The structure of the *Meiozoobenthos* community and its contribution to demersal fishery in mangrove forest ecosystem in Banyuwedang Bay, Buleleng, Bali

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**Abstract.** Meiozoobenthos are small animals of less than 1.0 millimeter in length that live in mud substrate. Meanwhile, demersal fish that live in the seabed is one of the predatory groups that allegedly exploit the existence of meiozoobenthos by preying on them. Some interesting issues to be studied are the ecological aspects of meiozoobenthos, especially meiozoobenthos community structures and their contribution to the existence of demersal fish. To answer this problem, field research has been conducted by taking a location in the mangrove ecosystem in Banyuwedang Bay. In this study, the researcher collected biotic and abiotic data, taken on 20 sample points spread over 4 (four) sub locations. The collected data is then analyzed by quantitative and qualitative descriptive approach. The results of this research are: (a) the diversity of meiozoobenthos communities in Banyuwedang Bay is high with the number of species of 53 species and diversity index of 3.78, (b) the diversity of demersal fish in Banyuwedang Bay is moderate with the number of species as many as 13 species with diversity index of 2.50, (c) meiozoobenthos community contributes greatly to the presence of demersal fish in Banyuwedang Bay through meiozoobenthos’s role as the food for demersal fish, and (d) ecologically, the condition of mangrove ecosystem in Banyuwedang Bay is quite feasible as a place to develop a demersal fishery.

1. **Introduction**

As an aquatic ecosystem, the sea has a complex biological component that according to its form (life form) can be divided into 6 (six) kinds which are neuston, plankton, nekton, periphyton, benthos, and microbes. Each of these six forms of aquatic life occupies its own place according to its role and position within the marine biological community. Phytoplankton and phytobenthos take on the role of producers producing organic materials that can be used by other components. Meanwhile, zooplankton, zoobenthos, neuston, and nekton take the role of the consumer at various levels depending on the food source. Microbes as microorganisms are components that take on the role of decomposers that decompose the bodies of other components and its group into more simple organic particles either stored in the substrate (deposit) or in the water column (suspension) [1].

About benthos, one of the most important benthos groups in marine ecosystems is the meiozoobenthos community, a small zoobenthos group (<1.0 mm) inhabiting a muddy and sandy seabed [1] [2]. Ecologically, meiozoobenthos are an important link in marine ecosystems that take on
the role of consumers that utilize organic particles trapped in sediment (sand and mud) as food [3]. This organic material is then converted by meiozoobenthos to the higher trophic level through predation events when the meiozoobenthos itself is preyed on by other consumers [3]. One group of consumers that used to prey on meiozoobenthos is a group of fish commonly associated with basic habitats commonly called demersal fish [4]. Therefore, the existence of meiozoobenthos for the demersal fish community is very important, especially in the waters that the decomposition and sedimentation process is quite large, as in the mangrove forest ecosystem. So it is very rational if the trophic relationship between meiozoobenthos and demersal fish becomes an inspiration for the development of demersal fisheries with mangrove-based silvo fisheries system.

As an important resource for the development of demersal fisheries, meiozoobenthos is very important to learn, especially from an ecological aspect so that the understanding of the ecological aspects of this unique meiozoobenthos community becomes clearer. Talking about the ecological aspects of the meiozoobenthos community, the important aspects to be studied are aspects of community structure and habitat requirements and a good environment for meiozoobenthos’ life. The study of meiozoobenthos community structure can provide an overview of diversity, dominance, relative abundance, trophic structures and the life forms of meiozoobenthos. This study of meiozoobenthos community structure can be used as a material to assess the potential of meiozoobenthos resources in an area. Meanwhile, the study of habitat and environmental requirements for pelos can provide an overview of the physical and chemical variables appropriate for meiozoobenthos’ life. Then, it can be used as a material to assess whether an area has a condition suitable for pelos’ life. Thus, these findings can be used as a consideration for making decisions about whether an area with certain conditions and meiozoobenthos resources is suitable to be used as a site for developing demersal fisheries.

