

# The Role of Mangrove Vegetation in Supporting Birdlife Diversity in Coastal Habitats, Study Case Benoa, Bali

Nathanya Christy Shanie Avissa<sup>1</sup> and Dian Saptarini<sup>1\*</sup>

<sup>1</sup>Biology, Department, Faculty of Sciences and Data Analytics, Institute Technology Sepuluh Nopember, Surabaya, East Java

**Abstract.** The mangrove ecosystem plays a critical role in maintaining biodiversity, particularly in supporting bird species diversity within coastal habitats by offering essential resources such as nesting sites, shelter, and food. This study analyzes the relationship between mangrove characteristics and the species composition of birds in coastal Benoa areas to explore the role of mangroves in Ngurah Rain Forest Park in supporting bird diversity. Point counts and line transects were utilized to obtain data to observe bird communities, and plot sampling was used to evaluate the characteristics of the mangrove vegetation, including species composition, tree height, and density. Bird diversity was analyzed using the Shannon-Weiner Index. This study found that the mangrove species identified included *Thespesia populnea*, *Avicennia lanata*, *A. marina*, *Rhizophora apiculata*, *R. stylosa*, *R. mucronata*, *Sonneratia alba*, *Xylocarpus granatum*, *Aegiceras corniculatum*, *Ceriops tagal*, and *Lumnitzera racemosa*. The observations revealed that at least 21 species of avifauna were identified, including 13 migratory bird species, 7 bird species protected by Minister of Environment and Forestry Regulation No. 106 Year 2018, and two endemic bird species, the bar-winged prinia (*Prinia familiaris*) and the blue kingfisher (*Alcedo coerulescens*). By examining various sites with differing mangrove structures, this research provides insights into how specific vegetation features influence bird species richness and distribution.

## 1 Introduction

In addition to providing vital terrestrial, marine, and aquatic habitats, mangrove areas are wetland areas that are valuable to coastal ecosystems [1]. They also provide a source of food, medicine, fuel and building materials for local communities [1]. Furthermore, mangrove forest is crucial for the conservation of resident species and for the protection of migratory and resident bird species because they offer habitat for a wide range of creatures. For daily necessities including food, housing, and nesting, these birds rely on mangrove forest [2-6].

Mangrove forest provides a home for a wide range of birds. Birds are a significant and prominent part of the ecosystem since they are involved in the food chain, from consumers

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\* Corresponding author: [dianssa@yahoo.com](mailto:dianssa@yahoo.com)

to predators. Their presence is advantageous for dispersal, pest control, plant pollination and environmental health indicators. Mangrove forests are home to both resident and nesting birds as well as those who occasionally stop by the mangrove for food or relaxation. Thus, the diversity of bird species in mangrove forest ecosystems is a sign of ecological stability, and species diversity is higher in more complex ecosystems [7-9]. Mangrove forest is home to both native birds that nest there and migratory birds who come to the mangroves for food or rest. As a result, the existence of birds is crucial to mangrove forest ecosystems because bird species variety implies ecological stability; higher species diversity means more stable ecosystems. The ecology depends heavily on birds [7],[10-11].

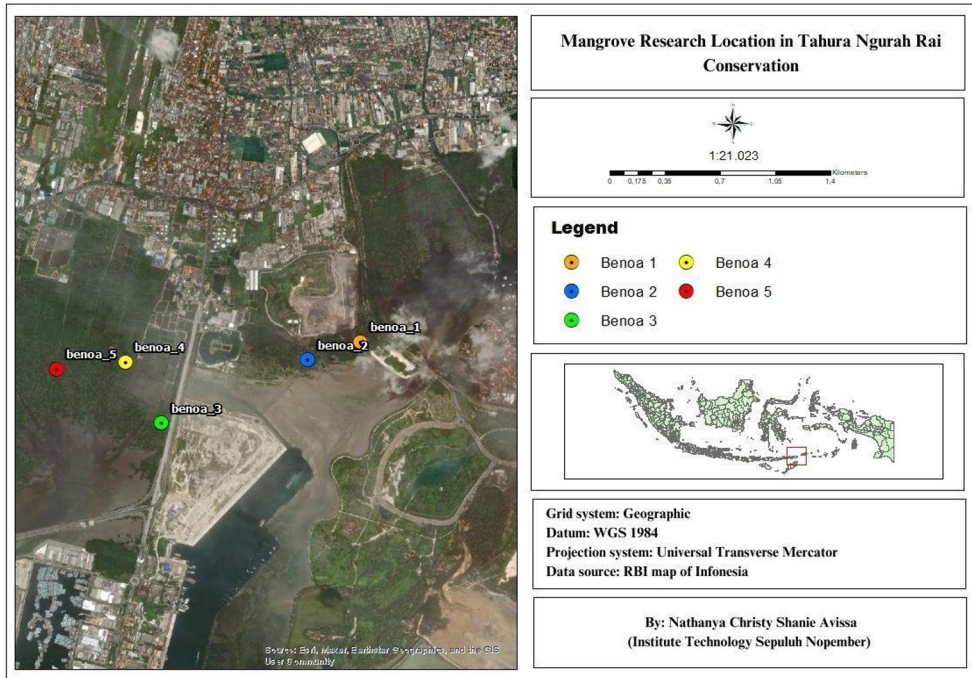
The mangrove forest in Bena Bay is the largest mangrove forest among the mangrove forests in Bali. This mangrove forest is in the Ngurah Rai Forest Park (Tahura) which has an area of 1,373.50 ha [12]. In addition, the mangrove forest in Tahura Ngurah Rai is in the strategic location of Bali tourism, between Nusa Dua, Kuta, and Sanur so that the mangrove ecosystem is under a lot of pressure [13]. The area of mangrove forest vegetation is also declining due to the conversion of forest to agriculture, aquaculture, tourism, and urban development. This is due to the Presidential Regulation of the Republic of Indonesia Number 51 of 2014 concerning the Urban Spatial Planning of Denpasar, Badung, Gianyar, and Tabanan changing the status of mangrove forests from protected forests to cultivation areas [13].

