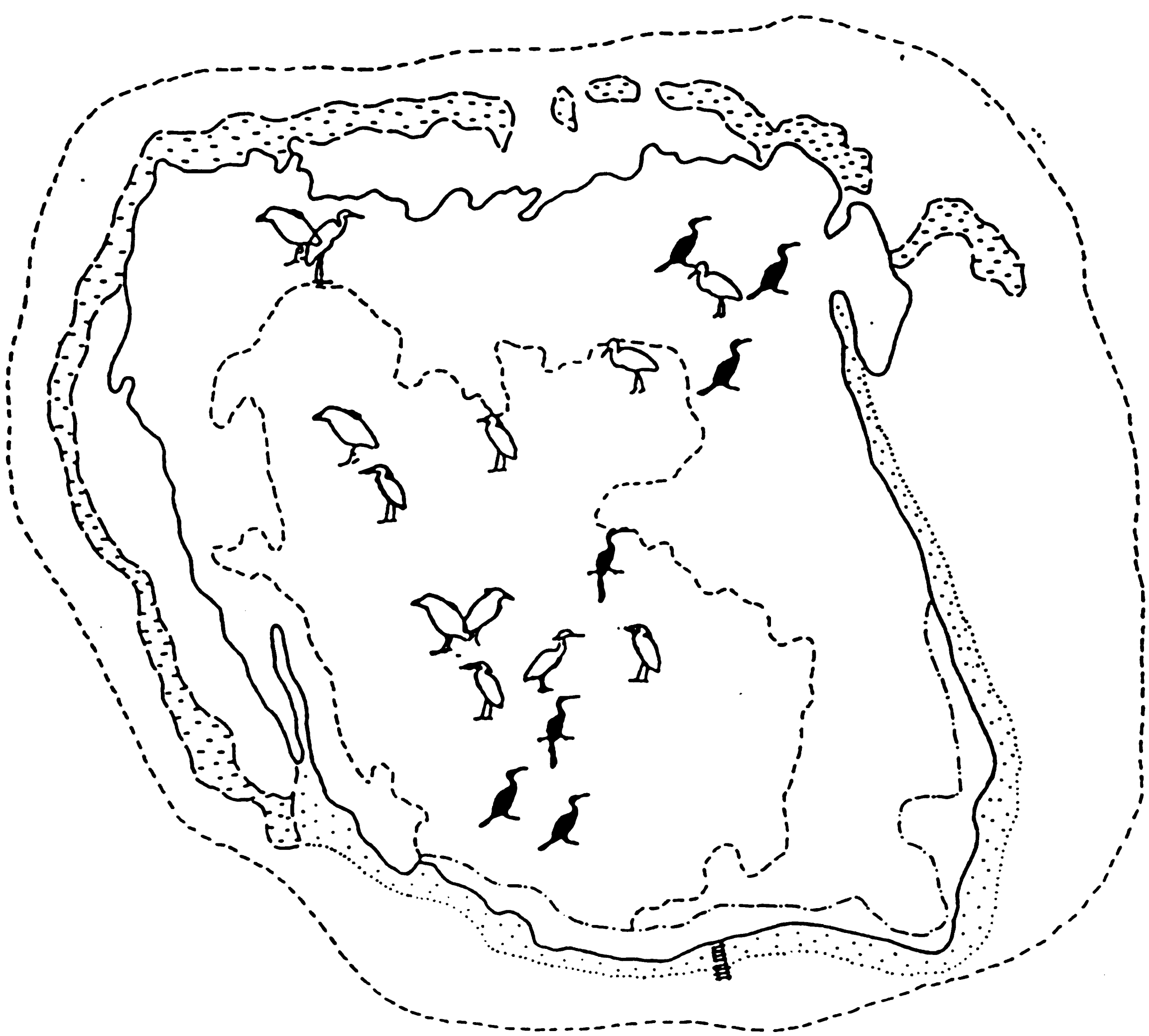
Appendix 11. Distribution of nesting waterbirds in Pulau Rambut heronry, Jakarta Bay, Indonesia, February 1991-March 1991.



