BIODIVERSITAS
Volume 24, Number 6, June 2023
Pages: 3583-3591

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d240658

Bird diversity and mangrove forest as potential ecotourism destinations in Kapo-kapo Bay, Cubadak Island, West Sumatra, Indonesia

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Manuscript received: 18 January 2023. Revision accepted: 28 June 2023.

Abstract. *Novarino W, Mukhtar E, Putri AS, Anggraini PL. 2023. Bird diversity and mangrove forest as potential ecotourism destinations in Kapo-kapo Bay, Cubadak Island, West Sumatra, Indonesia. Biodiversitas 24: 3583-3591.* Mangrove forests play an important role in the management of the coastal ecosystem of Indonesia. Research on bird diversity has been carried out to support ecotourism attractions in the mangrove area of Kapo-kapo Bay, West Sumatra. The objective of this study is to determine the bird diversity and mangrove plant diversity in the mangrove kapo-kapo Bay area, West Sumatra, using the point count method and transect method. Mangrove plants have been found in three families, five genera, and six species. The vegetation composition on this research site is lower than that on Sumatra's east coast. The composition of mangrove trees and tree diversity was lower on the west coast of Sumatra than on the east coast. The composition and diversity of birds at the study sites were not significantly different between the mangrove forests on Sumatra's west and east coasts. *Rhizophora apiculata* Blume species dominate the mangrove forests in Kapo-kapo Bay, while *Collocalia esculenta* species dominate the birds. The analysis of the suitability of mangrove ecotourism in Kapo-kapo Bay obtained a score of 111 or 92.5%, placing it in the Very Suitable category (S1) to be developed as an ecotourism area. The presence of birds and bird habitat use in mangroves are all interesting ecotourism attractions.

Keywords: Bird, diversity, Kapo-kapo Bay, mangrove, West Sumatra

INTRODUCTION

Southeast Asia's mangrove forests are rich in biodiversity and provide various ecosystem services on which millions rely. However, particularly in recent years, the proportional conversion of mangroves to other land use types has not been systematically quantified across Southeast Asia. In Indonesia, it is estimated that around 33% of mangrove areas have been degraded and converted in recent decades, such as aquaculture, logging, mining, and reclamation. Fragmentation is a major driver of ecosystem degradation, reducing the capacity of habitats to provide many important ecosystem services. Mangrove ecosystems have many services, such as erosion prevention (Richards and Riess 2016; Carugati et al. 2018; Bryan-Brown et al. 2020; Arifanti et al. 2021; Nawar et al. 2022). Furthermore, the dynamics of forest cover loss in mangroves along the east coast of North Sumatra between 1990 and 2020 revealed that mangrove forests lost about 34,063.12 ha, with conversion to agricultural lands and ponds being the primary cause of deforestation (Ginting et al. 2022). Changes in mangrove forest are also significant, as demonstrated by our previous studies (Mukhtar et al. 2021) in the Mandeh mangrove forest area of West Sumatra, where the mangrove forest area increased by 70.5 ha over three decades.

Mangroves are important habitats for terrestrial, marine, and aquatic species and are a source of food, medicine, fuel, and building materials for native communities. In addition, mangroves provide habitat for various animals, playing an important role in the conservation of resident species and migratory birds, as these birds rely entirely on mangroves for their daily needs, such as food, shelter, and loaf (Giri et al. 2011; Kasim et al. 2019, Asri et al. 2020, Eddy et al. 2021, Oracion et al. 2022). In addition, ecotourism is an alternative tourism activity that aims to develop ecologically-based sustainable tourism that can provide economic and social benefits to the surrounding community (Herwono 2016; Cita and Budiman 2019; Ramadhani et al. 2022).

Mangroves provide habitat for bird species in various ways. Furthermore, birds are a visible and important part of the ecosystem, occupying many trophic levels in the food chain, from consumers to predators. Their presence has been beneficial as an indicator of environmental health, plant pollinators, seed dispersal, and pest control. Birds in mangrove forests include birds that live and nest in mangroves and occasionally visit mangroves for food or rest. As a result, the presence of birds in mangrove forest ecosystems is important because the diversity of bird species describes an ecosystem's stability; the greater the diversity of species, the more stable the ecosystem (Cita and Budiman 2019; Mediaty et al. 2021, Zockler et al. 2021).