In relation to the study of the ecological aspects of meiozoobenthos and demersal fish communities, the mangrove forest ecosystem is a very good form of ecosystem used as the media to study it. It is because the ecosystem of mangrove forest is very rich with meiozoobenthos community, which in the end can invite the presence of various demersal fish in search of food in mangrove forest [5] [6] [7]. The existence of mangrove forests does not only support the existence of meiozoobenthos, but also supports the existence of demersal fish through the provision of food and shade of canopies. Leaf detritus, fruit, stems, twigs, and mangrove flowers are food for meiozoobenthos and some demersal fish species, while the shade of mangrove canopy can cover the forest floor including meiozoobenthos in it, and also shelter fish communities in the mangrove forest. Thus, meiozoobenthos and fish communities are safe from the hot sun [8].

In determining the mangrove forest as the media to study the ecological aspects of meiozoobenthos community in relation to the demersal fish community, the mangrove ecosystem in Banyuwedang Bay is a representative place to be used as the media. It is because the mangrove forest in this region is quite dense with a high diversity of mangroves (6 species), and with a thick sediment of forest (about 30 cm). In addition, the condition of mangrove ecosystems in this region is relatively good and natural. Thus, mangrove forests in this region are estimated to be rich of meiozoobenthos and demersal fish, so it is appropriate to be used as the media to examine the ecological aspects of meiozoobenthos and demersal fish communities. Based on the above description, there are a number of interesting issues to be studied, namely: (a) how is the structure of meiozoobenthos and demersal communities that inhabit mangrove ecosystem in Banyuwedang Bay; (b) whether pelos community has contributed to the existence of demersal fish community in mangrove ecosystem in Banyuwedang Bay, and in what form is the contribution given by pelos and; (c) based on existing conditions, is the mangrove ecosystem in Banyuwedang Bay suitable for developing demersal fisheries?

2. Research Method
This study is categorized as a descriptive exploratory study that takes place in Banyuwedang Bay, Gerokgak Sub-district, Buleleng Regency, Bali. The subjects in this study are meiozoobenthos and demersal fish communities that inhabit the base substrate of mangrove forest in Banyuwedang Bay, Buleleng, Bali. While the object of this research is the structure of meiozoobenthos and demersal fish community, and the contribution of meiozoobenthos community to the existence of demersal fish community in the mangrove forest area of Banyuwedang Bay, Buleleng, Bali. The population in this study is the whole meiozoobenthos and demersal fish that inhabit the base substrate of mangrove
forest in Banyuwedang Bay, Buleleng, Bali, while the sample of this research is a number of pelos and demersal fish that have been caught in the sampling done in accordance with sampling rules that have been set.

The study used a number of tools such as; (a) a set of mud sampling tools consisting of Petersen Grab and Mud Core, (b) a set of meiozoobenthos extraction tools consisting of UME (Uhlig Mud Extractor), MEA (Mud Elutriation Apparatus) [9]; (c) a set of fishing gear consisting of spreading nets, fishing rods, and traps; (d) a set of sea water filters comprising plankton net, bucket and Beker glasses; (e) a set of seawater quality checker called Water Quality Checker and Hand Refractometer; (f) a set of Rh Meter; (g) binocular stereoscopic microscope and; (h) a number of flakon bottles and plastic bags as the place to put the samples of meiozoobenthos, mud and seawater. Materials needed in this study were; (a) Rose Bengal coloring; (b) preservatives of 5% formaldehyde, and (c) seawater ice. All of these materials are in the laboratory (Biology and Aquaculture).

The data collection process consists of several steps, namely; (1) division of research sites into four sub locations covering sub location around Avicennia mangrove, sub location around Sonneratia mangrove, sub location around Rhizophora mangrove, and sub location around hot springs; (2) determination of sampling points in which there are five sampling points in each sub location, making 20 sampling points in total; (3) sampling of meiozoobenthos, demersal fish, substrate and seawater; (4) identification of meiozoobenthos samples and demersal fish as well as measurement of abiotic variables of seawater and substrate, and; (5) analysis of demersal fish stomach contents.

