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Community structure of zooplankton in the Lembeh Strait, Bitung, and Wori Beach, Manado, North Sulawesi, Indonesia

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Abstract

The community structure of zooplankton has been conducted in the Lembeh Strait in Bitung and Wori Beach in Manado, North Sulawesi in October 2015. Sampling of this research was conducted in 22 sampling sites along the strait. Zooplankton samples were collected from 22 stations, by NORPAC 300 μm net that was vertically hauled from maximum 10 m depth up to the surface water. The samples were poured into the bottle with formalin of 4% as preservative. The results showed that there were 43 taxa of zooplankton. The abundance of zooplankton was between 21.216–4 193.776 ind./m^3. The dominant taxa were copepod, especially Calanoida. The composition of zooplankton was relatively similar in all stations. We showed the abundance, dominance, composition and distribution of zooplankton at this research. More extensive studies concerning zooplankton is required to understand zooplankton biodiversity as a whole especially on the geographical and spatial distribution to describe population and community dynamic in the Lembeh Strait and Wori Beach.

Key words: Lembeh Strait, Wori Beach, zooplankton, copepoda, calanoida

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1 Introduction

The Lembeh Strait is one small part of this biodiversity hotspot which has many unique types of marine ecosystem. However this area also receives growing threat of environmental degradation due to antrophogenic activities in its coastline. The development of industrial zones along with international ports, also could potentially introduce new and invasive species to the Lembeh Strait and Wori Beach (Rumengen et al., 2011).

The Lembeh Strait is a narrow strait located east from Bitung, North Sulawesi. This strait is affected by hydrographic condition which relates to different kind of anthropogenic activities in the coastline. The northern part of Lembeh Strait is relatively pristine due to the existence of Batu Angus National Park and relatively low anthropogenic activities in the coastline. On the contrary, the southern part of Lembeh Strait has been degraded due to the existence of large city, heavy industries, ports and shipyards. The rapid development of the city, factories and ports has been progressing further to the north and become major impacting factors for the health of Lembeh Strait ecosystems, such as coral reefs and sea grasses. Nutrients, as well as pollutants, produced in the southern part of Lembeh Strait could be transferred by the currents to the waters in the northern strait. Research on the diversity pelagic marine organism has been conducted for many years, but no specific attention was given to the diversity of zooplankton species in the ecosystem.

Zooplankton communities are remarkable important in the coastal ecosystem since they play an important role in the functioning of marine ecosystems and in biogeochemical cycles. In fact, their abundance can show considerable variability which provides information about the dynamics of their natural populations. Information on plankton diversity at a regional scale is known essential for understanding its fluctuation as well as for ecosystem management. Its information is important because the science of biodiversity itself has primarily focused on the global features. Zooplankton is a key link between primary producers and larger predators and most zooplankton population changes can be attributed to environmental causes. Zooplankton is one of the components in the food chain especially in relation to the production of an ecosystem. Zooplankton is known as an important biological component of the marine environment. Zooplankton is a key component of marine ecosystems that serve several purposes in the sea. First, zooplankton is foods for many larger organisms, such as fish. Zooplankton also is used as an indicator of the overall state of the water environment and a healthy zooplankton population is generally reflective of a healthy environment. Zooplankton encompasses representing all the major invertebrate phyla, including some ones that can only be found in the plankton. Since zooplankton is the principal diet of most larger pelagic animals, including commercially important fish, their study is an essential component in forming a more complete understanding of the functioning of marine ecosystems (Sekiguchi, 2007).

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In October 2015, a survey was carried out in the Lembeh Strait in Bitung and Wori Beach in Manado, Sulawesi, Indonesia to understand the community structure of zooplankton such as abundance, dominance, composition and distribution of zooplankton assemblages at selected sites in the Lembeh Strait, Bitung, and Wori Beach, North Sulawesi in the eastern part of Indonesia.

2 Materials and methods

2.1 *Study area*

This research was conducted at October 2015 in the Lembeh Strait, North Celebes in Bitung and Wori Beach in Manado, Indonesia. There were 11 sampling stations scattered from the southern to the northern part of Lembeh Strait, Bitung, and 11 sampling stations at Wori Beach in Manado, Sulawesi, Indonesia (Fig. 1).