Birds found in mangrove forests include birds that live and nest in mangrove forests and birds from other habitats that occasionally visit mangroves for food or rest. As a result, the presence of birds is important in mangrove forest ecosystems because the diversity of bird species describes the stability of an ecosystem; the greater the diversity of

species, the more stable the ecosystem. Birds are animals that play an important role in ecosystems (Herwono 2016; Cita and Budiman 2019; Ramadhani et al. 2022).

Previous studies have been conducted in Mandeh Bay, West Sumatra, including research by Raynaldo et al. (2020) and Mukhtar et al. (2017, 2021) analyzing changes areas in the mangrove forest using Landsat Imagery. Sayuti et al. (2021) and Pohan et al. (2021) also researched zoning using the UAV method in the Mandeh Area in 2021. The current research aims to investigate the impact of mangrove vegetation on water bird species diversity in the mangrove ecosystem area, to enhance the value of conservation-based ecotourism.

MATERIALS AND METHODS

Study area

The study was conducted in Kapo-kapo Bay, Cubadak Island, Koto XI Tarusan, Pesisir Selatan District, West Sumatra, Indonesia. This location was located at 1011'10"-1013'50" E and 100022" 25-100024" 15" S. Data on mangrove vegetation were obtained from two locations such as the left side and right side of Kapo-kapo Bay (Figure 1).

Method

Vegetation sampling

The transect method was used to observe mangrove vegetation, which is perpendicular to the shoreline, by placing nested plots with a plot size of 10 x 10 m^2 for tree observations (tree diameter >10 cm) and 5×5 m^2 for sapling observations (2-10 cm) and 2×2 m^2 for the seedling (Mueller-Dombois and Ellenberg 2003). Two transects were drawn, one to the left and one to the right of Kapo-Kapo Bay, Cubadak Island. On Transect 1, have been 11 plots recorded, whereas, on Transect 2, nine plots were observed. In each plot, the species name and the total number of mangrove trees, saplings, and seedlings were identified and counted using a tally counter. In addition, all stem diameters at the breast height (DBH) of trees (≥5 cm DBH), and the DBH 1.3 m above the soil surface or 30 cm above the highest prop root for mangroves were measured.

Avifauna sampling

Bird species were also observed at two stations. The point count method was used to observe birds, with 10 observation points made at each research location. The species and number of individual birds encountered at each observation point were counted for 10 minutes before moving on to the next observation point. Each observation point is 50 m apart. Observations were made between 06:00 and 10:00 AM. Early morning when the sun has fully risen, is the best time to find more birds out feeding. Based on Nugroho et al. 2021, the abundance of birds was also similar between morning and afternoon counts, knowing that it can be assumed that morning observation is the same as afternoon observation; therefore, this assumption can be accepted as a replication of bird surveys. The data collected included bird species, number of birds, meeting time, and bird location. Birds that are identified by voice or sound without being directly (physically) found or other signs are considered data if they are still found in the observation path Nugroho et al. 2021).

