Faculty of Resource Science and Technology

TEMPORAL DIVERSITY AND ABUNDANCE OF ZOOPLANKTON FROM MIRI COASTAL WATERS

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Temporal Diversity and Abundance of Zooplankton from Miri Coastal Waters

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The thesis submitted in partial fulfilment of the
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DECLARATION

No portion of the work referred to in this dissertation has been submitted in support of an application for another degree qualification in this university or any other university or institution of higher learning.

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Date: 25/5/2019

Aquatic Resource Science and Management Programme

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Temporal Diversity and Abundance of Zooplankton from Miri Coastal Waters

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Abstract

Zooplankton is an aquatic animal that drift passively with water movement as well as actively move in the water column of seas, freshwater and oceans. They play an important role in the marine food web as they transfer the organic energy that being produced by unicellular algae to the higher trophic level. Studies of zooplankton in Malaysian coastal waters is limited to the Peninsular. Furthermore, research on distribution and composition of zooplankton in Miri, Sarawak had not been documented properly. Therefore, this study is designed to determine the temporal diversity and abundance of zooplankton from Miri coastal waters. Water samples had been collected by the previous researcher from four locations along Miri coastal waters using 100μm mesh size of plankton net and preserved in 5% formalin. In the laboratory, zooplankton species identification and enumeration have been done with the aid of compound microscope. *Paracalanus* sp., *Oithona* sp. and nauplii were the dominant taxa. The estimation of zooplankton alpha and beta diversity ranged from 37 to 78 and 15% to 214% respectively. The maximum density of zooplankton was recorded 2981 x 10^3 ind/L (*Paracalanus* sp.) in May 2017 and the minimum density for 7 other species was 2 x 10^3 ind/L. The zooplankton communities were comprised of 4 different phyla where Copepods were the most dominant group. The baseline data obtained during this study is hoped to shed lights on the temporal diversity and abundance of zooplankton in Miri coastal water.

Keywords: zooplankton, diversity, abundance, Miri.

Abstrak

Zooplankton merupakan haiwan akuatik yang terapung secara pasif bergantung kepada pergerakan air dan bergerak aktif secara vertikal di dalam kolum air laut, air tawar serta lautan. Mereka memainkan peranan yang penting dalam jaringan makanan laut kerana mereka memindahkan tenaga organik yang dihasilkan oleh alga uniselular ke rangkaian makanan yang lebih tinggi. Kajian zooplankton di perairan pantai Malaysia adalah terhad di Semenanjung sahaja. Penyelidikan tentang taburan dan komposisi zooplankton di Miri, Sarawak belum ada dokumentasi yang sistematik. Oleh itu, kajian ini direka untuk mengenalpasti kepelbagaian temporal dan kelimpahan zooplankton di perairan pantai Miri. Sampel air telah dikumpulkan oleh penyelidik terdahulu dari empat lokasi di sepanjang perairan pantai,Miri. Zooplankton disampel dengan menggunakan jaring plankton yang bersaiz 100μm dan diawet dengan formalin 5%. Di dalam makmal, mengenal pasti dan penghitungan spesies zooplankton telah dilakukan dengan bantuan mikroskop kompaun. *Paracalanus* sp., *Oithona* sp. dan nauplii merupakan taksa yang dominan. Anggaran nilai alpha dan beta zooplankton adalah di antara 37 hingga 78 dan 15% kepada 214%. Ketumpatan maksimum zooplankton yang direkodkan adalah 2981 x 10^3 ind / L (*Paracalanus* sp.) pada bulan Mei 2017 manakala ketumpatan minimum yang direkodkan untuk 7 species yang berlainan adalah 2 x 10^3 ind / L. Komuniti zooplankton terdiri daripada 4 phyla yang berbeza dimana Copepoda merupakan kumpulan yang paling dominan. Data yang diperolehi semasa kajian ini diharapkan dapat membantu memberikan maklumat tentang kepelbagaian temporal dan kekayaan zooplankton di air pantai Miri, Sarawak.