Zooplankton samples were collected using a plankton net with mesh size 300 μm. Method for collecting phytoplankton and zooplankton was done vertically from 10 m depth to surface. After hauling, the concentrated samples in the net's bucket was then removed out to another bottle sample and immediately put some fixative buffered formalin solution with concentration of 4%.

Zooplankton enumeration and identification were also done by fraction method. A 2.5 mL sample was taken using 2.5 mL stamp pipette then placed in Bogorov counting disc. The fractioned sample was then observed under 4× to 40× magnification using LEICA MZ-6 dissecting stereo microscope. During plankton identification process we use reference from Huang and Lin (2012), Young (2002), Zhong (1989), Yamaji (1976), Wickstead (1965), and Newell and Newell (1963). The number of counted zooplankton individuals in the samples was then converted into ind./m^3 using modified formula derived from Arinardi (1997) and Semina (1987). The number of zooplankter or abundance is then calculating with formula:

$$N = n \times \frac{V_t}{V_s} \times \frac{1}{V},$$

where N is total number of cells, V_t is volume of the sample, V_s is volume of the sub-sample, V is volume of the filtered seawater and n is number of cells observed.

3 Results and discussion

3.1 *Abundance of zooplankton*

The abundance of zooplankton throughout the waters of the Lembeh Strait varying from 212.16 to 4 193.776 ind./m^3, where the highest number was recorded in Sta. A20 and the lowest was in Sta. A01. The abundance of zooplankton throughout the waters of Wori Beach varying from 21.22 to 3 434.23 ind./m^3 where the highest number was recorded in Sta. A11 and the lowest was in Sta. A05 (Fig. 2). Zooplankton abundance in this study was higher than the results of previous studies in June 2012, with the value varying from 208 ind./m^3 up to 4 401 ind./m^3 and May 2014 same value varying from 2 178 to 5 787 ind./m^3. This value is similar in the Raja Ampat Island in West Papua (Thoha, 2009) and Gilimanuk Bay of National Park Ecosystem, West Bali (Thoha, 2007). Mulyadi and Rumengen (2007) have listed about 300 species, 55 new records and 11 new species of copepods from whole Indonesian waters. Zooplankton production related survey has been conducted during the Baruna Jaya Expedition I in 1964. The findings of more abundant zooplankton in the Java Sea rather than in the Indian Ocean were consistent with the results of the other studies afterwards. The similar tendency of temporal zooplankton distribution in the waters around the Seribu Islands and that in the Jakarta Bay has been found by the Research Center for Oceanography, Jakarta. Zooplankton abundance and biomass data (1970–1985) are available in the online database (global plankton database.htm), including those of Snellius II Expeditions (1984–1985).

