Diversity, composition, and abundance of zooplankton in the waters of Morella, Central Maluku, Indonesia

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Abstract. Generally, conditioning of surrounding waters caused variability of the diversity, composition and abundance of zooplankton organism, therefore, this research conducted during the rainy season (July 2019) in the waters of Morella. The zooplankton weekly collected using zooplankton net at three stations for the three weeks (periods). Each station is water with different ecosystem and conditions (sea grass, coral reefs and recreation area in coral reef area). 29 genera of zooplankton were encountered, which consisted of 25 genera of holoplankton and 4 genera of meroplankton, The copepods dominated the group of holoplankton, and reached the average value of 4708 individuals/m³. The highest abundance of the zooplankton reached the numbers of 19047 individuals/m³ (St 1, first period), while the lowest was 2547 individuals/m³ (St. 3, third period). Diversity indices (H') was in a range of 2.717-3.004, whilst the Evenness indices was ranging from 0.82-0.89 and the highest similarity indices was between station 1 and 3 (92.0%) and the lowest was between station 2 and 3 (83.64%). The Siphonophores species, Diphyes sp was the only genera, which found at station 3 from the whole periods of this research.

1. Introduction

Zooplankton play an important role in supporting the life of various marine organisms by transfer the organic matters from surface waters to deeper waters through daily vertical migration activities [1] and [2]. The zooplankton consist of holoplankton and meroplankton, which have differences due to their life cycle, they have a high abundance in different type of waters. Most of holoplanktonic are presence from coastal to the oceanic waters, while meroplanktonic mostly occurrence closed to coastal waters. The presence of meroplanktonic is a linked to the reproduction patterns of the adults and usually present throughout of the year.

The characteristic of zooplankton, they have wide distribution across of environmental determinant, but others are restricted to hydrological parameters fluctuation, therefore, they can used as biological indicators of waters-mass types they inhabit. Copepods can be characterized specific waters masses as they are usually sufficiently abundant in the marine water [1] and [3]. The waters quality parameters of the marine environment are influenced by biological, chemical and physical factors [1], [2], [4] and [5].

The zooplankton, copepods are common in marine waters throughout of the world, therefore, the copepods are always dominated the marine zooplankton. Some species of copepods are so common and they are the most abundant animal on earth [6]. In the order of copepods, the calanoids usually found with the most numerous, in bulk and in species [1], [2] and [3]. They are probably more calanoid copepods than other zooplankton group [6].

Morella surrounding waters is a part of Seram Sea, therefore, the waters is also part of Banda Sea. Morella waters provide a good habitat for coral reefs, seagrasses, and other those marine organisms, including giant clam, Tridacna maxima. Therefore, the waters of Morella designated as a conservation area for the giant clam Tridacna spp. On the other side, some of Morella's coastal waters also used as recreational purposes such as swimming, diving, snorkling and other recreation activities.
This research presents an analysis of the distribution, composition, and abundance of zooplankton, on the complex purposes of surrounding waters of Morella during the month of July 2019, which is known as the peak of the rainy season in Maluku. The structure

2. Methods
2.1. Field work
Research was carried out at the surrounding waters of Morella, Central Maluku, eastern part of Indonesia (figure 1). The sampling period covered the height of the rainy season (July 2019) from three stations and conducted weekly (three periods). The focus of research is the distribution, composition, and abundance of zooplankton and the community structure between the three different conditions of stations. The zooplankton was collected horizontally by towing the zooplankton net, which has a 200μm of mesh with a mouth area of 0.25 m². The catch preserved immediately in 4% formaldehyde in seawater. Zooplankton was identified to genera or species level as possible by following [8], [9] and [10].

![Figure 1. The map of sampling sites](image)

Morella surrounding waters is famous as fishing ground of pelagic fish, some areas of the waters are indicated as habitat of variety economically important fish. Geographically, position of research stations showed in Table 1. Each station has a different condition, which station 1, is on the waters with seagrass communities, station 2, is on the waters with coral reefs communities and the station 3, is on the recreation area with coral reefs communities. Hydrological parameters were measured (temperature, salinities and pH) at each station during the research.
2.2. Data analysis
The numbers of zooplankton is calculated to a numbers of individuals in cubic meter of sea water, which entered the zooplankton net as numbers of filtered water (V). Data were analyzed based on the formula developed by [11] as follow:

\[ A = \pi r^2 L \]  

(1)

Whilst, the abundance of zooplankton was counted followed the formula as follow:

\[ D = \frac{NfVp}{V} \]  

(2)

Where D is the abundance of zooplankton, Nf is the numbers of zooplankton in a drop of sample (1 ml). Vp is the numbers of total drop of sample and V is numbers of filtered sea water.