Kekunci: zooplankton, kepelbagaian, kelimpahan, Miri.

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LIST OF ABBREVIATION

ml	Millilitre
µm	Micrometre
ind	Individuals
L	Litre
α	Alpha
β	Beta
γ	Gamma
Pd1-5	Pedigerous somites 1-5
P1-5	Swimming leg 1-5
SWM	Southwest monsoon
NEM	Northeast monsoon
IM	Inter monsoon

1.0 INTRODUCTION

Plankton are small organisms that dwell in oceans, seas and bodies of fresh water (McManus *et al.*, 2012). Plankton is composed of viruses, bacteria, phytoplankton, zooplankton and the pelagic larvae of many marine invertebrates and fishes. This group displays a wide range of behavioral capabilities that bridge the transition from being a passive particle to being able to determine vertical and horizontal position in the ocean (McManus *et al.*, 2012). Zooplankton are the diverse, delicate and often very beautiful assemblages of animals that drift in the waters of the world oceans (Molly *et al.*, 2015). The name zooplankton is derived from the Greek: "zoon", animal; "planktos", wandering.

Zooplankton can be divided into groups based on temporary and permanent planktonic such as meroplankton and holoplankton (Sumich, 1999). Most meroplankton tend to be neritic, because comes a near-shore environments (Smith and Johnson, 1996). According to Sumich (1999), meroplanktons are usually spending their life as plankton during eggs or larvae stage. In addition, larvae of invertebrate organism such as mollusk and crustacean can be classified as meroplankton.

Holoplankton are planktonic of their entire lives. The taxonomic composition of holoplankton start with its most primitive components, the Protists (Smith and Johnson, 1996). They include the smallest zooplankton, their size ranging from less than 0.01 millimeter to a few millimeters. Holoplankton in estuarine is usually dominated by copepod which can adapt with marine and freshwater environment (Sumich, 1999).

Other researchers divided zooplankton into groupings based on sizes. Wimpenny (1966) said that the size range of picoplankton is from 0.2μm to less than 2μm, nanoplankton from 2μm to less than 20μm, microplankton from 20μm to less than 200μm, mesoplankton from 200μm to less than 2,000μm, macroplankton from 2,000μm to less than 20,000μm and megaplankton from 20,000μm and greater.

According to Keister (2012), zooplankton play an important role in aquatic ecosystems and global biogeochemical cycles. They function as prey for economically important fish, grazers of primary production, and drivers of carbon and nutrient cycles. Zooplankton growth and distribution are dependent on some biotic and abiotic parameters that give a higher potentiality as bioindicator (Ferdous and Muktadir, 2009). They play a key role in the marine food web by transferring the organic energy produced by the unicellular algae to higher trophic levels such as the pelagic stocks (Molly *et al.*, 2015).

The number of studies on marine or estuarine zooplankton in Malaysian waters have increased recently. However, no study of copepods has been reported particularly in the waters of Sabah and Sarawak (Johan *et al.*, 2013). Miri coastal waters is one of the places famous for sergestid shrimp fisheries (*Acetes* spp.) which shows peak season from February to April (Anandkumar *et al.*, 2017). The (krill like) shrimp species is commercially important in the Miri coast (Anandkumar *et al.*, 2017). *Acetes* spp. links with zooplankton of the higher trophic levels in the food chains and transports organic matter produced in the upper layer to the lower layer through vertical migration (Xiao and Greenwood, 1993). There is a strong relationship between the dynamics of zooplankton populations and fishery production (Dumont *et al.*, 1994). However, there is no studies yet in the terms of temporal diversity and abundance of zooplankton in Miri coastal waters. Therefore, this study will investigate the marine zooplankton species and abundance on Miri coastal waters.

OBJECTIVE

The objective of this study is to determine the temporal diversity and abundance of zooplankton from Miri coastal waters.

