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INSECT DIVERSITY IN MANGROVE ECOSYSTEMS IN PAYUM BEACH, MERAUKE REGENCY, PAPUA

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Abstract

Mangrove forest is a permanent habitat and transit area for various fauna. In the mangrove community, it forms a mixed habitat between terrestrial and aquatic fauna groups. This study aims to analyze the composition of mangrove species and the abundance of insects. There are 3 research station on the mangrove forest ecosystem on Payum beach. Sampling was carried out using the Line Transect method, starting with making a line transect (50 meters) on the outermost mangrove stands and pulling them inland. On each transect line a plot measuring 10 x 10 m is placed, in each of which 5 subplots/quadrants measuring 1 x 1 m are placed. Each transect line consist of 3 plots and 15 sub-plots will be obtained, so there are a total of 45 sub-plots. Based on the research results, it was found that several types of macrobenthos live abundantly and are associated with mangrove ecosystems, such as Terebralia palustris, Terebralia semistriata, Nerita sp., Cassidula angulifera, Cerithidea sp., Telescopium telescopium. Four species of mangroves are found on Payum Beach, Merauke Regency, South Papua Province, namely Avicennia alba, Rhizophora apiculate, Sonneratia alba, and Aegialitis annulata. The insect diversity index in the mangrove forest on Payum Beach in Merauke is H'=2.61, which indicates that the environmental conditions of Payum Beach are still quite good and insect diversity is in the medium category. The evenness index of 0.42 is included in the medium category because human activities vary, and the dominance index is 0.63 because the Payum Beach mangrove forest has various types of insects with moderate dominance.

Keywords*: Biodiversity; Mangroves; Merauke; Insects*

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INTRODUCTION

Indonesia's extensive mangrove forests feature amazing biodiversity due to their varied structure. This forest type grows in tidal areas, which are inundated at high tide, and at low tide, this area is free from inundation. Mangrove plants can generally adapt to extreme environmental conditions, such as stagnant, high salt levels, and unstable soil conditions. The ecological function of mangrove forests is very important for the ecosystem in facing climate change that increasingly threatens the sustainability of all creatures. The existence of mangrove forests is also very important in providing habitat and protection for various animals such as birds, fish, insects, mammals and plants. Estuary habitats along the mangrove coastline in coastal areas with intertwined mangrove roots are often important nurseries for marine species, such as shrimp, crabs, and various species of fish and insects (Haneda *et al*., 2013; Henri & Ardiawati, 2020; Febriyanti *et al*., 2023).

Insects are highly diverse organisms and are a wealth of biodiversity that must be preserved. The number of insects reaches around 250.000 species, or 15% of the biota in Indonesia (Hasan & Nurmiati, 2022). Insects have many roles in ecosystems as herbivores, carnivores, decomposers, and pollinators.

The Merauke coast has very high fishery potential (Masiyah & Monika, 2017) for both gastropod diversity (Merly & Elviana, 2017), fisheries (Wagemu *et al*., 2018), and mangrove ecosystems (Tjilen *et al*., 2019). Mangrove ecosystems have the most extraordinary biodiversity and productive and highly varied ecosystem structures (Carugati *et al*., 2018; Haneda *et al*., 2013). Mangrove ecosystems also affect the availability of biodiversity in tropical ecosystems (Carugati *et al*., 2018). Mangrove ecosystems have a strategic role in physical, economic, and ecological aspects (Haneda *et al*., 2013; Arvind & Mudhura, 2015). The balance of the coastal environment is very dependent on the existence of mangrove ecosystems which function as biofilters (Haris, 2010), places to find food (Syahrial *et al*., 2020), protect the coast, are helpful for fishermen, places to grow, find food and breed for marine and coastal biota. (Majid *et al*., 2016).

