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SEAWEED COMMUNITIES OF INTER-TIDAL ROCKY SHORES AROUND BINTULU, MALAYSIA

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SEAWEED COMMUNITIES OF INTER-TIDAL ROCKY SHORES AROUND BINTULU, MALAYSIA

By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

SEAWEED COMMUNITIES OF INTER-TIDAL ROCKY SHORES AROUND BINTULU, MALAYSIA

By

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July 2013

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Faculty: Agriculture and Food Sciences (Bintulu)

Assessments (environmental relationship, diversity and chemical composition) on seaweed communities were carried out at inter-tidal rocky shores around Bintulu, Sarawak from January to October 2008. A total of 35 species of seaweeds were recorded from five rocky shores: Tg. Batu (15 species), Telekom Beach (22 species), Similajau National Park (21 species), Kuala Similajau (27 species) and Kg. Kuala Nyalau (28 species). Rhodophyta was the most diverse division followed by Chlorophyta and Phaeophyta. There was no distinct zonation for seaweed distribution in all rocky shores with species of Chlorophyta, Phaeophyta and Rhodophyta divisions were recorded at different level of inter-tidal (lower, middle and higher) shores and overlapped.

Diverse life forms of seaweed were observed as adaption to the environment with many microhabitats. Five types of seaweed life forms were identified namely epilithic, epipelic, epiphytic, epizoic and drift. The same seaweed species can be found in any of the mode of life form such as *Ulva intestinalis*, *Padina minor* and

Amphiroa fragilissima. However, epilithic seaweeds (45-56.76%) occurred to be the most occurring life form at all study sites and followed by epizoic seaweeds (23.64-33.33%). Based on Bray-Curtis 70% similarity evaluation, three distinct clusters on the species occurrence in relation to months were observed at Tg. Batu, six at Telekom Beach, two at Similajau National Park, two at Kuala Similajau and three at Kg. Kuala Nyalau. Jaccard community similarity coefficient index showed that seaweed from Kuala Similajau and Kg. Kuala Nyalau were most similar.

Based on BVSTEP analysis, combination of four physical variables (salinity, turbidity, conductivity and total suspended solid) with Spearman rank correlation (ρ) 0.877 at Telekom Beach and a combination of two chemical variables (ammonium and orthophosphate) with (ρ) 0.771 at Kg. Kuala Nyalau were the best combinations for occurrence and distribution of seaweed at each site. No specific variable was recorded e.g. salinity at Similajau National Park with (ρ) 0.853 and nitrite at Tg. Batu with (ρ) 0.580.

There were significant difference ($p<0.01$) of proximate composition and minerals between selected seaweed species. Moisture content was found highest in Rhodophyta (82.68-88.56%) and ash highest in Chlorophyta (23.79-32.50%). Crude protein, crude fat, crude fiber were highest in *Padina minor* (6.36% of dry matter of 100 g of plant), *Acetabularia major* (0.84%) and *Anadyomene plicata* (16.77%). *Acanthophora spicifera* contained highest percentage of total carbohydrate with 67.32%. This study showed seaweeds contained high quantity of macro-minerals (Ca, Mg, N and K) ranged from 143.73-3360.33 mg/100g and micro-minerals (Fe, Zn, Cu and Mn) ranged from 1.34-650.81 mg/100g.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

KOMUNITI RUMPAI LAUT DI KAWASAN ANTARA AIR PASANG SURUT PANTAI BERBATU SEKITAR BINTULU, MALAYSIA

Oleh

WONG SIAW CHIA

Julai 2013

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Tinjauan (perkaitan persekitaran, kepelbagaian dan komposisi kimia) ke atas rumpai laut telah dijalankan di kawasan antara air pasang surut pantai berbatu sekitar Bintulu, Sarawak dari Januari hingga Oktober 2008. Sejumlah 35 spesies rumpai laut telah direkodkan dari lima pantai berbatu: Tg. Batu (15 spesies), Pantai Telekom (22 spesies), Taman Negara Similajau (21 spesies), Kuala Similajau (27 spesies) dan Kg. Kuala Nyalau (28 spesies). Rhodophyta adalah divisi yang paling pelbagai diikuti oleh Chlorophyta dan Phaeophyta. Tiada corak penzonan rumpai laut yang khusus di semua kawasan pantai berbatu dengan spesies dari divisi Chlorophyta, Phaeophyta dan Rhodophyta direkod pada tahap berbeza di kawasan antara air pasang surut (rendah, pertengahan dan tinggi) dan spesies didapati bertindih.

