

Biomass and Habitat Characteristics of Epiphytic Macroalgae in the Sibuti Mangroves, Sarawak, Malaysia

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Abstrak: Bakau menyokong himpunan kepelbagaian “epibiont” makroalga atas akar dan batang terapung pokok bakau. Makroalga membekalkan nutrien kepada pengguna utama dalam rantaian makanan akuatik dan telah dilaporkan menjadi penyumbang besar kepada ekosistem marin. Kepelbagaian spesies, biomass, dan ciri-ciri habitat makroalga bakau telah dikaji di tiga stesen bakau di muara Sibuti, Sarawak, Malaysia, dari bulan November 2012 hingga Oktober 2013. Tiga kumpulan makroalga direkodkan dan telah didapati tumbuh pada akar terapung pokok bakau, iaitu Rhodophyta (*Caloglossa ogasawaraensis*, *Caloglossa adhaerens*, *Caloglossa stipitata*, *Bostrychia anomala*, dan *Hypnea* sp.), Chlorophyta (*Chaetomorpha minima* dan *Chaetomorpha* sp.), dan Phaeophyta (*Dictyota* sp.). Biomass makroalga tidak dipengaruhi ($p > 0.05$) mengikut musim di habitat hutan bakau. Spesies makroalga iaitu *Hypnea* sp. menyumbang biomass yang paling tinggi di kedua-dua Stesen 1 (210.56 mg/cm²) dan Stesen 2 (141.72 mg/cm²), manakala biomass tertinggi disumbangkan oleh *B. anomala* (185.89 mg/cm²) di Stesen 3. Kajian ini menunjukkan bahawa taburan dan himpunan spesies daripada makroalga bakau dipengaruhi oleh parameter alam sekitar seperti nutrien dari air, pepejal terlarut, dan kemasinan di habitat muara bakau Sibuti, Sarawak.

Kata kunci: Makroalga, *Bostrychia anomala*, Biomass, Bakau, Sarawak

Abstract: Mangroves support diverse macroalgal assemblages as epibionts on their roots and tree trunks. These algae provide nutrients to the primary consumers in the aquatic food web and have been reported to be substantial contributors to marine ecosystems. The species diversity, biomass, and habitat characteristics of mangrove macroalgae were investigated at three stations in the Sibuti mangrove estuary, Sarawak, Malaysia, from November 2012 to October 2013. Three groups of macroalgae were recorded and were found to be growing on mangrove prop roots, namely Rhodophyta (*Caloglossa*

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ogasawaraensis, *Caloglossa adhaerens*, *Caloglossa stipitata*, *Bostrychia anomala*, and *Hypnea* sp.), Chlorophyta (*Chaetomorpha minima* and *Chaetomorpha* sp.), and Phaeophyta (*Dictyota* sp.). The biomass of macroalgae was not influenced ($p>0.05$) by the season in this mangrove forest habitat. The macroalgal species *Hypnea* sp. contributed the highest biomass at both Station 1 (210.56 mg/cm²) and Station 2 (141.72 mg/cm²), while the highest biomass was contributed by *B. anomala* (185.89 mg/cm²) at Station 3. This study shows that the species distribution and assemblages of mangrove macroalgae were influenced by environmental parameters such as water nutrients, dissolved solids, and salinity in the estuarine mangrove habitats of Sibuti, Sarawak.

Key words: Macroalgae, *Bostrychia anomala*, Biomass, Mangrove, Sarawak

INTRODUCTION

Mangrove forests are considered to be one of the most productive coastal intertidal ecosystems in the world (Hoque *et al.* 2015a). In mangrove habitats, litter production is usually the main source of energy and is the indicator of primary productivity, which subsequently contributes to adjacent estuarine ecosystems. Macroalgae associated with mangroves can also contribute similarly to the annual litter production of coastal forests (Rodriguez & Stoner 1990). Mangrove macroalgae is unique and can only be found growing epiphytically on pneumatophores, prop roots, stems, sediment, and other substrates (Zuccarello *et al.* 2001). Generally, this substrate is very important for mangrove macroalgae attachment, and these algae grow differently in different substrates (Aikanathan & Sasekumar 1994).

In coastal mangrove habitats, grazing small marine and estuarine invertebrates are dependent on macroalgae as a food source and for shelter (Aikanathan & Sasekumar 1994; Melville *et al.* 2005). The macroalgae growing within mangroves are important in estuarine ecosystems and supply an additional source of energy for nutrient cycling (Davey & Woelkerling 1985; McCluskey & Elliot 2004) and are an important source of carbon (Rodriquez & Stoner 1990). Studies have found that the distribution, tolerance, and adaptation of mangrove macroalgae are influenced by abiotic and biotic parameters (Oliveira 1984). Environmental parameters such as transparency, salinity, dissolved oxygen, and pH have been considered to be contributing factors that influence the presence or absence of macroalgae in mangrove ecosystems (Fernandes & Alves 2011).

Studies on the biomass and habitat characteristics of mangrove macroalgae are inadequate in Malaysia (Laursen & King 2000; Saifullah & Ahmed 2007). The taxonomy and morphology of mangrove algae have been previously described in Pakistan (Tanaka & Shameel 1992; Saifullah & Taj 1995). Aikanathan and Sasekumar (1994) reported 10 mangrove macroalgae in Malaysian marine waters. It is assumed that in Sarawak, Malaysia, there could be a wide variety of benthic epiphytic macroalgae in the mangrove habitats with ecological potential. Therefore, this study was carried out to assess the macroalgal community structure and habitat characteristics in the Sibuti mangrove forest, Sarawak, Malaysia.