The mangrove ecosystem is formed by the mangrove plants and various microorganisms, plants, and animals that make up the mangrove ecosystem (Ong & Gong, 2013). Mangrove forests have a significant role economically and ecologically. Mangrove forests function to

protect coastlines, process organic waste, produce wood, live places for insects that produce honey, and are natural habitats for various biota. Insects are essential to biodiversity and play a fundamental role in any ecosystem, including mangrove ecosystems (Ritter *et al*., 2019). The presence of insects in the mangrove ecosystem is significant because they are a food source, help plant reproduction, and help pollinate (Grampurohit & Karkhanis, 2013). Insect diversity indicates environmental conditions (Liu *et al*., 2018) (Chung *et al*., 2018). The spread of insects is strongly influenced by several factors, such as their ability to reproduce and feed, environmental factors (Haneda *et al*., 2013) as well as geological and ecological factors (Maulana *et al*., 2016)

Several orders of insects are found in mangrove ecosystems, such as Coleoptera, Diptera, Embiidina, Hymenoptera, Lepidoptera, Odonata, Orthoptera, Blattaria, and Homoptera (Haneda *et al*., 2013). Insects are also found in the Bhatye estuary area, such as Odonatan, Orthopteran, Coleopteran, Lepidoptera, and Hymenoptera (Arvind & Madhura, 2015). This study aims to measure mangrove species "composition and insects" abundance in Payum Beach, Merauke Regency, Papua Province.

RESEARCH METHODS

The research was conducted in September 2020 in the Payum Beach mangrove ecosystem area, Merauke Regency, Papua Province. There are 3 observation stations for conducting sampling.

The first station (St.1) is close to coastal community settlements, the second station (St.2) is a transition station located far from settlements where numerous community activities, like fishing and shrimp-catching, take place, and the third station (St.3) is far from the settlement with only a few community activities. Mangrove identification was carried out using the Guide to Mangrove Identification in Indonesia (Noor *et al*., 2006).

Table 1. Coordinates Research on Insect Diversity in the Mangrove Ecosystems at Payum Merauke Beach, Papua Indonesia

Location	St	Coordinate	
		S	E
Mangroves around community settlements	1	08°33'11.09"	140°25'30.90"
Mangroves around the fishing area	2	08°33'25.65"	140°25'45.75"
Mangrove without nearby community activities	3	08°34'00.26"	140°26'23.93"

Figure 1. Location of Research on Insect Diversity in Mangrove Ecosystems

Data Collection

1) Mangrove

Mangrove data were collected by making line transects and plots drawn from reference points (outermost mangrove stands) and perpendicular to the shoreline to the mainland (Ernanto *et al*., 2010), where line transects were made up of sample plots with a size of 10 x 10 m, 5 x 5m and 1 x 1m. Within the 10 x 10 m size, 5 subplots measuring 1 x 1 m are made for collecting mollusc. Each station consists of 3 plots, and each plot consists of 5 subplots, so the total number of subplots is 45. The density of mangroves on Payum Beach, Merauke Regency, Papua Province, was calculated using a calculating method that refers to English *et al*. (1994) and Bengen (2004).

2) Insects

Insect collection was carried out in the morning at 07.00-11.00 and in the afternoon at 15.00-17.00 WITA. The insect sampling procedure is carried out with the following steps: (i). Catching insects with insect nets by swinging the net around an insect-filled tree. (ii). Catching insects with the beating method: placing a white cloth measuring 2x2 meters under a tree stalk/branch and then shaking it ten times for three minutes.

Diversity index (Shannon-Wiener)

Species diversity was calculated using the Shanon-Wiener diversity index (Odum, 1971), as cited in Sirait *et al*. (2018) with the following formula:

$$H' = -\sum [(Pi)(LnPi)]$$

Where:

H' = Shannon-Wiener Diversity Index

Pi = Number of Individuals of a Species/total number of all species

ni = number of individual species (n)

N = Total number of individuals

Ln = Natural logarithm

Index of Evenness (Populations)

The evenness index value can describe the stability of a community. This can be calculated using the species evenness index with the formula:

$$E = H'/(\ln S)$$

Where:

E = Evenness index of types

H' = Species diversity index

S = number of types

Ln = Natural Logaritm

Ismaini *et al*. (2015) stated the criteria for the range of E as follows:

E < 0,4	Small Population Uniformity
0,4 < E < 0,6	Moderate Population Uniformity
E > 0,6	High Population Uniformity

Dominance Index (Simpson)

The dominance index value of each insect pest group is calculated using the formula:

$$C = \sum Pi^2 \quad \text{Where} \quad Pi = ni/N$$

Where:

C = Simpson's Dominance Index

ni = number of individuals of one type

N = number of individuals of all types

The level of insect dominance can be categorized based on the Simpson dominance index criteria as follows:

C < 0,50	Low Dominance
0,5 < C < 0,75	Moderate Dominance
0,75 < C < 1	High Dominance

Data Processing and Analysis

There are two ways to collect data: primary data and secondary data. Primary data were obtained by directly observing the mangrove area to be sampled. Secondary data were obtained from related offices and agencies in the research area. The data that have been collected are analyzed descriptively and presented in the form of tables and figures.