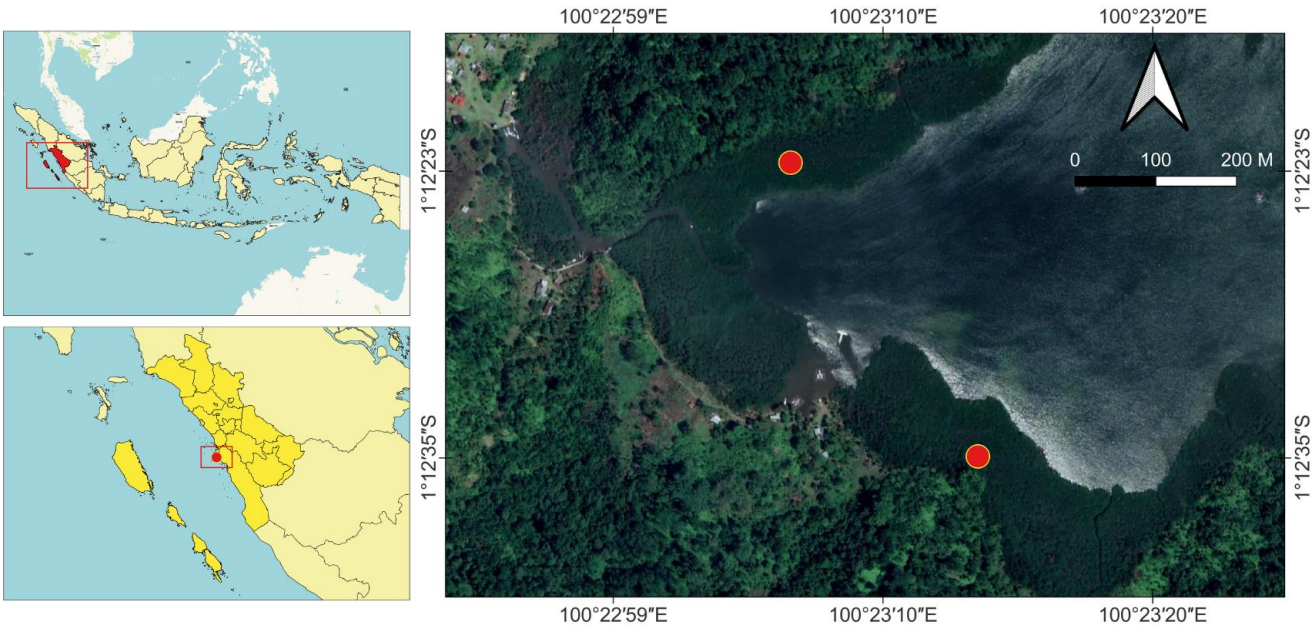

Figure 1. Location of the study area in Pesisir Selatan District, West Sumatra, Indonesia

Data analysis

Vegetation analysis

Importance Value Index (IVI). The mangrove data were analyzed using several parameters: population density, frequency, dominance, relative density, relative frequency, relative dominance, and the importance value (Legendre and Legendre 2012). The importance value index (IVI) is a metric that defines a plant species' dominance or importance within a vegetation community. It was calculated as follows:

$$Frequency = \frac{Area\ of\ plots\ in\ which\ a\ species\ occurs}{Total\ plot\ sampled}$$

$$Density = \frac{Number\ of\ a\ species}{Total\ area\ sampled}$$

$$Dominance = \frac{Total\ area\ of\ a\ species}{Total\ area\ sampled}$$

$$Relative\ Density = \frac{number\ of\ individuals\ of\ species}{total\ number\ of\ individuals} x\ 100\ \%$$

$$Relative\ Dominance = \frac{dominance\ of\ of\ species}{dominance\ of\ all\ species} x\ 100\ \%$$

$$Relative\ Frequency = \frac{frequency\ of\ species}{frequency\ of\ all\ species} x\ 100\ \%$$

Impotance Value Index (IVI) = Relative density + Relative Dominance + Relative Frequency.

The species indices diversity that showed the Diversity index values were calculated using the Shannon-Wiener Diversity Index (H') (Mueller-Dombois and Ellenberg 2003).

$$H' = - \sum(P_i \times \log P_i)$$

Where :
H' : index of diversity
P_i : N_i/N
N_i : the number of individual species to 1
N : number of individuals of all kinds

Criteria diversity index values are as follows H' <1 (low diversity); H' = 1-3 (moderate diversity); H'>3 = high diversity

Bird analysis

Diversity index values were calculated using the Shannon-Wiener Diversity Index (H').

Species Richness (SR) was based on Margalef's Index (R), and species evenness was based on Pielou's Index E (Legendre and Legendre 2012);

$$Species\ Richness = \frac{S-1}{LogN}$$

Where:
S : number of species present in the community
N : number of individuals in the community
Species Evenness is the variety of species or the number of different species;

$$C = \frac{H'}{LogS}$$

Where:
C : species Evenness
H': Shanon Weiner Index
S : number of species

Analysis of the suitability of mangrove ecotourism

The analysis takes into account potential resources as well as their designation (Nelly et al. 2020).

$$ESI = \sum (Ni/Nmax) \times 100\ \%$$

Where :
ESI : Ecoturism Suitabily Index
N_i : the-I variable (quality x score)
N_{max} : the maximum value of a variable

The following levels of suitability for mangrove ecotourism were assigned: S1: very suitable (81-100%), S2: suitable (61-80%), S3: conditional suitable (35- <60%), N: not suitable (<35%). Ni: the value parameter (quality x score), Nmax: maximum value of the mangrove tourism category.