For the data analysis, this research uses 2 (two) approach that are quantitative approach (statistic, descriptive) and qualitative approach (descriptive, inductive and deductive). The issues that require quantitative analysis (statistics) are; (a) determination of diversity index of meiozoobenthos and demersal fish; (b) determination of abundance value of meiozoobenthos and demersal fish, and; (c) determination of meiozoobenthos percentage in the whole contents of demersal fish stomach. Meanwhile, the problems that require qualitative analysis are; (a) the composition of pelos and demersal fish species; (b) meiozoobenthos species consumed by demersal fish, and; (c) the feasibility level of the mangrove ecosystem in Banyuwedang Bay for the development of demersal fisheries in terms of physical and chemical variables of the substrate and its waters. In this qualitative analysis, inductive and deductive approaches are used where the results are described in narrative with the help of graphics and illustrations.

3. Results and Discussions

3.1 Results

From the research conducted and from the results of data analysis, the following results have been obtained.

a. Diversity of Meiozoobenthos community in Banyuwedang Bay is very high with the number of species as many as 53 species with diversity index of 3.78. The 53 meiozoobenthos species mentioned are shown in the following table (Table 1).

| No | Species Names      | Groups      | Abundance |
|----|--------------------|-------------|-----------|
| 1  | Paramonohystera sp | Nematoda    | 65        |
| 2  | Microlaimus sp     | Nematoda    | 50        |
| 3  | Leptolaimus sp     | Nematoda    | 50        |
| 4  | Comacolaimus sp    | Nematoda    | 45        |
| 5  | Metalinhumous sp   | Nematoda    | 30        |
| 6  | Enoplus sp         | Nematoda    | 30        |
| 7  | Enoplodes sp       | Nematoda    | 30        |
| 8  | Bathylaimus sp     | Nematoda    | 25        |
| 9  | Halalaimus sp      | Nematoda    | 25        |
| 10 | Anticoma sp        | Nematoda    | 20        |
| 11 | Draconema sp       | Nematoda    | 20        |
| 12 | Axonolaimus sp     | Nematoda    | 15        |
| No  | Sub location | ∑ Species | Abundance | Diversity |
|-----|--------------|-----------|-----------|-----------|
| 1   | Avicennia     | 39        | 325       | 3.55      |
| 2   | Sonneratia   | 36        | 285       | 3.47      |
| 3   | Rhizophora   | 32        | 260       | 3.34      |
| 4   | Hot Spring   | 27        | 160       | 3.25      |

These 53 meiozoobenthos species were extracted from four sub locations with the following details

Table 2. Number of Species, Abundance and Diversity of Living Meiozoobenthos in Each Sub Location in Teluk Banyuwedang
Graphically, species richness, individual abundance and diversity index of *Meiozoobenthos* in each sub location can be described as follows.

**Figure 1.** Meiozoobenthos species richness in each sub location in Banyuwedang Bay.

![Meiozoobenthos Species Richness](image)

**Figure 2.** Meiozoobenthos abundance in each sub location in Banyuwedang Bay.

![Meiozoobenthos Abundance](image)

**Figure 3.** Meiozoobenthos diversity index in each sub-location in Banyuwedang Bay.

![Meiozoobenthos Diversity](image)

b. The demersal fish community in Banyuwedang Bay is quite diverse with the number of species as many as 13 species with a diversity index of 2.50. The 13 species of demersal fish mentioned are shown in the following table (Table 3).

**Table 3.** The Species Composition of Demersal Fishes in Banyuwedang Bay

| No | Species          | Native name  | Abundance |
|----|------------------|--------------|-----------|
| 1  | *Mugil labiosus* | Ikan Belanak | 45        |
| 2  | *Terapon jarbua* | Ikan Kerung  | 35        |
These 13 demersal fish species live in four sub-district as shown in the table below.

