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Diversity of fauna species in the mangrove ecosystem of Youtefa Bay Tourism Park, Papua, Indonesia

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Abstract. *Sari A, Tuwo A, Saru A, Rani C. 2022. Diversity of fauna species in the mangrove ecosystem of Youtefa Bay Tourism Park, Papua, Indonesia. Biodiversitas 23: 4490-4500.* Youtefa Bay Tourism Park is a mangrove ecosystem in Jayapura City, Papua, Indonesia with high importance for biodiversity conservation as well as providing livelihood for local communities. Yet, information regarding the biological diversity of the mangrove ecosystem is lacking. This information is important to assess the state of the mangrove and to support its sustainable management of this area. This research aimed to determine the faunistic diversity of Youtefa Bay Tourism Park. The research was conducted from August 2019 to February 2020 using line transect method with quadrant to record species and the number of individuals. The results showed that in the studied area there were six, five and 27 species of birds, reptiles and macrozoobenthos, respectively. The density of birds ranged from 2.35-23.94 ind/ha with *Sterna hirundo* of the Sternidae family having the highest density. The reptile species density ranged between 20 and 66.67 ind/ha, while the most common macrozoobenthos species were from Gastropoda and Pelecypoda classes. The highest and lowest relative abundance for birds were *S. hirundo* and *Sula lencogastes* with 20% and 5%, while that of reptiles were *Mabouya* sp. and *Varanus salvadorii* with 37% and 15%, and for macrozoobenthos species were *Duplicaria duplicata* and *Solen* sp. with 9.93% and 0.35%, respectively. The Diversity Index (H') of birds, reptiles, and macrozoobenthos ranged of 0.29-1.39, 0.27-1.61, and 2.92-3.04, respectively. The diversity index was as low at Abepantai and Youtefa Bay Pier, while moderate at Tobati, Enggros, and Nafri Villages. Water quality parameters indicated that the waters in Youtefa Bay Tourism Park were still suitable for the survival of biota and the preservation of the mangrove ecosystem. The results of this study might be useful for monitoring the status of the mangrove ecosystem in the future and for baseline information in developing sustainable management of Youtefa Bay Tourism Park.

Keywords: Birds, community distribution, macrozoobenthos, reptile, water quality

INTRODUCTION

Mangrove forest plays a vital role in various ecosystem functions (Katili et al. 2017). It protects coastline from abrasion, filters pollutants, deposits mud and acts as a barrier to large waves including as tsunamis (Garcia et al. 2014; Kannan 2013; Khakhim et al. 2021). Mangrove ecosystem is also important habitat for a great number of biodiversity. In term of socio-economic aspect, it provides various benefits for communities as source of timber, firewood, food and medicine (Haris 2014). In many places nowadays, mangrove forest is also developed for tourism activities.

Mangrove is a complex ecosystem due to the uniqueness of its environmental characteristics, the variety of species contained and the interrelationships among them. The ecological system occurring in mangrove forest is dynamic because mangrove species can grow in extreme areas, develop continuously, and experience succession according to changes in their natural places. The natural processes that occur in mangrove forest (e.g. precipitation, weathering, and soil erosion) and anthropogenic activities (including human exploitation of its resources, urban development, and industrial and agricultural activities) both have an impact on environment quality of the ecosystem (Yang et al. 2012; Wang et al. 2012; Fatema et al. 2016).

Mangroves are a habitat for various wildlife species such as fishes, crustaceans, primates, reptiles, and birds (Garcia et al. 2014). Many marine species use mangroves as breeding, spawning, hatching, and nursery grounds because they thrive in a special environment. Wild animals found in this ecosystem are the combination of terrestrial, transitional, and aquatic fauna. Terrestrial animals mostly live in mangrove trees, while transitional and aquatic live in trunks, roots, and water columns (Asri et al. 2020; Hakim et al. 2012). Fauna that temporarily lives around the mangrove area generally occupies the top of the mangrove tree, consisting of insects, birds, bats, monkeys, langurs, mangrove cats and snakes. Meanwhile, organisms living on hard substrates to mud include macrozoobenthos species which will descend to the substrate when the water recedes (Azlad et al. 2015).

Indonesia has the largest extent of mangrove forest in the world with 3,364,080 hectares. Mangrove is one of significant contributors to the existence of biodiversity in Indonesia, thus it has becomes one of the main concerns in conservation and development (Murdiyarso et al. 2015). Papua alone has 1,009,062 hectares of mangrove forests

and is among regions in Indonesia with the most intact mangroves. Youtefa Bay Tourism Park is a mangrove tourism area that still maintains the beauty of the forest and its marine potential. It was designated as a nature tourism park in 1996 according to the Minister of Forestry Decree Number 714/Kpts-II/1996, with an area of 1,675 Ha to preserve the nature of Youtefa Bay. It is located in a strategic location in Jayapura City, Papua, Indonesia, hence, access to the park is easy. The condition of the mangrove ecosystem in Youtefa Bay Tourism Park continues to experience degradation in extent and quality due to the increase in human population and their needs. According to Hamuna et al. (2018), the mangrove ecosystem in Youtefa Bay is an important location to obtain shellfish (or locally called *bia*). In addition, mangroves in Youtefa Bay are also pressured by human activities which convert the mangrove forest into ponds, settlements, hotels, and tourist attractions. The destruction of mangroves has a detrimental effect on the variety of animals living in the ecosystem (Idrus et al. 2019).

While the pressures to the mangroves in Youtefa Bay Tourism Park continues, the available information related to diversity of fauna species at a local scale is minimal and inadequate. One of the efforts that can be made to maintain the fauna's survival and preserve the mangrove ecosystem is by investigating the diversity of species. Species diversity combines species richness and evenness. Richness implies the number of species in an area as community assemblage, while evenness is the distribution of individuals in the area. Each species that compose a community may not have the same individual numbers (Afonso et al. 2016; Rumahorbo et al. 2020; Dharmawan et al. 2016).

This research was conducted to obtain scientific information on the diversity of fauna species in mangrove forest in Youtefa Bay Tourism Park by determining the number and diversity of fauna species occurring on the area. The results can be used as a baseline information for the management of Youtefa Bay Tourism Park and in particular to support its development as tourism spots.