Therefore, this study analyzed the relationship between mangrove characteristics and bird species composition in the Bena coastal area to explore the role of mangroves in Ngurah Rai Grand Forest Park in supporting bird diversity. In addition, this study provides insight into how certain vegetation features.

## **2 Material and Methods**

### **2.1 Study Area**

The study was conducted at Tahura (Taman Hutan Raya) Ngurah Rai Conservation, Bali, Indonesia. Bena 1 and 2 represented the eastern side of Tahura Ngurah Rai Conservation. Bena 3, 4, and 5 represented the western side of Tahura Ngurah Rai Conservation. Bena 1-5 represented the mangrove side of the Tahura Ngurah Rai Port Development Project.



**Fig. 1.** Location of observation in Tahura Ngurah Rai Conservation, Bali.

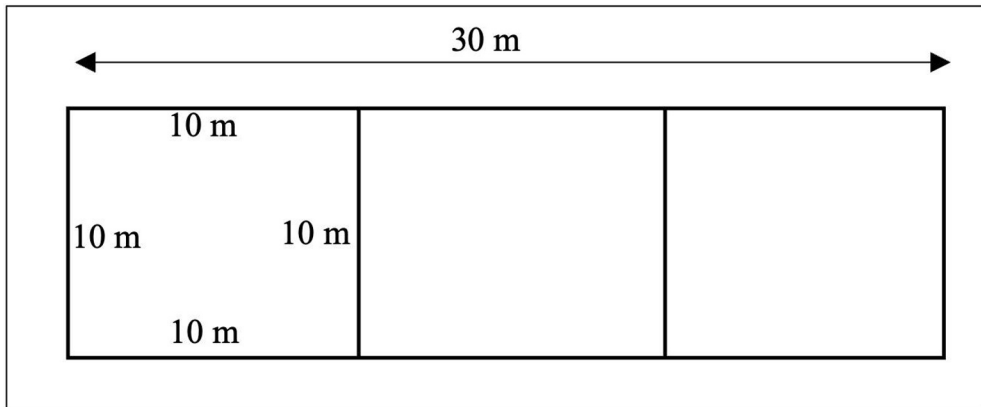
## 2.2 Method

### 2.2.1 Vegetation Sampling

Vegetation sampling was carried out using a purposive random sample approach, with three observation plots 10 x 10 meters each. Each mangrove at the observation plot had its diameter at breast height (DBH) measured and recorded. They were then categorized as trees, saplings, and seedlings. Mangrove trees have a diameter 20 cm, saplings are 1.5 cm tall and have a diameter less than 10 cm, and seedlings are less than 1.5 meters tall [13]. Guidebooks (e.g. Giesen *et al.*, 2007; Hamzah and Pancawati, 2013; Chapman, 2016; Hirsch, 2016; Tomlinson, 2016) were used to identify species.

### 2.2.1 Avifauna Community

The variety of birds or avifauna was documented both within and beyond the observation plot. "A Field Guidebook to Birds of Borneo, Sumatra, Java, and Bali" by MacKinnon *et al.*, 2010 was consulted in order to identify the species that were sighted. The Republic of Indonesia's regulations were used to establish each species conservation status.



**Fig. 2.** Method of sampling [13].

### 2.3 Data Analyzed

The mangrove data was analyzed using population density and it was calculated as follows [14]:

$$D_i = \frac{n_i}{A} \quad (1)$$

Were,

$D_i$  : Density

$N_i$  : Number of type individual

$A$  : Total area sampled

The species diversity of birds was analyzed using the Shannon-Wiener diversity index ( $H'$ ) and it was calculated as follows [15]:

$$H' = -\sum P_i \ln(P_i) \quad (2)$$

Were,

$H'$  : Species diversity index

$P_i$  : Quantitative value of type individual/ total all quantitative value of all species

Criteria diversity index values are as follows  $H' < 2$  (low diversity);  $H' = 1-3$  (moderate diversity);  $H' > 3$  (high diversity) [15].