MATERIALS AND METHODS

Study Area

This study was carried out in the Sibuti mangrove estuary, Sarawak, Malaysia (Fig. 1). Three stations were established, i.e., Station 1 (03° 25' 00.5" N & 113° 23' 13.5" E), Station 2 (03° 58' 55.4" N & 113° 44' 18.8" E), and Station 3 (03° 59' 28.7" N & 113° 44' 35.3" E). The distance between the stations was approximately 1 km. This site is considered to be an undisturbed mangrove forest dominated by *Rhizophora apiculata*, followed by *Xylocarpus granatum* and *Nypa fruticans*. The forest is regularly inundated by a normal high tide, and inundation occurs up to 34 times per month on average (Saifullah *et al.* 2014). Hence, the forest can be classified under class 3 according to Watson (1928). The estuary is semi-diurnal, and the tidal range varies between 0.2 to 2.0 m during neap and spring tide, respectively (Hoque *et al.* 2015b; Kaleem *et al.* 2015).

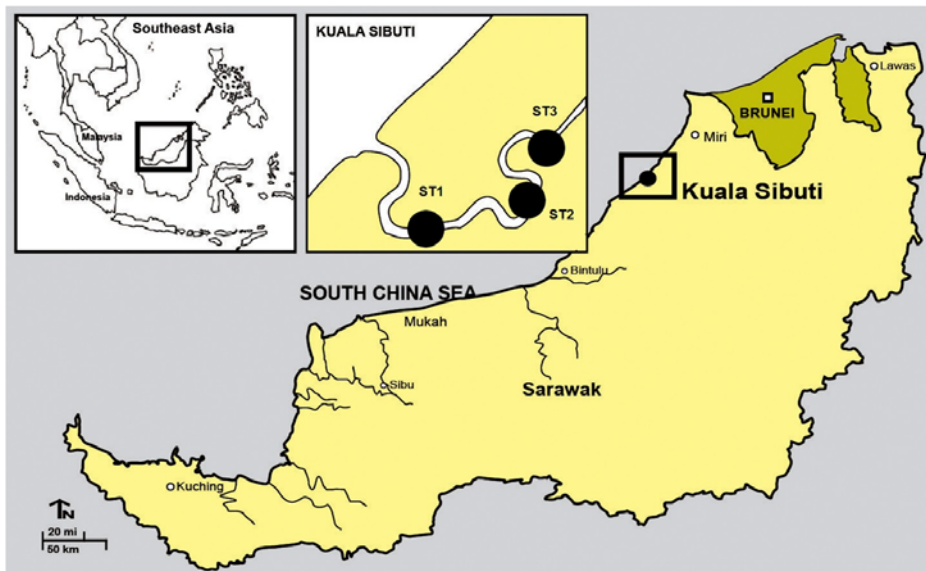


Figure 1: Map of the study area showing the locations of stations in the Sibuti estuary, Sarawak, Malaysia.

Collection of Macroalgae

Macroalgae were collected randomly from the three stations on a monthly basis for one year from November 2012 to October 2013. The prop roots of *R. apiculata* were selected for collecting macroalgae, as this was the most common and dominant species in this estuary. Prop roots (20 cm long) covered with macroalgae were randomly cut from the 3 stations. The samples were placed into Ziploc polyethylene bags, which were labelled and transported back to the Ecology and Biology Laboratory (Department of Animal Science and

Fisheries, Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Sarawak Campus) for further processing (Melville & Pulkownik 2007). All macroalgae from the pneumatophores were sorted and cleaned and then placed into a drying oven pre-set to 80°C to obtain a constant weight for the measurement of biomass. The biomass was expressed as the algal weight per unit area (mg/cm²) following the procedure described by Saifullah and Ahmed (2007). For identification, the macroalgae were preserved in a 4% formalin solution (Bouzon & Ouriques 1999). Identification was conducted based on the works of Zeng (1983), King and Puttock (1994), Qian *et al.* (2005), and Zhao (2012), and some of the samples were sent to School of Biology Science, Victoria University, New Zealand, to confirm the identifications.

Observation of Ecological Parameters

The ecological parameters of the Sibuti mangrove estuary were recorded monthly at the three stations. The physico-chemical parameters of the estuarine water, i.e., the pH, temperature, salinity, turbidity, and dissolved oxygen were detected in situ using a multi-parameter probe (model WQC-24, Jaya Chemical Supplier, Bintulu, Sarawak). The total rainfall and air temperature at the Sibuti estuary were obtained from the Meteorological Department of Sarawak. To determine the estuarine water nutrient content, water samples (three replicates from each station) were collected from the three stations with pre-cleaned plastic bottles, which were brought back to the laboratory using ice boxes. Pore water was collected from the forest floor by digging in the soil to create small holes and waiting for the water to fill the holes. Pore water can also be observed at the bottom of ditches. Once the holes had filled with water, three replicates of pore water were collected from each station in pre-washed bottles and were brought back to the laboratory within ice boxes. The ammonium, nitrate, and phosphate in the water were detected using the methods of Weatherburn (1967), Kitamura *et al.* (1982), and Parsons *et al.* (1984), respectively. Three replicate mangrove soil samples were collected from each station and brought back to the laboratory for analysis using ice boxes. In the laboratory, the soil samples were placed in an oven at 70°C until dry and were passed through a 250 µm sieve to detect the total phosphorous, nitrogen, sulphur, and carbon following Kim (2003) and Bray and Kurtz (1945) using a carbon, nitrogen, sulphur (CNS) analyser (LECO Truspec Micro CHNS elemental analyser, New York).

Statistical Analysis

Factorial analysis and one-way ANOVA were used to determine if there were any significant differences among the nutrients with respect to the sampling locations. The statistical significance was set at $p < 0.05$, and the stability of the estimate was reflected by 95% confidence intervals. All tests and analyses were performed with SAS 9.2 for Windows by the SAS Institute Inc., Cary, NC, USA (2002–2008). The correlations among species diversity and the physico-chemical parameters were tested using multivariate analysis of ecological data (CANOCO for Windows 4.5) for redundancy analysis (RDA) following Jongman *et al.* (2003).