Table 1. The matrix of potential suitability for mangrove ecotourism development (Yuliana et al. 2019)

Parameters	Weight	Score 4	Score 3	Score 2	Score 1
mangrove forest thickness (m)	5	>500	201-500	50-200	<50
mangrove density (individual/100 m^2)	4	>15	11-15	5-10	<5
Mangrove density	5	>5	3-4	1-2	0
Bird species	5	>15 species	11-15 species	6-10 species	1-5 species
Characteristics of the area	4	4 requirements	3 requirements	2 requirements	1 requirement
Accessibility	3	4 requirements	3 requirements	2 requirements	1 requirement
Tide (m)	3	0-1	>1-2	>2-5	>5

RESULTS AND DISCUSSION

Mangrove vegetation composition

Mangrove vegetation in the site comprises three families, five genera, and six species, while *Rhizophora apiculata* was found on both observation transects. In addition, *Rhizophora mucronata* Lam, *Ceriops tagal* CB Rob, and *Bruguiera gymnorrhiza* Blume were discovered only at station 1, whereas *Scyphiphora hydrophylacea* Gaertn.f and *Xylocarpus granatum* J. Koenig were discovered only at station 2. Vegetation in Station 1 had more species than in Station 2, but Station 2 had more tree levels and saplings (and also for seedlings. Furthermore, the IUCN red list classifies all mangrove species as LC (Least Concern) (Table 2). Moreover, the number of species, genera, and families of mangrove vegetation in this research location is not so different compared to several studies in other mangrove forests on the West Coast of Sumatra. However, the number of species in this study was lower than on the East coast of Sumatra. A detailed explanation is shown in Figure 2. Mangrove vegetation types also differ between the west and east coasts of Sumatra.

On the Westcoast Sumatra, the species are dominated by *R. apiculata, S. marina*, and *S. alba* on Baii Island, Bengkulu (Apriyanto et al. 2021), *S. caseolaris, S. alba*, and *R. mucronata* on Apar Pariaman, (Alpian et al. 2021); also this study found *R. mucronata, C. tagal*, and *B. gymnorrhiza* in Mandeh. Furthermore, the types of mangrove vegetation on Eastcoast Sumatra are dominated by *Avicenna marina, R. apiculata*, and *S. alba* on Pulau Sembilan, North Sumatra (Nawar et al. 2022) by *B. cylindrica, S. alba*, and *R. mucronata* on Inderagiri Hilir, Riau (Irma et al. 2020), by *S. caseolaris, A. officinalis*, and *B. sexangula* species on Rimau Island, South Sumatra (Yuliana et al. 2019). Therefore, the comparison above shows that *R. apiculata* and *S. alba* species can be found on both sides of Sumatra's west and east coasts.

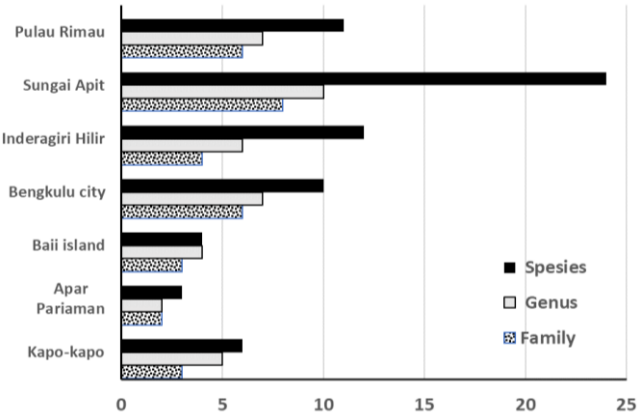

Figure 2. Tree composition in several mangrove forests in Sumatra. Source: Apar Pariaman (Alpian et al. 2021), Baii Island (Fatimatuzzahra et al. 2020), Bengkulu City (Soeprobowati et al. 2022), Inderagiri Hilir (Irma et al. 2020), Sungai Apit (Efriyeldi et al. 2022), Pulau Rimau (Yuliana et al. 2019)

Table 2. Tree species composition in Kapo-kapo Bay, West Sumatra, Indonesia

Family	Genus	Species	Station 1			Station 2			Status in IUCN Redlist
			T	Sp	Sd	T	Sp	Sd	
Rhizophoraceae	*Rhizophora*	*Rhizophora apiculata* Blume	1	36	4	5	52	16	LC
		Rhizophora mucronata Lam	-	2	-	-	-	-	LC
	Ceriops	*Ceriops tagal* CB Rob	1	-	-	-	-	-	LC
	Bruguiera	*Bruguiera gymnorrhiza* Blume	-	1	2	-	-	-	LC
Rubiaceae	*Scyphiphora*	*Scyphiphora hydrophylacea* Gaertn.f	-		-	-	1	-	LC
Meliaceae	*Xylocarpus*	*Xylocarpus granatum* J. Koenig	-		-	-	2	-	LC