MATERIALS AND METHODS

Study area

This research was conducted from August 2019 to February 2020 in Youtefa Bay Tourism Park, Jayapura, Indonesia. Fauna sampling was carried out at five stations, namely: (i) ST1 in Tobati Village: Mangrove ecosystem was close to residential areas, and part of the land had been converted into a ring road bridge construction area; (ii) ST2 in Enggros Village: Mangrove conditions were relatively natural which were located along the Enggros Village area; (iii) ST3 Nafri Village: Mangrove conditions were relatively natural and were located in the Youtefa Bay basin, far from settlements; (iv) ST4 Abepantai: Mangrove ecosystem was close to settlements and part of the land used as a burial area; (v) ST5 Youtefa Bay Pier: Development region for Mangrove Tourism Area and there was mangrove rehabilitation conducted (Figure 1).

Data collection procedures

Mangrove observation

Mangrove sampling was conducted using the quadratic transect method with the length of 50 m and each quadrants measuring 10 m x 10 m. Three stations (Tobati, Enggros, and Nafri Villages) were used to collect mangrove vegetation data at the pole and tree level with a diameter of 10-20 cm. Species identification mangrove using book by Djamaluddin (2018).

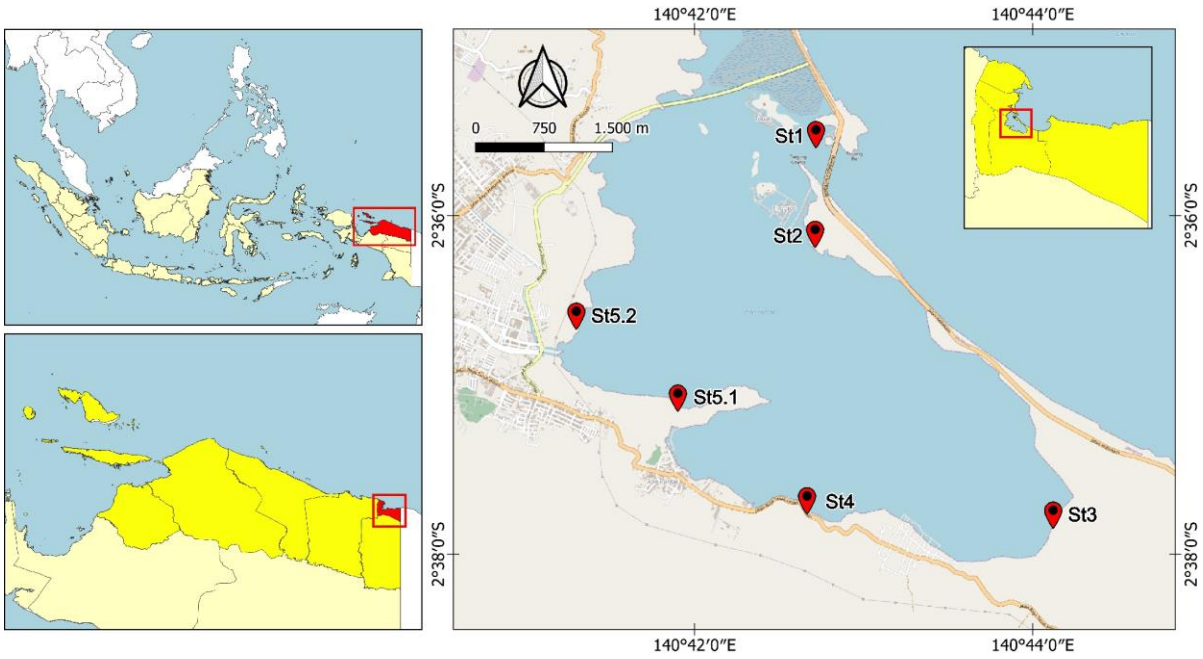

Figure 1. Map of studied area in Youtefa Bay Tourism Park, Jayapura, Papua, Indonesia

Bird and reptile observation

The bird observation was carried out using the counting point method (Bibby et al. 2000). The observation was conducted in silence at a predetermined point, and the encounter with the bird was recorded. Parameters measured were bird species, number of birds, and time of encounter. The observation used six counting points/observation stations; all were located on a transect line with a length of ± 1,800 m as possible as the eye could see at a radius of 50 m. The average sampling time was ± 30 minutes, ± 20 minutes for observation, and ± 10 minutes for walking to the following observation point. At each point in the observation path, every bird species encountered and all forms of activity were recorded (Figure 2).

The observation was made in the morning from 06:00 to 09:00 AM and in the afternoon from 03:00 to 06:00 PM. It was repeated three times for each location every two weeks for three months, and the population calculation was carried out by directly counting the number of birds and species identification using the book by Bibby et al. (2000) (Figure 3).

Macrozoobenthos observation

Macrozoobenthos (mollusks and crustaceans) data were obtained using the visual census method by performing direct observation and taking pictures with a camera, where benthos was taken as samples of biota on the roots, stems, and leaves of mangroves. Benthos sampling was performed within each plot at the mangrove observation point every two weeks for three months. Subsequently, bivalves sampling was carried out at five points representing the plot area of 10x10 cm^2, namely two points at the corner of each plot and one in the center. The samples were taken in the substrate with the help of an Eckman grab tool measuring 20x20 cm. The depth of the substrate was ±10-15 cm based on the consideration that some benthos could immerse themselves up to several cm. Furthermore, the samples obtained were filtered to separate from the sediment, cleaned, sorted, preserved using 70% alcohol, and stored in a cool box (Sari et al. 2019). Bivalve samples were identified using books on the identification of macrozoobenthos by Dharma (2005).

Water quality observation

In-situ observations of water quality were conducted using a thermometer to measure water temperature, a water quality checker (WQC) to measure salinity, pH, and dissolved oxygen (DO), a Secchi disc to measure transparency, and a turbidity meter to measure suspended particles. Measurement of chemical waters was conducted using laboratory test. Water samples were taken using a water sampler which was then put into a container with volume of five liters, replicated twice per observation location. Water samples were taken every month and taken to the Environmental Quality Management Laboratory, Department of Environmental Engineering, Faculty of Civil, Environmental and Earth Engineering, Sepuluh November Institute of Technology (ITS) and LABKESDA RSUD Jayapura.