2.0 LITERATURE REVIEW

2.1 Zooplankton Overview

In the coastal waters, most plankton are microscopic, yet many are visible to the naked eye. The animals in the plankton are called zooplankton (Smith and Johnson, 1996). Zooplankton are minute aquatic animals that are non-motile or are very weak swimmers and they drift in water column of ocean, seas or freshwater bodies to move any great distance (Ferdous and Muktadir, 2009). According to Khan *et al.* (2015) zooplankton is an aquatic animal community that has limited swimming capacity against the ambient currents. Even with their limited swimming capacity, they carry out day-night periodic movements of hundreds of meters. They prefer to feed at night on the water surface and effectively graze the phytoplankton, and hence they referred to the as living machines (Khan *et al.*, 2015). Zooplankton live together with phytoplankton in the same environment. According to Goswami (2004), majority of zooplankton are microscopic, unicellular or multicellular.

Zooplankton are categorized according to the size class into which they fall. Classification systems are numerous. Wimpenny (1966) breaks down plankton communities into classes (Table 1.0) according to their sizes. Zooplankton can range in size from microns to meters. Among the organisms greater than 60 μm (microplankton to megaplankton) size, many of them are herbivores (grazers) and carnivores (predators), each playing a part in the complex marine food web (Smith and Johnson, 1996). Table 1.0 describes classes of zooplankton according to size as suggested by Wimpenny (1966).

Table 1.0: Plankton size classes according to Wimpenny (1966)

Plankton class	Size
Picoplankton	0.2 to less than 2.0 μm
Nanoplankton	2.0 to less than 20 μm
Microplankton	20 to less than 200μm
Mesoplankton	200 to less than 2,000 μm
Macroplankton	2,000 to less than 20,000 μm
Megaplankton	20,000 μm and greater

2.2 Classification of Zooplankton

Zooplankton are represented by temporary meroplankton, including larval stages of shallow-water invertebrates and fishes, and a variety of permanent planktonic forms, the holoplankton (Sumich, 1999).

Meroplankton are concentrated in near shore neritic provinces over continental shelves and near shallow banks, reefs and estuaries. According to Sumich (1999), the distribution and abundance of meroplankton are related to the seasonal distribution and productivity cycles of local phytoplankton communities. Most meroplankton tend to be neritic, because it comes from a near-shore environments (Smith and Johnson, 1996). As the life cycles of most bottom marine invertebrates and fish include planktonic developmental stages, meroplankton is more frequent in the vicinity of the coast, where rich communities of bottom living invertebrates develop, and fish concentrate to lay eggs. Sponges, gastropod, bivalve molluscs, sea urchins and sea stars, most of the sessile fauna, have planktonic larval stages, some of them named as new species by the first planktologists when their relation with adults was unknown (Alcaraz and Calbet, 2009).

According to Smith and Johnson (1996), holoplankton are found everywhere, and are found more often than meroplankton in pelagic waters. More than 5,000 species of holoplankton have been described from numerous phyla in two kingdoms. Prominent among these are protozoans, cnidarians, ctenophores, mollusks, chaetognaths, crustacean, arthropods and invertebrate chordates. Because of their very small cell sizes, they have great difficulty trying to overcome the viscous forces between water molecules by swimming (Sumich, 1999). According to Sumich (1999), holoplankton employ flotation and buoyancy devices similar to those found in phytoplankton. Because most holoplankton are characteristically small, they increase their frictional resistance to the water by having surface-area-to-body-volume ratios.

2.3 Importance of Zooplankton

The role of zooplankton in functioning and productivity of aquatic ecosystems is vital. This role arises from its influence on nutrients dynamics and from its tropic position in aquatic food chains (Dumont *et al.*, 1994). As major primary consumers many zooplankton convert algal production into animal material for carnivorous invertebrates and fishes further up the food chain. Therefore, a strong direct relationship between the dynamics of zooplankton populations and fishery production (Dumont *et al.*, 1994).

