

**COMPARISON OF ENVIRONMENTAL
PARAMETERS AND GROWTH OF GREEN
MUSSEL (*Perna viridis*) CULTURE IN
MARUDU BAY AND AMBONG BAY, SABAH,
MALAYSIA**

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UMS

**THESIS SUBMITTED IN FULFILLMENT OF
THE REQUIREMENT FOR THE DEGREE OF
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DECLARATION

I hereby declare that the material in this thesis is my own except for quotation, equation, summaries and references which have been duly acknowledged.

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ABSTRACT

A study to compare the environmental parameters and growth of Asian green mussel (*Perna viridis*) was conducted at Marudu Bay and Ambong Bay for 12 months (September 2017-August 2018). Marudu Bay was the main study area and as comparison Ambong Bay was selected. Physicochemical parameters (DO, pH, salinity, current speed, water transparency, depth & chlorophyll-a), nutrient, sediment composition and heavy metal were studied in both locations. One station from each location was selected to study the correlation of growth parameters with the other parameters. A significant correlation was observed between the physicochemical parameters in Marudu bay either temporal or spatial. Temperature, salinity and chlorophyll-a were low during Northeast Monsoon (NEM) meanwhile water velocity, water transparency and DO was high during NEM compare to South West Monsoon (SWM). Nutrient was fluctuated throughout the sampling period. Composition of the silt-clay percentage and high concentration of heavy metal (Zn, Ni, Cr, Cu, Co and Pb) was also observed during NEM. Generally, the physico-chemical, nutrient, sediment composition and heavy metal that was studied in Marudu bay was influenced by the monsoon especially NEM, where during this season, the rain was also found to be higher. The growth parameters (90 at each site) were found significantly correlated with physico-chemical parameters (dissolved oxygen, pH, salinity, temperature, water transparency, chlorophyll-*a*), nutrients (phosphate (PO_4^{3-}), ammonia ($\text{NH}_3\text{-N}$), nitrate ($\text{NO}_3\text{-N}$) and nitrite ($\text{NO}_2\text{-N}$), and condition index of green mussel from each study site, as well as between the study sites. The initial size (mean) of the mussel seed used was $47.7 \pm 3.5\text{mm}$, attained mean size of $73.47 \pm 11.05\text{ mm}$ (increased 54%; SGR $0.17\% \pm 0.22$) and $51.1 \pm 3.9\text{ mm}$, attained mean size of compared to $64.05 \pm 7.44\text{ mm}$ (increased 25%; SGR $0.11\% \pm 0.22$) for Marudu Bay and Ambong Bay at the end of the experiment. Meanwhile the cumulative mortality rates were $9.2\% \pm 4.9$ and $55.5\% \pm 30.0$ for Marudu Bay and Ambong Bay respectively. A Pearson correlation indicated a significant correlation between mortality and water transparency ($r=0.856$, $p<0.05$), water velocity ($r=0.620$, $p<0.05$), pH ($r=0.506$, $p<0.01$) and Pb ($r=0.520$, $p<0.05$). Meanwhile spearman rank order correlation, indicated a significant correlation between mortality and Ammonia ($r=-0.561$, $p<0.01$), Ni ($r=-0.565$, $p<0.01$) and Co ($r=-0.519$, $p<0.01$). A significant correlation between growth and Cd ($r=-0.683$, $p<0.01$) was also observed. Overall, the growth performance of green mussels farmed in Marudu Bay was better than in Ambong Bay, however, the mortality of mussels in Ambong Bay was higher.

ABSTRAK

PERBANDINGAN PARAMETER PERSEKITARAN DAN TUMBESARAN SIPUT SUDU (*PERNA VIRIDIS*) YANG DITERNAK DI TELUK MARUDU DAN TELUK AMBONG, SABAH, MALAYSIA.

