Pertanika J. Trop. Agric. Sci. 35 (3): 623 - 630 (2012)

PERTANIKA JOURNALS

TROPICAL AGRICULTURAL SCIENCE

Journal homepage: http://www.pertanika.upm.edu.my/

Three Months' Monitoring of Environmental Factors, Biomass, Length and Size Classes Variation of *Sargassum* Species at Cape Rachado, Port Dickson

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ABSTRACT

Seasonality in biomass, thallus length and size classes of three *Sargassum* species, namely, *S. baccularia (Mertens) C. Agardh, S. binderi Sonder ex J. Agardh* and *S. siliquosum J. Agardh*, was analysed based on destructive sampling using line-transect-quadrat method from October to December 2008. Results showed that *S. baccularia* was most abundant among the three species. The plant was frequently found in the length class of 0 – 4.9 cm (79.68 %), and this was followed by *S. binderi* in length class of 5.0 – 9.9 cm (44.12 %), and *S. siliquosum* in the length class of 0 – 4.9 cm (66.67 %). The *Sargassum* species were observed to increase gradually in their biomass and mean thallus length further away from shore. Within three months, *S. baccularia* experienced a growth in its biomass and mean thallus length, while both *S. binderi* and *S. siliquosum* experienced a decrease in terms of biomass but an increase in their mean thallus length. Data also showed a correlation with environmental parameters, such as pH, DO, salinity, nitrate, phosphate and ammonia.

Keywords: Biomass, Cape Rachado, Port Dickson, Environmental parameters, Mean thallus length, *Sargassum*

INTRODUCTION

Seaweeds are macroscopic algae that can be divided into *Chlorophyceae, Rhodophyceae* and *Phaeophyceae*, based on their colour pigment. Lüning (1990) stated that diversity of seaweed species worldwide includes a rough figure between 6500 to 8000 species. Under *Phaeophyta,* more than 400 species have been estimated as belonging to the genus of *Sargassum* (Wong & Phang, 2004).

Seaweeds have enormous potential to be used as raw materials in producing many economically important products. Besides

ARTICLE INFO

Article history:
Received: 5 March 2010
Accepted: 12 May 2011

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ISSN: 1511-3701

being eaten and used as fertilizer, seaweeds contain many commercially important polysaccharides such as agar, alginate and fucoids. Seaweeds, especially those of the *Sargassum* species, have also been utilized in the bioremediation of contaminated water (Bina *et al*., 2006).

The site of the study, i.e. Cape Rachado, is a stretch of coast surrounded by coral reefs, sandy beaches, rocky shores and mangroves. Each of these geographical areas exposes seaweeds to different environmental stresses that allow the growth of only a few selected species. This is evident in the zonation patterns caused by gradually varying parameters from shore towards sea. Ooi (2001) pointed out that diversity and abundance of seaweeds in a particular area could also give a rough indication as to the general health of a particular ecosystem.

Seaweeds show a seasonal growth cycle that is caused by climatic changes occurring throughout the year. In particular, *Sargassum* has been shown to exhibit seasonal cycles of growth, reproduction, senescence and die back (Ang, 2006). Thus, phenological studies on these seaweeds are important to provide precious information for local seaweed cultivation. The objectives of this study were to determine the diversity and the abundance of *Sargassum* species found along the fringing coral reef flats of Cape Rachado, Port Dickson, compare the zonation patterns of *Sargassum* species and also determine the growth of *Sargassum* species over a period of three months in relation to the varying environmental parameters.

MATERIALS AND METHODS

Samples of seaweed were collected from Cape Rachado on a monthly basis from October to December 2008. Line-transect and systematic quadrat sampling methods were employed. Three 100 m line-transects, marked as Line 1, Line 2 and Line 3, were placed perpendicular to the shore. On each line, a 0.09 m^2 (0.3 m × 0.3 m) quadrat was placed every 10 m interval and all seaweeds within each quadrat were harvested and placed separately in labelled plastic bags. Water sampling data were taken at the site using portable HANNA meter (HI 98280, USA). In addition, seawater samples were collected for nutrient analysis.