Data analysis

The data obtained were analyzed descriptively and then displayed as figures and tables. To calculate the density of birds and other biotas, the formula prescribed by Cox (1972) was used as follow:

$$Di = \frac{ni\ (number\ of\ individual\ type\ i\ (ind)}{A\ (total\ area\ transect\ on\ the\ i\ plot\ (Ha)}$$

The relative abundance (RD_i) was calculated to see the ratio between the number of individuals in species i and the total number of all species following English et al. (1997):

$$RDi = \left(\frac{ni}{\sum n}\right) x\ 100$$

Where:
RD_i : Relative density;
ni : Number of individuals in species i;
$\sum n$:Total number of all species

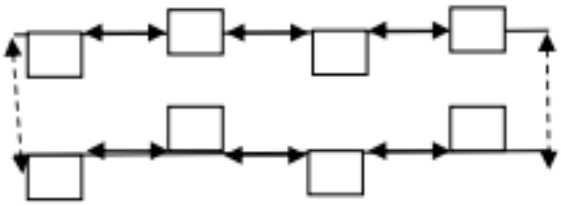

Figure 2. Diagram of line transect establishment and mangrove observation plot (modified from Siegers et al. 2021). Note: Distance between line transects was 50 m; Distance between plots was 10 to 20 m

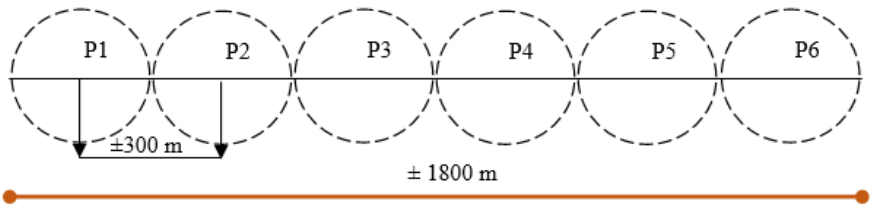

Figure 3. Bird observation path using the counting point method (modified from Bibby et al. 2000)

The diversity index was calculated using the Shannon-Wienner formula (Spellerberg et al. 2003) and formulated as follow:

$$H' = -\sum pi \ln pi$$

Where:
H' : Diversity index
Ln : Natural logarithm
pi : Number of individuals in each species

The H' value is categorized as low if $H' < 1$; as moderate if $1 < H' < 3$; and high if $H' > 3$

RESULTS AND DISCUSSION

Terrestrial fauna found during the observation of the mangrove ecosystem in Youtefa Bay Tourism Park included bird and reptile species, while aquatic groups were macrozoobenthos (mollusks and crustaceans). The mangrove and fauna observation results are described as follows.

Mangrove species

The mangrove ecosystem is a habitat and place for shelter, reproduction, and foraging for fauna, starting from the roots, stems, and branches. Based on observation results, mangrove species found in Tobati, Enggros, and Nafri Villages were from the genus *Bruguiera* (*Bruguiera gymnorhiza*), *Xylocarpus* (*Xylocarpus granatum*), *Sonneratia* (*Sonneratia ovata* and *S. alba*), *Avicennia* (*Avicennia alba*), and *Rhizophora* (*Rhizophora mucronata*, *R. apiculata*, and *R. stylosa*). There were several mangrove species recorded in Tobati, Enggros, and Nafri Villages because these regions were relatively undisturbed mangrove areas. On the other hand, there was only *Rhizophora mucronata* discovered near Youtefa Bay Pier because the location was a rehabilitation area. *R. mucronata* is commonly used for rehabilitation activities because the seed is easy to find, sow, and can grow at high and low tides. The most common species of mangrove found in the Jayapura area are *Avicennia* sp. and *Rhizophora* sp. Mangrove species found during observation are not too different from previous research. According to Hamuna et al. (2018); Kalor et al. (2018); Rumahorbo et al. (2019) mangrove species in Youtefa Bay Tourism Park include the genera *Sonneratia*, *Rhizophora*, *Avicennia*, *Xylocarpus*, and *Bruguiera*. The genus *Sonneratia* consists of *Sonneratia ovata* and *S. alba*. The genus *Rhizophora* includes *R. mucronata*, *Rhizophora apiculata*, and *Rhizophora stylosa*. The genus *Avicennia* is *Avicennia alba*, while *Xylocarpus* is *Xylocarpus granatum*, and *Bruguiera* is.

The mangrove density in Enggros was 1455,6 trees/ha, Naftri was 1477,8 trees/ha, and Tobati was 1033,5 trees/ha. Since the density of the three locations is in the range between 1000 and 500, therefore, the forest is categorized as medium and good density (Kalor et al. 2018). According to Sari et al. (2019), *Avicennia apiculata*, *Sonneratia caseolaris*, and *Sonneratia alba* dominated mangrove community structures in five locations in Jakarta Bay that are experiencing environmental degradation. The *Avicennia* genus was found on the edge of the coastal zone and was resistant to environmental stress (Sari et al. 2019; Rajpar and Zakaria 2014; Murtini et al. 2018).

Distribution of fauna in Youtefa Bay Tourism Park

The total birds recorded in the studied area were 880 individuals consisting of three families and six species, namely sea eagles (*Sula lencogastes*), little egrets (*Egretta garzetta*), striated herons (*Butorides striata*), White-wing tern (*Chlidonias leucopterus*), common tern (*Sterna hirundo*) and common white tern (*Gygis alba*). The birds were almost entirely encountered around the Youtefa Bay. According to the Natural Resources Conservation Center (2018), many different kinds of birds occurred in this area. These included sea eagles, small egrets, striated herons, pigeons, cockatoos, king prawns, large hornbills, and Papuan king parrots. These birds are rarely found because of the high activity around Youtefa Bay waters, illegal catching, and the damaged environment.