## 3 Result and Discussion

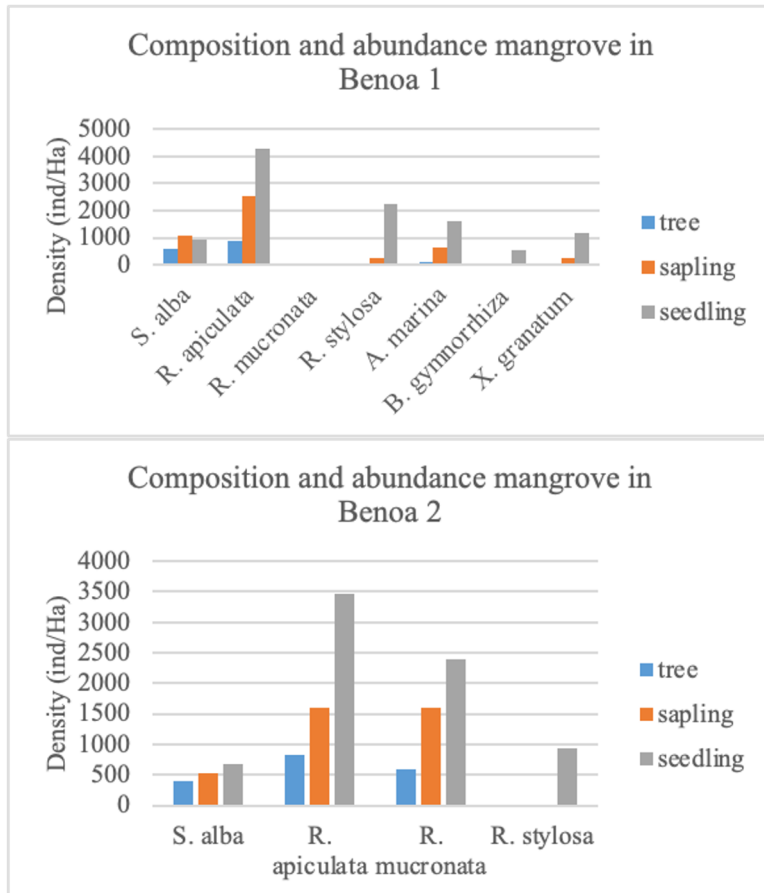
### 3.1 Mangrove Community

The mangroves around the study area are part of the Tahura Ngurah Rai conservation area. At both analyzed sites, the bottom substrate was dominated by mud. We observed the vegetation community at two sites on the eastern side (Benoa 1 and Benoa 2) and three sites on the western side (Benoa 3, Benoa 4, and Benoa 5) of the Benoa Port Development Project. The vegetation analysis results for the eastern side (Benoa 1 and 2) and western side (Benoa 3, 4, and 5) are shown in Table 1 in terms of composition and density.

**Table 1.** Composition and abundance of mangrove species of the Benoa Port Development Project.

No.	Species	Local Name	Famili	Density				
				Benoa 1	Benoa 2	Benoa 3	Benoa 4	Benoa 5
<b>Category: Tree</b>								
1	<i>Thespesia populnea</i>	Waru laut	Malvaceae	0	0	0	67	0
2	<i>Avicennia lanata</i>	Api-api daun lebar	Avicenniaceae	0	0	100	0	0
3	<i>Avicennia marina</i>	Api-api putih	Avicenniaceae	133	0	33	0	0
4	<i>Xylocarpus granatum</i>	Nyiri hutan	Meliaceae	0	0	67	133	0
5	<i>Aegiceras corniculatum</i>	Gedangan	Myrcinaceae	0	0	0	0	0
6	<i>Rhizophora apiculata</i>	Bakau minyak	Rhizophoraceae	900	833	867	967	1067
7	<i>Rhizophora stylosa</i>	Bakau kurap	Rhizophoraceae	0	0	67	133	133
8	<i>Rhizophora mucronata</i>	Tanjang lanang	Rhizophoraceae	33	600	0	133	200
9	<i>Bruguiera gymnorrhiza</i>	Tanjang merah	Rhizophoraceae	67	0	0	0	0
10	<i>Ceriops tagal</i>	Tengar	Rhizophoraceae	0	0	0	0	0
11	<i>Lumnitzera racemosa</i>	Teruntum	Combretaceae	0	0	0	0	0
12	<i>Sonneratia alba</i>	Perepat	Sonneratiaceae	600	400	533	900	633
<b>Total</b>				<b>1733</b>	<b>1833</b>	<b>1667</b>	<b>2333</b>	<b>2033</b>
<b>Category: Sapling</b>								
1	<i>Thespesia populnea</i>	Waru laut	Malvaceae	0	0	0	0	0
2	<i>Avicennia lanata</i>	Api-api daun lebar	Avicenniaceae	0	0	267	0	0
3	<i>Avicennia marina</i>	Api-api putih	Avicenniaceae	667	0	400	0	0
4	<i>Xylocarpus granatum</i>	Nyiri hutan	Meliaceae	267	0	1733	933	0
5	<i>Aegiceras corniculatum</i>	Gedangan	Myrcinaceae	0	0	1200	800	0
6	<i>Rhizophora apiculata</i>	Bakau minyak	Rhizophoraceae	2533	1600	2267	1867	0
7	<i>Rhizophora stylosa</i>	Bakau kurap	Rhizophoraceae	267	0	533	800	2533
8	<i>Rhizophora mucronata</i>	Tanjang lanang	Rhizophoraceae	0	1600	0	0	133
9	<i>Bruguiera gymnorrhiza</i>	Tanjang merah	Rhizophoraceae	0	0	0	0	0
10	<i>Ceriops tagal</i>	Tengar	Rhizophoraceae	0	0	267	400	0

