BENTHIC HARPACTICOID COPEPOD DIVERSITY AND THEIR ADAPTATIONS TO THE CORAL AREA OF PULAU TIOMAN

BY

AZRINA BINTI SHAM

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Kulliyyah of Science
International Islamic University Malaysia

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ABSTRACT

The study is carried out to investigate the identity of harpacticoid species, morphology and ultrastructure which might serve as their living strategy in adapting the coral environment. Field samplings were carried out between August, September and October 2017 at six selected stations, which are Salang, Tulai Station 1, Tulai Station 2, Batu Malang, Renggis and Soyak. Sediment cores were obtained by scuba divers using transparent hand core (3.5 cm mouth diameter) which later been preserved with 10% formalin added with Rose Bengal. The meiobenthos were extracted from the sediment through decantation and sieving process using 500 microns and 63 microns mesh sieve. Harpacticoid specimen were dissected and prepared for taxonomic examination with the help of Lucida camera attached to a compound microscope. The ultrastructure of the species was determined from the micrograph resulted from Scanning Electron Microscope examination. Analysis on the diversity of the species found in the study area was done by determining the Shannon's Weiner (H'), Margalef (d) and Evenness Pielou, (J'). A total of 14 harpacticoid species representing 9 genera from the family of Dactylopusiidae (*Dactylopusia* sp.), family Ectinosomatidae (*Ectinosoma* sp.), family Miraciidae (*Robertgurneya smithi*, *Typhlamphiascus lamellifer*, *Typhlamphiascus blanchardi* and *Delavalia clavus*), family Laophontidae (*Laophonte cornuta*, *Laophonte expansa*, *Quinquelaophonte quinquespinosa* and *Asellopsis* sp.), family Tetragonicipitidae (*Phyllopodopsyllus* sp. 1 and *Phyllopodopsyllus* sp. 2) and family Canuellidae (*Canuellina nicobaris* and *Brianola* sp.) were discovered from the sampling sites. Based on taxonomic identification, the harpacticoid species in Pulau Tioman did not show a marked different from other area except presence row of spinules on the surface of swimming leg in *Devalia clavus* and *Robertgurneya smithi*, conical shape of furcal rami in *Typhylamphiascus lamellifer*, five setae ornamented the caudal rami of *Quinquelaophonte quinquespinosa* and 7 arthrites on maxillule on *Canuellina nicobaris*. The micrograph revealed features like strong and jagged claw of maxilliped of *Asellopsis* sp., and; thick and pitted integuments ornamented the cephalotorax and somites of *Laophonte cornuta* and *Laophonte expansa*. Harpacticoids in Renggis were significantly related with the hard coral ($p = 0.030$, $p < 0.05$), sand ($p = 0.046$) and dead coral ($p = 0.031$, p, 0.05), while species diversity of harpacticoid copepods from the Tioman coral reef area is considered high with the H' value > 1.8, d > 1.5 and J > 1.8. The taxonomic data and biodiversity could be further through field experimental approach to understand the harpacticoid strategy towards environmental factor.