In total, the reptiles found in Youtefa Bay Tourism Park area were 19 individuals, consisting of four families and five species, including monitor lizards (*Varanus* sp.) and lizards (*Mabouya* sp. and *Tiliqua* sp.), geckos (*Gecko gecko*), and pythons (*Liasis* sp.). Generally, they are found in mangrove areas or on the beach with moist vegetation. Based on our observation, reptiles were generally active at night (nocturnal), such as geckos (*Gecko gecko*) which often found attached to tree branches or twigs. Therefore, they seek prey at night and prefer to hide in the crevices of trees during the day. Monitor lizards (*Varanus* sp.) were animals that active during the day around water, swamps, or near plants to look for prey. According to Idrus et al. (2019), the distribution of fauna in the mangrove ecosystem is a type of ecological function provided by mangroves. Crustaceans, insects, fish, vertebrates (*Varanus* sp., *Chrysopelea* sp., *Cerberus* sp.), mammals (*Lutrogale* sp., *Callosciurus* sp.), primates, and birds comprise the biological diversity connected with mangroves in Gili Sulat (Idrus et al. 2019).

Macrozoobenthos are food sources for bird; thereby they are essential in the food chain of the mangrove ecosystem. Macrozoobenthos that live in waters (substrate) are very sensitive to changes in the quality of their habitat, thereby affecting their distribution, composition, and abundance. The species found in all stations during the observation consisted of five classes: *Polychaeta*, *Clitellata*, *Gastropoda*, *Bivalvia*, and *Crustacea*. In total, 282 individuals were recorded belonging to 27 species of 24 genera and 17 families. The variation in the distribution across observation stations is due to differences in habitat characteristics, availability of organic matter as a food source, and adaptability to environmental changes (Suresh et al. 2012). The distribution of fauna in Youtefa Bay Tourism Park is shown in Table 1.

Table 1. Distribution of fauna in Youtefa Bay Tourism Park, Jayapura, Indonesia

Species	Tobati	Enggros	Nafri	Abepantai	Pier
Birds					
Butorides striata	√	√	√	√	√
Chlidonias leucopterus	√	√	√	√	√
Egretta garzetta	√	√	√	√	√
Gygis alba	√	√	√	√	√
Sterna hirundo	√	√	√	√	√
Sula lencogastes	√	√	√	√	√
Reptiles					
Gecko-gecko	√	-	√	-	-
Liasis sp.	√	-	√	-	√
Mabouya sp.	√	√	√	√	√
Tiliqua sp.	√	√	√	-	-
Varanus salvadorii	√	√	√	-	-
Macrozoobenthos					
Anadara antiquata	√	√	√	√	√
Asaphis deflorata	√	√	-	-	√
Cassidula aurisfelis	√	√	√	√	√
Cerithidae cingulata	√	√	√	√	√
Chicoreus capucinus	√	√	√	√	-
Clypeomorus moniliferus	√	√	√	√	√
Conus catus	√	√	√	√	√
Duplicaria duplicata	√	√	√	√	-
Isognomon perna	√	√	√	√	√
Littorina scabra	√	√	√	√	√
Lophiotoma indica	√	√	√	√	-
Mactra violacea	√	√	√	√	-
Marphysa sanguinea	√	√	-	-	-
Marphysa sp.	√	√	√	√	-
Morula margariticola	√	√	√	√	-
Nerita planospira	√	√	√	√	√
Oligochaeta sp.	√	√	√	√	√
Papuina labium	√	√	√	√	√
Penaeus monodon	√	√	√	√	√
Scylla sp.	√	√	√	√	-
Scrobicularia planata	√	√	√	√	-
Sinum perspectivum	√	√	√	√	√
Solen sp.	√	-	-	-	-
Teleskopium telescopium	√	√	√	√	-
Terebralia molustis	√	√	√	√	√
Terebralia palustris	√	√	√	√	-
Thiara scabra	√	√	√	√	-

Note: (√): found; (-): not found

Density of fauna species

The results of analysis showed bird species density ranged from of 2.35 to 23.94 ind/ha. Common tern (*S. hirundo*) of the Sternidae family was the species with the highest (23.9 ind/ha) found in Nafri Village (Figure 4). Waterbirds from the *Sternidae* family are migratory bird species that group in large numbers, which usually reach hundreds of individuals and use trees as place to perch. Therefore, this caused its number to be quite large compared to other shorebird species (Rajpar and Zakaria 2012; Asri et al. 2020). Dharmawan et al. 2016 also stated that they are most often found in primary and reforested mangroves, followed by little egrets (*Egretta garzetta*) and striated herons (*Butorides striata*). Birds from the *Ardeidae* family use mudflat areas, ponds, and rivers for foraging as well as mangrove trees for perching and nesting. Another study in Kelantan Delta showed that the highest density of waterbird species was recorded in aquatic vegetation such as sedges and rush, grasses, reeds, and herbaceous plants (Asri et al. 2020). Vegetation is important for the waterbird species activity and will create suitable habitat, provide food resources, safe nesting sites, and shelter from predator and weather (Rajpar and Zakaria 2012; Asri et al. 2020). The density of mangrove vegetation affects fauna in the mangrove ecosystem, making it a habitat, shelter, and a place to find food. Loss of mangroves results in a decline in both the quality and quantity of biodiversity due to the loss of an extensive biological niche for the feeding, spawning, and hatching of fish and marine organisms, as well as migratory species (Manju et al. 2012; Rajpar and Zakaria 2013; Hakim et al. 2017). This will lead to substantial impacts on coastal economies.

The reptile species density in Youtefa Bay Tourism Park showed a range of 20-66.67 ind/ha (Figure 5). The highest density was lizards (*Mabouya* sp.) found at Abepantai Station and Youtefa Bay Pier (66.67 ind/ha). It was widely found in these locations due to a large amount of household waste from the Youtefa market. Lizards are a group of reptiles with a scaly body, smooth, long tongue, long tail, and four legs in which their color indicates age and species. They are commonly found in trees, above ground, and sometimes underground, and prefer humid places with lots of litter, trees, and bushes or swamps. According to Apriyanto et al. (2015), lizards from the family Scincidae, consisting of 48 individuals, were the most commonly reptile group found in three forest sites in Sungai Ambawang Sub-district (Pontianak, Indonesia). Scincidae is the most adaptable reptile family to the environment and has a wide distribution.