Notes: T: Trees, Sp: Sapling, Sd: Seedling, LC: Least Concern

Table 3. Important Value Index of mangrove species in Kapo-kapo Bay, West Sumatra, Indonesia

Species	Important Value Index (%)					
	Station 1			Station 2		
	T	Sp	Sd	T	Sp	Sd
Rhizophora apiculata	141.4	263.7	141.7	300	270.3	200
Rhizopora mucronata	-	25.6	-	-	-	-
Bruguiera gymnorrhiza	-	10.7	58.3	-	-	-
Ceriops tagal	158.6	-	-	-	-	-
Scyphiphora hydrophylacea	-	-	-	-	14.6	-
Xylocarpus granatum	-	-	-	-	15.1	-

Note: T: Trees, Sp: Sapling, Sd: Seedling

Mangrove vegetation structure

Rhizophora apiculata was found on both research transects at the growth level of seedlings, saplings, and trees according to the importance value index. Two tree species, such as *R. apiculata* and Ceriops tagal, were found at tree levels. On transect 1, four species were observed at the sapling level, while three were observed on transect 2; at the seedling level, only two mangrove species were found. That indicates *R. apiculata* is the dominant species and has a strong potential for growth and development in the future. In addition, *Rhizophora apiculata* species had the highest density, frequency, cover, and important value index for tree and sapling groups values in Sungai Apit Sub-district, Siak District (Efriyeldi and Amin 2022). Based on a study conducted in Pasaman, West Sumatra, by Kamal (2011), it was found that *R. apiculata* and *R. mucronata* exhibit year-round flowering. These conditions will enhance the beauty of tourist sites in that area and the continuity of the plant regeneration process.

Mangrove vegetation diversity index

The diversity index of mangrove vegetation at the study site was classified as low at the seedling, sapling, and tree levels (Table 4). *C. tagal* had the highest diversity index for the tree stage, *R. mucronata* had the highest diversity index for the sapling level, and *B. gymnorhiza* had the highest diversity index for the seedling level. This location's mangrove diversity index value is 0.54, indicating a low diversity index. However, compared to Sumatra's west coast, species diversity is not significantly different. The east coast of Sumatra has a greater diversity of mangrove species than the west coast (Table 5). According to Yuliana et al. 2019 the mangrove diversity index in Pulau Rimau, South Sumatra, was also low at 0.82. The diversity of mangrove species in an area becomes an important value in supporting the management activities of a tourist area and increasing visitor attraction. Mangrove ecotourism can be a choice that tourists will favor because they can enjoy the beauty of nature and fresh air and get insight into the environment and the importance of mangrove ecosystems in the structure of coastal ecosystems (Pin et al. 2021).

Composition of mangrove birds

The research revealed that Kapo-kapo Bay contained 23 families and 32 species of birds. The research was conducted in two locations: Station 1 is located to the right of Kapo-Kapo Bay, at the back of the mangrove forest, close to community plantations, and the secondary forest to the left. Station II is situated to the left of Kapo-kapo Bay, in front of a mangrove forest near residential areas. Station 1 had 26 bird species and 120 individuals, while Station 2 had 22 birds and 132 individuals. *Collocalia esculenta* from the Apodidae family dominates the bird community in Kapo-kapo Bay, followed by the Pycnonotidae and Columbidae families. Bird composition in Kapo-kapo Bay is shown in Table 6. *Loriculus galgulus* is one of the bird species listed in CITES Appendix II (Convention on International Trade in Endangered Species of Wild Fauna and Flora). Furthermore, according to Indonesian laws and regulations, six species are protected, including *Halcyon smyrnensis, Prionochilus maculates, Aethopyga siparaja, Anthreptes malacensis, Nectarinia jugularis,* and *Sasia abnormis*; this research only found 3 (Table 6). In addition, five bird species, *Charadrius peronii, Hirundo tahitica, Phylloscopus* sp., *Muscicapa dauurica,* and *Tringa* sp., were identified as mangrove migrants.

The comparison of the number of bird species between the west and east coast was not so different (Table 7). However, several species can be found on Sumatra's west and east coasts. For example, *Collacalia* species have been discovered in Kelagian Besar, Lampung (Nugraha et al. 2021) and Pawang, Lampung (Iswandaru et al. 2020) on the east coast, and this research site (west coast). *Treron vernans* was also discovered in Rempang, Batam (Syamsi 2017), Kelagian Besar, Lampung (Nugraha et al. 2021), and this research site. *Orthotomus ruficeps* and *Nectaria jugularis* were also discovered in Karang Gading, North Sumatra (Adil et al. 2010) and at the site of this study. Therefore, the comparison above concludes that several species of birds on Sumatra's west and east coasts are similar.