11	<i>Lumnitzera racemosa</i>	Teruntum	Combretaceae	0	0	0	0	0
12	<i>Sonneratia alba</i>	Perepat	Sonneratiaceae	1067	533	1467	1200	1600
		<b>Total</b>		<b>4800</b>	<b>3733</b>	<b>8133</b>	<b>6000</b>	<b>4267</b>
<b>Category: Seedling</b>								
1	<i>Thespesia populnea</i>	Waru laut	Malvaceae	0	0	0	0	0
2	<i>Avicennia lanata</i>	Api-api daun lebar	Avicenniaceae	0	0	800	0	0
3	<i>Avicennia marina</i>	Api-api putih	Avicenniaceae	1600	0	2133	0	0
4	<i>Xylocarpus granatum</i>	Nyiri hutan	Meliaceae	1200	0	2000	1733	0
5	<i>Aegiceras corniculatum</i>	Gedangan	Myrcinaceae	0	0	1600	667	0
6	<i>Rhizophora apiculata</i>	Bakau minyak	Rhizophoraceae	4267	3467	3333	4133	5467
7	<i>Rhizophora stylosa</i>	Bakau kurap	Rhizophoraceae	2267	933	1733	2133	1733
8	<i>Rhizophora mucronata</i>	Tanjang lanang	Rhizophoraceae	0	2400	0	267	800
9	<i>Bruguiera gymnorrhiza</i>	Tanjang merah	Rhizophoraceae	533	0	0	0	0
10	<i>Ceriops tagal</i>	Tengar	Rhizophoraceae	0	0	0	1067	0
11	<i>Lumnitzera racemosa</i>	Teruntum	Combretaceae	0	0	133	0	0
12	<i>Sonneratia alba</i>	Perepat	Sonneratiaceae	933	667	800	1867	2933
		<b>Total</b>		<b>10800</b>	<b>7467</b>	<b>12533</b>	<b>11867</b>	<b>10933</b>



**Fig. 3.** Graphic for composition and abundance of mangrove species on the eastern side of Bena port development project.

According to figure 3, the dominant mangrove species on the east side for Category tree is *Rhizophora apiculata* with a density of 900 stands/ha (Bena 1) and a density of 833 stands/ha (Bena 2), and category sapling is *Rhizophora apiculata* with a density of 2533 stands/ha (Bena 1) and a density of 1600 stands/ha (Bena 2), and in Bena 2 category sapling which is mostly found is *Rhizophora mucronata* with a density of 1600 stands/ha. *Rhizophora apiculata* is also most found in the seedling category with a density of 4267 stands/ha and 3467 stands/ha in Bena 1 and Bena 2 respectively.

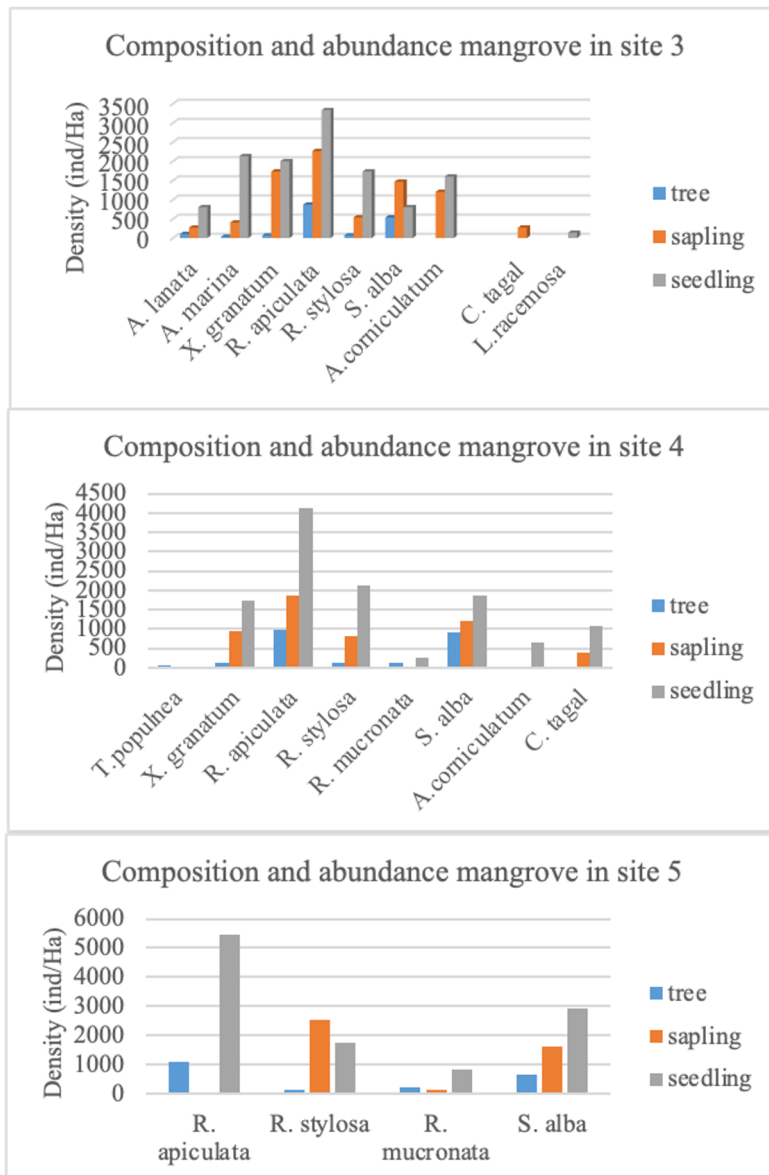
*Rhizophora apiculata* is found on the east side because according to [16], explained that this mangrove species is an abundant species in Indonesia with a dominance rate of up to 90% in a location that has a suitable substrate, namely, muddy soil, smooth, deep, and inundated at normal tide. In other words, *Rhizophora apiculata* is one of the mangrove species that has good adaptability to the environment [17].