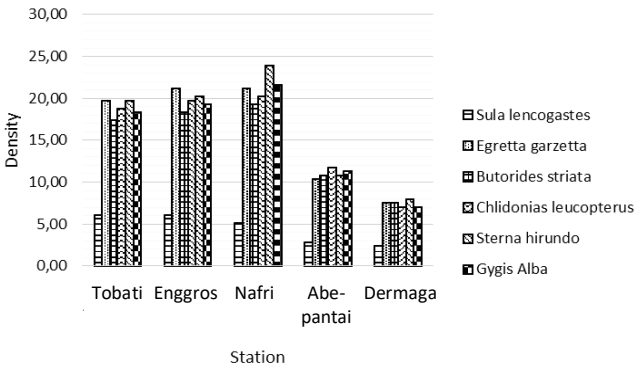

Figure 4. Density of bird species (ind/ha) in Youtefa Bay Tourism Park, Jayapura, Papua, Indonesia

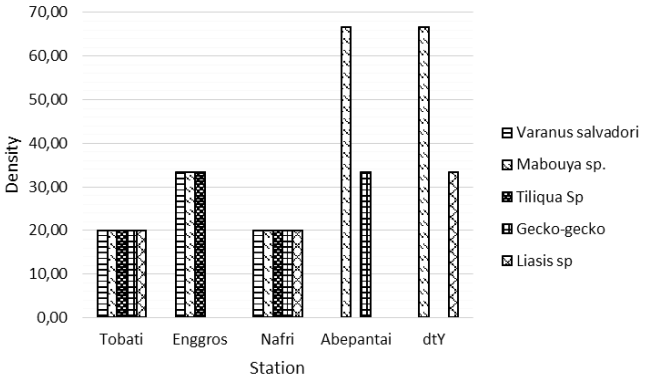

Figure 5. Density of reptile species (ind/ha) in Youtefa Bay Tourism Park, Jayapura, Papua, Indonesia

Meanwhile, the lowest density was snake (*Liasis* sp.), which is non-venomous snake species that usually lives in swamps and damp areas, lake shores, brackish, or coastal waters. One reason for the low density of *Liasis* sp. at the observation site was because snakes are active at night, while the observation lasted until 05:00 PM. Moreover, many of these snakes are caught and sold for consumption and as pets for reptile lovers. These snakes are in great demand because of their unique color (green similar with olives) (Natural Resources Conservation Center 2018).

The most commonly found macrozoobenthos species were from *Gastropoda* and *Pelecypoda* (Figure 6). They were dominant because of the high adaptability and were found on all types of substrates with broad food niches in the subtidal bottom area. The dominant species were detritus or plankton eaters, which were always abundant (Nybakken and Willard 1992). The form of adaptation of gastropods is by crawling for food up to the roots of trees or immersing themselves in muddy sand to maintain survival. Sites with multispecies and dense seagrass vegetation are suitable as a habitat for macrozoobenthos (Tajalli et al. 2021). Meanwhile, the highest and lowest density was found in duplicate auger (*D. duplicata*) and razor clams (*Solen* sp.), respectively. Chemical and physical factors in water and macro-micronutrients determine the presence and growth of organisms (Aslamyah et al. 2016; Nursidi et al. 2017; Muhtar et al. 2021). According to Siegers et al. (2021), the highest density in the seagrass area at Tobati village is duplicate auger (*D. duplicata*) of 36.51 ind/m², while the lowest is sea worm (*Marphysa sanguinea*), Gaudy sanguine (*Asaphis deflorata*), razor clams (*Solen* sp.), the necklace (*Clypeomorus moniliferus*), Indian turrid (*Lophiotoma indica*), shouldered castor bean (*Morula margariticola*), mangrove crabs (*Scylla* sp.), and papuina (*Papuina labium*) of 1.59 ind/m².

Relative abundance (RD%)

The analysis on relative abundance of birds showed that Common tern (*S. hirundo*) was the highest with 20%, and the lowest was sea eagles (*S. lencogastes*) with 5% (Figure 7.A). Common terns (*S. hirundo*) and other birds use mangrove tree branches as nesting places, interacting in the morning and looking for food in evening. The families of Sulidae, Sternidae, and Laridae are fish, fruit, and insect eaters commonly found in primary and secondary mangrove forests with ecological niches in the middle of the tree canopy layer (Sawitri et al. 2013; Azlad et al. 2015). In particular, birds from the Sternidae family are also species often found in primary and reforested mangrove forests. According to Angga and Yanti (2015), when a habitat contains the preferred type of food, it will be frequently visited by certain bird species, thus their populations are very vulnerable if such habitat is disturbed due to human activities. The presence and activity of humans indirectly degrade the ecosystem hence, affecting the presence, distribution, and abundance of birds (Jumilawaty 2012).