2.3.1 Role of Zooplankton in biogeochemical cycles

Zooplankton directly affect the elemental stoichiometry and material fluxes between particulate and dissolved matter through various processes associated with the selective consumption and subsequent processing of their food resources (Noji, 1991). As key drivers of the biological pump, zooplankton feed in the surface waters and produce sinking faecal pellets, and actively transport dissolved and particulate matter to depth via vertical migration. Zooplankton grazing and metabolism transforms particulate organic matter into dissolved forms, affecting primary producer populations, microbial remineralization, and particle export to the ocean's interior (Noji, 1991). The elemental stoichiometry of zooplankton and their prey often differ, resulting in non-Redfield cycling of C, N, and P (Keister et al., 2012). According to Hofmann and Klinck (2001), given the full spectrum of pelagic consumers (including protists) and the extent of their interactions within food webs, however, this is by no means the only way in which zooplankton can regulate the efficiency of the biological carbon pump or influence elemental cycles. Implications of zooplankton-mediated processes can be seen in modifying sinking particulate fluxes, in recycling and distributing inorganic and organic materials throughout the water column, and in determining the complex dynamics of food-web structure and trophic flows (Hofmann and Klinck, 2001).

2.3.2 Zooplankton as bioindicator

Zooplankton have a higher potentiality as bioindicator because their growth and distribution are dependent on some biotic and abiotic parameters. Ferdous and Muktadir (2009) claimed that the abiotic parameters and the seasonal fluctuation influence zooplankton abundance. According to Ferdous and Muktadir (2009), to monitor the aquatic ecosystems and integrity of water, plankton has been used recently as bioindicator. Bioindicators and biotic indexes are being used by the Europeans to assess water quality of water bodies for last 100 years. The growth and distribution of zooplankton are dependent on some abiotic (e.g., temperature, salinity, stratification, pollutants) and biotic parameters (e.g., food limitation, predation, competition) that make them to have potential as bioindicator is very high (Ferdous and Muktadir, 2009). For example, *Trichotria tetratis* could be used as a pollution indicator as they were found in the lake with rich in amount of phosphorus and other heavy metal ion.

2.4 Studies related to Marine Zooplankton in the South China Sea

Malaysia is one of the three mega-biodiversity countries in the ASEAN region besides Indonesia and the Philippines surrounded by the Malacca Straits on the west coast and the South China Sea in the east (Yoshida *et al.*, 2011). The shallow water body of the Malacca Straits is characterized by soft-bottom habitats, fringing coral reefs, seagrass beds and mangroves lining the coastline (Chua *et al.*, 2000) while Ng and Tan (2000) stated that the South China Sea is an important area for the ecosystem which believed to harbor one-third of the world's marine biodiversity.

Studies on taxonomic records and diversity were common in the 1980–90s, zooplankton research has advanced further into the investigation of ecology and distribution (Yoshida *et al.*, 2011). A total of 36 species were identified by Idris *et al.* (1999) who conducted a twelve-month study on the population dynamics of planktonic copepods in the coastal waters off Port Dickson, Malacca Straits towards the end of the 90's. Idris *et al.* (1999) claimed that there was an increasing trend from the northeast monsoon to southwest monsoon with the highest peak during the southwest monsoon period of copepod density were identified. In addition, four distinct populations were observed throughout the 12-month period (Yoshida *et al.*, 2011). Johan et al. (2002) conducted a study of zooplankton in the coastal waters off Port Klang, Selangor where 35 species were identified and stated that copepods of Family Paracalanidae was dominant.

Zaleha *et al.* (2006) conducted a study on ecological of zooplankton from 2002 to 2005. The study was carried out in the east coast of Peninsular Malaysia (Terengganu, Pahang and Johor) where samples were collected from a total of 105 stations along 19 transects laid 60km seaward. Zaleha *et al.* (2006) claimed that the temporal variation in zooplankton density and composition was not entirely attributed to the monsoon season and the importance of harpacticoid copepods in the zooplankton biomass was suggested.