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Kepelbagaian cara hidup rumpai laut diperhatikan beradaptasi dengan persekitaran yang mempunyai banyak habitat mikro. Lima jenis cara hidup rumpai laut telah dikenalpasti iaitu epilitik, epipelik, epifitik, epizoik dan hanyut. Spesies rumpai laut yang sama boleh ditemui dalam cara hidup yang berbeza seperti *Ulva intestinalis,*

Padina minor dan *Amphiroa fragilissima.* Walau bagaimanapun, rumpai laut epilitik (45-56.76%) menunjukkan cara hidup yang paling kerap dijumpai di semua kawasan kajian dan diikuti oleh rumpai laut epizoik (23.64-33.33%). Berdasarkan penilaian persamaan Bray-Curtis 70%, tiga kelompok berbeza bagi kehadiran spesies berkaitan dengan bulan telah diperhatikan di Tg. Batu, enam di Pantai Telekom, dua di Taman Negara Similajau, dua di Kuala Similajau dan tiga di Kg. Kuala Nyalau. Indeks komuniti persamaan Jaccard menunjukkan bahawa rumpai laut dari Kuala Similajau dan Kg. Kuala Nyalau paling serupa.

Berdasarkan kepada analisis BVSTEP, kombinasi daripada empat pembolehubah fizikal (saliniti, kekeruhan, konduktiviti dan jumlah pepejal terampai) dengan korelasi Spearman (ρ) 0.877 di Pantai Telekom dan satu kombinasi daripada dua pembolehubah kimia (ammonium dan ortofosfat) dengan (ρ) 0.771 di Kg. Kuala Nyalau yang merupakan kombinasi terbaik untuk kehadiran dan taburan rumpai laut di setiap kawasan kajian. Tiada pembolehubah spesifik yang direkodkan contohnya saliniti di Taman Negara Similajau dengan (ρ) 0.853 dan nitrit di Tg. Batu dengan (ρ) 0.580.

Terdapat perbezaan ketara ($p<0.01$) pada komposisi proksimat dan mineral di antara rumpai laut terpilih. Kandungan lembapan didapati paling tinggi pada Rhodophyta (82.68-88.56%) dan abu paling tinggi pada Chlorophyta (23.79-32.50%). Protein kasar, lemak kasar dan serat kasar paling tinggi dalam *Padina minor* (6.36% daripada 100 g bahan kering tumbuhan), *Acetabularia major* (0.84%) dan *Anadyomene plicata* (16.77%). *Acanthophora spicifera* mengandungi jumlah peratusan karbohidrat paling tinggi dengan 67.32%. Kajian ini menunjukkan rumpai

laut mengandungi kuantiti makro mineral yang tinggi (Ca, Mg, Na dan K) iaitu di antara 143.73-3360.33 mg/100g dan mikro mineral (Fe, Zn, Cu dan Mn) di antara 1.34-650.81 mg/100g.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or any other institution.

WONG SIAW CHIA

Date: 29 July 2013

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LIST OF ABBREVIATIONS

%	Percentage
% D.W	Percentage dry weight
% W.W	Percentage wet weight
mg/100g	Milligram per hundred gram
mL	Millilitre
TSS	Total suspended solid
psu	Practical salinity units
℃	Degree Celsius
NTU	Nephelometric turbidity unit
mS/cm	Milli Siemens per centimetre
mg/L	Milligram per litre
g	Gram
cm	Centimetre
m	Metre
µm	Micrometre
mg	Milligram
mm	Millimetre
NO_3^-	Nitrate ion
% w/v	Percentage mass per volume
% v/v	Percentage volume per volume
µg-at N/L	Microgram of atomic nitrogen per litre
UV	Ultraviolet
nm	Nanometre

NO_2^-	Nitrite ion
NH_4^+	Ammonium ion
PO_4^+	Orthophosphate ion
ppm	Parts per million

CHAPTER 1

INTRODUCTION

Seaweeds refer to multicellular marine algae (Lobban and Harrison, 1994; Karleskint 1998) which is also known as macroalgae (Dawes, 1998; McHugh, 2003). They are non-flowering (Lewmanomont and Ogawa, 1995), non-vascular (Pritchard and Bradt, 1984), macroscopic, visible to naked eye (Chapman, 1979; Teo and Wee, 1983; Lobban *et al.*, 1985; Lobban and Harrison, 1994) which are differentiated into division Chlorophyta, Phaeophyta and Rhodophyta (Chapman, 1979; Lobban *et al.*, 1985; Lobban and Harrison, 1994; Ahmad, 1995; Dawes, 1998; McHugh, 2003; Dhargalkar and Kavlekar, 2004).