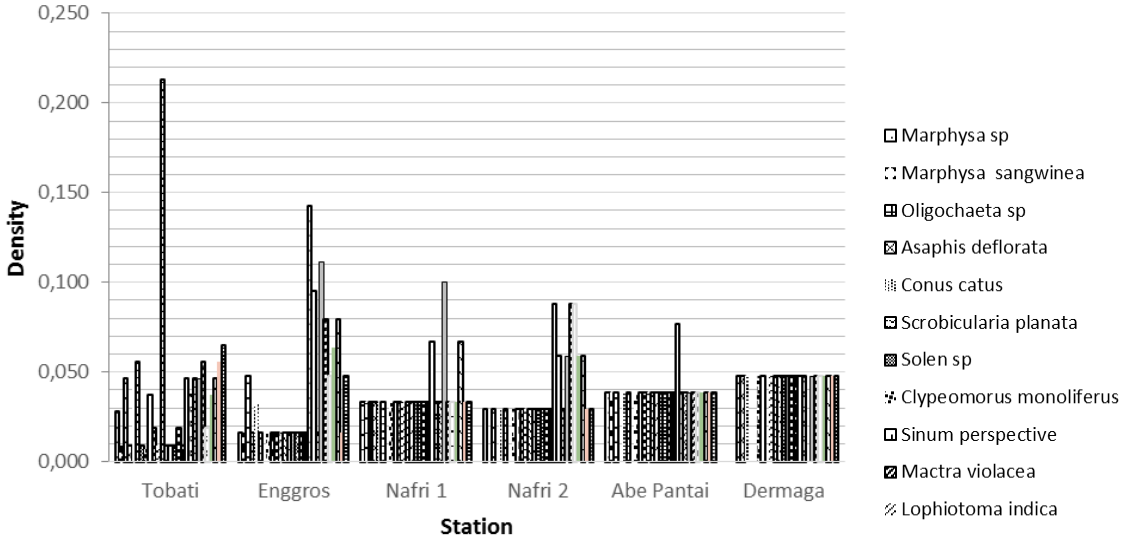

Figure 6. Density of macrozoobenthos species (ind/ha) in Youtefa Bay Tourism Park, Jayapura, Papua, Indonesia

The highest relative abundance of reptiles was lizards (*Mabouya* sp.) with 37%, and the lowest was monitor lizards (*Varanus salvadorii*) with 15% (Figure 7.B). The low abundance of monitor lizards was likely caused by catching for pets or consumption. According to Sari et al. (2019), reptiles from eastern Indonesia are widely traded, including monitor lizard (*V. salvadorii*) and blue-tongue skink (*Tiliqua* sp.). Monitor lizard (*V. salvadorii*) is endemic reptile species to Papua, with yellow spots on the body and ring-like circles on the tail. The characteristic that distinguishes *V. salvadorii* from other monitor lizards is that it has a more oval head shape of up to 2 m (Natural Resources Conservation Center 2018). The snake species observed included water pythons (*Liasis* sp.), which mainly inhabit swampy and humid areas as well as brackish or coastal waters, and it is an animal active at night (nocturnal).

The highest abundance of macrozoobenthos species was duplicate auger (*Duplicaria duplicata*) with 9.93%, and the lowest was Razor clams (*Solen* sp.) with 0.35% with a low distribution because it was only found in Tobati Village. Macrozoobenthos of the class Polychaeta and gastropods have habitat preferences of fine substrates, high organic matter in sediments and relatively high salinity of the waters. According to Siegers et al. (2021), the macrozoobenthos species consists of five classes, namely Clitellata, Bivalvia, Gastropoda, Polychaeta, and Crustacea. The highest relative density was *Duplicaria dupatta* with 44,23%, while the lowest were *Marphysa sanguinea, Asaphis deflorata, Solen* sp., *Clypeomorus moniliferus, Lophiotoma indica, Morula margariticola, Scylla* sp., and *Papuina labium* with 1.92% (Figure 7.C).

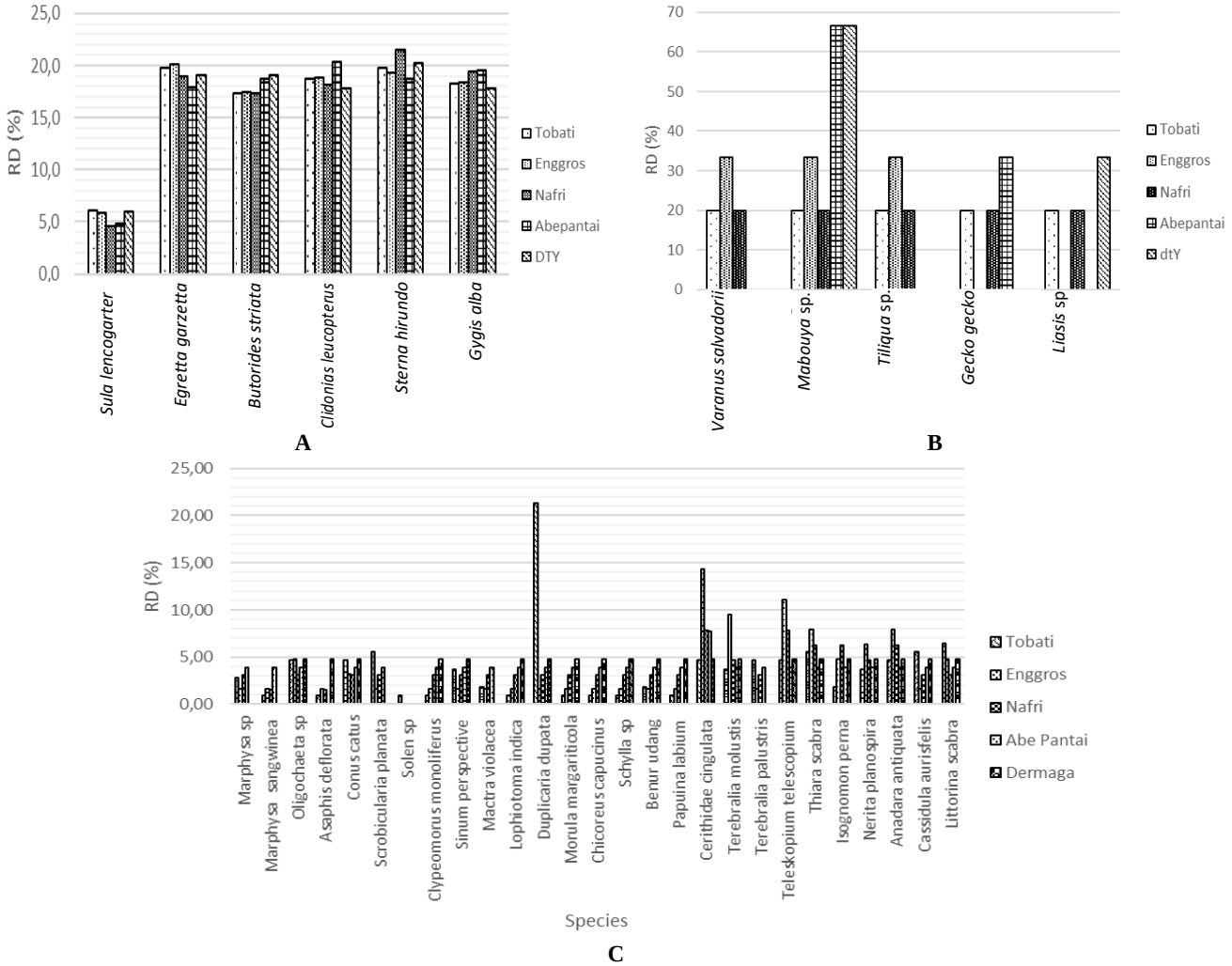

Figure 7. Relative Abundance (RD%) of (A) birds; (B) reptiles, and (C) macrozoobenthos in Youtefa Bay Tourism Park, Jayapura, Papua, Indonesia