The eastern mangrove forest has a lower tree-level density (sparse density) in both Bena 1 and Bena 2 when compared to the western side, although the sapling and seedling category has a high density indicating good natural establishment. According to [18], whether the vegetation community in an environment is disturbed or not can be seen from the high density of vegetation. On the eastern side, high density in the seedling category is due to competition for space, nutrients and nutrients that are smaller than when it has entered the sapling or tree

category. In the seedling category, mangrove propagules generally have their own food reserves since falling from the parent tree and nutrient requirements are not too high, so they can grow side by side with other individuals. However, as the size of diameter and height increases, competition between mangrove individuals occurs so that the strongest individuals will be able to grow well because they are able to optimize the absorption of nutrients and nutrients [17].

[19], said that density can be used to see the magnitude of disturbance to a habitat. If the density value of plant species is low or small, then damage occurs in that habitat; conversely, if the density value of plant species is large or high, then damage does not occur in that habitat [20]. Referring to the mangrove tree density value, the mangrove forest on the east side of the project site falls into the 'poor' or 'sparse density' category; based on the Minister of Environment Decree No. 201 Year 2004 concerning Standard Criteria and Guidelines for Determining Mangrove Damage; where the tree density criteria for sparse conditions are <1000 stands/ha.





**Fig. 4.** Graphic for composition and abundance of mangrove species on the western side of Benoa port development project.

According to figure 4, on the western side, the mangrove species found in the tree Benoa for the tree category is *Rhizophora apiculata* with the density of each Benoa being 867 stands/ha (Benoa 3), 967 stands/ha (Benoa 4), and 1067 stands/ha (Benoa 5). The sapling category is also dominated by *R. apiculata* in Benoa 3 and Benoa 4 with densities of 2267 stands/ha and 1867 stands/ha respectively, while in Benoa 5 the dominant sapling category is *R. stylosa* with a density value of 2533 stands/ha. *R. apiculata* is also commonly found in the seedling category with stand values of 3333 stands/ha (Benoa 3), 4133 stands/ha (Benoa 4) and 5467 stands/ha (Benoa 5).

The western side of the mangrove forest has a diverse density, with Benoa 3 and 4 having a low tree-level density when compared to Benoa 5 (Figure 4). Referring to the mangrove tree density values, the mangrove forest on the western side of the project site, especially Benoa 3 and Benoa 4, has a low tree-level density falls into the 'damaged' category; based on Minister of Environment Decree No. 201 Year 2004 on Standard Criteria and Guidelines for Determining Mangrove Damage; where the tree density criteria for sparse conditions are <1000 stands/ha, while Benoa 5 falls into the 'average' category; based on Minister of Environment Decree No. 201 Year 2004 on Standard Criteria and Guidelines for Determining Mangrove Damage, where the tree density criteria for medium conditions are >1000-1500 stands/ha.

**Table 2.** Standard criteria for mangrove damage.

Density	Criteria	Explanation
>1500	Dense	Very Good
>1000-1500	Average	Average.
<1000	Rare	Poor/ Damaged

### 3.2 Avifauna Community

Various bird species use mangrove forests as places to find food, mate, and rest. Based on avifauna observations, several bird species were found which are shown in table 3 and table 4,

**Table 3.** Abundance and activity of birds around western side of Benoa port development project.

No	Local Name	Famili	Scientific Name	Individual	Status	Bird's Activity
1	Kerakbasi ramai	Acrocephalidae	<i>Acrocephalus stentoreus</i>	1	-	Fly, perch, find food
2	Cekakak sungai	Alcedinidae	<i>Todiramphus chloris</i>	5	-	Fly, perch, find food
3	Cekakak australia	Alcedinidae	<i>Todiramphus sanctus</i>	1	-	Fly, perch, find food
4	Raja-udang biru	Alcedinidae	<i>Alcedo coerulescens</i>	6	E	Fly, perch, find food
5	Kapinis rumah	Apodidae	<i>Apus nipalensis</i>	3	-	Fly
6	Walet sapi	Apodidae	<i>Collocalia esculenta</i>	23	-	Fly