In the laboratory, water samples were tested for ammonia, nitrate and phosphate concentrations using Hach meter (DR/890, USA) while pH was measured using a pH meter (Delta 320, China). The seaweed samples were washed thoroughly with tap water, after which, three different species of *Sargassum* were identified and separated according to their quadrats. Individual samples were also measured for their lengths and weighed according to species per quadrat using an analytical balance (Adventurer™ Pro Av812, USA) to obtain the wet weight per quadrat. As for the dry weight per quadrat, the samples were oven-dried at 105 °C for 48 hours and then reweighed. Biomass per quadrat was divided by the area of the quadrat (0.09 m^2) and recorded in g WW m^{-2} for wet weight and g DW m^{-2} for dry weight. Thallus length of all the plants was measured before obtaining wet weight. The thallus length was measured as the distance from the end of the holdfast to the apex of the longest branch. The measured length of all the plants was averaged to give the mean plant length. The overall percentage coverage of each species in the study area was obtained by dividing the number of plants from each *Sargassum* species with the total number of the *Sargassum* plants and then multiplied by 100%.

All the statistical analyses were conducted using the SPSS 15.0 software. One way ANOVA and Post Hoc Test (Tukey HSD) were also applied to determine any significant differences in biomass and mean thallus length of each *Sargassum* species between months. Meanwhile, the Pearson's correlation coefficient analysis was applied to correlate changes in the dry weight of *Sargassum* species with the environmental parameters.

RESULTS AND DISCUSSION

The seaweed samples found from the study site included *S. baccularia, S. binderi* and *S. siliquosum,* among a vast variety of other species. Results presented in Fig.1 show that the thallus length of *S. baccularia* most frequently range in the length class of 0.0 – 4.9 cm (79.68 %), with a maximum length of 20.0 – 24.9 cm (0.32 %). As for *S. binderi*, the samples of length class of 5.0 – 9.9 cm were most frequently found (44.12 %), with the maximum thallus length of 30.0 – 34.9

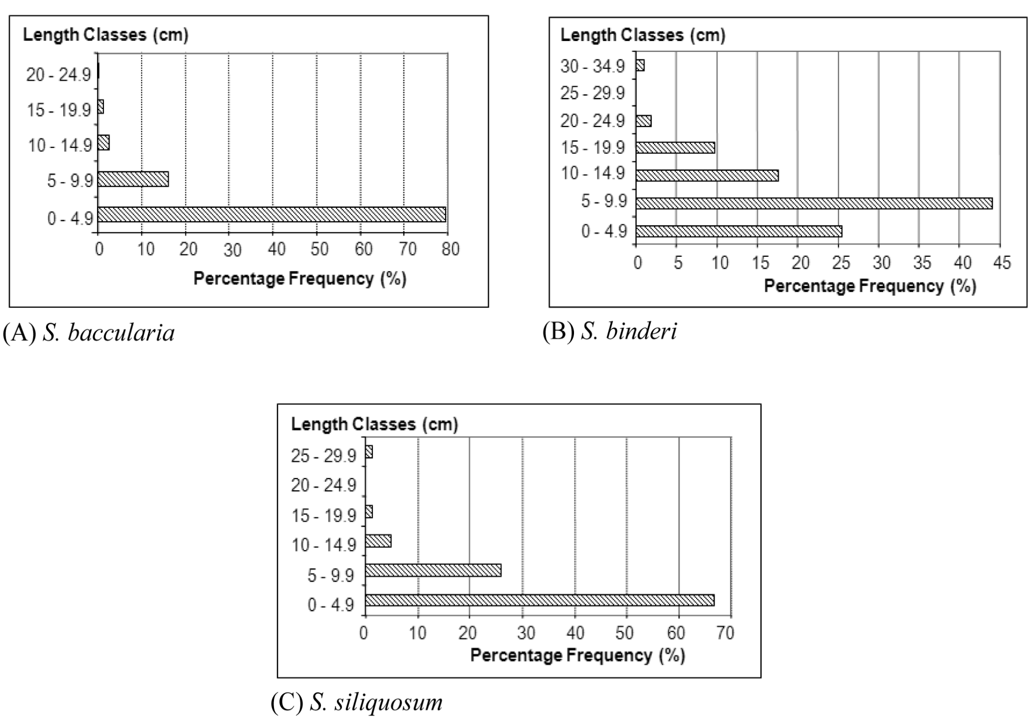


Fig.1: Overall Percentage Frequency for Various Length Classes.