Perbandingan faktor-faktor persekitaran dan tumbesaran siput sudu (*Perna viridis*) telah dilakukan di Teluk Marudu dan Teluk Ambong selama 12 bulan (September 2017 – Ogos 2018). Teluk Marudu merupakan kawasan utama kajian sementara Teluk Ambong dipilih sebagai perbandingan. Parameter fisiko-kimia (DO, pH, saliniti, arus, turbiditi, kedalaman & klorofil-a), nutrien, komposisi sedimen dan logam berat telah dikaji di kedua-dua teluk. Dua (2) stesen kajian yang menternak siput sudu daripada kedua-dua lokasi dikaji perbandingan faktor-faktor berkaitan tumbesaran serta hubungkait pelbagai parameter persekitaran. Hasil kajian mendapati parameter fisio-kimia, nutrien, sedimen dan logam berat yang dikaji di kawasan Teluk Marudu dipengaruhi oleh monsun terutama Monsun Timur Laut (NEM), yang mempunyai kadar hujan yang tinggi. Suhu, Saliniti dan Klorofil-a dalam keluk yang menurun semasa NEM sementara kelajuan air, kecerahan air dan DO adalah tinggi semasa NEM berbanding Monsun Barat Daya (SWM). Nutrien didapati turun naik sepanjang tempoh kajian dilaksanakan. Sementara itu komposisi peritus lumpur-tanah liat didapati agak tinggi pada musim NEM berbanding komposisi sedimen yang lain. Logam berat seperti Zn, Ni, Cr, Cu, Co dan Pb turut didapati tinggi konsentrasinya pada musim NEM dan keluk semakin menurun menjelang SWM. Kajian terhadap kadar tumbesaran dan mortaliti siput sudu (90 daripada setiap lokasi) didapati korelasi signifikan dengan faktor-faktor fisiko-kimia (Oksigen terlarut, pH, saliniti, suhu, turbiditi dan klorofil-a), nutrien (Fosfat (PO_4^{3-}), ammonia (NH_3-N), nitrat (NO_3-N) and nitrit (NO_2-N) dan kondisi indeks daripada setiap stesen dan di antara stesen. Saiz permulaan siput sudu yang dikaji adalah 47.7 ± 3.5 mm telah meningkat kepada 73.47 ± 11.05 mm, (meningkat 54%; SGR $0.17\% \pm 0.22$) dan 51.1 ± 3.9 mm telah meningkat kepada 64.05 ± 7.44 mm, (meningkat 25%; SGR $0.11\% \pm 0.22$), masing-masing di Teluk Marudu dan Teluk Ambong pada hujung tempoh kajian. Kumulatif mortaliti didapati berada pada kadar $9.2\% \pm 4.9$ dan $55.5\% \pm 30.0$ masing-masing untuk Teluk Marudu dan Teluk Ambong. Korelasi pearson menunjukkan korelasi yang signifikan antara kadar kematian siput sudu dan kecerahan air ($r=0.856$, $p<0.05$), kelajuan air ($r=0.620$, $p<0.05$), pH ($r=0.506$, $p<0.01$) dan Pb ($r=0.520$, $p<0.05$). Sementara korelasi 'spearman rank order' antara kadar kematian dan Ammonia ($r=-0.561$, $p<0.01$), Ni ($r=-0.565$, $p<0.01$) dan Co ($r=-0.519$, $p<0.01$). Selain daripada itu, korelasi signifikan antara kadar tumbesaran siput sudu dan Cd ($r=-0.683$, $p<0.01$) turut direkodkan. Secara keseluruhan, faktor kimia fizikal dipengaruhi oleh monsun terutamanya NEM. Kadar tumbesaran siput sudu di Teluk Marudu adalah lebih baik berbanding Teluk Ambong selain daripada kadar kematian di Teluk Ambong yang agak tinggi.

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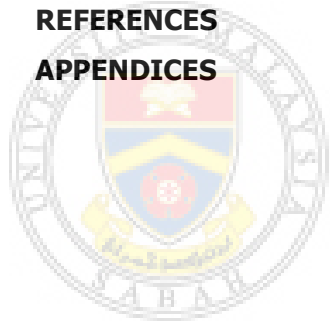
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LIST OF ABBREVIATIONS

°C	-	degree celcius
PPT	-	Part Per Thousand
mL	-	millilitre
mm	-	millimetre
mg/L	-	milligram per litre
cm/s	-	centimetre per second
µg/L	-	micro-gram per litre
µm	-	micro metre
nm	-	nanometre
mg/kg	-	milligram per kilogram
cm	-	centimetre
NEM	-	North East Monsoon
SWM	-	South West Monsoon
DO	-	Dissolve Oxygen
SL	-	Shell length
HL	-	Height Length
WL	-	Wide Length
BW	-	Body weight
CI	-	Condition Index
ICP-OES	-	Inductively Coupled Plasma-Optical Emission Spectroscopy
SD	-	Standard Deviation

