

Morphological Studies of Marine Macroalgae at Sri Rusa Beach, Port Dickson, Negeri Sembilan, Malaysia

*Kajian Morfologi Makroalga Marin di Pantai Sri Rusa, Port Dickson, Negeri Sembilan,
Malaysia*

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Abstract

An attempt was made to record the biodiversity and morphological characteristics of marine macroalgae within the littoral and sublittoral zones at Sri Rusa beach, Port Dickson, Negeri Sembilan, Peninsular Malaysia. Samples collected during low tides consisted a total of nine species represented by three divisions, six of which were from the Chlorophyta, two from the Phaeophyta and one species of the Rhodophyta. Among the dominant species commonly found in this study area were the Phaeophytes *Sargassum polycystum* C. Agardh and *Padina minor* Yamada. For the division Chlorophyta, the genus *Caulerpa* was the largest, represented by five species, namely *C. lentillifera*, *C. microphysa*, *C. prolifera*, *C. racemosa* and *C. sertulariodes*. The genera *Cladophora* from Chlorophyta and *Acantophora* from Rhodophyta were each represented by one species, namely *Cladophora* sp. and *Acantophora specifera*. Most of the macroalgae found in the littoral and sublittoral zones were attached to sand and rock as their substrates. The presence of dead and living corals provide additional habitat. Descriptions of the general morphology of these macroalgae are presented.

Keywords biodiversity, chlorophyta, macroalgae, phaeophyta, rhodophyta

Abstrak

Satu usaha telah dijalankan untuk merekod biodiversiti dan ciri-ciri morfologi makroalga marin dalam zon litoral dan sublitoral pantai Sri Rusa, Port Dickson, Negeri Sembilan, Semenanjung Malaysia. Sampel yang telah dikumpulkan semasa air laut surut berjumlah sebanyak sembilan spesies dan mewakili sebanyak tiga divisi, enam daripadanya Chlorophyta, dua daripada Phaeophyta dan satu spesies dari Rhodophyta. Antara spesies dominan yang biasa dijumpai di kawasan kajian ini ialah Phaeofita *Sargassum polycystum* C. Agardh and *Padina minor* Yamada. Daripada divisi Chlorophyta, genus *Caulerpa* merupakan yang terbesar yang diwakili oleh lima spesies, iaitu *C. lentillifera*, *C. microphysa*, *C. prolifera*, *C. racemosa* and *C. sertulariodes*. Genera *Cladophora* daripada Chlorophyta dan *Acantophora* daripada Rhodophyta setiap satunya diwakili dengan satu spesies iaitu, *Cladophora* sp. and *Acantophora specifera*. Kebanyakan makroalga yang dijumpai melekat di permukaan batu dan pasir. Terumbu karang sama ada hidup atau mati

berperanan sebagai habitat kepada makroalga. Huraian morfologi asas spesies makroalga ini juga dikemukakan.

Kata kunci biodiversiti, chlorophyta, makroalga, phaeophyta, rhodophyta,

INTRODUCTION

Marine macroalgae or seaweeds are plant-like organisms that generally live by attaching themselves onto rocks and other hard substrata in coastal areas. The plant body is generally undifferentiated into leaves, stem, or roots. However, not all sea plants are seaweeds for there are some flowering plants found in the sea, such as the sea-grasses (Teo & Wee, 1983).

Studies on geographical distribution patterns of organisms are important in predicting the effects of global climate on algal distribution and biodiversity. Changes in the global environment, including temperature, ocean pH, UV levels and nutrient content of coastal waters, are all expected to affect algal biodiversity and associated organisms (Raven, 2009). Su and Tse-Min (2007) postulated that understanding the macroalgae abundance and the factors influencing the species structure were important aspects of the ecological, environmental, aesthetic, and socioeconomic value of reefs.

Malaysia has a high diversity of marine algae. All together there are 261 taxa (Wong & Phang 2004) with about 6,000 species that have been identified and grouped into classes, namely green (Chlorophyceae), brown (Phaeophyceae) and red (Rhodophyceae) algae (Chee et al., 2011). The distribution and growth of macroalgae is influenced by physical and biological factors. The important parameters regulating algal growth are nutrient quantity and quality, light intensity, pH, wave action, substrate types, temperature and herbivory. Light intensity plays an important role but the requirement greatly varies with the depth and density of the macroalgae. Macroalgae are extremely tolerant to changes in salinity. The above mentioned factors are known limiting factors for growth, reproduction, settlement and dispersal of the macroalgae.

For more than 100 years, China and the neighbouring Asian nations have grown marine macroalgae for food, animal feed, pharmaceutical remedies, and cosmetic purposes. Macroalgal polysaccharides are used in food, cosmetics, paints, crop, textile, paper, rubber and building industries (Nirmal-Kumar et al., 2010). Macroalgae can provide food to the marine ecosystems. It is also ecologically important in providing an accommodating environment for other living organisms by supplying oxygen to the sea and acts as one of the primary producers in the marine food chain. Due to these properties, it is considered an important organism which is needed to maintain the ecosystem's stability.

Sharif Hossain et al., (2008) reported that macroalgae were one of the best sources of biofuel. Macroalgae grow faster than terrestrial crops, easily harvested compared to microalgae and can be harvested up to six times a year in warm climates. Besides, they have high sugar content for conversion to advanced biofuels and ethanol, absorb more airborne carbon than land-based plants, have no lignin and require no pretreatment for ethanol production. In fact, producing biofuel from macroalgae could be the only way to produce enough automotive fuel to replace current gasoline usage.