One of the main importance of seaweeds is the role as primary producers (Bold and Wynne, 1978; Lee, 1989; Trono, 1997, 2004) and habitats (Major, 1977; Earle, 1980) in the coastal environment. They are normally found living attached to the seabed between the upper of inter-tidal zone and the maximum depth (high tide to low tide) to which adequate photosynthetic light (approximately 0.01%) for growth is available. Studies on seaweed at coral reef flats or seagrass beds had been conducted in several parts of the world such as Enewetak Atoll Lagoon, Marshall Island (Cohn, 1986), Ischia, Gulf of Naples (Mazzella *et al.*, 1989), South Singapore (Goh and Chou, 1992), Kaneohe Bay (Hawaii), Discovery Bay (Jamaica), La Saline Reef (Reunion), Moorea (French Polynesia) and Great Barrier Reef (Done, 1992), Gazi Bay, Kenya (Copejans *et al.*, 1992), Seribu Island, Indonesia (Suharsono, 1992) and Ambon Island, Indonesia (Grevo *et al.*, 2006).

Seaweeds are great natural resource which is very important to the livelihood of human being. Seaweeds raise its economic values as food (Levring, 1977; Abbott, 1978; Riley, 1988; Trono, 1997, 2004; Tsutsui *et al.*, 2005) and raw materials – phycocolloids (Hoppe amd Schmid, 1969; Teo and Wee, 1983; Miller, 1999). In the east coast of Peninsular Malaysia, local Malays consume raw *Gracilaria* and *Caulerpa*. *Gracilaria* or more commonly known as 'saghe' is a part of diet for local communities of Kelantan and Terengganu. In Langkawi, *Caulerpa* or 'lato' is consumed as supplementary food. Several species of *Gelidium* are served raw as salads and for agar extraction. In Sabah, *Eucheuma* and *Kappaphycus* are cultured where there are two factories for production of semi-refined carrageenan had been established (Phang, 2006). In Malaysia, seaweed had been documented as being utilized as animal feed, fertilizer and traditional medicine (Zaneveld, 1959; Hooper, 1960; Burkill, 1966; Phang, 1984).

In other places of the Asia, research on seaweed diversity and distribution had been done. For instance, Port Okha of Northwest coast of India (Thakur *et al.*, 2008), Trat peninsula of Thailand (Petsut *et al.*, 2012), St. John's Island of Singapore (Noiraksar *et al.*, 2012) and Muttom coastal waters of Southwest coast of India (Domettila *et al.*, 2013).

Studies regarding diversity of seaweed around Malaysia had been partially carried out at places such as Pulau Tioman (Ahmad and Go, 1992), Sungai Pulai Estuary, South-West Johore (Japar Sidik *et al.*, 1996), coastal areas of Sarawak (Fisheries Research Centre Sarawak, 2000), Northeastern region of Langkawi Islands (Phang *et al.*, 2005), rocky shores around Bintulu, Sarawak (Muta Harah *et al.*, 2005; 2006;

2007) and also Perak Island, Jarak Island and Sembilan Group of Islands in the Straits of Malacca (Phang *et al.*, 2008).

In Malaysia, the research pertaining to seaweed resource is rare compared to other countries particularly inter-tidal rocky shores. Seaweed grows in niche. Different seaweed has unique tolerance towards environmental variations. The information of how environmental factor of different area affects the occurrence of seaweed is still a riddle to many people. Previous information of seaweed diversity in Bintulu, Sarawak mostly carried out at the sub-tidal area. The livelihood, diversity and distribution and composition of seaweed in Bintulu, Sarawak are still lacking due to evolution and extinction of some species over time and change in tide level, environmental changes, grazing activity and pollution. Some seaweeds are potentially useful living organism, thus the composition of the flora is crucial. Therefore, update of the previous findings is necessary to find out the exact species that occurred at a particular month. The information from this study also can be beneficially to the policy makers in maintenance, preservation and protection of the natural environment wisely.