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CHAPTER 1

INTRODUCTION

1.1 Growth of Green Mussel and Environmental Parameters

According to FAO (2017), Green mussels was commonly found in the coastal area of Indian and Pacific Oceans. Based on records, worldwide production of the green mussel harvested from the wild was around 50,000 metric tonnes (MT) in the 1950's, with dramatic increased to 150,000 MT in the 70's. *Perna viridis* is particularly cultured in many aquaculture projects in the tropical country, where from 2000 to 2005, aquaculture-based production has increased 100,000 MT to 300,000 MT. These figures show the great potential of this species to the aquaculture project.

The green mussels found to be well adapted to wide range of different environmental conditions and makes it normally found in the estuaries and coastal area (Wicaksono *et al.*, 2019) with a range of 18-33 ppt salinity and can be tolerated with high range of temperature of 11-32°C as described by Vakily, (1989). The green mussel has been exploited as a cheap food source by the coastal community many parts of the world (Kamal & Khan, 1998) and could provide an alternative source of protein (Khan *et al.*, 2010).

According to Vakily (1989), growth probably one of the most important factors to be monitored, the faster it growth will reduce the time in farms. It is eventually will help the farmer fetch a good price and at the same time will reduce the operation cost. Gosling (2003) has describe one of the easiest methods to study the growth of the bivalve was by doing the measurement from anterior to posterior of the shells, in this case mussels. There is another method to study growth by the measure the meat weight of the mussels.

It is notable the bigger size of the mussels will fetch a better price for it. Study by Vakily (1989), also reported the growth of some mussels from genus *Perna* can reach 70-80mm in the first year and 110-120mm in the second year. Study by Vural *et al.*, (2015), managed to identify that growth are much faster at the early stage of mussels and slow down when size is longer and bigger. Meanwhile according to Rajagopal *et al.*, (1998b), in his study in Edaiyur backwaters, East Coast of India, the green mussel growth can reach 83mm in 1 year farmed period. Meanwhile study by Tuaycharden *et al.*, (1980), in Thailand found out that, the green mussel can reach market size of 5-6cm within 6-7 month of growing period.

Overall, the growth of the green mussels was influenced by many factors such as environmental parameters (Tan *et al.*, 2016); food availability (Gosling, 2003; Rajagopal *et al.*, (1998b); Nutrients (Tan & Ransangan 2017) as well as food composition (Tan & Ransangan, 2014).

Marudu bay and the surrounding area was rich in diversity of coral reef, mangrove, mollusks, crustaceans as well as marine plants as described by Faridah-Hanum *et al.*, (2012). The area within the bay in particularly, was one of an important area for fishing activities such as gill nets, lift nets as well as bivalve farming (Busing, 2011; Zakaria & Rajpar, 2015). The fishing activities from this area and surrounding contributed 12% of the fish production with a value of RM183 million of the total fish production of the Sabah in 2018 (DOFS, 2018).

Green mussel is one of bivalve species that was cultured in Marudu bay. This species can be considered as one of the important bivalve's for aquaculture project. The broodstock was brought from the Peninsular Malaysia in the late 80's and was successfully farmed in Marudu bay in year 2000 (Tan & Ransangan, 2015). Other bivalve liked Asiatic hard clam was also found distributed in the coastal and shallowed area especially in the pocket bay area as reported by Tan *et al.*, 2017. Mohd Hamdan *et al.*, 2019, in his study has found the mud clams or locally known as *lokan*, naturally abundance in the mangrove area, and has a great potential for aquaculture.