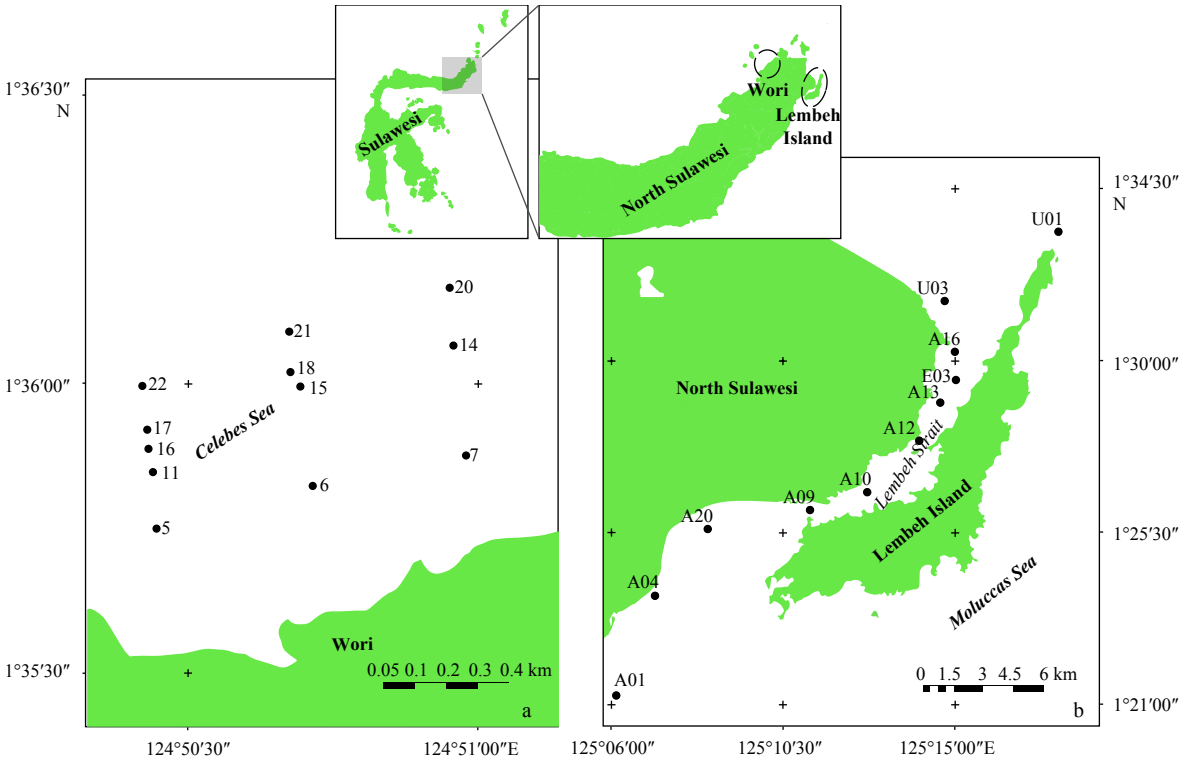

Fig. 1. Location of Wori (a), and Lembeh Strait (b), North Sulawesi, Indonesia.