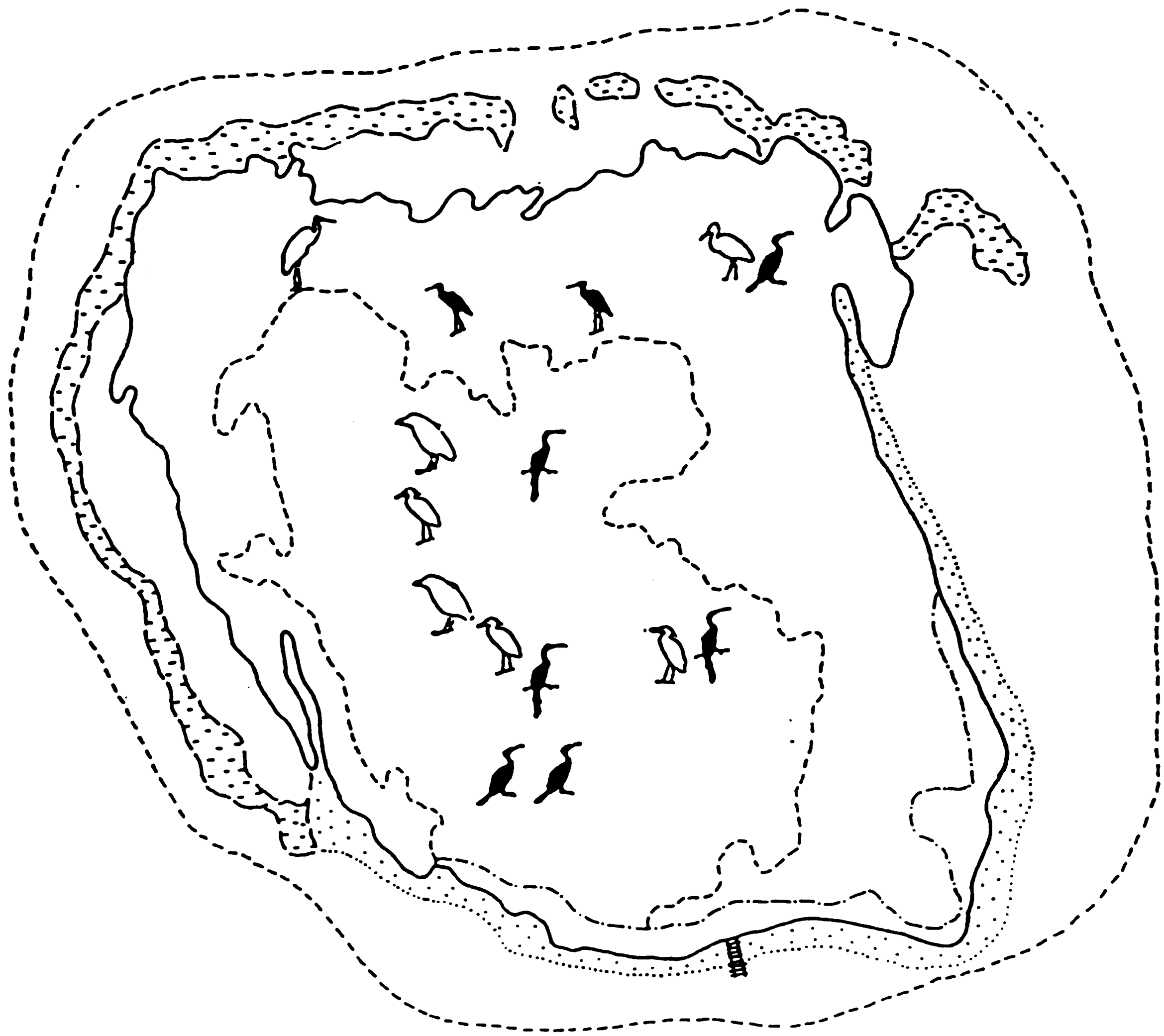
Appendix 12. Distribution of nesting waterbirds in Pulau Rambut heronry, Jakarta Bay, Indonesia, April 1991.