خلاصة البحث

أجريت هذه الدراسة لتحقق من طبيعة الهاربا كتيكويدات، وتشكلها، وتركيبها الدقيق والتي قد تكون إستراتيجيتها المعيشية في التكيف مع البيئة المرجانية. تم أخذ العينات الميدانية بين أغسطس وأيلول وأكتوبر في عام 2017 في ست محطات مختارة، وهي سالانغ، ومحطة تولاي 1، ومحطة تلاوي 2 ، وباتو مالانغ ، وورينقيس، وسوياك. تم الحصول على لب الرواسب بمساعدة غواصين باستخدام لب يدوي شفاف (قطر الفم 3.5 سم) والتي تم حفظها لاحقا بإضافة 10٪ من الفورمالين مع صبغة وردة البنغال. تم استخراج الكائنات القاعية من الرواسب من خلال عملية التصفية والغربلة باستخدام منخل شبكي بمقياس 500 ميكرون و63 ميكرون. تم تشريح عينة الهاربا كتيكويدات وإعدادها للفحص التصنيفي بكاميرا استجلائية مركبة على مجهر مركب. تم تحديد التركيب الدقيق للأنواع من الصور المجهرية الصادرة من الفحص المجهري الإلكتروني الماسح. تم إجراء تحليل الأنواع الموجودة في مناطق الدراسة من خلال تحديد مؤشر شانون وبينر (H') ومؤشر مارقالف (d) ومؤشر إيفينيس بيلو (J'). تم اكتشاف 14 نوعًا من الهاربا كتيكويدات والممثلة لـ 9 أجناس وهي من عائلة داكتيلوبوسيدا (*Dactylopusia* sp)، وعائلة إكتينوسوماتيدا (*Ectinosoma* sp)، وعائلة ميراسيدا (*Robertgurneya smithi*، *Typhlamphiascus lamellifer*، *Typhlamphiascus blanchardi*، *Delavalia clavus*)، وعائلة تيتراقونيسيبيتيدا (*Phyllopodopsyllus* sp. 1 و *Phyllopodopsyllus* sp. 2)، وعائلة كانولينا (*Canuellina nicobaris* and *Brianola* sp). استنادًا إلى التعريف التصنيفي، لم تظهر أنواع الهاربا كتيكويدات في جزيرة تيومان على اختلاف كبير عن غيرها من المناطق باستثناء وجود صف من الشويكات على سطوح السيقان السابحة في *Devalia clavus* و *Robertgurneya smithi* ، والشكل المخروطي للفروع الشوكية في *Typhylamphiascus lamellifer* ، وخمسة شعيرات مزينة للفروع الشوكية في *Quinquelaophonte quinquespinosa* و 7 arthrites على الفك العلوي في *Canuellina nicobaris*. كشفت الصور المجهرية ميزات عدة مثل المخلب القوي والخشن للفك العلوي لنوع *Asellopsis*، والغشاء السميك والمحفور المزخرف لرأس السيفالوتوراكس وفلقات اللاوفونت كورنوتا ولوفونت اكسبانسا. يساعد الشكل المضغوط ظهريا وبطنيا للاوفونتيديا والكانوليدا ووجود الجزء الاندوبي المتمسك للسيقان السابحة على التمسك بشظايا الشعاب المرجانية في حين أن شكل الجسم المغزلي والمتمسك للأكتينوما يساعدها على الجحور نحو الرواسب السفلية. ارتبطت الهاربا كتيكويدات في منطقة رنقيس بشكل كبير بالمرجان الصلب (p=0.030 ، p<0.05). بشكل عام، يعتبر تنوع أنواع مجدافيات الأرجل من نوع الهاربا كتيكويدات من منطقة الشعاب المرجانية لجزيرة تيومان مرتفعة بقيمة H' > 1.8، d > 1.5، و J' > 1.8 H> 1.8، d> 1.5 و J> 1.8. يمكن أن تكون البيانات التصنيفية والتنوع البيولوجي أبعد من ذلك من خلال النهج التجريبي الميداني لفهم إستراتيجية القاتل تجاه العامل البيئي.

APPROVAL PAGE

The thesis of Azrina binti Sham has been approved by the following:

_____

Zaleha binti Kassim
Supervisor

_____

Nurul Huda binti Ahmad Ishak
Co-Supervisor

_____

Zuhairi bin Ahmad
Co-Supervisor

_____

Ahmad Jalal Chowdary Khan
Internal Examiner

_____

Zaidi bin Che Kob
External Examiner

_____

Muhammad Taher bin Bakhtiar
Chairman

DECLARATION

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LIST OF ABBREVIATIONS

Abd.	Abdomen
A1	Antennule
A2	Antenna
CMCP-9	Lactophenol, a mouning media with low viscosity
Enp	Endopod
Exp	Exopod
ind. /10 cm^2	Individual per centimetre square
Mxp.	Maxilliped
N	North
P1-P4	swimming legs (Leg 1- Leg 4)
P5	Leg 5
SST	Sea surface temperatures
µm	micrometre
mm	millimetre
%	percentage
º	degree
‘‘	minute
‘	seconds