RESULTS

Macroalgal Species Composition and Biomass

The macroalgae in the Sibuti mangrove estuary included members of three groups, Rhodophyta, Chlorophyta, and Phaeophyta. Eight species of macroalgae from the three divisions of Rhodophyta (*Caloglossa ogasawaraensis*, *Caloglossa adhaerens*, *Caloglossa stipitata*, *Bostrychia anomala*, and *Hypnea* sp.), Chlorophyta (*Chaetomorpha minima* and *Chaetomorpha* sp.), and Phaeophyta (*Dictyota* sp.) were recorded growing on prop roots at Station 1. Rhodophyta (*Hypnea* sp.) and Chlorophyta (*C. minima*) were the most common at Station 2, while Rhodophyta (*B. anomala* and *Hypnea* sp.) was common at Station 3 in this estuarine mangrove habitat.

Hypnea sp. was found year-round at all studied stations (Table 1). However, the distributions and presence of *Caloglossa* spp., *Bostrychia* spp. and other macroalgae formed an irregular pattern in this study area. The biomass of *Hypnea* sp. was found to be higher at both Station 1 (210.56 mg/cm²) and Station 2 (141.72 mg/cm²). At Station 3, the highest biomass (185.89 mg/cm²) was derived from *B. anomala* (Table 2). The macroalgal biomass did not significantly differ ($p>0.05$) during the study period (Fig. 2).

Ecological Parameters

The physico-chemical parameters of soil and water showed significant differences ($p<0.05$) among the months and stations during the study period (Figs. 3 and 4). The range of the total soil carbon concentrations was found to be 0.45%–18.89% in this mangrove ecosystem, and the highest value was recorded at Station 3 and the lowest at Station 1. The total carbon content in the soil did not vary during the sampling period and was related to the total nitrogen in the soil.

The pore water had higher concentrations of ammonium, nitrate, and phosphate than the river water (Table 3). The monthly ammonium and nitrate concentrations were slightly higher at Station 1 than at Stations 2 and 3, while the phosphate concentration was marginally higher at Station 3 (Fig. 4). The water pH, total dissolved solids (TDS), and salinity were found to be higher at Station 1 and lower at Station 3 (Fig. 5). The rainfall was recorded as higher in December, February–May and September, with a mean value of 10.90–15.50 mm.

Table 1: Mangrove macroalgae composition on the prop roots at three difference stations during the study period (November 2012–October 2013) at Sibuti estuary, Malaysia. (✓ = present); (– = absence); NO = November; DE = December; JA = January; FE = February; MR = March; AP = April; MA = May; JN = June; JU = July; AU = August; SE = September; OC = October.

Species	NO	DE	JA	FE	MR	AP	MA	JN	JU	AU	SE	OC
Stations	1	2	3	1	2	3	1	2	3	1	2	3
Rhodophyta												
<i>C. ogasawaraensis</i> (Okamura)	–	–	–	–	–	–	–	–	–	–	–	–
<i>C. adhaerens</i> (King et Putlock)	–	–	–	–	–	–	–	–	–	–	–	–
<i>C. stipitata</i> (E. Post)	✓	–	–	–	–	–	–	–	–	–	–	–
<i>B. anomala</i> (J.A West, S. Loiseaux de Goer, G.C Zuccarello)	✓	–	–	–	–	–	–	–	–	–	–	–
<i>Hypnea</i> sp. (Esper) J.V Lamouroux	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Chlorophyta												
<i>C. minima</i> (C. Agardh)	✓	–	–	–	–	–	–	–	–	–	–	–
<i>Chaetomorpha</i> sp. (C. Agardh)	–	–	–	–	–	–	–	–	–	–	–	–
Phaeophyta												
<i>Dictyota</i> sp. (Hudson) Lamouroux	✓	–	–	–	–	–	–	–	–	–	–	–

Table 2: Yearly means biomass (mg/cm² ± SD) of mangrove macroalgae on the prop roots of three stations in Sibuti estuary Sarawak, Malaysia.

Species	Means biomass (mg/cm ²)		
	Station 1	Station 2	Station 3
<i>C. ogasawaraensis</i>	4.97±5.74	0.00±0.00	0.00±0.00
<i>C. adhaerens</i>	2.52±4.19	0.00±0.00	0.00±0.00
<i>C. stipitata</i>	12.14±17.89	0.00±0.00	0.00±0.00
<i>B. anomala</i>	1.03±2.86	0.00±0.00	185.89±248.29
<i>C. minima</i>	4.11±7.78	2.57±8.89	0.00±0.00
<i>Chaetomorpha</i> sp.	5.09±12.14	0.00±0.00	0.00±0.00
<i>Hypnea</i> sp.	210.56±114.11	141.72±92.57	54.29±87.18
<i>Dictyota</i> sp.	6.18±21.39	0.00±0.00	0.00±0.00
Total	246.63	144.29	240.18

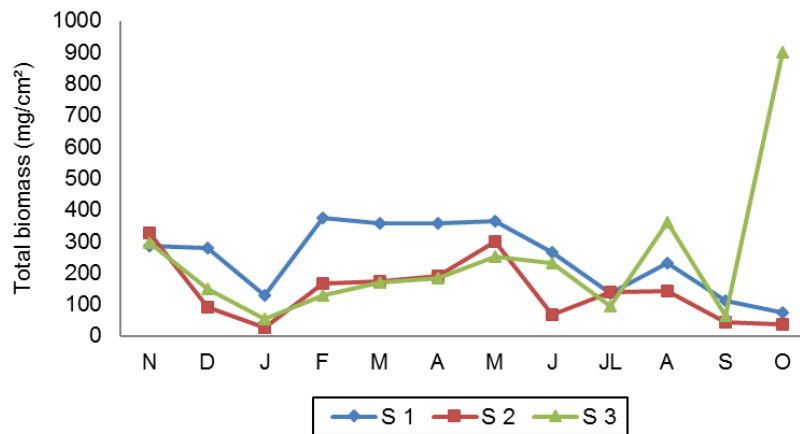


Figure 2: Monthly variation in total biomass (mg/cm²) of mangrove macroalgae at three different stations.

Macroalgal Biomass and Habitat Characteristics

The RDA for biomass and the environmental parameters showed that all canonical axes were significantly correlated ($p < 0.05$; Monte Carlo simulations at 499 permutations) for the three stations in the Sibuti mangrove estuary.