Table 4. Diversity Index in Kapo-kapo Bay, West Sumatra, Indonesia

Species	Diversity index		
	Tree	**Sapling**	**Seedling**
Rhizophora apiculata	0.15	0.10	0.10
Rhizophora mucronata	-	0.13	-
Bruguiera gymnorrhiza	-	0.07	0.23
Ceriops tagal	0.30	-	-
Scyphiphora hydrophylacea	-	0.01	-
Xylocarpus granatum	0.09	-	-
Total	0.54	0.30	0.33

Table 5. Diversity index of mangrove vegetation in several mangrove forests in Sumatra

Location		Diversity index	Source
West coast of Sumatra			
Kapo-kapo	West Sumatra	0.54	*This research*
Kuala Batee	Aceh	0.76	Bahri et al. (2019)
Baii island	Bengkulu	0.46	Apriyanto et al. (2021)
East coast of Sumatra			
Karang Gading	North Sumatra	1.74	Adil et al. (2010)
Inderagiri Hilir	Riau	2.03	Irma et al. (2020)
Pulau Sembilan	North Sumatra	1.11	Basyuni et al. (2021)
Pulau Rimau	South Sumatra	0.82	Yuliana et al. (2019)

Table 6. Bird composition in the mangrove habitat of Kapo-kapo Bay, West Sumatra, Indonesia

Species	Family	Local name	Station		Conservation status	
			1	2	LHK	IUCN
Halcyon smyrnensis	Alcedinidae	*Cekakak belukar*	1	1	-	LC
Collocalia esculenta	Apodidae	*Walet sapi*	14	53	-	LC
Butorides striatus	Ardeidae	*Kokokan laut*	-	2	-	-
Charadrius peronii	Charadriidae	*Cerek melayu*	1	-	-	-
Orthotomus ruficeps	Cisticolidae	*Cinenen kelabu*	4	10	-	LC
Prinia familiaris	Cisticolidae	*Perenjak jawa*	1	4	-	-
Ducula bicolor	Cisticolidae	*Pergam laut*	10	1	-	-
Treron vernans	Columbidae	*Punai gading*	11	6	-	LC
Cacomantis merulinus	Cuculidae	*Wiwik kelabu*	-	2	-	-
Centropus sinensis	Cuculidae	*Bubut besar*	1	1	-	LC
Dicaeum cruentatum	Dicaeidae	*Burung cabai merah*	2	-	-	LC
Dicaeum trigonostigma	Dicaeidae	*Burung cabai bunga api*	6	3	-	LC
Prionochilus maculatus	Dicaeidae	*Pentis raja*	3	-	-	-
Dicrurus paradiseus	Dicruridae	*Srigunting batu*	4	3	-	LC
Lonchura striata	Estrildidae	*Bondol tunggir putih*	1	4	-	LC
Hirundo tahitica	Hirundinidae	*Layang-layang batu*	6	1	-	-
Lanius cristatus	Laniidae	*Bentet coklat*	-	1	-	LC
Merops viridis	Meropidae	*Kirik-kirik biru*	4	2	-	-
Ficedula zanthopygia	Muscicapidae	*Sikatan emas*	1	-	-	-
Muscicapa dauurica	Muscicapidae	*Sikatan bubik*	6	-	-	-
Aethopyga siparaja	Nectariniidae	*Brg madu sepah raja*	2	-	P	-
Anthreptes malacensis	Nectariniidae	*Burung madu kelapa*	4	-	-	-
Nectarinia jugularis	Nectariniidae	*Burung madu sriganti*	1	9	-	LC
Passer montanus	Passeridae	*Burung gereja*	-	2	-	LC
Phylloscopus sp.	Phylloscopidae	*Cikrak*	-	1	-	-
Picus miniaceus	Picidae	*Pelatuk Merah*	3	-	-	-
Sasia abnormis	Picidae	*Tukik tikus*	-	1	-	-
Loriculus galgulus	Psittaculidae	*Serindit melayu*	5	3	-	-
Pycnonotus brunneus	Pycnonotidae	*Merbah mata merah*	16	18	-	-
Rhipidura javanica	Rhipiduridae	*Kipasan belang*	7	4	P	-
Tringa sp.	Scolopacidae	*Trinil*	1	-	P	-
Macronous gularis	Timaliidae	*Ciung air coreng*	5	-	-	-
	Total		120	132		