RESULTS AND DISCUSSION

1) Mangrove Species Composition and Diversity

The research results in Payum Beach found that there are 4 (four) mangrove species: *Avicennia alba, Rhizophora apiculate, Sonneratia alba,* and *Aegialitis annulata*. Reny & Devi (2018) found that there are 3 mangrove species on Payum Beach, namely *Avicennia alba, Rhizophora apiculata,* and *Sonneratia alba,* with the *Avicennia alba* species dominating the zone close to the sea, while *Rhizophora apiculata* and *Sonneratia alba* dominating the zone close to the mainland. Sunarni *et al*. (2019) found 9 mangrove species on the pay-up coast with the type *Avicennia sp.* and *Rhizophora sp*., which dominate the mangrove ecosystem in Payum Beach. Furthermore, for the diversity index of mangroves in three stations more details can be seen in figure 2.

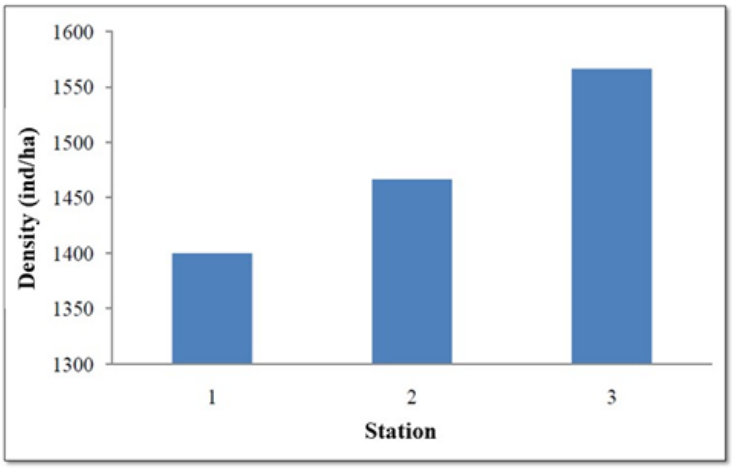

Figure 2. Mangrove density at each station

The Payum Beach area is one of the mangrove areas in Merauke Regency (Merly & Elviana, 2017). Payum Coast is one of the coastlines geographically opposite the Arafura Sea. Ecologically, Payum Coast is very strategic and has very high fishery potential (Masiyah & Monika, 2017). At the study site, various types of benthos were found that lived and were abundant in mangrove ecosystems such as *Terebralia palustris*, *Terebralia semistriata*, *Nerita sp, Cerithidea sp., Cassidula aguilera,* and *Telescopium telescopium,* as well as various types of bivalves and other organisms. Furthermore, 4 species of mangrove succesfully identified there are *Avicennia alba, Rhizophora apiculate, Sonneratia alba,* and *Aegialitis annulata*.

The density analysis of the mangroves at Payum Beach in Merauke Regency, Papua Province, yielded the following results: Station 3 has the highest density (1566.67 ind/ha), and Station 1 has the lowest density (1400.00 ind/ha). The high density of mangroves at Station 3 is believed to be anthropogenic, caused by insufficient logging activity and its remote position. According to UNEP (2014), the threat of mangrove forests around the world is caused by human anthropogenic impacts on mangrove forests, where the potential for the addition of the world's mangrove area cannot offset the loss due to human anthropogenic that continues to occur (Feller *et al*., 2017) and public pressure experienced by the mangrove ecosystem from anthropogenic humans is the conversion of cultivation land use, agriculture, and urban development (Friess & Webb, 2013). Additionally, it can be brought on by industrial and port activities (Zhang *et al*., 2014), as well as rapid population growth (Green *et al*., 1996; UNEP, 2014; Pramudji & Dharmawan, 2016). Furthermore, mangrove known as a great important to community intropical shoreline with

fundamental function such as cooking, heating, construction, and direct dependence of mangrove like dwellings, wood, thatch, honey and fish. (Bandaranayake *et al.,* 1998; Mitra *et al.,* 2021).