TABLE 1
Number of Plants and Percentage Coverage of the *Sargassum* species at Cape Rachado, Port Dickson from October to December 2008

Species	October 2008		November 2008		December 2008		Total %	
	No. of Plants	%	No. of Plants	%	No. of Plants	%		
S. baccularia	157	59.02	203	84.94	265	86.88	625	77.16
S. binderi	56	21.05	32	13.39	16	5.25	104	12.84
S. siliquosum	53	19.93	4	1.67	24	7.87	81	10.00
Total	266	100	239	100	305	100	810	100

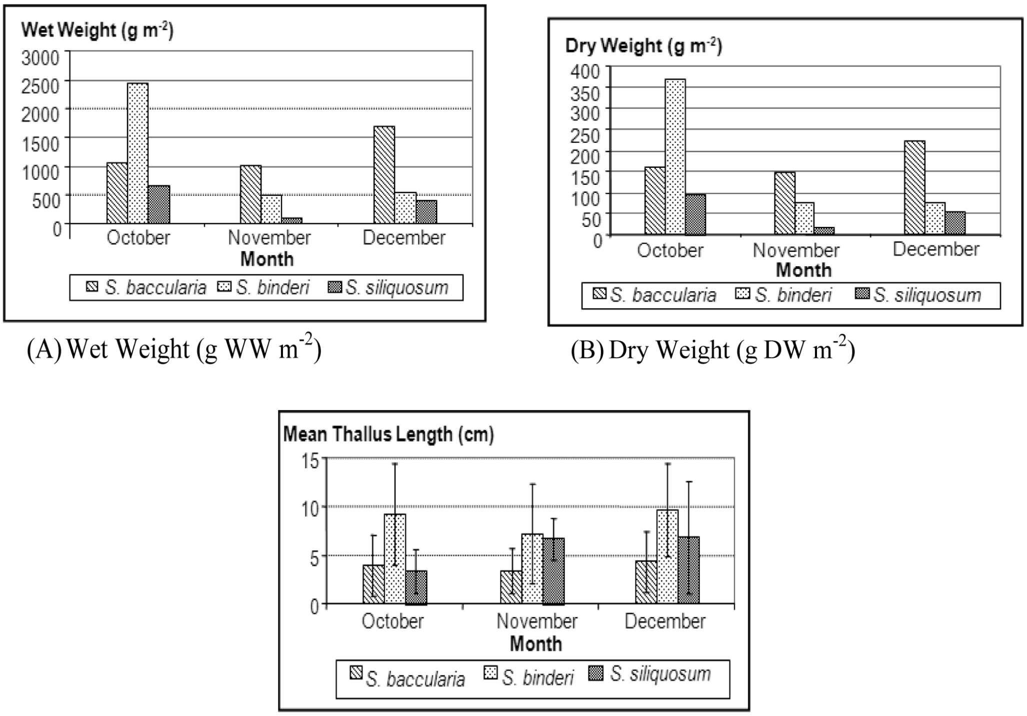
cm (0.98 %). Lastly, *S. siliquosum* was most frequently found in the length class of 0.0 – 4.9 cm (66.67 %), with the longest samples from the length class of 25.0 – 29.9 cm (1.23 %).

These obtained length classes are relatively very short compared to those found in the neighbouring countries such as Philippines (Trono, 1998) and Thailand (Noiraksa *et al*., 2006). Wong and Phang (2004) stated that *S. baccularia* and *S. binderi* plants of Cape Rachado were generally found to be in smaller length classes throughout the year. This is due to the spatial distribution that places these seaweeds at the mid to upper intertidal zone, as opposed to the species of other countries that were placed at the lower intertidal zone. Therefore, desiccation stress that is experienced by seaweeds exposed to air restricts the growth of seaweeds in Cape Rachado. Moreover, some plants were observed to detach from the holdfast once the tide comes in.

Table 1 shows that within three months, *S. baccularia* represented the most abundant *Sargassum* species along the fringing coral reef flats (77.16 %), followed by *S. binderi* (12.84 %) and *S. siliquosum* (10 %). In addition, the total number of plants collected decreased from October (266 plants) to November (239 plants), but increased in December (305 plants).

S. baccularia biomass (wet and dry weight) increased within three months, while *S. binderi* and *S. siliquosum* decreased (Fig.2). Similarly, the mean thallus lengths of *S. baccularia* and *S. binderi* decreased from October to November, but these increased in December. However, *S. siliquosum* gradually increased in length within three months. Meanwhile, the mean thallus length of *S. baccularia* was significantly different (F = 5.707, $p < 0.05$) between the months of November (i.e. mean thallus length = 3.43 ± 2.34 cm) and December (i.e. mean thallus length = 4.33 ± 3.05 cm) 2008; as for *S. siliquosum,* F = 7.513, $p < 0.05$ between October (mean thallus length = 3.49 ± 2.24 cm) and December (mean thallus length = 6.78 ± 5.73 cm) 2008.