Table 4. Species richness, Abundance and the diversity of demersal fish that live in each sublocation in Banyuwedang Bay.

| NO | SUB LOCATION | ∑ SPECIES | ABUNDANCE | DIVERSITY INDEX |
|----|--------------|-----------|-----------|-----------------|
| 1  | Avicennia     | 12        | 140       | 2.43            |
| 2  | Sonneratia    | 13        | 115       | 2.47            |
| 3  | Rhizophora    | 13        | 115       | 2.43            |
| 4  | Hot Spring    | 5         | 35        | 1.48            |

Graphically, the abundance, species richness, and diversity of the demersal fish that live in those four sub-locations in Banyuwedang Bay are shown below.

**Figure 4.** Species richness of demersal fish in each sub location in Banyuwedang Bay

**Figure 5.** The abundance of demersal fish in each sub-location in Banyuwedang Bay.
Meiozoobenthos has a major contribution to the life of demersal fish. The contribution is given by acting as a food for demersal fish. This is proved by the results of the analysis of stomach contents of some demersal fish caught like Mud Grouper (*Epinephelus lanceolatus*), Kerung fish (*Lutjanus argentimaculatus*), Sembilang fish (*Plotusus canius*), and blisters (*Scorpaenopsis sp*). From those five fishes stomach, it was obtained a percentage of average pelos as follows: (a) Crustaceans as much as 24%, (b) Polichaeta as much as 26%, (c) Tardigrada as much as 12%, (d) Nematodes as much as 14%, and (e) others as much as 24%. Identifying the other contents in the demersal fish stomach (probably meiozoobenthos) is difficult because it was completely destroyed.

d. Judging from the ecological conditions, the mangrove forest ecosystems in the Bay of Banyuwedang is pretty decent to be used as a place for demersal fisheries development. It is based on the results of monitoring and measurement of the ecological condition of the mangrove ecosystem, where all physical and chemical variables showed pretty good condition, viewed from the requirements of life for demersal fish community and the meiozoobenthos community. In addition, the water is not polluted and guarantees the survival of demersal fish and meiozoobenthos in the region. More than that, mangrove vegetation condition are still relatively intact and natural, and has enough diverse types so that it can guarantee the life and development of demersal fish and meiozoobenthos that live in the region. For sustainability, the ordinance of West Bali National Park is quite a guarantee that there will be no destruction of mangrove forest ecosystems in this region, considering this area is still in the area of West Bali National Park.

3.2 Discussion

By seeing all the data above, we can conclude that the diversity of meiozoobenthos in Banyuwedang Bay is very high. This can be seen from the number of species reaching 53 species, and the value of the Diversity Index reaching 3.78. The high diversity of meiozoobenthos in this region is estimated to be caused by 3 (three) important factors namely; (a) the variety of meiozoobenthos habitats in this region; (b) the good condition of meiozoobenthos habitats in the region; and; (c) the stability of the mangrove ecosystem in the region.

Seen partially for each sub-location, it appears that the diversity of meiozoobenthos in each sub-location is slightly varied. The results showed that the highest meiozoobenthos diversity was found around the mangrove of the Avicennia family (3.55), followed by the meiozoobenthos diversity in the vicinity of the Sonneratia cluster mangrove (3.47), the diversity of meiozoobenthos around the mangroves of the Rhizophora clan (3.34), and the variety of meiozoobenthos around the hot springs (3.25). This variation is suspected to be closely related to the tannin content of each mangrove species. According to Lemmen and Wulijarni (1992) the content of tannins in Sonneratia ranged from 9 to 15%, whereas in Rhizophora ranged between 8 - 40% [10]. It is known that tannin has properties that suppress meiozoobenthos population, so the higher the tannin in mangrove, the greater the pressure on the meiozoobenthos population [5]. The diversity of meiozoobenthos in sub-hot springs that show the smallest number compared to the other sub-sites is probably caused by the relatively warm water temperature (31°C) and high sulfur content. The water temperature is relatively warmer than the temperature of the surrounding sea water. It tends to be suppressing meiozoobenthos.