In this study, Marudu bay which is located in the northern part of Sabah was selected as a main sampling site because, the coastal area from Kg. Teritipan to Tg. Batu used to be the main producer of the green mussels during the year 2000-2010. The bay itself has a unique topographic setup especially in the pocket bay area (southern part) was narrow and become an end point of at least 5 major rivers (Sg. Bandau, Sg. Rasak, Sg. Teritipan, Sg. Tandek & Sg. Rakit). The rivers in this area not only serves as a main route for the fishermen, but also as a link of the development impact in the mainland to the bay. Coincidentally the pocket bay area was covered by vast mangrove especially in area where the river was located. More over the Kota Marudu town, palm oil plantation and other types of other agriculture activities were located at the southern part of the bay which might have a direct impact to what happen at the bay. Meanwhile Ambong bay, located in Tuaran District was selected for comparison because this bay has a different topographic setup and character from Marudu bay.

Generally, Marudu bay and Ambong bay were influenced by tropical climate with two prominent monsoons; Southwest Monsoon (SWM) (May-September) and Northeast Monsoon (NEM) (November – March). The SWM basically has the wind came from south-west and relatively dry except for Sabah, and during NEM, most of the area will experience with wind from the north-east which brought heavy rain to this bay. These prominent tropical climates have a uniform temperature, heavy rainfall and high in humidity. According to Meteorological Department of Malaysia, during the monsoon transition phase (Oct-Nov) and (April-May) was expected to bring along the thunderstorm, strong wind and heavy rain in a short period of time which could trigger flood event in lower area. With this unique climate character and various activities that occurred in the surrounding especially in the terrestrial area has increased the pressure to the bay that might affected to the growth of the green mussel. Therefore, this study was conducted with the possibility to be able to identify the differences in environmental parameters and growth of the green mussel in Marudu Bay and Ambong Bay.

1.2 Problem Statement

One of current issue that was affected the growth and production of the green mussels were the occurrences of mortality when it reached certain size due to unforeseen circumstances. This study was conducted with a purpose to obtain the data on environmental parameters, nutrients, sediment, heavy metal and growth of the green mussel. Marudu bay was the main sampling site of the study, meanwhile Ambong bay was selected as a comparison. These parameters collected from the both bays were analysed and compared.

1.3 Significance of the Study

Most of the previous study of green mussels was focusing only Marudu Bay area, for example study from Tan *et al.*, (2016) focusing on mortality and growth of green mussels in high chlorophyll-a environment. Taib *et al.*, (2014), was focusing on the density, recruitment and growth of green mussels in Marudu Bay after the massive mortality event. In recent study by Ong and Ransangan (2019), focusing on the effect of physicochemical parameters and phytoplankton composition on the growth performance of the green mussels in Ambong and Marudu Bay.

This study was first to collect the physico-chemical properties, chlorophyll-a, nutrients, sediments and heavy metal from major rivers in Marudu Bay. The parameters analysed for the spatial and temporal and compared between the stations for 12-month period. The second parts of the study were to compare the same parameters and growth green mussels between one station in Marudu Bay with another station in Ambong Bay, where both has the farm for green mussel. Then comparing the effects of various variables to the growth performance of the green mussels that farmed in Marudu Bay and Ambong Bay. Marudu Bay is an example of area where very much influenced by active activities especially in the land and terrestrial area. There are many rivers surrounding the bay, especially in the pocket bay. These rivers systems became an important connector between the terrestrial and the water bodies in the bay.

Any effluents from the terrestrial area will eventually enter the bay through the river systems especially in the pocket bay where most of the rivers is located. As a comparison, Ambong Bay was selected where the fishing activities was similar to Marudu Bay. The differents of this bay compared with Marudu Bay was this bay slightly smaller, no major river and less agricultural activities in the terrestrial area. By obtaining and comparing most of the parameters and variables could provide a clearer picture of the both bays.

1.4 Aim

The aim of this study was to obtain and compare the environmental parameters and growth of the green mussels that was farmed in Marudu Bay and Ambong Bay.

1.5 Objectives

The objectives of this study are

- a. To determine the spatial and temporal variation of physico-chemical properties parameters, chlorophyll-*a*, nutrients, sediment and heavy metals in Marudu Bay (major rivers and estuaries)
- b. To compare the physicochemical properties parameters, chlorophyll-*a*, nutrients, heavy metals and growth of the green mussels farmed in Marudu Bay and Ambong Bay.
- c. To identify the effect of the physicochemical parameters, chlorophyll-*a*, nutrients, sediment and heavy metals to the growth performance of the green mussels farmed in Marudu Bay and Ambong Bay.