Table 2. Diversity index of fauna in Youtefa Bay Tourism Park, Jayapura, Papua, Indonesia

Diversity Index (H')	Tobati	Enggros	Nafri	Abepantai	Youtefa Bay Pier
Birds	1.15	1.24	1.39	0.51	0.29
Reptiles	1.61	1.10	1.61	0.27	0.64
Macrozoobenthos	2.92	2.92	3.20	3.20	3.04

Diversity index (H')

The analysis results of the diversity index (H') of birds showed a range of 0.29-1.39 (Table 2). These values indicate that bird diversity was classified in the low category (H' < 1) at Abepantai Station and Youtefa Bay Pier, moderate (1 < H' < 3) at Tobati, Enggros, and Nafri. The highest diversity index was found in Nafri Village (1.39), because it had very good mangrove conditions. One function of mangroves is as a place for shelter and foraging for organisms. Meanwhile, Youtefa Bay Pier had a low diversity index of 0.29 because it has been gradually damaged due to household waste, resulting in an ecosystem imbalance caused by disturbance or pressure. Angga and Yanti (2015) obtained an H' value for Peniti Luar and Sungai Bakau Kecil Villages at 2.14 and 1.87, respectively. This indicates the higher the H' value, the more diverse the species found in the community. The species diversity index can be used to assess the condition of a community.

The diversity index (H') of reptiles in Youtefa Bay Tourism Park area showed a range of 0.27-1.61. The diversity of reptiles in Abepantai and Youtefa Bay Pier was in the low category (H' < 1), while a moderate diversity index (1 < H' < 3) was found in Tobati, Enggros, and Nafri Villages (Kalor et al. 2018). The index (H') of macrozoobenthos showed a range of 2.92-3.20. Tobati and Enggros Villages were in moderate diversity, while the rest sites were in high category. The distribution of the individuals number was also moderate, and no species dominated the site.

Diversity index is closely related to ecosystem conditions in which high and low diversity means a good and a damaged ecosystem, respectively. The difference in the diversity index (H') of fauna in Youtefa Bay Tourism Park is due to the variations in vegetation composition and habitat type, the number of species, and distribution at each research location, affecting the individual birds, reptiles, and macrozoobenthos.

Water quality parameters

Based on observation results, the water quality in Youtefa Bay was still in good condition for the life of biota, as seen from the transparency level of 0.7-5 m (Table 3). This value is higher than Sari et al. (2021), which found that the transparency level in the area of Tobati, Enggros and Nafri ranged from 0.6 to 2.8 m. The level is good according to the standards for biota according to the Minister of Environment Decree Number 51 of 2004 at <5 m.

Table 3. Results of analysis of physical and chemical abiotic component in Youtefa Bay Tourism Park, Jayapura, Papua, Indonesia

Parameter	Unit	Quality standard[1]	Average measurement results				
			Tobati	Enggros	Nafri	Abepantai	Pier
Physical:							
Smell	-	-	Odorless	Odorless	The odor is not pungent	The odor is not pungent	Strong scent
Suspended solids	mg/L	Coral 20; Mangrove 80; Seagrass 20	20	19.8	20	14	19
Rubbish	-	-	Plastic waste, drink bottles, building scraps	Plastic waste, drink bottles, building scraps	Plastic waste, drink bottles, fishing nets	Plastic waste, drink bottles, building scraps	Plastic waste, drink bottles, diapers, cardboard, building scraps, wood, oil
Temperature	°C	Coral 28-30; Mangrove 28-32; Seagrass 28-30	24	23	24	25	29
Transparency	M	Coral > 5; Mangrove - Seagrass > 3	3	4.5	5	0.8	0.7
Chemical:							
pH	-	7-8.5	8.4	8.4	7.9	7.5	7
Salinity	‰	Coral 33-34; Mangrove $\underline{<}$ 34 Seagrass 33-34	32	30	30	21	25
Dissolved Oxygen (DO)	mg/L	> 5	5	5.2	5	5	5.3

Note: 1. The Minister of Environment Decree Number 51/2004

Garbages found in the waters of the studied area were plastic, drink bottles, building materials, and residual oil from industrial and ship waste disposal. These cause unpleasant odor that reduces the aesthetic value of tourism sites in Youtefa Bay. Mangrove forest degradation reduces water quality which has an indirect impact on the richness of fauna species present in mangrove environments. Other studies by Breckwoldt et al. (2016) and Dsikowitzky et al. (2018) found that high levels of urbanization in Jakarta and the surrounding area are the driver for the accumulation of plastic garbage, household waste, and other solid waste. A huge volume of rubbish in the mangrove habitats of Jakarta Bay is indication of poor waste management, which can lead to the death of local plants and animals (Rinawati et al. 2012; Alimba et al. 2019; Mishra et al. 2019), affecting conservation, economy, and society in the broader sense (Sindern et al. 2016; Lohr et al. 2017; Chung et al. 2019; Mishra et al. 2019).