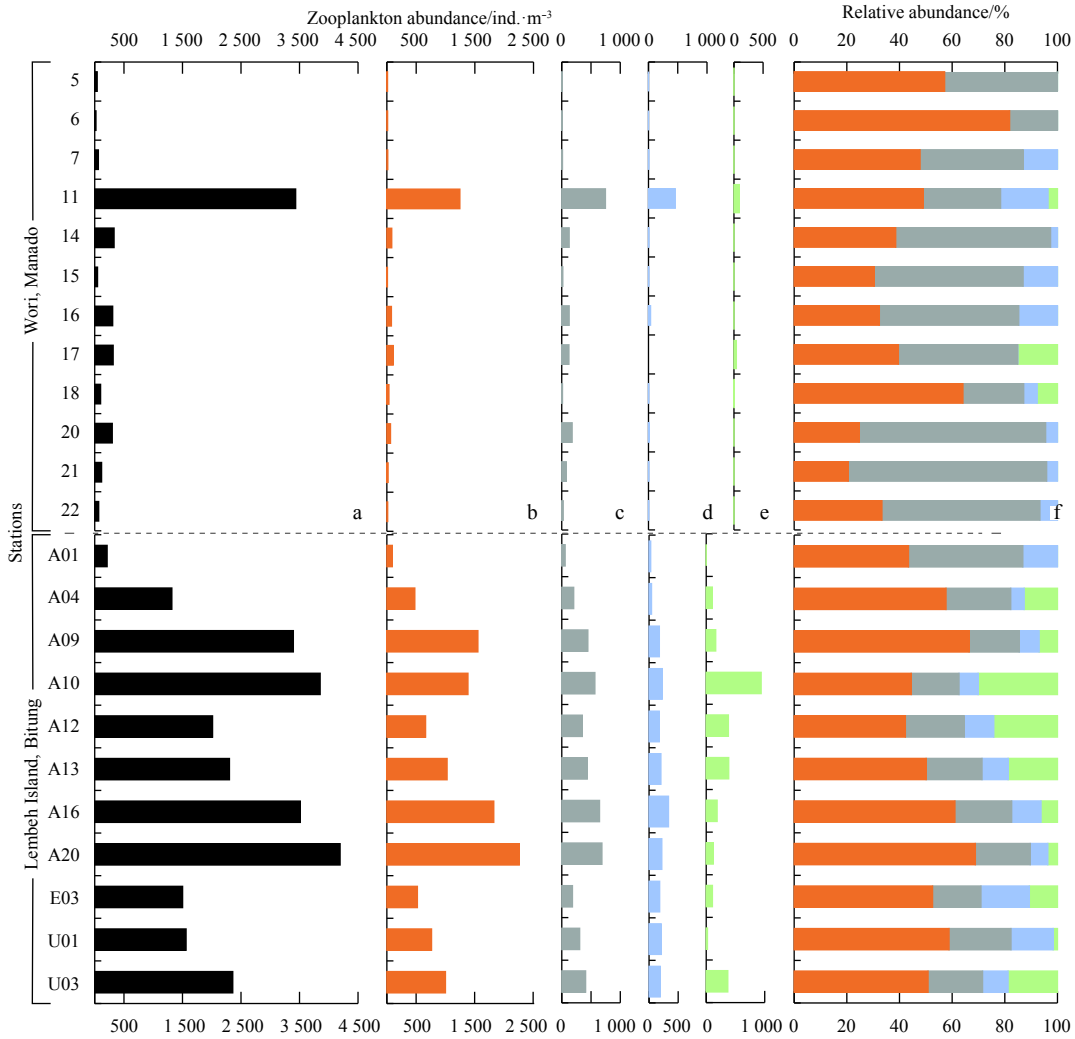

Fig. 2. Total abundance of zooplankton (a), and the dominance zooplankton taxa: Calanoida (Copepoda, b), Cyclopoida (Copepoda, c), Oikopleura (d), Luciferidaezoea (e), and its relative abundance (%) in the Wori and Lembeh Islands.

Variation of zooplankton abundance was found on three observations at this location influenced by various environmental factors that varied according to the location of the study sites. Turbidity caused by erosion or coastal water mixing (turbulence), and the mass of both the fresh water and the oceanic environment are factors that affect the abundance of plankton. Turbidity can hinder the process of photosynthesis for phytoplankton (blanketting effect) and so easy to disrupt the movement of zooplankton prey. Being the mass of water that comes from the land will greatly decrease the salinity value so that only the plankton are euryhaline (salinity levels greater range) that can stay alive. In addition, the river water was also very instrumental in influencing the lives of plankton, namely by bringing all sorts of domestic sewage and industrial waste into coastal waters (Arinardi, 1994; Sekiguchi, 2007).

The highest abundance of zooplankton was found in Sta. A20 which is located closer to the Girian River while the lowest abundance in Sta. A01 that is located more towards the open sea around the Lembeh Strait. It shows that the distribution of dense zooplankton is generally found in the waters close to the mainland and the farther into the middle of the zooplankton abundance will decrease. Wiadnyana (1997) and Sekiguchi (2007) stated that the biomass of plankton both wet and dry on the water near the shore were always higher than the open sea. Handayani and Patria (2005) stated that the zooplankton community structure in a body of water is determined by environmental conditions and food availability. This situation indicated the availability of food (phytoplankton) support the growth of zooplankton.

Figure 2 showed that the zooplankton abundance was high around Sta. A20 in the Lembeh Strait. This area located near the Girian River of the Lembeh Strait. On the contrary, the area with low abundance of zooplankton was observed around Sta. A01. The zooplankton abundance in Wori Beach is Sta. 11 and low abundance is Sta. 5. It was interesting that the pattern of zooplankton distribution in the Lembeh Strait and Wori Beach did not match with the pattern of phytoplankton distribution (Anonymous, 2014). If the area of zooplankton high abundance was observed inside the Lembeh Strait, the area of phytoplankton high abundance was observed far outside the Lembeh Strait. Although some area inside of the Lembeh Strait, such as Sta. A01 showed relatively high abundance of phytoplankton. Unfortunately due to lack of supporting data, we are unable to determine whether this different pattern happened due to influence of some specific water physical-chemical condition or due to biotic interaction between phytoplankton and zooplankton in the ecosystem.