2) Insect Catching by Nets and Beating

Based on sampling collection in field, we had identified 11 genus of insect which is classified into 11 family and 5 ordo The sampling results caught bu nets and beating are shown in the following table (table 2 and table 3).

Table 2. Insects caught by nets

Ordo	Family	Genus	STATION			Average
			I	II	III	
Diptera	Dolichopodidae	Dolichopus	2.83	3.83	0	2.22
	Stratiomyidae	Helmetia	2	2	1.5	1.83
	Muscidae	Neomyia	2.17	3	0	1.72
Hemiptera	Coreidae	Acanthocephala	0.5	3.83	2.83	2.39
	Pyrrhocoridae	Dysdercus	1	1	0	0.67
Hymenoptera	Vespidae	Polistes	0	0.67	2	0.89
	Formicidae	Bombus	0	2.83	1	1.28
	Apidae	Apis	3	1	2	2.00
	Formidable	Stenodynerus	0	1	1	0.67
Lepidoptera	Peridae	Pieris	0.5	1	0	0.50
Blattodea	Blattidae	Periplaneta	1	2	2	1.67
Average			**1.18**	**2.02**	**1.12**	

Table 3. Insects caught by beating

Ordo	Family	Genus	STATION			Average
			I	II	III	
	Carabidae	Antichus	5	1.88	3	3.29
Coleoptera	Carabidae	Nebria	1	7.2	0.66	2.96
	Cantaridae	Cantharis	0.67	10	2	4.22
Hemiptera	Reduvidae	Reduvius	2.17	5.6	1	2.92
Homoptera	Cercopidae	Philaenus	1	2	1	1.33
	Formicidae	Anoplolepis	3.33	10.5	3.83	5.89
	Formicidae	Camponotus	5	2	2.83	3.28
Hymenoptera	Formicidae	Monomorium	2	3	2.66	2.56
	Formicidae	Odontumachus	2.17	2.83	2.5	2.50
	Formicidae	Oechophylla	5	5.6	5	5.22
	Formicidae	Pheidole	2	1	4.16	2.39
	Formicidae	Tetramorium	0	1	0	0.33
Isoptera	Rhinotermitidae	*Prorhinotermes*	10	20	5	11.67
Average			**3.03**	**5.59**	**2.59**	

Insects were caught on average at Station I (1.18 individuals), Station II (2.02 individuals), and Station III (1.12 individuals). The dominating insects are from the order *Diptera,* the family *Dolichopodidae,* and the family *Muscidae*. Due to its proximity to human settlements and agricultural habitats, the Diptera order is particularly abundant at Stations I and II. Still, the local community's actions significantly impact the ecosystem. I. By contrast, the ecology at Station II is close to several of the community agricultural areas.

The *Diptera* order inhabits all environments at observation stations I and II and consumes various plants (Table 2). Many types of *Diptera* feed on plant fluids (*nectar*), as well as animal fluids (*blood*), and feed on decaying organic matter. Several types of *Diptera* act as vectors for human disease, predators, and pollinators (Borror *et al*., 1996). Diptera larvae live in moist and watery locations, rarely in dry areas. The *Dolichopodidae* family has moist habitats, wet meadows, forest edges, shrubs, and hedges. This follows the characteristics of Stations I and II. The *Stratiomyidae* family has a habitat in decaying plants, from leaf litter to rotting fruit, under fallen tree bark, and the larvae like wet places such as tree holes and seepage areas. Imago is usually found on leaves and plants with flowers and is close to the food sources of the larvae. A plant is visited by many or few insects related to its ecological function (Hasan & Nurmiati, 2022).

The genus *Neomyia* has a habitat in various flowers, dirt, and carrion. This is also supported by the characteristics of Station I, which is close to fishing activities and residential areas. The diversity of vegetation types significantly contributes to the existence of insects because insects will spend half their life cycle in a habitat that can provide an optimal amount of food sources as needed (Kautsar, 2015). The types of insects caught by beating were dominated by the Hymenoptera order at all observation stations. There are 12 genera at Stations I and III and 13 at Station II. The average number of individuals caught at Station I was 3.03, Station II was 5.59, and Station III was 2.59.