Studies on marine zooplankton in South China Sea had been done by Relox *et al.* (1999) in western Philippines. This study on the abundance and distribution of zooplankton in the South China Sea, Area III: Western Philippines, under the Interdepartmental Collaborative Research Program of SEAFDEC was undertaken to obtain information on the distribution, abundance and biomass estimate of zooplankton in the study area (Relox *et al.*, 1999). Researches on marine zooplankton in Thailand were continuously conducted though limited number of institutions and researchers involved. During the past 10 years, the taxonomic works were conducted through educational staff, while monitoring projects in general groups (higher taxa) were done by the research departments (Satapoomin *et al.*, 2012). Studies in the research institutions focused more on ecological aspects and/or identified zooplankton only to higher taxonomic groups and their estimation of abundance and biomass (Satapoomin *et al.*, 2012).

2.5 Coastal Water of Miri

According to Perillo *et al.* (2009), coastal wetlands include salt marshes, mangroves, tidal flats and seagrasses. They are found in all continents and at all latitudes. Cliffs and rocky shores are probably the only coasts with minimal wetlands. The coastal zone is the area between the land and the open sea. It is characterized by freshwater fluxes, a large amount of nutrients and organic matter from land due to shallow water depth (Lessin & Raudsepp, 2007). Most of the marine production takes place in coastal waters. Coastal wetlands provide numerous ecological services to humanity for example, they protect the coast against erosion and guard against loss of capital infrastructure and human lives (Perillo *et al.*, 2009). Coastal wetlands also are habitats that support seasonal or perennial fisheries and are vital for migratory and resident birds. In addition, they provide ecological services that have socioeconomic benefits to the human population including fuel, forage, building material, timber, fisheries and protection of commercial, recreational and naval vessels (Perillo *et al.*, 2009).

Miri, the second largest city in the state of Sarawak, Malaysia, has been gazetted as Malaysia's city of petroleum. It is the birthplace of Malaysia's petroleum industry where the first oil well in the country was drilled in the city in 1910 (Adriansyah *et al.*,2016). It is located on the northern region of Sarawak in East Malaysia. The latitude and longitude of Miri is situated at 04° 23' 0"N and 113° 59'0"E. The length of coastline is approximately 32km. Miri is also known for its exotic coral reefs which are located in the southern Miri coast. The majority of coral reefs that mainly found are at the coast of Bakam. However, there are many places for industrial activities such as fisheries, oil and gas production and agriculture in the northern Miri coast.

Another important activity in Miri is the Sergestid shrimp (*Acetes* sp.) fisheries. In Sarawak, the locals called them as bubok. Local people harvested the shrimp during peak season February to April every year (Anandkumar *et al.*, 2017) for domestic consumption and process shrimp paste called "belacan".

3.0 MATERIAL AND METHODS

3.1 Field trip

The sampling was carried out by previous researcher from 17th May 2017 until 17th April 2018 at Miri Coastal Water, Sarawak, Malaysia (Figure 1.0) on monthly basis, where the total of 64 bottles of marine zooplankton had been collected (Table 2.0). There were 4 sampling stations from Kuala Baram to Batu 1, Miri that have been selected along coastal water on each day of the month (Table 3.0). The coordinates of every station were recorded using GPS (GARMIN 62s). The plankton net (100μm mesh size) was used to collect the sample of zooplankton with duplicate samples per station. All samples were transferred into a properly labeled plastic bag, then preserved with 5% formalin and transported back to the laboratory in Faculty Resource Science and Technology, UNIMAS for further analysis.

3.2 Laboratory Work

Samples were analyzed using Sedgewick-Rafter counting cells (Marsden, 1991). One ml water sample was pipetted and transferred into the Sedgwick-Rafter Counting Chamber. Then, the chamber was placed on compound microscope (Olympus SZ51) (10x or 40x magnification) stage, and the zooplankton samples were allowed to settle to the bottom of chamber. A total of 5 mL sub-sample from each group were identified to the lowest possible taxon using standard zooplankton identification keys of Johnson & Allen (2012), Al-Kandari *et al.* (2009) and Hasle *et al.* (1996). The description of zooplankton was carried out by referring to the Marine Zooplankton Practical Guide for the Northwestern Arabian Gulf written by Al-Yamani *et al.*, (2011). Cell enumeration was carried out for each species with the aid of compound microscope following methods by Goswami (2004).