3.2 *Predominant of zooplankton*

The percentages of predominant groups of zooplankton in site locations of Lembeh Strait and Wori Beach are shown in Figs 3 and 4. It is interesting to note that copepods group (Calanoida and Cyclopoida) were occurred predominantly in all of site locations. There are only two groups of zooplankton which predominantly occurred throughout the waters during the study, such as Calanoida and Cyclopoida. There were more frequently occurred in the population of zooplankton throughout the waters. The relative abundance of Calanoida varied from 20% to 80% and Cyclopoida varied from 12.02% to 25.83%. Occurrence of those two groups was relatively low during the study. It was recorded that luciferid zoea was predominantly occurred in those two sites with amount of 46.42% and 33.43%, respectively. Luciferids is known as predator for other smaller groups of zooplankton. So, their occurrences in population may influence the abundance of copepods decreased. Other factors that influence the distribution of zooplankton include predation reproduction, community interactions and the amount of available resources. Zooplankton can also be predators of algae or protozoa causing the sizes of these organisms to change through evolution.

Calanoid and Cyclopoid as the dominant taxa were also found with wide distribution range in the study site. The other highly abundant zooplankton taxa such as Oikopleura, Siphonophora and Luciferidaezoea could also found in all sampling station in the Lembeh Strait, suggesting their wide distribution range in the ecosystem. In this research it was found that macro-crustacean zooplankton, such as Brachyura, Caridea, Stomatopoda, Euphausiaceae, were found in very low abundance and very limited range of abundance in the Lembeh Strait. This condition might happen due to limited range of tolerance of those zooplankton taxa to spatial heterogeneity of water column in the Lembeh Strait. But this could also occur due to inability of those macro-crustacean zooplankton taxa to use the most abundant phytoplankton in the Lembeh Strait (*Chaetoceros*) as its main diet.

Overall results indicated a dominance of copepods, especially Calanoida. The dominance of Calanoida in this study is a common condition that occurs in the waters, both coastal and