The Shannon-Wiener diversity indices calculated using natural logarithms (H’) were used to describe species diversity and species richness as well as Evenness indices within zooplankton during the research periods [12] as follow:

\[ H' = - \sum_{i=1}^{S} P_i \ln P_i \]  

(3)

\[ E = \frac{H'}{H'Maks} \]  

(4)

Similarity indices could be determined by using Sorenson’s index as follow:

\[ S = \frac{2C}{A+B} \]  

(5)

Where C is the numbers of species the two communities have in common. A is the total numbers of species found in communities. A, B are the total numbers of species found in community B.

3. Result and Discussion
3.1. Distribution
The total of zooplankton genera found in the water of Morella was 29 genera and they were distributed across the waters. Calanus spp were more abundant than other zooplankton throughout all stations and periods. While Euconchoecia sp was only dominant in the first and second periods, as well as Sagitta spp showed the similar pattern.

Larval of Cyphonaetes sp was not found during the third period of sampling, this can be expained that at the end of the month of June, the larvae attached to a substrate and then they metamorphose to adult form, since the larva has a limited period as a planktonic organism [13].

Fish eggs were found at all station and periods, but their abundance decreases at the end of July. This is because the eggs have started to hatch in the second and third period. According to [14], fish eggs that have small egg yolks will hatch no more than 12 hours, while those with large egg yolks will hatch 2 or 3 days after being released. Overall it can be said that meroplankton distributed at each station and period although with different abundance (figure 2).
Figure 2. Distribution of Holo and meroplankton at all stations and periods in waters of Morella

3.2. Composition

There were 29 genera of zooplankton encountered from the Morella surrounding waters, which consisted of 25 genera of holoplankton and 4 others from genera of meroplankton. From those all, they are belonging to eight phylum e.g. Arthropoda (19 genus), Cnidaria (Diphyes sp), Urochordata (Fritillaria spp, Doliolum sp and Oikopleura spp), Chaetognatha (Sagitta spp), Annelida (larva Polychaeta), Mollusca (Larval Bivalve and Creseis sp), Bryozoa (larva Cyphonaetes ) and Chordata (Fish eggs) (figure.3). Phylum Arthropoda, copepods were dominant, which calanoids were bulk in numbers and species.

From 25 holoplanktonic found in this research, 16 genus are belonging to copepods. Calanoids, Calanus spp were the most abundant at three stations and the whole periods of research. Other important genera of zooplankton, Sagitta spp were found throughout sampling periods. They are common in the zooplankton of marine waters and present from coastal to open sea in the Baguala surrounding waters [15]. They serve as useful biological indicators of particular oceanic water types, since chaetognaths apparently respond to and associate with subtle physical characteristics of seawater [16].

Figure 3. Phylum of zooplankton found in the waters of Morella

The composition of zooplankton occurred in waters of Morella differs between stations and between periods (figure. 4), Composition was high in station 2 (28 genera), except for the third period (24 genera), while Diphyes sp was the only genera occurred at the station 3.
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Figure 4. Numbers of Genera of zooplankton at each station on July 2019

All the meroplanktonic genera occurred at station 2 during the first and the second period, the waters at station 2 was dominated by coral reefs communities, while at station 1 was dominated by seagrass communities. Numbers of genera found at station 3 higher than those at station 1, the waters at station 3 was dominated by coral reef communities and used as recreation area. This condition explained that all activities carried out in that area do not influence the condition of water.

3.3. Abundance
The total of individual zooplankton encountered at all stations during the whole period reached the value 19047 individuals/m³ (the highest) and 3297 individuals/m³ (the lowest). The high abundance value of zooplankton is a contribution to the abundance of copepods (figure 5).

Figure 5. The abundance of zooplankton at all stations and periods in the water of Morella

The highest abundance was at station 2 in the first period and the lowest was at station 3 in the third period. The pH value is constant at all stations and periods, therefore, there was no correlation between the abundance of zooplankton and the value of acidity (pH). The value in the waters of Morella was still
in the range of pH values that can be tolerated by the zooplankton (table 2). According to [17], in general, the ideal value of pH for marine organisms is in the range of 7-8.5.