In the view of the problem statements above, the objectives of the research study were:

1. To examine the ecology and habitat of seaweed of inter-tidal rocky shores around Bintulu
2. To determine the diversity of seaweed of inter-tidal rocky shores around Bintulu
3. To assess the chemical composition of selected seaweed of inter-tidal rocky shores around Bintulu

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BIODATA OF STUDENT

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Ms. Wong Siaw Chia was born at Kuching in 1982. She obtained her Sijil Pelajaran Malaysia (SPM) from Sekolah Menengah Kebangsaan Bandar Bintulu in 2000 and Sijil Tinggi Persekolahan Malaysia (STPM) from Sekolah Menengah Kebangsaan Bintulu in 2002. In 2007, she was graduated with Bachelor of Science in Bio-industry (Hons.) with Second Class Upper from Universiti Putra Malaysia. In July 2007, she continued her study in Master of Science in Aquatic Biology.

Previous Academic and Other Relevant Appointments

Year	**Appointments**
January until June 2008	**Research Assistant** Department of Animal Sciences and Fisheries Faculty of Agriculture and Food Sciences Universiti Putra Malaysia

LIST OF PUBLICATIONS

Publication produced from this Thesis

(1) Wong, S.C., Muta Harah, Z., Japar Sidik, B., Arshad, A. and Ogawa, H. 2010a. Macroalgal Communities of Intertidal Rocky Shores around Bintulu, Sarawak. *In* Proceeding of the International Symposium, Biodiversity-Biotechnology: Gateway to Discoveries, Sustainable Utilization and Wealth Creation, Kuching, Sarawak. Rita, M., Zaliha, C.A., Fasihuddin, B.A. and Kuek, C. (eds.), pp 102-108. The Sarawak Biodiversity Centre, Kuching.

(2) Wong, S.C., Muta Harah, Z. and Japar Sidik, B. 2010b. Changes in macroalgae species composition, assemblage and coverage at an inter-tidal rocky shores. *Coastal Marine Science* 34(1): 113-116.

(3) Wong, S.C., Muta Harah, Z. and Japar Sidik, B. 2012. Comparison of seaweed communities of the two rocky shores in Sarawak, Malaysia. *Coastal Marine Science* 35(1): 78-84.

Related publication during study period

(1) Muta Harah, Z., Wong, S.C., Japar Sidik, B., Arshad, A. and Ogawa, H. 2007. Macroalgae diversity and life forms of inter-tidal rocky shores. *Marine Research Indonesia* 32(2): 163-168.

Paper and poster presentation

(1) Wong S.C., Muta Harah, Z., Japar Sidik, B., Arshad, A., Ogawa H. 2008. Macroalgal Communities of Intertidal Rocky Shores Around Bintulu, Sarawak. Paper presented at Biodiversity and Biotechnology Symposium 2008. (Biodiversity-Biotechnology: Gateway to Discoveries, Sustainable Utilization and Wealth Creation 19th – 21st November 2008, Hilton Kuching Sarawak, Malaysia.)

(2) Wong S.C., Muta Harah, Z., and Japar Sidik, B. 2009. Status of seaweeds around Bintulu, Sarawak. Paper presented at International Workshop and field study on the JSPS Multilateral Cooperative Research Program, 13 Aug. 2009, Kasetsart University, Thailand.

(3) Wong S.C., Muta Harah, Z. and Japar Sidik, B. 2009. Changes in macroalgae species composition, assemblage and coverage at the intertidal rocky shores. Poster presented at Fourth Vast-JICA Joint Seminar on Coastal Marine Science, 25-29 Oct. 2009. Hai Phong, Vietnam.

(4) Muta Harah, Z., Japar Sidik, B. and Wong S.C. 2010. Seaweeds of Bintulu: With Emphasis on Two Rocky Shores. Paper presented at

JSPS-AORI International Workshop on Biodiversity of Seaweed and Seagrass, Kagoshima, 2010. 8th August to 13th August, 2010, Faculty of Fisheries, Kagoshima University, Japan.

(5) Wong S.C., Muta Harah, Z. and Japar Sidik, B. 2010. Seaweed communities of two rocky shores. Paper presented at JSPS Tokyo Conference, Horiba, Japan. 25-29 Oct. 2010.