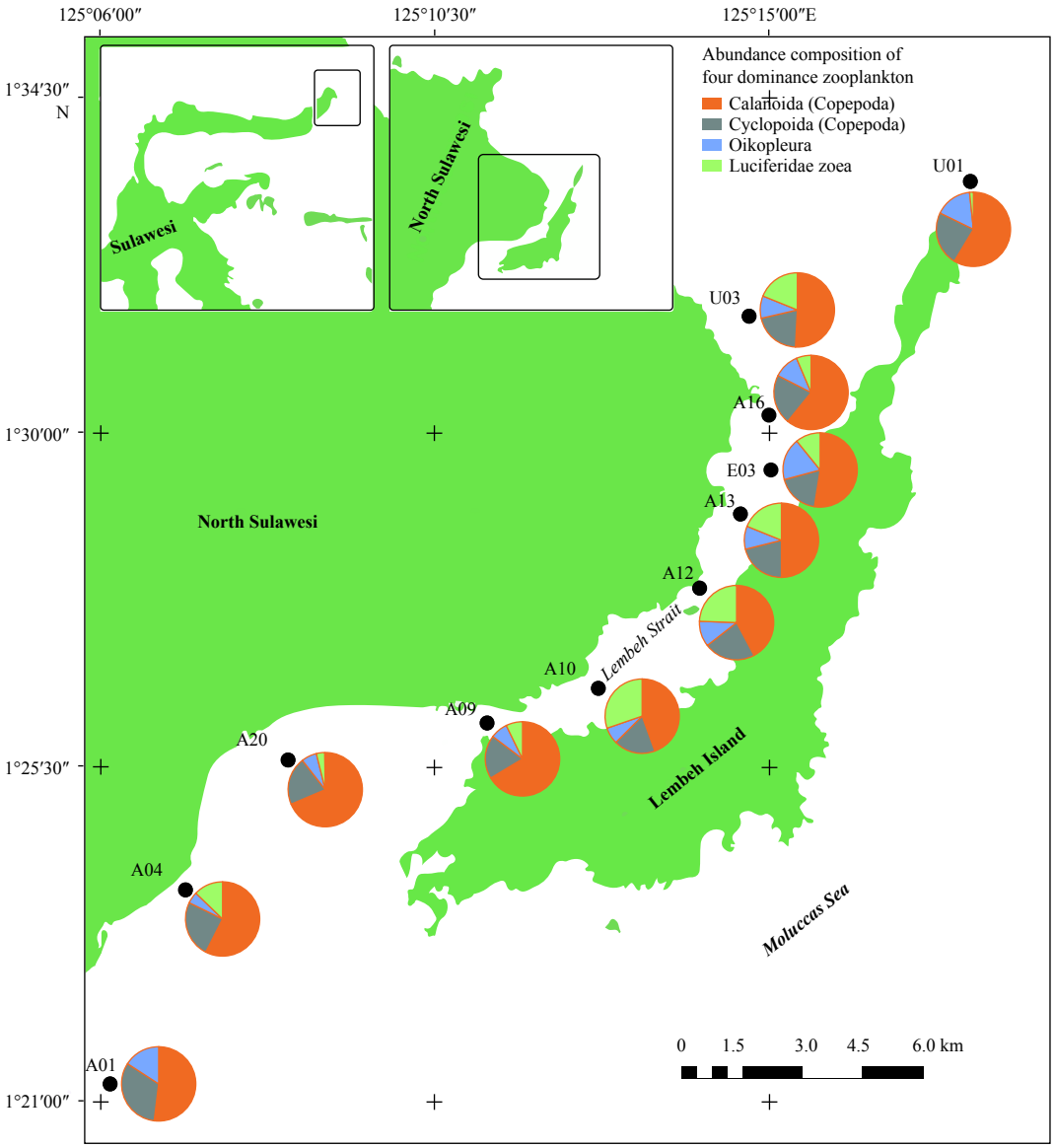

Fig. 3. Abundance composition of four dominance zooplankton taxa: Calanoida (Copepoda), Cyclopoida (Copepoda), Oikopleura, and Luciferidaezoea in the Lembeh Strait, Bitung.

ocean. Therefore, holoplanktonik Crustacea Copepoda as a relatively small-sized and acts as a liaison transfer of organic material from the lower trophic levels (primary producers or phytoplankton) to higher trophic levels, the abundance changes will directly affect the overall zooplankton community. Indeed, copepods dominate the zooplankton community in waters, both in number of species and their abundance is very high. In addition, because of its small size but very dominant in the waters, the copepod is often dubbed as the insect of the sea. Copepod group is regarded as an element representing zooplankton community because these groups often dominate the zooplankton community in a variety of waters (Wiadnyana, 1997). Calanoida as the dominant taxa found during observation in the Lembeh Strait is indeed one of the group of copepods that are abundant and have diverse types with a total of approximately 70% of the total zooplankton in the oceans (Kim, 1985; Sekiguchi, 2007). Calanoida as the highest dominant taxa in this observation is neritik types that are relatively small and usually live in waters that are still influenced by the mainland, as many have discovered in the Java Sea (Arinardi, 1995). The importance value analysis clearly