The ordination diagram of the RDA showed strong correlations among the species (dependent variables) and the environmental parameters (independent variables) for all stations (Tables 4–6 and Figs. 6–8) of the study area.

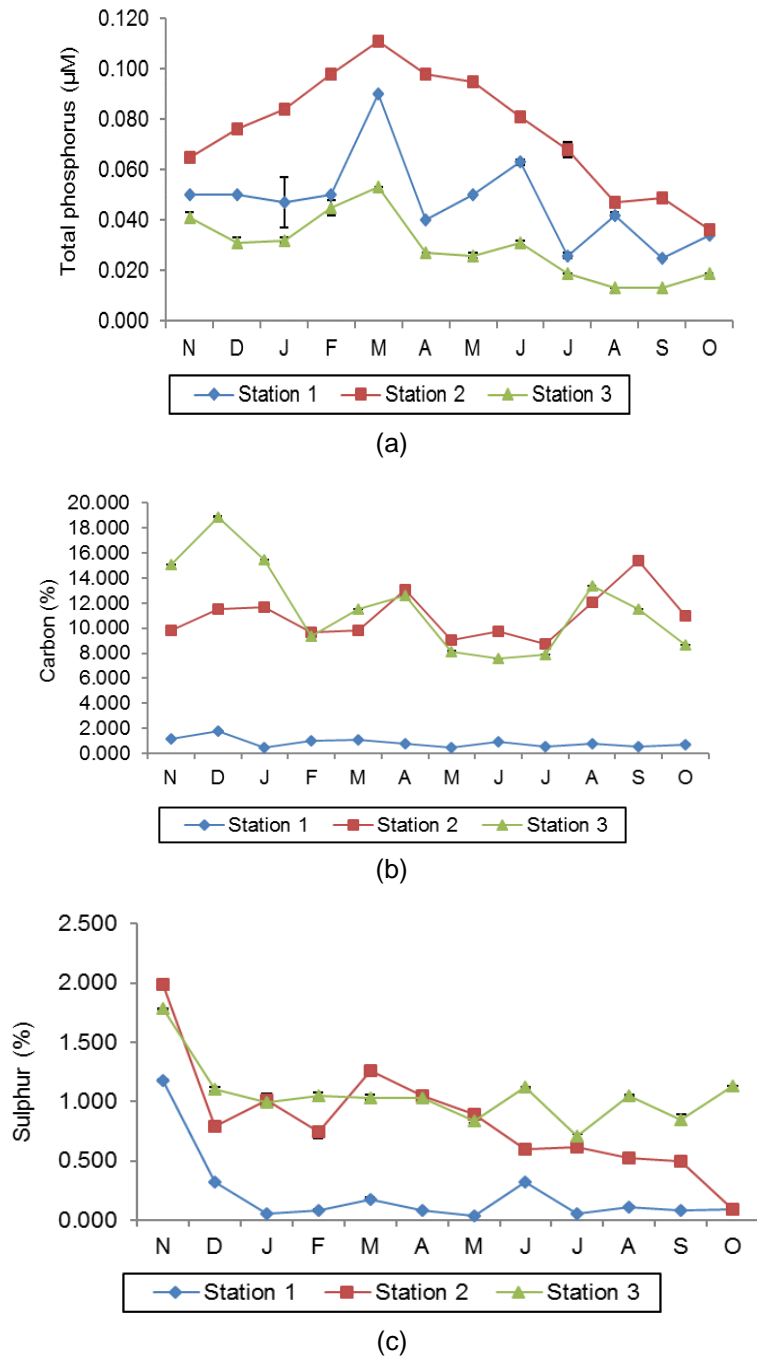
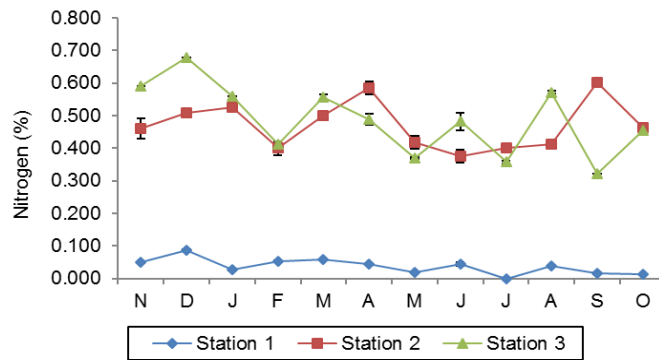
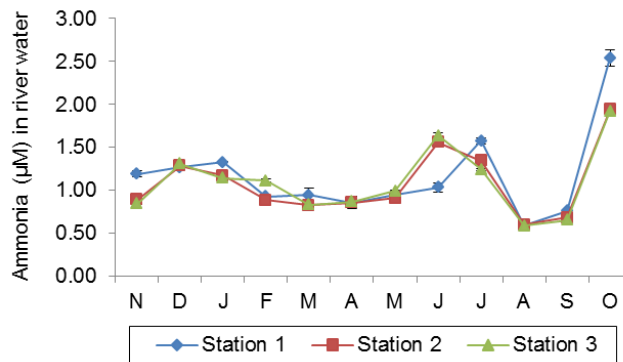


Figure 3: Monthly variation in physico-chemical parameters of the soil at different stations in Sibuti estuary: (a) total phosphorus; (b) carbon; (c) sulphur; (d) nitrogen. (continued on next page)

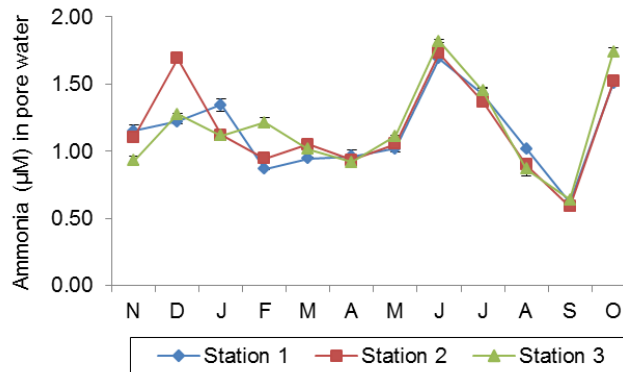


(d)

Figure 3: (continued).