Notes: IUCN: Status according to IUCN Red List of Threatened Species: LC: Least Concern; LHK: Status according to the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number; P.106/MENLHK/SETJEN/KUM.1/12/2018, regarding Protected species of Plants and Animals; P: Protected

Mangrove birds diversity index

In general, Station 1 has a higher diversity index, evenness index, and species richness index than Station 2. However, both locations have H' values in the medium range (Table 8). A species diversity index can be used to evaluate the health of a community. The species diversity index value indicates that the bird community in the mangrove ecosystem of Kapo-Kapo Bay is stable or that no bird species dominate extremely. Overall, the bird diversity index in Kapo-kapo Bay is 2.78, indicating that species diversity is medium. The availability and diversity of feed types strongly influence bird diversity; the more diverse types of feed that exist in a location, the greater the number of bird species in that location. The presence of a particular species of bird is also adjusted to its preference for a specific habitat. *Tringa* sp., for example, prefers tidal mud and sand, whereas the *Charadrius peronii* prefers sandy beaches. Our result indicated that the Bird diversity index between Sumatra's west and east coast were similar (Table 9).

Mangrove ecotourism suitability analysis in Kapo-kapo Bay

The value of the mangrove ecotourism area's suitability index indicates the feasibility of mangrove ecotourism level as mangrove ecotourism suitable areas to serve as ecotourism objects; this is very useful in managing ecotourism. The mangroves in Kapo-kapo Bay range in thickness from 900 to 1,100 m, while the density of mangroves is 35 individuals/100 m^2. There are six mangrove species including *Rhizophora apiculata, Rhizophora mucronata, Ceriops tagal, Bruguiera gymnorrhiza, Scyphiphora hydrophylacea*, and *Xylocarpus granatum.* The diversity index, evenness, and species richness are all in the high category in Kapo-kapo Bay (as shown in Table 8). In addition, there is a protected species in the form of the *Loriculus galgulus*, listed in CITES Appendix II. Meanwhile, the area is classified as conditional, with two requirements: a good road to the location and a pier as supporting facilities. The tides in Kapo-kapo Bay can reach 1.2 meters with a length of 4.1-9.5 km; the detailed analysis is shown in Table 10. The analysis of the suitability of mangrove ecotourism in Kapo-kapo Bay obtained a score of 107 or 89%, making it in the Very Suitable category (S1) to be developed as an ecotourism area.

The vegetation composition of the mangrove ecosystem on the west coast of Sumatra, which includes the location of this research, is less diverse compared to the east coast

of Sumatra (Adil et al. 2010, Jumilawaty et al. 2011, Aini et al. 2015, Dharma el. 2021, Nugraha et al. 2021, Octarin et al. 2021). The composition of mangrove trees and tree diversity was lower on the west coast of Sumatra than on the east coast. However, the composition and diversity of birds at the study sites were not significantly different between the mangrove forests on Sumatra's west and east coasts. *Rhizophora apiculata* species dominate the mangrove forests in Kapo-kapo Bay, while *Collocalia esculenta* species dominate the birds. The analysis of the suitability of mangrove ecotourism in Kapo-kapo Bay making it in the Very Suitable category (S1) to be developed as an ecotourism area. Birds and their habitats used in mangrove forests are all interesting ecotourism attractions.

Mangrove plant species are found in Kapo-kapo Bay, Mandeh, and the number of species is comparable to other west coasts of Sumatra, which also have ecotourism potential. For example, Fatimatuzzahra et al. 2020 discovered four species of mangrove trees on Bai Island in Bengkulu. Alpian et al. 2021 also discovered three species of mangrove trees in Pariaman, West Sumatra, and Nelly et al. 2020 discovered three in Sabang, Aceh. On the contrary, Herison et al. 2021 in Maringgai, East Lampung, and Soeprobowati et al. 2022 discovered ten species of mangrove trees in Bengkulu City. Therefore, variations in species are also linked to environmental characteristics in each location. Several locations of mangrove forest areas with only three species are very feasible or have the potential to be proposed as ecotourism areas, such as in Karawang, West Java (Pin et al. 2021), in Lembar village, West Lombok (Sukuryadi et al. 2020), in Kunkun village, Mandailing (Harahap and Absah 2021), and in Bai Island, Bengkulu (Apriyanto et al. 2021).