Coleoptera and *Hymenoptera* dominate the insect species caught with the beating method (Table 3). At the same time, the highest populations are found in the *Formicidae* family, especially the *Anoplolepis* genus, which is abundant in forests (Depari *et al*., 2021). Ants are social insects that hunt for food in groups. Some species specialize in preying on termites and forming certain colonies to

protect themselves. The genus *Oecophylla* is an organism that forms nests among the leaves of mangrove trees. Ant colonies may have several nests in one tree or spread over adjacent trees. Ants are an essential part of the ecosystem (Mazlan *et al*., 2019) and are predators of other insects.

The *Rhinotermitidae* family, including wood-eating termites, prefers slightly open canopy conditions as their habitat. The average for this family was found at all observation stations, especially at locations close to the coast or in open canopy conditions. The behavior of insects and environmental factors from each stand affect variations in insect abundance at the three observation sites. Moreover, the abundance of plant species, trees, and undergrowth influences the composition and abundance of insects. This is consistent with the study results, which showed that the abundance of plants affected the composition and abundance of insects at the three observation stations.

a) Diversity Index

The species diversity index (H') is a parameter commonly used to determine the condition of a particular community using the Shannon-Wiener equation (Krebs, 1989, as cited in Kusumaningsari *et al*., 2015). The mangrove forest on the Payum Merauke coast has a diversity index value of H' = 2.61. As a result, if H' = 2-3, the diversity of insects in the land is included in fairly good environmental conditions, indicating that the insect diversity in the mangrove forest on Payum Merauke beach is categorized as moderate. Furthermore, insects play a crucial role in an ecosystem; this role can be detrimental or beneficial. Beneficial insects are pollinators, natural enemies, and decomposers of organic matter. In addition, insects that have economic value are honey bees and weaver ants (Nuraeni *et al*., 2016). Numerous factors, such as food availability and environmental conditions that favor development, contribute to insect variety.

Conversely, the insect population will decrease if the food cannot maintain quality or quantity (Keleb *et al*., 2015). The diversity and abundance of insects, in general, will also be determined by environmental factors. Each type of insect has a suitability for a particular environment. Therefore, environmental and physical factors significantly affect the type and population of insects.

b) Evenness Index Value

The evenness index (E) calculates how evenly dominant species are distributed across a mangrove community. The evenness index in the

Payum Merauke mangrove forest is 0.42, which falls under the medium category (Ismaini *et al*., 2015). The evenness index is caused by human activities at Station I and Station III. Insect populations may be lower in damaged ecosystems than in unaffected environments (Husamah *et al*., 2016).

Human activities in fishing and gardening significantly affect the evenness index. The community has a high evenness value when each species has the same number of individuals. On the other hand, if the evenness is low, a dominating species already exists in that group. Environmental factors largely determine the abundance and evenness of insects. Each insect has a suitability for its environment (Ubina & Cheng, 2022).

c) Simpson's Dominance Index (C) Value

The dominance index determines whether or not a type of arthropod dominates in a community (Zainuri *et al*., 2017). The dominance index in the mangrove forest on Payum Beach is 0.63, indicating that the land has a variety of insect species with moderate dominance. The insects were dominated mainly by the *Formicidae* family. Sanjaya *et al*. (2012) stated that the dominance of the species in the observed insect community was calculated based on the Simpson dominance index. The prevalence of insects varies at each observation station due to various environmental factors. Temperature and humidity affect the selection of insect habitats. This follows the findings of Ruslan and Noor (2007) referred to in Tofani (2008), *Formicidae* and *Nitidulidae* will be found mainly on the soil surface during the dry season, while the *Formicidae* and *Tenebrionidae* families will be found more on the soil surface during the rainy season. The health and diversity of forests are highly dependent on species diversity.

CONCLUSIONS

Four mangrove species are found in Payum Beach, Merauke Regency, South Papua Province, namely *Avicennia alba, Rhizophora apiculate, Sonneratia alba,* and *Aegialitis annulata.* The index of insect diversity in the mangrove forest on the Payum Merauke coast is H'=2.61, which demonstrates that Payum Beach's environmental conditions are still pretty good and that the diversity of insects is categorized as moderate. The evenness index was 0.42, which falls into the medium category due to varied human activities, and the dominance index was 0.63 because the Payum Beach mangrove forest has a variety of insect species with moderate dominance.

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