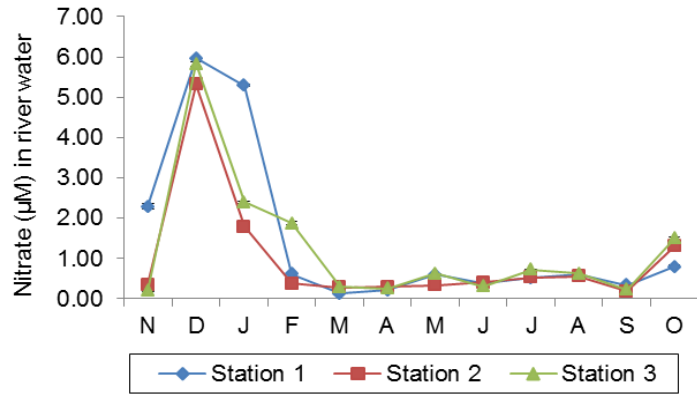


(a)

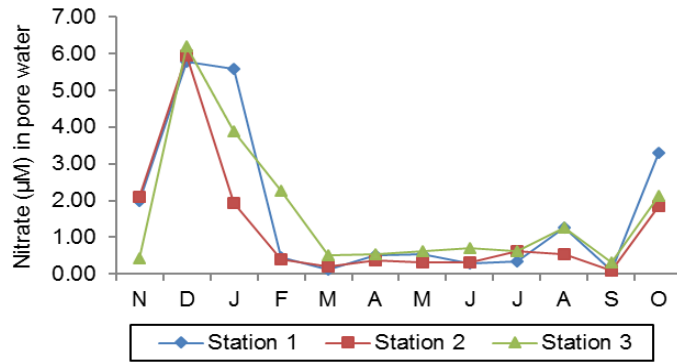


(b)

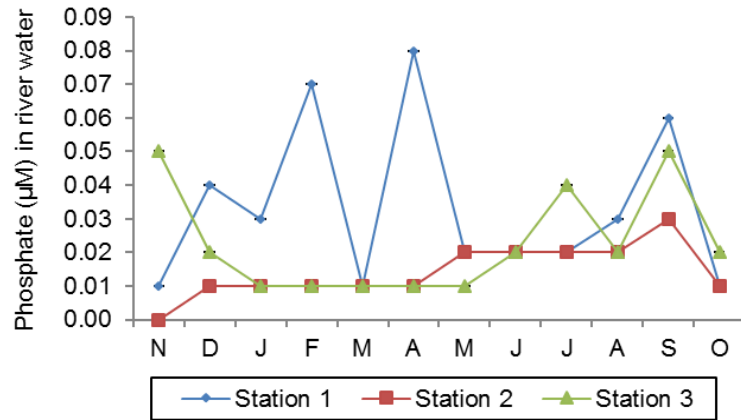
Figure 4: Monthly variation in physico-chemical parameters of river and pore water at different stations in Sibuti estuary: (a) ammonia in river water; (b) ammonia in pore water; (c) nitrate in river water; (d) nitrate in pore water; (e) phosphate in river water; (f) phosphate in pore water. (continued on next page)



(c)

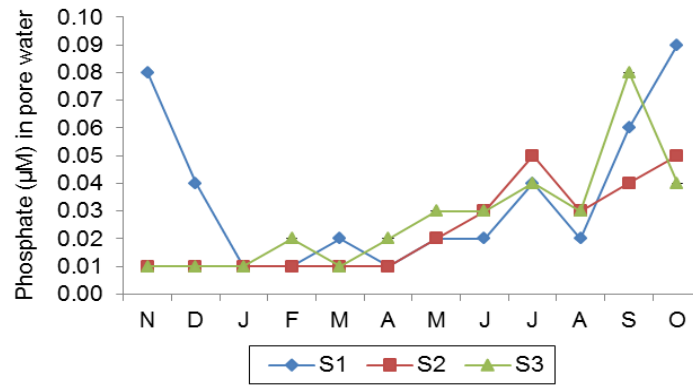


(d)



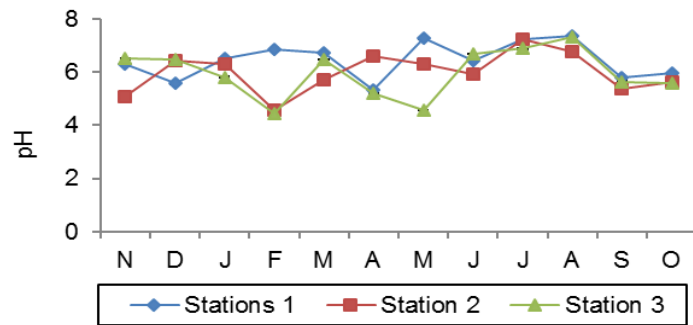
(e)

Figure 4: (continued)

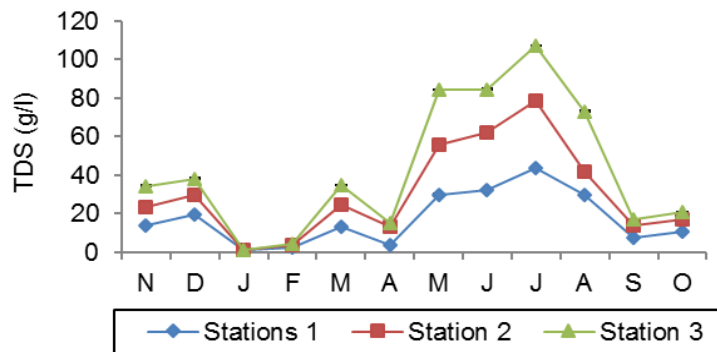


(f)

Figure 4: (continued)