Studies by Phang (1995) and Wong (1997) reported that the abundance of *Sargassum* species peaked during the hot and dry inter-monsoon seasons but



(A) Wet Weight (g WW m^{-2})

(B) Dry Weight (g DW m^{-2})

(C) Mean Thallus Length (cm) (± SD)

Fig.2: Three months monitoring for all the *Sargassum* species.

degenerated during the wet and rainy monsoon seasons, as experienced during the period of this study. Wong (1997) observed that the peak growth and reproduction of the *Sargassum* species occurred in June 1995, but thereafter, the mean thallus length decreased up to December 1995. This represented the degeneration of seaweeds after the peak reproduction (Wong & Phang, 2004). The appearances of new recruits were evident only after a few months from the reproduction phase. This resulted in a shift of seaweed mean thallus length to smaller length classes the subsequent months, as seen in this current study. In seaweed cultivation, it would be a bad period to harvest the crops during the last quarter of the year, as opposed to middle of the year where growth is at its peak.

In addition, the changes in the environment play an important role in determining the growth or degeneration of seaweed. Table 2 records the monthly average measurements of environmental parameters. In the present study, the dry weight of the *Sargassum* species was found to correlate with environmental parameters (Table 3). *Sargassum baccularia* experience positive growth, and also increase in pH and phosphate levels. For *S. binderi* to grow, there should be increases in pH, DO and salinity, but decreases in nitrate, ammonia

TABLE 2
Averaged Measurements of Monthly Environmental Parameters

Parameters	October	November	December
*Water Temperature (°C)	29.73	-	30.2
*DO (ppm)	4.11	-	1.66
*Salinity (ppt)	29.87	-	28.79
pH	7.86	7.65	6.43
Phosphate (mg L^{-1})	0.07	0.09	0.04
Nitrate (mg L^{-1})	0.3	1.25	0.5
Ammonium (mg L^{-1})	0.02	0.05	0.04

*Measurements for November 2008 are unavailable due to faulty equipment.

TABLE 3
Correlation of dry weight (g DW m^{-2}) with environmental parameters

Parameters	Correlation Coefficient (r) for *Sargassum* species		
	S. baccularia	*S. binderi*	*S. siliquosum*
pH	0.639*	0.499*	0.363
Phosphate (mg L^{-1})	0.824*	0.386	0.925*
Nitrate (mg L^{-1})	-0.441	-0.698*	-0.532*
Ammonium (mg L^{-1})	-0.102	-0.646*	0.082
Water Temp (°C)	-0.175	-0.782*	0.189
DO (ppm)	0.427	0.918*	0.075
Salinity (ppt)	-0.061	0.613*	-0.414

* Significantly correlated ($p < 0.05$)

and water temperature. Meanwhile, for *S. siliquosum* to grow, there should be an increase in phosphate, while a decrease in the nitrate level.

It is crucial to highlight that pH, phosphate and nitrate concentrations play very important roles in the growth of *Sargassum*. These are in agreement with the results by Wong and Phang (2004), whereby the increase in *S. baccularia* biomass was found to be significantly correlated with the increase in the phosphate levels, while an increase in the dry weight of *S. binderi* was significantly correlated with the decreases in the ammonia and nitrate levels.

According to Wong and Phang (2004), rainfall was the most important factor influencing the growth of *Sargassum*. Coincidently, the period of this particular study fell in the monsoon period which receives constant rainfall. Combined with strong waves and high turbidity, this will affect the parameters tested below. For instance, slightly acidic water droplets from the rain will affect pH of seawater, which in turn discourages the growth of seaweeds during that period. Strong waves that constantly disturb the seabed will also encourage circulations of nitrate and ammonia, and thus increasing their concentrations in seawater.

Meanwhile, high nitrate concentrations affecting *S. binderi* and *S. siliquosum* more than *S. baccularia* can be explained by the spatial distribution of these plants. In particular, *S. baccularia* has been found to be more abundant nearer to shore, while *S. binderi* and *S. siliquosum* were found more in deeper waters, or further away from shore. This indicates that both *S. binderi* and *S. siliquosum* were exposed more to the high nitrate levels detrimental to their growth.

CONCLUSIONS

In conclusion, the analysis of the length and size classes revealed that the three *Sargassum* populations comprised mainly small plants, indicating the recruitments of new plants during the three months monitoring. The important parameters affecting the biomass of *S. baccularia* are pH and phosphate, and these include all the parameters tested except for phosphate for S. binderi, whereas for *S. siliquosum* are phosphate and nitrate, respectively.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge Department of Science, Faculty of Engineering and Science, Universiti Tunku Abdul Rahman (UTAR), for providing financial support and research facilities.

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