![Demersal Fish Diversity](image)
The meiozoobenthos population, except the population of certain meiozoobenthos types that have adapted well in hot water. In relation to sulfur substances in the form of H2S, these sulfuric substances can be toxic to most meiozoobenthos types, even in low concentrations [2]. It is said to be toxic, because H2S compounds can block the enzyme cytochrome oxidase acting on the cellular respiration chain [2].

In relation to the diversity of demersal fish which is not too high ($H' = 2.50$) in Banyuwedang Bay area, this is rationally acceptable because Banyuwedang Bay waters are almost isolated from seawater around it. Therefore the demersal fish in this bay is almost entirely a permanent species settled in this bay. In other words, it is very difficult to find marine migrant species that come to Banyuwedang Bay. Thus it can be understandable that the number of species and their diversity are in the moderate category.

Seen partially for each sub location, it appears that demersal fish diversity in each sub location is almost the same that is classified as moderate, except for sub hot springs location where the diversity is low. The factors that may cause the high diversity of demersal fish in the other three sub-sites (Avicennia, Sonneratia, and Rhizophora) are because there are no dividing boundaries between the sub-sites so that demersal fish can still move from one sub-location to another sub-location. Thus the diversity of demersal fish in the three sub locations is almost the same. The low diversity of demersal fish in hot springs sub-locations is probably due to a relatively higher water temperature factor and the presence of sulfuric substances in the form of H2S. The relatively warm water temperature is generally avoided by the fish because it is less convenient, also because the oxygen solubility is lower than the water with the lower temperature. Low oxygen content in the water will make it difficult for the fish to breathe.

The fact that meiozoobenthos is a food source for demersal fish, especially the carnivores, is very much in line with the previous researches conducted around the world that conclude meiozoobenthos as an important source of energy and material for the demersal fish community in addition to other sources such as detritus, carcasses, phytobenthos and zoobenthos from the epifauna group. These are the previous researches that are very much in line; (1) The 1976 Ankar and Elmgren studies in the Asko estuary around the Baltic Sea, and; (2) Warwick and Radford's 1979 study in the Lynher estuary, southern England [11].

In terms of ecological conditions, the mangrove ecosystem in Banyuwedang Bay is suitable to be used as a place to develop mangrove-based demersal fisheries. It is because the measurement results of all physical and chemical variables of the waters as well as the observation of the condition of the mangrove vegetation generally indicate the condition is good. The salinity, temperature, pH, DO, and turbidity show a range within feasible limits for aquatic biota, except for physical and chemical variables in hot springs sub-location that appear less friendly. Then, the vegetation of the mangrove is quite diverse and still in relatively good condition and natural. Therefore, everything can certainly support the existence of demersal fisheries in this bay, except in sub hot water spots that appear to be less suitable for demersal fisheries development. This is because the water temperature is warm and the content of sulfur is less favored by most species of fish, including demersal fish. The existence of mangrove vegetation for demersal fish is as a place to find food, a place to reproduce, a place to live as well as to take a shelter [12].

4. Conclusions and Suggestions

4.1 Conclusion

There are some findings after the research was conducted: (a) the diversity of meiozoobenthos communities living within the mangrove ecosystem in Banyuwedang Bay is very high where 53 species were identified with the Diversity Index of 3.78, (b) the diversity of demersal fish communities living within the mangrove ecosystem of Banyuwedang Bay is moderate with 13 species were identified, with a Diversity Index of 2.50, (c) a meiozoobenthos community in Banyuwedang Bay has a major contribution to the presence of demersal fish in this bay, because meiozoobenthos can be a food source for demersal fish, especially carnivorous and omnivorous, and (d) based on its good ecological condition, the mangrove ecosystem in Banyuwedang Bay is feasible as a place to develop demersal fisheries.
4.2 Suggestions

Based on the research results, there are some suggestions: (1) to ensure the survival of demersal fishery in Banyuwedang Bay, it is suggested not to damage or convert the existing mangrove forest area, and (2) to ensure the survival of demersal fishery in Banyuwedang Bay, it is suggested to use an environmentally friendly way to exploit the yield and pay attention on its sustainability.

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