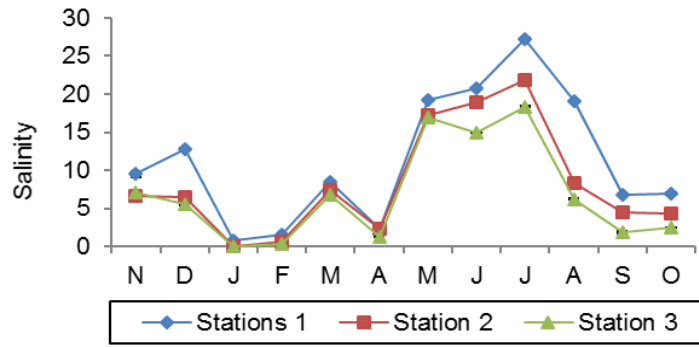


(a)

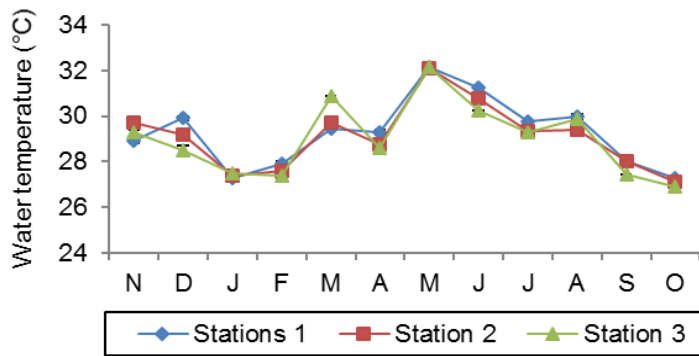


(b)

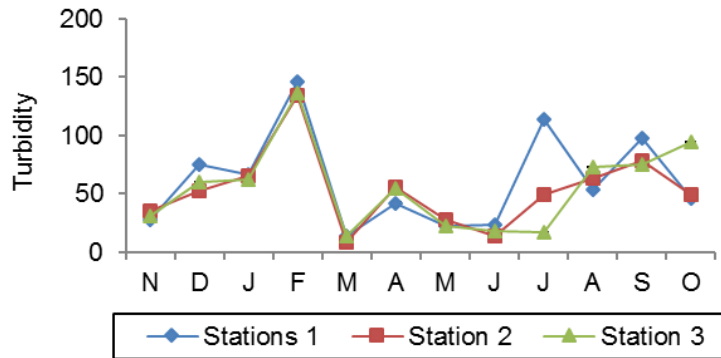
Figure 5: Monthly variation in physico-chemical parameters of river water at different stations in Sibuti estuary: (a) pH; (b) TDS; (c) salinity; (d) water temperature; (e) turbidity; (f) conductivity; (g) dissolved oxygen. (continued on next page)



(c)



(d)



(e)

Figure 5: (continued).

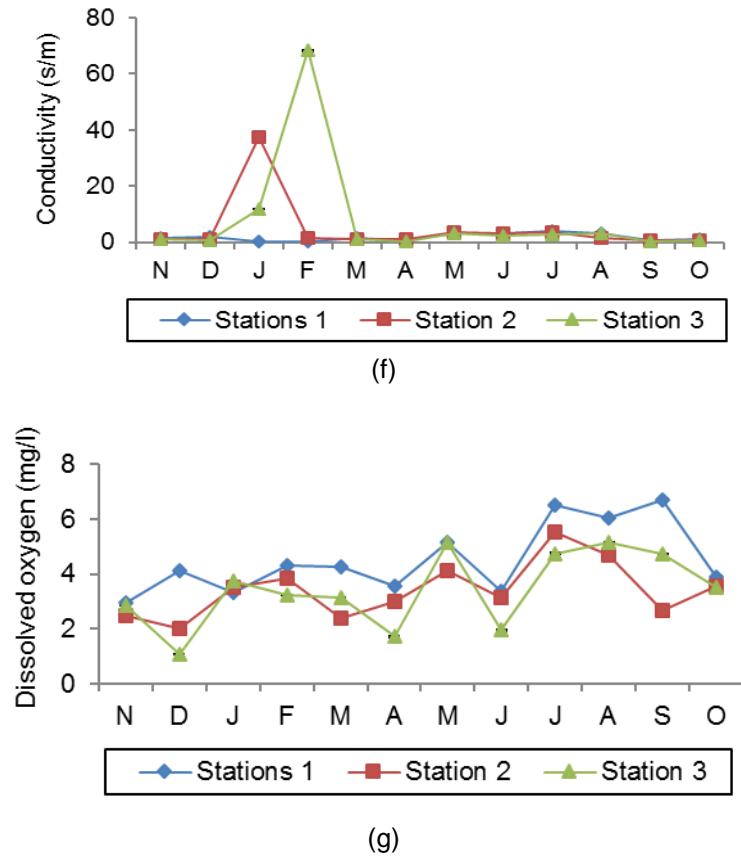


Figure 5: (continued).

Table 3: Yearly mean value of ammonium, nitrate, and phosphate contents (mg/L \pm SD) in the pore water and river water at three stations in Sibuti estuary, Sarawak Malaysia.

Nutrient	Pore water			River water		
	St 1	St 2	St 3	St 1	St 2	St 3
Ammonium	1.15 \pm 0.02	1.17 \pm 0.02	1.17 \pm 0.02	1.16 \pm 0.04	1.08 \pm 0.02	1.09 \pm 0.02
Nitrate	1.69 \pm 0.02	1.23 \pm 0.03	1.62 \pm 0.02	1.48 \pm 0.02	0.98 \pm 0.02	1.24 \pm 0.02
Phosphate	0.04 \pm 0.00	0.02 \pm 0.00	0.03 \pm 0.00	0.03 \pm 0.00	0.01 \pm 0.00	0.02 \pm 0.00

Note: St = station.

Table 4: Results of RDA for Station 1. Eigen values, species-environment correlation, and percentage variance of species data and species-environment relation at Station 1 in Sibuti estuary.