However, the number of mangrove species and available fauna does not guarantee that the mangrove forest area is suitable for ecotourism. For example, research in Bagan Serdang, North Sumatra (Ulfa and Harahap 2022) has 21 mangrove species and nine fauna species but access and accommodation to the mangrove area is bad that the area is not suitable for being proposed as an ecotourism area. Therefore, to ensure the long-term use of mangrove biodiversity as a tourist attraction, it is critical to understand the basic characteristics of mangroves and to establish mangrove tourism programs that can support conservation efforts. It is also critical to involve and strengthen the participation of local communities in the areas surrounding mangroves. Local knowledge could help increase mangrove ecosystems' sustainability (Hakim et al. 2017).

Table 7. Bird composition in several mangrove forests in Sumatra

Location		Family	Species	Source
West coast of Sumatra				
Kapo-kapo	West Sumatra	23	32	*This research*
Putroe Phang Park	Aceh	9	13	Dharma et al. (2021)
Ujung Seurundong	Aceh	29	29	Aini et al. (2015)
East coast of Sumatra				
Rempang	Batam	12	23	Syamsi (2017)
Air Telang	South Sumatra	22	38	Eddy et al. (2021)
Deli Serdang	North Sumatra	5	33	Jumilawaty et al. (2011)
Kelagian Besar	Lampung	21	27	Nugraha et al. (2021)
Pahawang	Lampung	21	21	Iswandaru et al. (2020)

Table 8. Diversity index of birds in Kapo-kapo Bay, West Sumatra, Indonesia

Index	Station		Kapo-kapo
	Station 1	Station 2	
Diversity Index (H')	2.92	2.25	2.78
Evennes Index (C)	0.90	0.73	0.80
Species Richness Index (SR)	5.22	4.30	5.61

Table 9. Diversity index of birds in several mangrove forests in Sumatra

Location		Diversity index	Source
West coast of Sumatra			
Kapo-kapo	West Sumatra	2.78	*This research*
Putroe Phang Park	Aceh	1.78	Dharma et al. 2021
Ujung Seurundong	Aceh	2.13	Aini et al. 2015
East Coast of Sumatra			
Pasir Sakti	East Lampung	2.86	Octarin et al. 2021
Deli Serdang	North Sumatra	2.74	Jumilawaty et al. 2011
Karang Gading	North Sumatra	2.60	Adil et al. 2010
Kelagian Besar	Lampung	2.26	Nugraha et al. 2021

Table 10. Area suitability matrix for mangrove ecotourism (Yuliana 2019)

Parameter	Weight	Category	Score	Weight x Score
Mangrove forest thickness (m)	5	1,100 m	4	20
Mangrove density (individual/100 m^2)	4	35 individuals/100 m^2	4	16
Mangrove species	5	6 species	4	20
Bird species	5	32 species	4	20
Regional characteristics	4	4 determinate	4	16
Accessibility	3	2 determinate	2	6
Tide (m)	3	1.2 m	3	9
Ni		-	-	107
N max		-	120	-
IKW		-	89 %	Very suitable for

The vegetation composition of mangrove vegetation on Sumatra's west coast, including this research site, is lower than that on Sumatra's east coast. The composition of mangrove trees and tree diversity was lower on the west coast of Sumatra than on the east coast. Fortunately, the composition and diversity of birds at the study sites were not significantly different between the mangrove forests on Sumatra's west and east coasts. *Rhizophora apiculata* tree species dominate the mangrove forests in Kapo-kapo Bay, while *Collocalia esculenta* species dominate the birds. The analysis of the suitability of mangrove ecotourism in Kapo-kapo Bay concluded that the mangrove ecosystem is classified as the Very Suitable category (S1) to be developed as an ecotourism area. The presence of birds and their habitat use in mangrove forests are all interesting ecotourism attractions.

ACKNOWLEDGEMENTS

We would like to thank the Department of Marine and Fisheries and the Department of Tourism, Youth and Sports, Pesisir Selatan Regency of West Sumatra, been permitted to conduct research and accommodation assistance and field staff. We also would like to express our appreciation to thank who have helped in collecting data in the field. This study was supported Directorate General of Higher Education, Research and Technology, Ministry of Education, Culture, Research and Technology of the Republic of Indonesia Fiscal Year 2022 (Grant Number 033/E5/PG.02.00/2022).

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