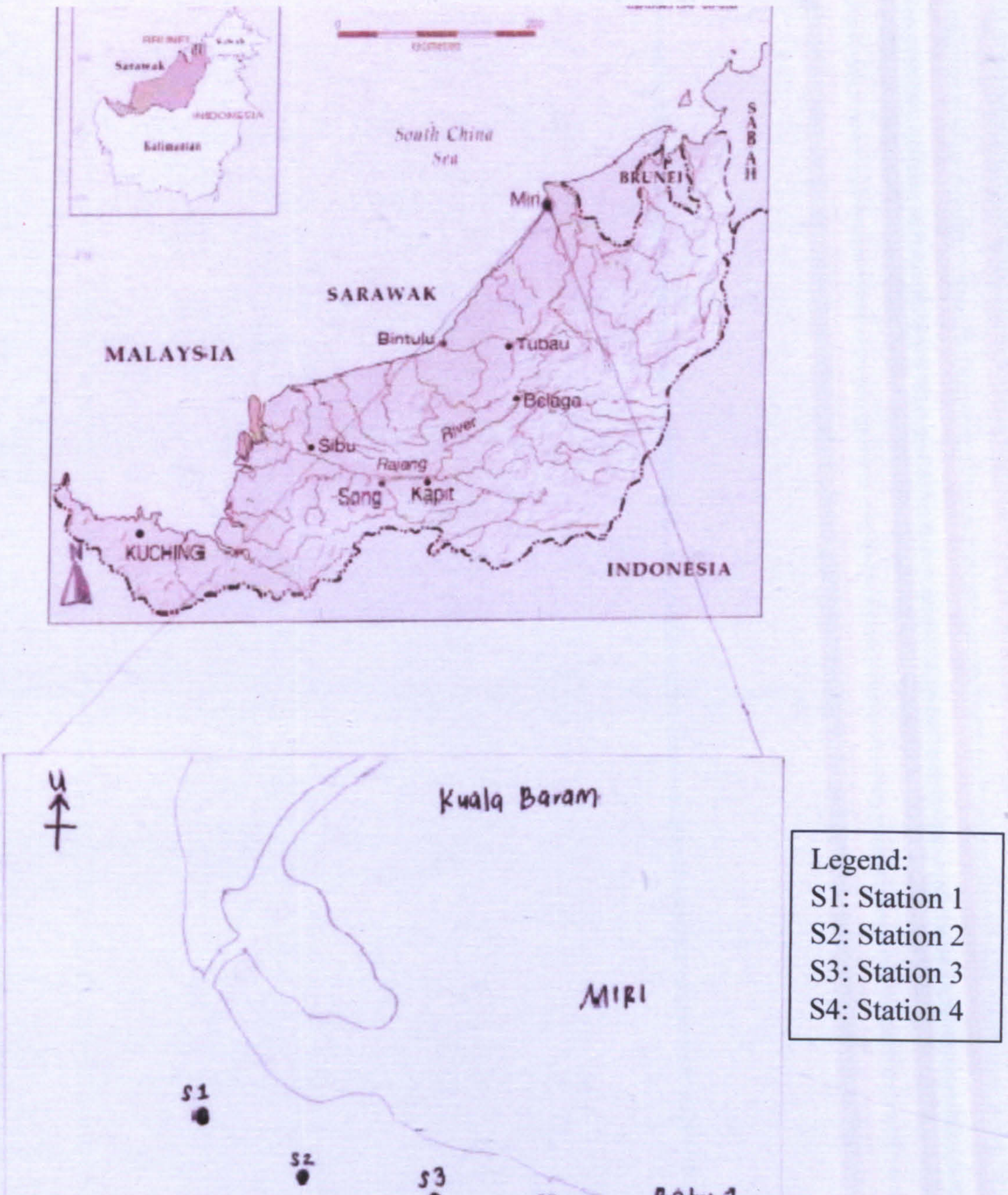

Figure 1.0: Map of four sampling site along Kuala Baram to Batu 1 (Miri Coastal Waters), Sarawak (adapted from google maps).