Axes	1	2	3	4	Total
Eigenvalues	0.930	0.036	0.022	0.008	1.000
Species-environment correlations	1.000	1.000	1.000	1.000	
Cumulative percentage variance					
of species data	93.000	96.700	98.800	99.600	
of species-environment relation	93.000	96.700	98.800	99.600	
Sum of all canonical eigenvalues					1.000

Table 5: Results of RDA for Station 2. Eigen values, species-environment correlation, and percentage variance of species data and species-environment relation at Station 2 in Sibuti estuary.

Axes	1	2	3	4	Total
Eigenvalues	0.994	0.006	0.000	0.000	1.000
Species-environment correlations	1.000	1.000	0.000	0.000	
Cumulative percentage variance					
of species data	99.400	100	0.000	0.000	
of species-environment relation	99.400	100	0.000	0.000	
Sum of all canonical eigenvalues					1.000

Table 6: Results of RDA for Station 3. Eigen values, species-environment correlation, and percentage variance of species data and species-environment relation at Station 3 in Sibuti estuary.

Axes	1	2	3	4	Total
Eigenvalues	0.910	0.090	0.000	0.000	1.000
Species-environment correlations	1.000	1.000	0.000	0.000	
Cumulative percentage variance					
of species data	91.000	100.00	0.000	0.000	
of species-environment relation	91.000	100.00	0.000	0.000	
Sum of all canonical eigenvalues					1.000

For Station 1, the first axis showed that *Hypnea* sp. was correlated with the total phosphorous, nitrogen, and carbon content in the soil, while the second axis showed that *Dictyota* sp., *B. anomala*, *C. stipitata*, and *C. minima* were correlated with soil sulphur, the pore water phosphate, and nitrate (river and pore water). The biomass of *C. ogasawaraensis* was correlated with the water temperature, air temperature, rainfall, and river phosphate and was heavily affected by the pH, TDS, and salinity. *Chaetomorpha* sp. and *C. adhaerens* were

correlated with the turbidity and dissolved oxygen and were heavily affected by the ammonium from the pore and river water.

For Station 2, the first axis showed that no macroalgal species was correlated with the environmental parameters, while the second axis showed that *C. minima* and *Hypnea* sp. were surprisingly affected by the soil sulphur.

For Station 3, the first axis showed that *Hypnea* sp. was correlated with sulphur, the phosphate from river water, soil carbon, soil nitrogen, pH, the total soil phosphorous, and the nitrate from the river and pore water. The concentrations of sulphur govern the existence of *Hypnea* sp., while the second axis showed that the presence of *B. anomala* was influenced by the ammonium in the river water.

DISCUSSION

The species of macroalgae recorded in this study are normally abundant in mangrove habitats and are rarely found in other habitats (Melville *et al.* 2005). Generally, *Bostrychia* and *Caloglossa* include common species that are found in mangrove ecosystems, which has been reported in Australian (Davey & Woelkerling 1985; King 1995; Melville & Pulkownik 2007), Asian (Aikanathan & Sasekumar 1994; Lin *et al.* 1997), and African mangrove habitats (Coppejans & Gallin 1989; King 1990; Phillips *et al.* 1994). The *Bostrychia*–*Caloglossa* association has been globally considered to be representative of the macroalgal assemblage composition of mangrove ecosystems on tropical coasts (Tanaka & Chihara 1987). *B. anomala* was the first reported species of mangrove macroalgae in Malaysian waters (John *et al.* 2013).

The presence and absence of macroalgae showed non-significant ($p>0.05$) monthly fluctuations during the one-year study period. This has also been observed in other marine and coastal habitats worldwide (Laursen & King 2000; Melville *et al.* 2005; Melville & Pulkownik 2007). In Brazil, the majority of epiphytic algae experience their maximum growth during the spring and autumn (Bouzon & Ouriques 1999) as well as during the dry season (Fernandes & Alves 2011). Researchers have also found higher amounts of mangrove macroalgae during the summer season (Steinke & Naidoo 1990), which was found to be influenced by nutrient availability, temperature, and light intensity. In contrast, studies by Perez-Estrada *et al.* (2012), Nedumaran and Perumal (2009), Liu *et al.* (2001), El-Sharouny *et al.* (2001), and Lin *et al.* (1997) found that mangrove macroalgae grow throughout the year, and seasonal influences on their growth were not noticed. It has been observed that the three stations in the Sibuti mangroves have their own biotic and abiotic factors that influence the species abundance of macroalgae (Broderick & Dawes 1998). In addition, the positions of mangrove trees and canopy gaps as well as light penetration are also likely related to the abundance and distribution of the macroalgal assemblage.

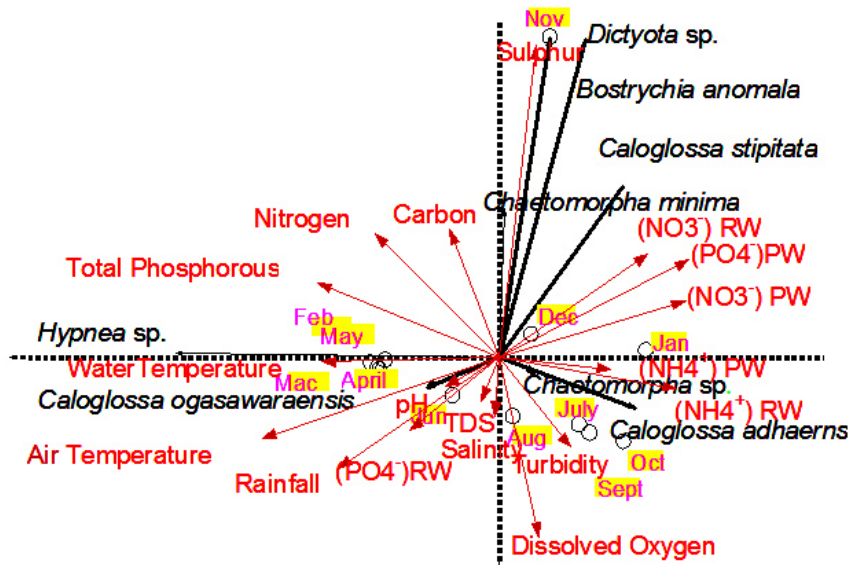


Figure 6: RDA showing tri-plots for macroalgae species vs. environmental variables at Station 1 in Sibuti estuary.