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Corals are a part of Cnidarian which includes the jellyfishes, hydroids and sea anemones. They are amazing marine invertebrates exhibit in two forms, polyps (sessile) and medusae (mobile), enable them to form an outstanding ecosystem. This will give benefit not only to their colony, but also to the entire benthic communities that includes the hard coral and coralline algae (Williams et al., 2013). They are also associated with many marine lives such as fishes, arthropods and crustaceans (Brandl et al., 2014; Kramer et al., 2014). Under the soft bodies of scleractinian, or stony corals the corals build up their simple structure by the secretion of calcium carbonates which fusing all the body walls into reef system. As a living system, their stability, growth and survival were exposed to the changes of several environmental factors. Some could grow well, while some other colonies died out and form coral rubbles due to certain environmental pressures such as sea acidification and temperature rise (Stubler & Peterson, 2016). On another occasion, human intervention on the land could contribute to the lessen water clarity and increase sedimentation which also kills corals. These incidents create different features of bottom substrates in the coral area (Fraschetti et al., 2002).

Different animal taxa can be found inhabiting the coral area. They are ranged from the microscopic to large size animals including bacteria, meiobenthos, macrobenthos, small and large fishes. They form a complex food web which have inter-dependency, thus making up the productive coral ecosystem. The benthic group will be

particularly depending on the different type of substrates found in the ecosystem. Being benthic organism, they could be crawl on, burrowing into or even live within the substrates. Some could be specialized to certain bottom substrates, but some could be more general (Ruiz-Abierno et al., 2017).

Benthic fauna is a group of animals with microscopic size (<42 microns), which includes the microbenthos, size range between 42-60 microns, the meiobenthos (32-64 microns) and those >60-500 micron, the macrobenthos. Being in between the smaller and bigger benthos, the meiobenthos contribution to the benthic ecosystem as the link between primary producer to the higher trophic level is well recognized. In the coral ecosystem, the major group of meiobenthos taxa is the benthic harpacticoid copepod. Being very small in size of adult and larval stages could be the main reason that they become the main available food for small fishes inhabiting the ecosystem. Harpacticoid copepods are mostly benthic in nature, but some are strong swimmers that can swim into the water column. Their mode of living and adaptability could be depending on the environmental setting including the substrates they live on. There could be certain life-history strategies that have been adopted by the copepods to endure the various substrate types found on the sea bottom particularly in the coral area.

There are few reports on coral exposure towards rising of sea temperature (Foster & Rohling, 2013; Ekwurzel et al., 2017), unpredictable change of weather condition (Deryugina, 2013) and exploitation by the tourism activities such as snorkeling and diving (Sarmento & Santos, 2012). Any of these factors will directly influence the bottom substrate condition which will alter the composition of harpacticoids species inhabiting it. Species with poor adaptability would slowly reduce their population and substituted by the stronger species. In long run, this situation could alter the species

composition from the upper trophic level and subsequently change the community structure in the coral area.

To date there is no comprehensive data on the species composition or species list of harpacticoid copepods reported from Pulau Tioman. Ecological or taxonomic research on meiobenthos from the island or any other islands in the east coast of the Malay Peninsula is not well-established yet. This could be due to the tedious work to handle the minute animal samples and consequently harpacticoids as the members of the meiobenthos remained unknown. Harpacticoid taxonomic study is uncommon in Southeast Asia and Malaysia. Little is known on their numbers and inventory data is not found. In Malaysia the expense of the study is still very slow despite their application in other field such as aquaculture and pollution study.