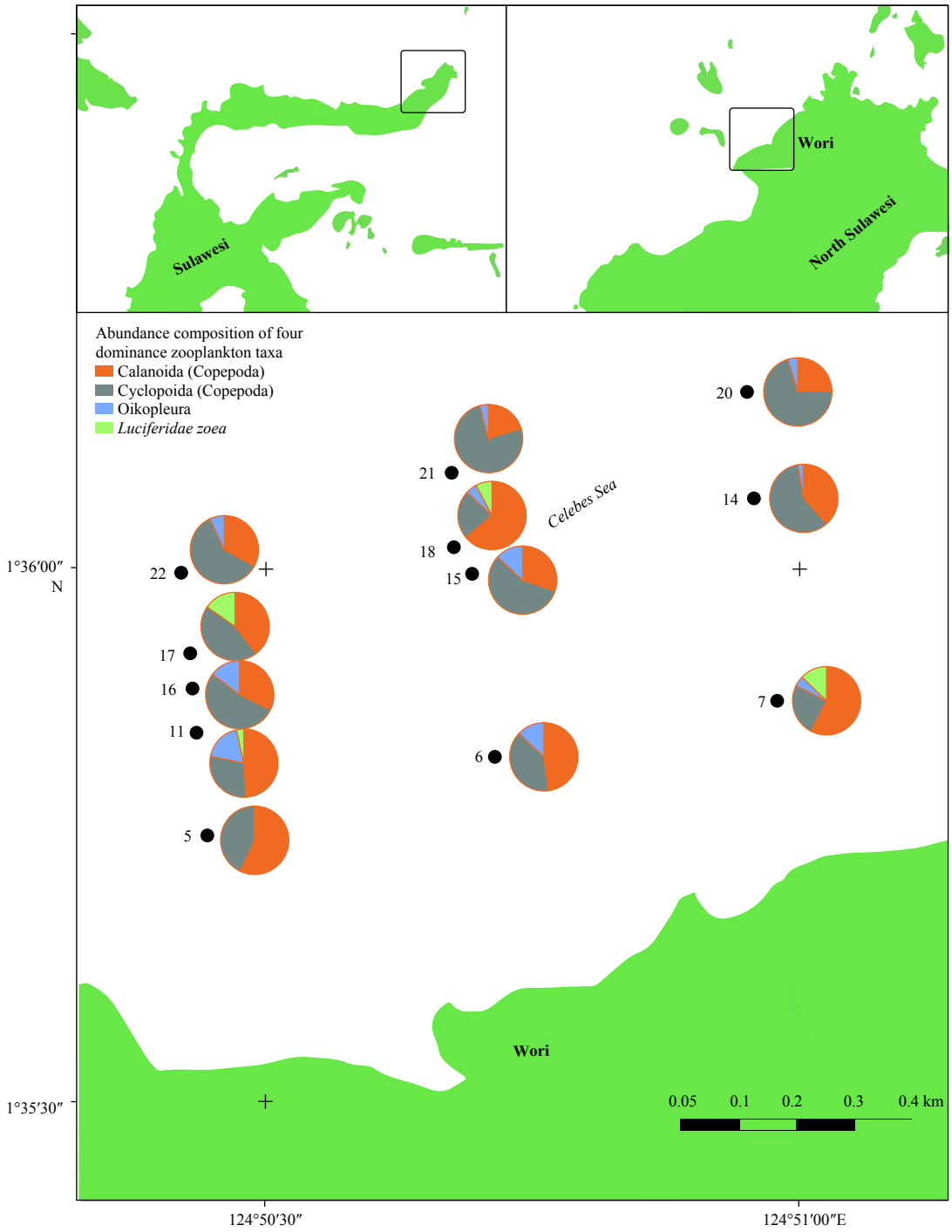

Fig. 4. Abundance composition of four dominance zooplankton taxa: Calanoida (Copepoda), Cyclopoida (Copepoda), Oikopleura, and Luciferidaezoea in Wori, Manado.

showed the extremely high importance of Calanoida in zooplankton community of the Lembeh Strait. This high importance value strongly suggested that Calanoida hold very important roles in regulating the entire zooplankton community in the ecosystem. It also suggested that these taxa might also responsible for any changes in the distribution or abundance of various higher trophic level organisms, such as fish and macro-crustaceans. Calanoida might also regulate the phytoplankton community by acting as phytoplankton grazer.

3.3 *Composition of zooplankton*

It was observed that there were 43 groups which composed the population of zooplankton in the waters. A number of 24 groups belong to holoplankton and 15 groups belong to meroplankton. There are two categories used to classify zooplankton by their stage of development: meroplankton and holoplankton. Meroplankton is actually larvae that eventually changes into worms, molluscs, crustaceans, coral, echinoderms, fishes, or insects. Holoplankton remains as plankton for their entire life cycle and includes pteropods, chaetognaths, larvaceans, siphonophores and copepods. The predominant group such as copepods belonged to holoplankton, and the predominant group such as bivalve and gastropod belonged to meroplankton. Fish eggs were found at entire site locations and fish larvae were also found at few site locations. The height of meroplankton groups found in these areas indicating that the waters is naturally good for nursery ground of some marine biota. Specific species of zooplankton occupy particular marine habitats. Each species is uniquely adapted to factors like light, temperature, turbulence, and salinity in its environment.