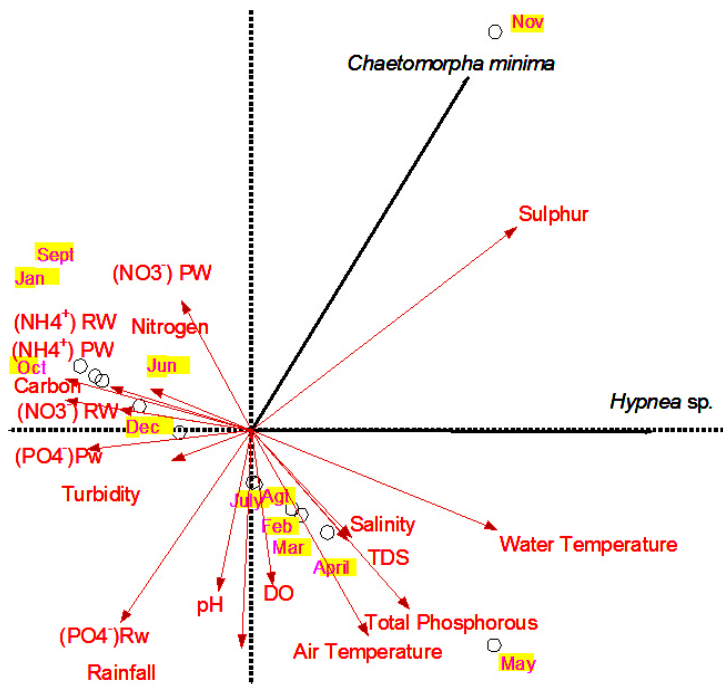


Figure 7: RDA showing tri-plots for macroalgae species vs. environmental variables at Station 2 in Sibuti estuary.

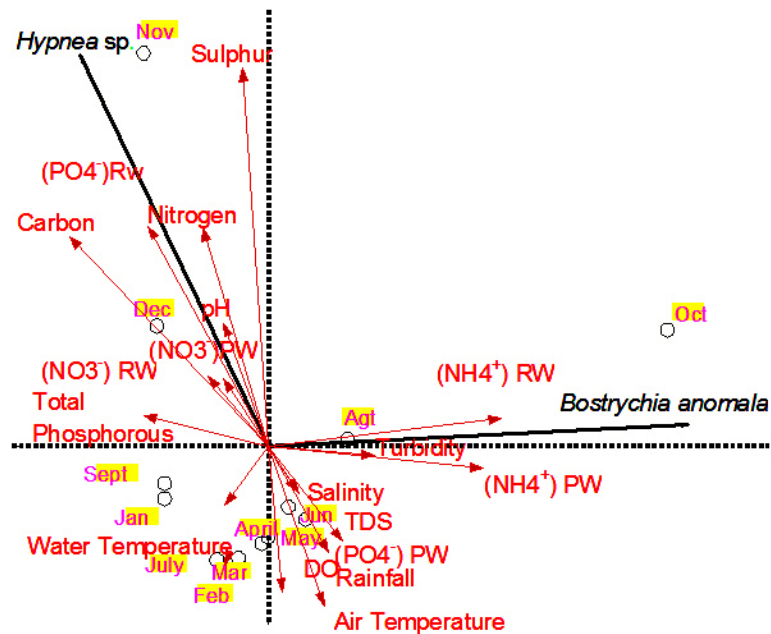


Figure 8: RDA showing tri-plots for macroalgae species vs. environmental variables at Station 3 in Sibuti estuary.

The mangrove trees were sparse at Station 1 but were dense at Stations 2 and 3 (Kaleem *et al.* 2015). This pattern could be of paramount importance by affecting the shading of the forest floor by preventing light penetration and eventually promoting the homogenous distributions of red algae (Karsten *et al.* 1994). Studies by Yubin *et al.* (2014) revealed that macroalgal biomass and species diversity are higher under high-density canopy than low-density forest canopy. The air and water temperature were significantly different among the months and stations. Water temperature, especially at the surface of a water body, is the physical factor influencing macroalgal growth, abundance, and geographical distribution in different regions (Nedumaran & Perumal 2009). According to Karsten *et al.* (1994), warmer air and water temperatures and suitable light intensity support macroalgal growth and result in higher species diversity and biomass.

The macroalgal frequency and biomass varied among the study stations in the Sibuti mangrove estuary. The biomass and number of macroalgae at Station 1 was found to be higher, most likely due to the suitable salinity range (~11.52 psu). Furthermore, this station is situated at the river mouth and has a direct connection with incoming seawater through the tides. This is in agreement with some other published reports worldwide (Oliveira 1984; Bouzon & Ouriques 1999; Nedumaran & Perumal 2009). The species *Bostrychia* sp. and *Caloglossa* sp. were not detected at Stations 1 and 2 in the present study, most likely due to the lower salinity (6.81 to 8.23 psu) at these stations. Being a hardy species, *Hypnea* sp. was found at all stations throughout the year in the Sibuti mangroves,

with a mean biomass ranging from 141.72 to 210.56 mg/cm². It is well-known that macroalgal species are normally long-lived plants, and they can store huge amounts of nutrients during the nutrient limitation and environmental restriction phase in mangrove habitats (Hein *et al.* 1995; Pedersen & Borum 1996, 1997). Hence, it is not surprising that the abundance of *Hypnea* sp. was not found to be influenced by the monthly variation in the environmental parameters in the present study. Indeed, excess growth of this species during the rainy season or mortality during summer was not noticed.

CONCLUSION

Eight species from three groups of macroalgae, namely Rhodophyta and Phaeophyta, were found in this mangrove ecosystem. The first distributional record of mangrove macroalgae in Malaysian waters was for the species *B. anomala*. The macroalgal distribution was influenced by some abiotic and biotic factors, such as water nutrients, dissolved solids, and salinity, in the mangrove habitat of Sibuti.

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