7	Cangak merah	Ardeidae	<i>Ardea purpurea</i>	1	M	Fly
8	Cangak besar	Ardeidae	<i>Ardea alba</i>	3	M	Fly, perch, find food
9	Kuntul perak	Ardeidae	<i>Egretta intermedia</i>	6	1,M	Fly, perch, find food
10	Kuntul kecil	Ardeidae	<i>Egretta garzetta</i>	15	-	Fly, perch, find food
11	Bambang n hitam	Ardeidae	<i>Ixobrychus flavicollis</i>	1	1	Fly, find food
12	Bambang n kuning	Ardeidae	<i>Ixobrychus sinensis</i>	1	M	Fly, find food
13	Kokokan laut	Ardeidae	<i>Butorides striata</i>	2	-	Fly
14	Blekok sawah	Ardeidae	<i>Ardeola speciosa</i>	5	-	Fly, find food
15	Kowak- malam kelabu	Ardeidae	<i>Nycticorax nycticorax</i>	2	-	Fly
16	Perenjak Jawa	Cisticolidae	<i>Prinia familiaris</i>	1	E	Fly, perch, find food
17	Tekukur biasa	Columbidae	<i>Spilopelia chinensis</i>	3	-	Fly, perch, find food
18	Gagak kampung	Corvidae	<i>Corvus macrorhynchos</i>	2	-	Fly
19	Wiwik kelabu	Cuculidae	<i>Cacomantis merulinus</i>	1	-	Fly, find food
20	Dara-laut jambul	Laridae	<i>Sterna bergii</i>	1	1	Fly, find food
21	Dara-laut biasa	Laridae	<i>Sterna hirundo</i>	2	1,M	Fly, find food
22	Dara-laut kumis	Laridae	<i>Chlidonias hybridus</i>	4	1,M	Fly, find food

23	Dara-laut kecil	Laridae	<i>Sterna albifrons</i>	2	1,M	Fly, find food
24	Kirik-kirik senja	Meropidae	<i>Merops leschenaulti</i>	2	-	Fly
25	Burung-madu sriganti	Nectariniidae	<i>Cinnyris jugularis</i>	3	-	Fly, perch, find food
26	Pecuk-padi belang	Phalacrocoracidae	<i>Phalacrocorax melanoleucos</i>	7	-	Fly, perch, find food
27	Pecuk-padi hitam	Phalacrocoracidae	<i>Phalacrocorax sulcirostris</i>	2	-	Fly, perch, find food
28	Caladi tilik	Picidae	<i>Picoides moluccensis</i>	1	-	Fly, find food
29	Merbah cerukcuk	Pycnonotidae	<i>Pycnonotus goiavier</i>	3	-	Fly, perch, find food
30	Kareo padi	Rallidae	<i>Amaurornis phoenicurus</i>	1	-	Fly, in the bush looking for food
31	Kipasan belang	Rhipiduridae	<i>Rhipidura javanica</i>	3	1	Fly, perch, find food
32	Gajahan pengala	Scolopacidae	<i>Numenius phaeopus</i>	26	1,M	Find food
33	Gajahan timur	Scolopacidae	<i>Numenius madagascariensis</i>	25	1,M	Find food
34	Trinil pantai	Scolopacidae	<i>Actitis hypoleucos</i>	8	M	Fly, perch, find food
35	Trinil kaki-merah	Scolopacidae	<i>Tringa totanus</i>	63	M	Fly, perch, find food
36	Trinil kaki-hijau	Scolopacidae	<i>Tringa nebularia</i>	24	M	Fly, perch, find food
37	Trinil semak	Scolopacidae	<i>Tringa glareola</i>	1	M	Fly, perch, find food

<b>Total of Abundance</b>	<b>260</b>
<b>H'</b>	<b>2,825</b>

### Description

- 1 Protection status in the Republic of Indonesia Regulation (Minister of Environment and Forestry Regulation No. 106 Year 2018)
- E Fauna endemic in Indonesia
- N<> Migratory bird species
- H' Shannon-Weiner diversity index value ; diversity status : low ( $H' < 1$ ) ; medium ( $1 < H' < 3$ ) ; high ( $H' > 3$ ).

Based on the result, the western study of Benoa consisted of 37 species of avifauna (birds) from 17 families (Table 3). We also found 8 bird species protected by the Minister of Environment and Forestry Regulation No. 106 Year 2018, namely, *Ardea alba*, *Ixobrychus flavicollis*, *Sterna hirundo*, *Chlidonias hybrida*, *Sterna albifrons*, *Rhipidura javanica*, *Numenius madagascariensis*, and *Numenius phaeopus*. In addition, we also found 15 species of migratory birds such as *Ardea alba*, *Egretta intermedia*, *Egretta garzetta*, *Ixobrychus sinensis*, *Butorides striata*, *Cacomantis merulinus*, *Sterna hirundo*, *Sterna albifrons*, *Amaurornis phoenicurus*, *Numenius phaeopus*, *Numenius madagascariensis*, *Actitis hypoleucos*, *Tringa tetanus*, *Tringa nebularia*, and *Tringa glareola*. We also found 2 endemic bird species, *Alcedo coerulescens* (Blue Shrimp King) which is endemic to Sumatra, Java, Bali, and Nusa Tenggara and *Prinia familiaris* (Javanese Perenak) which is endemic to Java, Sumatra, and Bali. *Scolopacidae* is the family with the highest number of species from the total species in the western study of Benoa, especially the species *Tringa totanus* (Red-footed Trinil) because the main habitat of this bird species is in wetlands such as mangrove forests, swamps, and beaches [21].