1.1.1 Meiobenthic Fauna and Harpacticoid Ecology

Meiofauna or meiobenthos are referring to 'small animal'. The term benthos originated from the Greek words *vanthos* which means bottom and it also refers to organism dominating the ocean floor in aquatic ecosystem (Kingston, 2001; Campbell, 2002) while the word meiofauna was first defined by Mare in 1942 as a metazoan that can pass through a mesh sieve of certain size. Higgins and Thiel (1988) designated the meiobenthos as metazoan which can pass through a 500 µm of mesh sieve but retained on 40 µm sieve while, Coull and Chandler (2001) defined the term as a smaller size class of animals and protists passing through a 1 mm sieve but retained on 64 µm or 31 µm mesh sieve or on a 63 µm or 32 µm mesh sieve (Jochem, 2005). It also denoted as microscopic and mobile aquatic organisms found inhabiting the soft sediments of different depths both in marine and freshwater ecosystem (Ansari et al., 2012). Nematodes is the most dominant taxa followed by harpacticoid copepod in most of the

aquatic ecosystem. There were between 31 to 83 species of nematodes found inhabiting the coral area of Cuban Archipelago (Armentos et al., 2012), 25 families from mangroves forest of Northeastern Brazil (Pinto et al., 2013), 51 species ten estuaries along the coastline of Sarawak (Chen et al., 2012).

Harpacticoid play an important role as a primary consumer which linked the producer (microalgae) and secondary consumer (fishes). The coral ecosystem also provide microhabitat for meiofauna. Copepods is the rightful candidate for environmental assessment since they can produce a quick response towards changes (Fraschetti et al., 2006; Gyedu-Ababio & Baird, 2006; Harguinteguy et al.,2012) due to their short life cycles, high reproduction rates and explicit growth. They often used as biomonitoring tools (Moreno et al., 2011; Balsamo et al., 2012; Semprucci et al., 2013) in measuring the anthropogenic impact and enviromental changes that occur naturally Sakri et al. (2006) concluded that the harpacticoid density is higher in coral but decreasing gradually towards the non-coral area in Karah Island. The harpacticoid density was higher with the presence of more live corals and this can be indicated that the live coral was food for the copepod. However, the results were contrast with Zaleha et al. (2016) where the number of harpacticoids were higher in non-coral area compared to the coral area which possibly due to fluctuations in environmental conditions and high amount of slit and clay. In coral ecosystem, harpacticoid often the most dominant taxa in reef carbonate ecosystem mostly in dead coral sediments (Kramer et al., 2014). The presence of harpacticoid copepod in epilithic algal matric (EAM) in a huge number showed that it may play an ample role to the trophic structure in the reef area (Kramer et al., 2012). EAM is the main food source for fishes in the reef ecosystem.

The disruptions in both biological and physiological of tropics coral area which covers various types of tropics marine sediments including the coral area triggers a

wider dimension of potential microhabitats for the meiobenthos specifically harpacticoid copepod. There are several factors which change the copepod community structure such as warmer water temperature and anthropogenic impacts like eutrophication, acidification and coastal degradation. This was proved by Chew and Chong (2016), where the calanoid copepod with robust body were more sensitive to eutrophication and hypoxia compared to the flexible cosmopolitan species which not affected by the environmental changes. The reduced number of sensitive species definitely affect the production of coastal fish production.

1.2 STATEMENT OF THE PROBLEM

To date, there is no comprehensive data on the species composition or species list of harpacticoid copepods reported from Pulau Tioman. Harpacticoid taxonomic study is uncommon in Southeast Asia and Malaysia. Little is known on their numbers and inventory data is not found. In Malaysia the expense of the study is still very slow despite their application in other field such as aquaculture and pollution study. Nevertheless, a wide range of potential microhabitats is available for benthic fauna in the large variety of dead coral substrates, which originate from physical and biological breakdown of coral skeletons.

Pulau Tioman has been known for decades as tourist attraction's spots because of the biodiversity of its coral ecosystem. The harpacticoid copepod species found in this area can be the main food for the fish larvae. Pulau Tioman is gazetted as Marine Park which become the natural breeding ground for fish, and this is because of the flourish condition of the coral reef. Harpacticoid copepod existence is vital to support the growth in the coral ecosystem. Thus, understanding the biodiversity, adaptability and composition of harpacticoid in the island is also crucial.