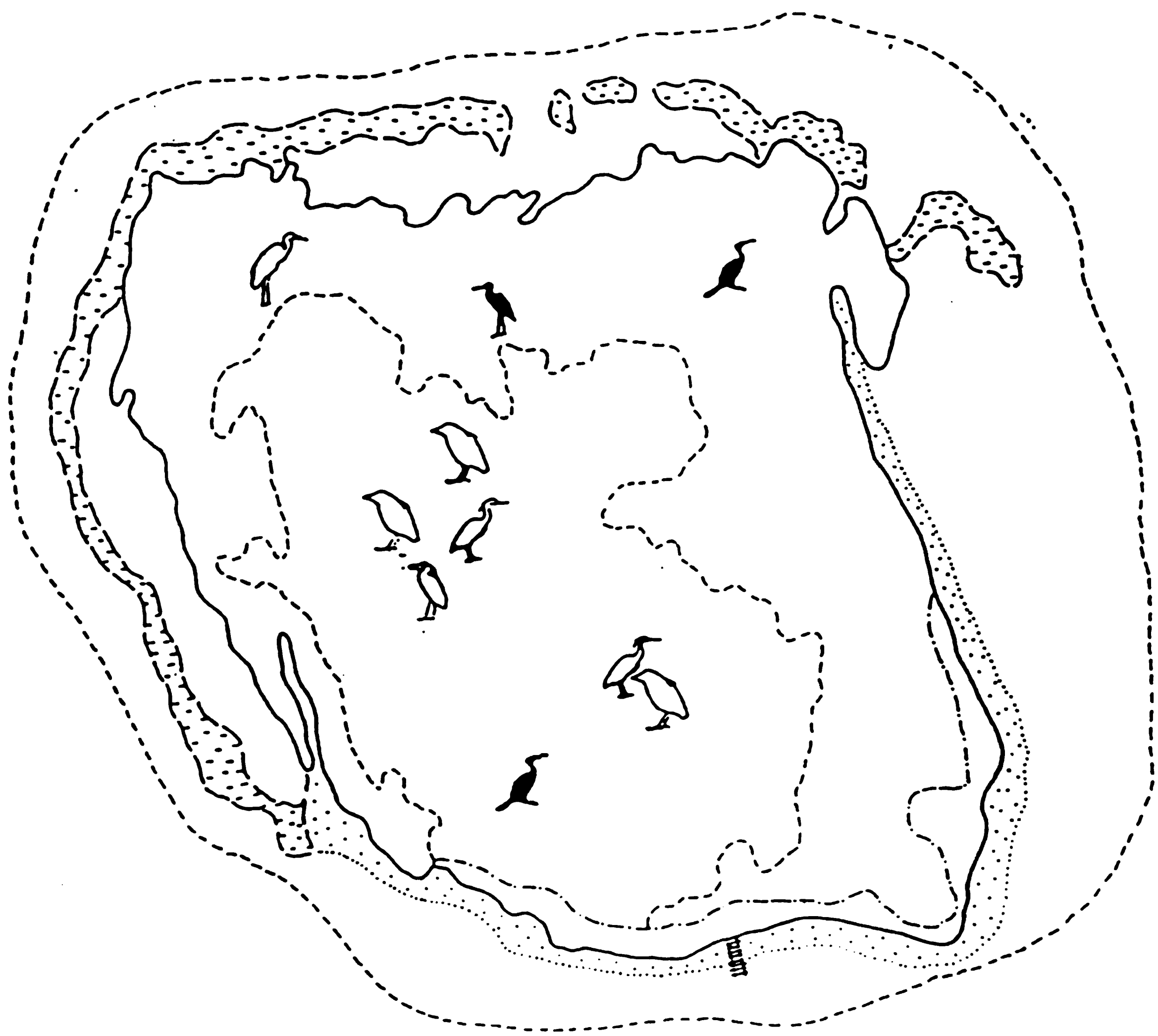
Appendix 13. Distribution of nesting waterbirds in Pulau Rambut heronry, Jakarta Bay, Indonesia, May 1991.