The highest number of zooplankton group was observed in Sta. A20 with 26 groups and the lowest number was recorded in Sta. A03 with 17 groups. The number of zooplankton group in the 12 selected sites of Lembeh Strait is shown in Fig. 3. Most of zooplankton group was dominated by copepods such as Calanoids and Cyclopoids and constitute the population of zooplankton up to 39.22% and 12.02% of the total population, respectively.

Cluster diagram of sampling stations was based on abundance composition of four dominance zooplankton species. The scale indicates the Bray-Curtis similarity coefficient showed that the station variations in community structure were separated by two groups. Group I, the location is Wori Beach, the abundance composition closely related with are Stas 14, 15, 16, 17, 20, 21 and 22 except Stas 5, 6, 7 and 18; Group II, such four stations (Stas 5, 6, 7 and 18), closely related with the Lembeh Strait are E03, A04, A10, A12, A13, U03, 11, A01, U01, A09, A16 and A20 (Fig. 5).

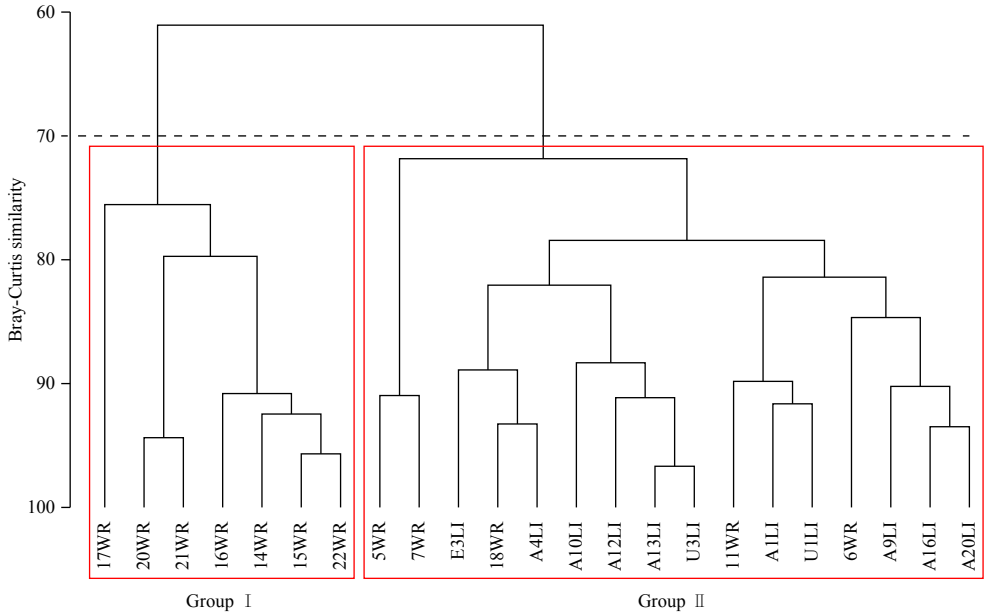

Fig. 5. Cluster diagram of sampling stations based on abundance composition of four dominance zooplanktons. The scale indicates the Bray-Curtis similarity coefficient. Sufix WR are the stations in Wori, whereas LI are the stations in the Lembeh Island.

4 Conclusions

The population of zooplankton in the Lembeh Strait, Bitung consists of 43 groups. The groups of zooplankton in the Lembeh Strait and Wori Beach during the study was dominated by Copepods, such as Calanoida and Cyclopoida. The abundance of zooplankton throughout the waters of the Lembeh Strait varying from 212.16 to 4 193.776 ind./m^3, where the highest number was recorded in Sta. A20 where the highest was observed in Sta. A20 (near the narrow opening of the Lembeh Strait and Girian River) and the lowest was in Sta. A01 that is located more towards the open sea around the Lembeh Strait (the southern part of Lembeh Strait). The abundance of zooplankton throughout the waters of Wori Beach varying from 21.22 to 3 434.23 ind./m^3 where the highest number was recorded in Sta. A11 where is the Lembeh Port and the lowest was in Sta. A05 where is sea grass location.

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