The total suspended solids ranged from 14 to 20 mg/L, which is within the normal range for water quality standards of 20 mg/L, 80 mg/L, and 20 mg/L for coral reefs, mangroves, and seagrass, respectively. Total suspended solids (TSS) consist of silt, organic and inorganic materials, fine sand, and micro-organisms, which originate from soil erosion and are carried to water bodies. Suspended material has a negative impact on water quality because it reduces the penetration of sun light into water bodies, increasing water turbidity and hindering the growth of producer organisms (Syafaat et al. 2021; Wasielesky et al. 2017; Tanjung et al. 2022). The impact of high suspended solids in waters causes reduced levels of dissolved oxygen in the water, directly affecting biota's survival in the waters (Liu et al. 2016)

Based on observation results, the water temperature ranged from 23 to 29^{o}C, which is within the water quality standards for biota. The water temperature was not significantly different across the observation sites, and this was probably due to the location of the mangrove vegetation. The temperature range of 25-36^{o}C is ideal for the survival of macrozoobenthos (Vincy et al. 2012). According to Kalor et al. (2018), water temperature of 29-30^{o}C is an ideal range for the growth of biota and mangroves. Temperature directly affects the photosynthesis rate of plants and animal physiology and indirectly affects the degree of metabolism and reproductive cycle (Fatema et al. 2014; Zakaria et al. 2015). Furthermore, the temperature directly affects enzyme activity and the life cycle stages of organisms. The temperature of the water is a crucial factor in the development of cultured organisms (Muhtar et al. 2021; Tahmid et al. 2015; Ali et al. 2016). It is a limiting factor for the spread of a species for survival, reproduction, development, and competition. Temperature is also very influential on the life and growth of aquatic biota. Water bodies are influenced by season, latitude, time of day, air circulation, cloud cover, water flow, and depth (Lee et al. 2014; Hamuna et al. 2021; Pujiyati et al. 2022). Temperature controls behavioral characteristics of organisms, solubility of gases and salts in water (Vincy et al. 2012).

The observation results of the acidity rate (pH) value at each station ranged from 7-8.4. This is still in a good range for the life of organisms according to the Minister of the Environment Decree Number 51 of 2004, which stated that the appropriate range for aquatic biota is 7-8.5. This is in line with Manalu et al. (2011) which obtained the pH value of Youtefa Bay waters across nine stations ranging from 7.15-7.65, with an average of 7.45. The highest value was at Abepantai (7.65), while the lowest was at Youtefa Bay Pier (7.15). This shows that the Youtefa Bay waters are still within the tolerable range of aquatic organisms. The difference in pH values is due to the indirect effect of photosynthesis from organisms, temperature, and salinity. According to Pacris et al. (2020), marine organisms prefer pH values between 7.67 and 7.73.The factor of pH is one of the vital environmental variables that determines the survival, metabolism, physiology and growth of aquatic organisms (Varol et al. 2012; Mane et al. 2013; Yusuf et al. 2016). The variety of pH values in waters affects the distribution and number of biota species including macrozoobenthos. However, an extremely acidic or alkaline can interfere with an organism's metabolism.

Salinity is the concentration of the entire salt solution in water. It proportionally affects the osmotic pressure of water (Behrouzi-Rad et al. 2014; Tiquio et al. 2017). In this study, the salinity ranged between 18.6-32 ppt. Salinity levels at Abepantai and Youtefa Bay Pier were low, hence, are influenced by fresh water. This result is in line with Hamuna et al. (2018), which stated that the supply of fresh water caused the low salinity in the Kampung Depapre waters through rivers that flow into the sea. Meanwhile, Pujiyati et al. (2021) reported that the salinity range in Humbold Bay was 33.7-35.89 ppt due to the difference in the mass between seawater and fresh water. Muhtar et al. (2021) also stated that an estuary is an area where salinity levels are influenced by incoming fresh water and tides. The differences are due to the influence of fresh water from the estuary and human activities (Salem et al. 2014).

Organisms need dissolved oxygen (DO) in waters for respiration, metabolic processes, the exchange of substances, and energy production for growth and reproduction. Furthermore, DO is one of the parameters needed by aquatic biota, and the decrease in oxygen in the waters is very dangerous for the life of aquatic organisms (Manalu et al. 2011; Hamuna et al. 2021). Based on observation results, the range of DO varied from 5 to 5.3. The range of water quality parameters is still within the standards, indicating that Youtefa Bay is suitable habitat for living organisms with DO >5. Hamuna et al. (2018) stated that the DO measurement in Depapre waters varied from 5.1 to 5.6 mg/L. The value obtained at each data collection station indicated the waters are in very good condition. Sari et al. (2021) also reported that the pollution index value shows that the waters in Tobati Village and Youtefa Bay Pier are suitable for marine life.

In conclusion, this study found there were several mangrove species found in Youtefa Bay Tourism Park, namely genus *Bruguiera* (*Bruguiera gymnorhiza*), *Xylocarpus* (*Xylocarpus granatum*), *Soneratia* (*Sonneratia ovata* and *S. alba*), *Avicennia* (*Avicennia alba*), and

Rhizophora (*R. mucronata*, *R. apiculata*, and *Rhizophora stylosa*). Fauna species documented in the study area included birds, reptiles, and macrozoobenthos which occurred in tree trunks, canopy, roots, and substrates. The bird species density ranged of 2.35-23.94 ind/ha in which *S. hirundo* from the *Sternidae* family showed the highest density. The density of reptile species ranged between 20 and 66.67 ind/ha, while the most common macrozoobenthos species were from Gastropoda and Pelecypoda classes. Bird species with the highest and lowest relative abundance were *S. hirundo* and *S. lencogastes* with 20% and 5%, while of reptiles were *Mabouya* sp. and *V. salvadorii* with 37% and 15%, and for macrozoobenthos were *D. duplicata* and *Solen* sp. with 9.93% and 0.35%, respectively. The Diversity Index (H') of birds, reptiles, and macrozoobenthos ranged of 0.29-1.39, 0.27-1.61, and 2.92-3.04, respectively. The diversity can be categorized as low category (H' < 1) at Abepantai Station and Youtefa Bay Pier, while moderate diversity (1 < H' < 3) was found in Tobati, Enggros, and Nafri Villages. Water quality parameters indicated that the waters in Youtefa Bay Tourism Park were still suitable for the survival of biota and the preservation of the mangrove ecosystem.

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