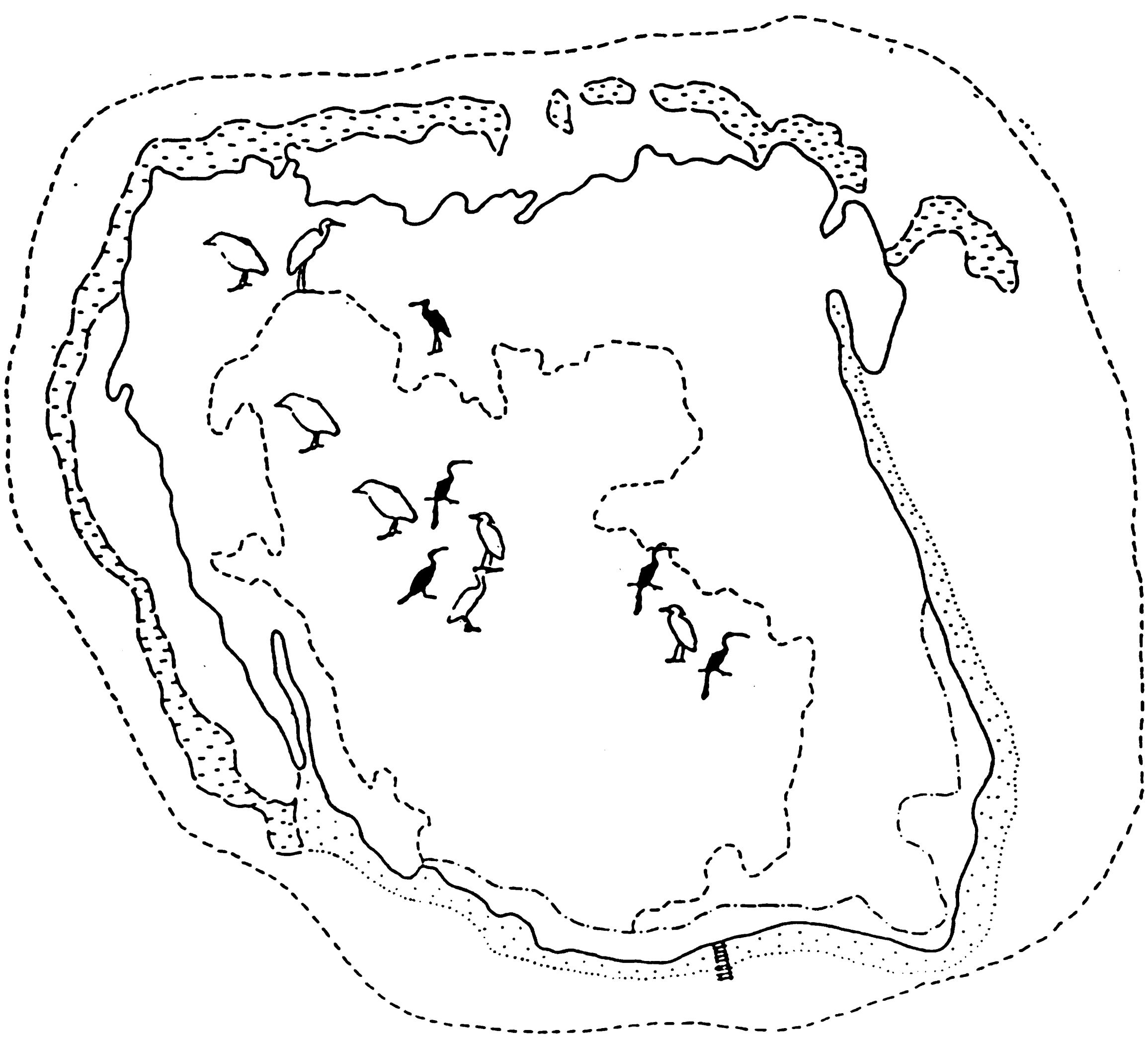
Appendix 14. Distribution of nesting waterbirds in Pulau Rambut heronry, Jakarta Bay, Indonesia, June 1991.



Appendix 15. Distribution of nesting waterbirds in Pulau Rambut heronry, Jakarta Bay, Indonesia, July 1991-August 1991.



Appendix 16. Distribution of nesting waterbirds in Pulau Rambut heronry, Jakarta Bay, Indonesia, July 1991-August 1991.



Appendix 17. Chi-square values for nesting association of waterbirds in Pulau Rambut Nature Reserve, Jakarta Bay, Indonesia, 1990-1991.

Species Compared	Chi-square Value
Purple Heron vs. Grey Heron	0.000
Purple Heron vs. Great Egret	5.175*
Purple Heron vs. Little Egret	4.693*
Purple Heron vs. L.B. Cormorant	0.000
Purple Heron vs. B.c. Night Heron	0.011
Purple Heron vs. Oriental Darter	0.000
Purple Heron vs. Milky Stork	0.000
Purple Heron vs. Glossy Ibis	0.000
Grey Heron vs. Great Egret	0.033
Grey Heron vs. Little Egret	0.000
Grey Heron vs. L.B. Cormorant	0.000
Grey Heron vs. B.c. Night Heron	4.619*
Grey Heron vs. Oriental Darter	12.070**
Grey Heron vs. Milky Stork	7.205**
Grey Heron vs. Glossy Ibis	0.000
Great Egret vs. Little Egret	0.168
Great Egret vs. L.B. Cormorant	0.000
Great Egret vs. B.c. Night Heron	0.240
Great Egret vs. Oriental Darter	0.000
Great Egret vs. Milky Stork	0.000
Great Egret vs. Glossy Ibis	0.000
Little Egret vs. L.B. Cormorant	22.688**
Little Egret vs. B.c. Night Heron	0.096
Little Egret vs. Oriental Darter	0.000
Little Egret vs. Milky Stork	0.000
Little Egret vs. Glossy Ibis	0.879
L.B. Cormorant vs. B.c. Night Heron	6.510*
L.B. Cormorant vs. Oriental Darter	0.000
L.B. Cormorant vs. Milky Stork	0.000
L.B. Cormorant vs. Glossy Ibis	7.088*
B.c. Night Heron vs. Oriental Darter	0.040
B.c. Night Heron vs. Milky Stork	0.061
B.c. Night Heron vs. Glossy Ibis	2.001
Oriental Darter vs. Milky Stork	1.028
Oriental Darter vs. Glossy Ibis	0.000
Milky Stork vs. Glossy Ibis	0.000

$X^2_{(0.05)} = 3.48$; $X^2_{(0.01)} = 6.63$
** Highly significant association (at 99% level)
* Significant association (at 95% level)