**Table 4.** Abundance and activity of birds around eastern side of Benoa port development project.

No	Local Name	Family	Scientific Name	Individual	Status	Bird's Activity
1	Cekakak sungai	Alcedinidae	<i>Todiramphus chloris</i>	2	-	Fly, perch, find food
2	Raja-udang biru	Alcedinidae	<i>Alcedo coerulescens</i>	1	E	Fly, perch, find food
3	Kapinis rumah	Apodidae	<i>Apus nipalensis</i>	3	-	Fly
4	Walet sapi	Apodidae	<i>Collocalia esculenta</i>	8	-	Fly
5	Cangak besar	Ardeidae	<i>Ardea alba</i>	4	1,M	Fly, perch, find food

6	Kuntul perak	Ardeidae	<i>Egretta intermedia</i>	2	M	Fly, perch, find food
7	Kuntul kecil	Ardeidae	<i>Egretta garzetta</i>	14	M	Fly, perch, find food
8	Kokokan laut	Ardeidae	<i>Butorides striata</i>	1	M	Fly
9	Blekok sawah	Ardeidae	<i>Ardeola speciosa</i>	5	-	Fly, find food
10	Kapasan sayap-putih	Campephagidae	<i>Lalage sueurii</i>	4	-	Fly, perch, find food
11	Tekukur biasa	Columbidae	<i>Spilopelia chinensis</i>	6	-	Fly, perch, find food
12	Perkutut Jawa	Columbidae	<i>Geopelia striata</i>	1	-	Fly, find food
13	Cerek Jawa	Charadriidae	<i>Charadrius javanicus</i>	4	M	Look for food
14	Cerek-kalung kecil	Charadriidae	<i>Charadrius dubius</i>	8	M	Look for food
15	Cerek-pasir besar	Charadriidae	<i>Charadrius leschenaulti</i>	13	M	Look for food
16	Cerek tilil	Charadriidae	<i>Charadrius alexandrinus</i>	3	1,M	Look for food
17	Cerek kernyut	Charadriidae	<i>Pluvialis fulva</i>	13	M	Look for food
18	Dara-laut jambul	Laridae	<i>Sterna bergii</i>	1	1	Fly, find food
19	Dara-laut biasa	Laridae	<i>Sterna hirundo</i>	6	1,M	Fly, find food
20	Dara-laut kumis	Laridae	<i>Chlidonias hybridus</i>	5	1,M	Fly, find food

21	Daralaut kecil	Laridae	<i>Sterna albifrons</i>	1	1,M	Fly, find food
22	Daralaut sayapputih	Laridae	<i>Chlidonias leucopterus</i>	5	1,M	Fly, find food
23	Daralaut tiram	Laridae	<i>Sterna nilotica</i>	2	1,M	Fly, find food
24	Camar kepala-hitam	Laridae	<i>Larus ridibundus</i>	1	1,M	Fly, find food
25	Kirik-kirik senja	Meropidae	<i>Merops leschenaulti</i>	2	-	Fly
26	Kirik-kirik laut	Meropidae	<i>Merops philippinus</i>	1	-	Fly
27	Burung-madu sriganti	Nectariniidae	<i>Cinnyris jugularis</i>	2	-	Fly, perch, find food
28	Pecuk-padi belang	Phalacrocoracidae	<i>Phalacrocorax melanoleucos</i>	1	-	Fly, perch, find food
29	Merbah cerukcuk	Pycnonotidae	<i>Pycnonotus goiavier</i>	8	-	Fly, perch, find food
30	Kipasan belang	Rhipiduridae	<i>Rhipidura javanica</i>	4	1	Fly, perch, find food
31	Gajahan pengala	Scolopacidae	<i>Numenius phaeopus</i>	24	1,M	Find food
32	Gajahan timur	Scolopacidae	<i>Numenius madagascariensis</i>	18	1,M	Find food
33	Trinil pantai	Scolopacidae	<i>Actitis hypoleucos</i>	8	M	Fly, perch, find food

34	Trinil kaki-merah	Scolopacidae	<i>Tringa totanus</i>	46	M	Fly, perch, find food
35	Trinil kaki-hijau	Scolopacidae	<i>Tringa nebularia</i>	18	M	Fly, perch, find food
36	Kedidi leher-merah	Scolopacidae	<i>Calidris ruficollis</i>	7	M	Fly, find food
37	Gajahan besar	Scolopacidae	<i>Numenius arquata</i>	5	1,M	Find food
38	Trinil bedaran	Scolopacidae	<i>Xenus cinereus</i>	2	M	Fly, perch, find food
<b>Total of Abundance</b>				<b>259</b>		
<b>H'</b>				<b>3,169</b>		