### Table 2. Temperatures, Salinities and acidity (pH) in the waters of Morella

| Hydrological Parameters | St1, P1 | St2, P1 | St3, P1 | St1, P2 | St2, P2 | St3, P2 | St1, P3 | St2, P3 | St3, P3 |
|-------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Temperature (ºC)        | 27      | 28      | 28      | 27      | 27      | 27      | 27      | 28      | 27      |
| Salinities (‰)         | 34      | 35      | 35      | 36      | 34      | 35      | 35      | 35      | 35      |
| pH                      | 7       | 7       | 7       | 7       | 7       | 7       | 7       | 7       | 7       |

In general, it can be said that the correlation between the total abundance of zooplankton with temperature and salinity (figure 6 and 7) is very small ($R^2 = 0.2495$ and 0.0527 respectively). This is because the research was conducted during the month of July, which is the month of the rainy season with evenly distributed rainfall throughout the month, so that the water conditions are somewhat uniform.

![Correlation between Abundance and temperature](image1)

**Figure 6.** Correlation between the abundance of zooplankton and temperatures

![Correlation between Abundance and Salinities](image2)

**Figure 7.** Correlation between the abundance of zooplankton and salinities

However, the further study of the correlation between the abundance of zooplankton with temperatures and salinity at station 1 during 3 periods (figure 8 and 9), it turns out the result that there
is the same significant correlation ($R^2 = 0.9349$). The position of station 1 is the waters which are far from residential areas and dominated by coral reefs which used as the breeding grounds for the giant clam, *Tridacna maxima*.

![Figure 8](image1.png)

**Figure 8.** Correlation between the abundance of zooplankton and temperatures at station 1, at all periods

![Figure 9](image2.png)

**Figure 9.** Correlation between the abundance of zooplankton and salinities at station 1, at all periods

### 3.4. Diversity, evenness and similarity of zooplankton

The Zooplankton communities at all stations in the surrounding water of Morella reflect that the structure communities at station 3 at the third period were higher than others ($H' = 3.004$) and the lower was in station 1, at second period (table 3). This condition illustrates that in the third period and at station 3, the level of genera uniformity of zooplankton and the matching abundance of several genera collected during the research. Overall it can be stated that the zooplankton community during the month of July 2019 in the water of Morella was almost in a steady-state [18], that the value of $H' = 2.737 - 3.004$ and $E = 0.813 - 0.892$. 
Table 3. Ecological Indices of zooplankton communities in the surrounding waters of Morella

| Ecological Indices | St1, P1 | St2, P1 | St3, P1 | St1, P2 | St2, P2 | St3, P2 | St1, P3 | St2, P3 | St3, P3 |
|--------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| H'                 | 2.782   | 2.935   | 2.928   | 2.737** | 2.866   | 2.761   | 2.847   | 2.747   | 3.004** |
| E                  | 0.826   | 0.872   | 0.870   | 0.813*  | 0.851   | 0.820   | 0.845   | 0.854   | 0.892** |

The percentage of similarity index of zooplankton in waters of Morella showed that the similarity index of the zooplankton genera found in Morella waters during July 2019 is that the presence of plankton genera at stations 1 and 3 shows that as much as 92% of zooplankton are from the same genera compared to the numbers of genera at other stations. This is because the waters at station 1 and 3 are dominated by coral reefs, while the waters of station 2 are dominated by seagrass. However, it can be said that the similarity percentage of the zooplankton genera collected (table 4) is very high (83.64-92.00%), this figured that there were only a few genera that did not exist at the same time.

Table 4. The percentage of Similarity in zooplankton communities between Stations

| Station | Percentage of Similarity |
|---------|--------------------------|
|         | St.1 | St.2 | St.3 |
| St.1    |      |      |      |
| St.2    |      |      |      |
| St.3    |      |      |      |

Overall, it can be stated that the condition of Morella surrounding waters is almost in a steady-state, when it was viewed from the diversity, the richness of identified genera and the abundance of zooplankton during the research conducted in July 2019.

4. Conclusion
The abundance of zooplankton in the surrounding waters of Morella from station 1, 2 and 3 at the all periods showed there were no significant correlation between abundance and temperature, salinities and pH. However, there appears to be a strong correlation between the abundance of zooplankton at station 1 with temperatures and salinities along the whole periods and it showed the same value ($R^2=0.9349$). The abundance of zooplankton reached the highest numbers at station 2, in the first period and the lowest was at station 3 in the third period (19,047 individuals/m$^3$ and 2,547 individuals/m$^3$ respectively). While the highest numbers of genera was at station 2 during the first and second period (28 genera) and the lowest was at station 1 in the second period (22 genera). However, the similarity index showed the values of high similarity, were ranged from 82.64% to 92.00%.

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