### Description

1 Protection status in the Republic of Indonesia Regulation (Minister of Environment and Forestry Regulation No. 106 Year 2018)

E Fauna endemic in Indonesia

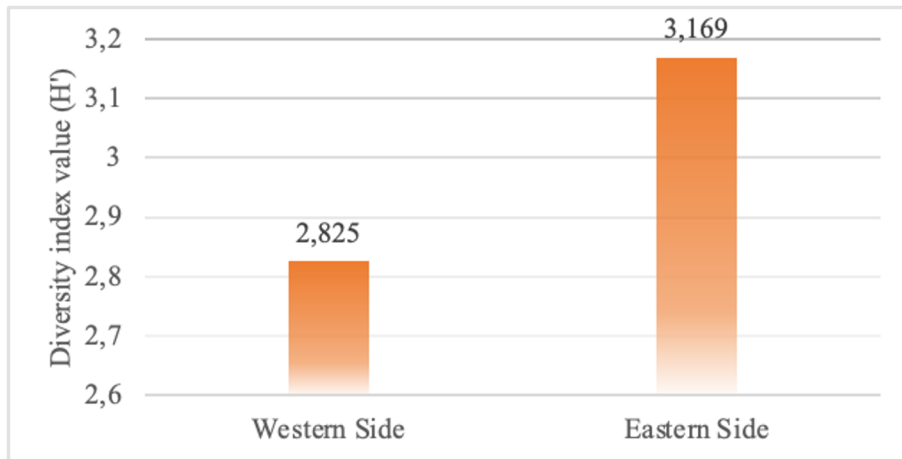
N<> Migratory bird species

H' Shannon-Weiner diversity index value ; diversity status : low ( $H' < 1$ ) ; medium ( $1 < H' < 3$ ) ; high ( $H' > 3$ ).

Based on the result, the eastern study of Benoa consisted of 38 species of avifauna from 13 families (Table 4). In the eastern Benoa we found 11 species of birds protected by the Minister of Environment and Forestry No. 106 Year 2018, namely, *Ardea alba*, *Ixobrychus flavicollis*, *Sterna hirundo*, *Chlidonias hybrida*, *Sterna albifrons*, *Chlidonias leucopterus*, *Larus ridibundus*, *Rhipidura javanica*, *Numenius madagascariensis*, *Numenius phaeopus*, *Charadrius alexandrinus*, and *Numenius arquata*. We also found migratory birds such as *Ardea alba*, *Egretta intermedia*, *Egretta garzetta*, *Butorides striata*, *Sterna hirundo*, *Sterna albifrons*, *Numenius phaeopus*, *Numenius madagascariensis*, *Actitis hypoleucos*, *Tringa tetanus*, *Tringa nebularia*, *Pluvialis fulva*, *Calidris ruficollis*, *Charadrius dubius*, *Charadrius leschenaultia*, *Charadrius alexandrinus*, *Numenius arquata*. In this observation location, only one endemic bird species was found, namely *Alcedo coerulescens* (Blue Shrimp King) which is an endemic bird species of Sumatra, Java, Bali and Nusa Tenggara Islands.

We also counted the diversity index using Shannon-Weiner Index ( $H'$ ) and based on that we found that the eastern side of Benoa port development project has the highest diversity (3.169) than the western side of Benoa port development project (2.825). This means that the mangrove areas on the western and eastern sides of the Benoa Harbor development site fall into the very good category. The high value of bird species diversity indicates that the mangrove area in the observation location is still able to provide basic needs for avifauna life.





**Fig. 5.** Graphic of Shannon-Weiner diversity index of bird species on the western and eastern side of Benoa port development project.

## 4 Conclusion

Based on the research paper, can be concluded that:

1. The mangrove forests around the Benoa Port Development Project showed varying levels of density between eastern and western sides. The eastern side had lower tree-level density (sparse density) in both Benoa 1 and 2 compared to the western side. Most areas fell into the 'poor' or 'damaged' category according to the Minister of Environment Decree No. 201 Year 2004, with tree density <1000 stands/ha. *Rhizophora apiculata* was the dominant species across most sites. Only Benoa 5 on the western side showed 'average' density conditions (>1000-1500 stands/ha).
2. The bird diversity on the eastern side showed higher bird diversity ( $H' = 3.169$ ) compared to the western side ( $H' = 2.825$ ). The western side contained: 37 species from 17 families, 8 protected bird species, 15 migratory bird species, and 2 endemic species (*Alcedo coerulescens* and *Prinia familiaris*). While the eastern side contained: 38 species from 13 families, 11 protected bird species, 17 migratory bird species and 1 endemic species (*Alcedo coerulescens*)
3. Despite the generally poor mangrove density, both areas still maintain high bird diversity. The high bird diversity values indicate that the mangrove areas are still capable of providing essential resources for avifauna. The presence of numerous protected, migratory, and endemic species suggests the ecosystem remains important for bird conservation. The research highlights the need for conservation efforts to maintain and improve the mangrove forest condition, particularly given its importance as a habitat for diverse bird species
4. This study demonstrates the crucial role of mangrove forests in supporting bird diversity in the Benoa coastal area, even though the mangrove vegetation shows signs of degradation in most locations

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