The objectives of this study were to collect, identify and examine the morphology and ultimately record the marine macroalgae communities found at Sri Rusa Beach, Port Dickson, Negeri Sembilan, Malaysia.

MATERIALS AND METHODS

Samples Collection Sites

Port Dickson is a well-known town in Negeri Sembilan, situated on the west coast of Malaysia 32 km from Seremban and 60 km from Kuala Lumpur. Port Dickson is situated facing the Straits of Malacca that separates Peninsular Malaysia from Sumatera Indonesia. Along the seashores of Port Dickson there are developments for tourism, urbanization and seashore activities. Study area surveys were undertaken from March to December 2011. A location of sampling sites was then identified at Marin Research Station, University Putra Malaysia, Teluk Kemang, Sri Rusa, Port Dickson, Negeri Sembilan, Malaysia (Figure 1).



Figure 1 Location of sampling sites, Sri Rusa beach, Port Dickson (circled area)

Collection of Macroalgae

Sampling and collecting of macroalgae were carried out during low tide at littoral and sublittoral zones. The area covered ranged within 20-200 meters of the seashore and focused on rocky terrain and other hard substrates along the coastal areas. Scalpels were used to cut away the main macroalgae from the substrates.

The collected samples were cleaned from debris and epiphytes with seawater and kept in polystyrene boxes. The algae were kept fresh by wrapping them in cotton soaked in sea water.

Samples were immediately transferred to the laboratory and cleaned thoroughly with tap water to remove the salt from the surface of the samples. The samples were immediately sorted and remains of epiphytes were completely removed using a soft brush so as not to damage the samples. The macroalgae were finally rinsed with sea water in order to maintain freshness of the samples.

Identification

Identification was carried out based on colour as well as morphological characteristics such as form, size and branch of thallus. Variations in pigmentation were used to categorize the samples which were then grouped into Chlorophyta, Phaeophyta and Rhodophyta.

RESULTS AND DISCUSSION

Nine species of macroalgae covering the whole division of Chlorophyta, Phaeophyta and Rhodophyta were then identified from the Sri Rusa beach, Port Dickson (Table 1).

Table 1 A list of macroalgal species collected from Sri Rusa Beach, Port Dickson

Division	Species	Order: Family
Chlorophyta	<i>Caulerpa lentillifera</i>	Caulerpales: Caulerpaceae
	<i>Caulerpa microphysa</i>	Caulerpales: Caulerpaceae
	<i>Caulerpa prolifera</i>	Caulerpales: Caulerpaceae
	<i>Caulerpa racemosa</i>	Caulerpales: Caulerpaceae
	<i>Caulerpa sertulariodes</i>	Caulerpales: Caulerpaceae
Phaeophyta	<i>Cladophora</i> sp.	Cladophorales: Cladophoraceae
	<i>Sargassum polycystum</i>	Fucales: Sargassaceae
Rhodophyta	<i>Padina minor</i>	Dictyotales: Dictyoceae
	<i>Acantophora spicifera</i>	Gigartinales: Rhodomelaceae

Under Chlorophyta the largest family was Caulerpaceae of which *Caulerpa* was the largest genus represented by five species, namely *C. lentifera*, *C. microphysa*, *C. prolifera*, *C. racemosa* and *C. sertulariodes*. The most dominant species found in this study area were the *Sargassum polycystum* and *Padina minor* from Phaeophyta. The genera *Cladophora* from Chlorophyta and *Acantophora* from Rhodophyta were each represented by one species, namely *Cladophora* sp. and *Acantophora spicifera*.

Figure 2a shows a stoloniferous plant, *Caulerpa lentifera*, that could grow up to 10 cm tall. It produces branched stolon, cylindrical in cross section and measures 1-2 mm in diameter. The descending branches bear tuft rhizoids (Figure 2b) that arise at irregular intervals from the ventral side of the stolon. The fronds (Figure 2c) are rather densely set, without or with very short stalks, naked at the lower section on the upright axis, usually less than 5 mm

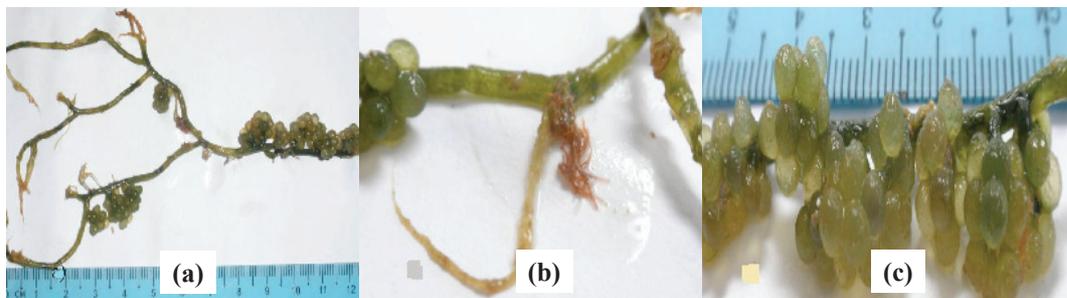


Figure 2 *Caulerpa lentifera*; a) branched stolon with fronds, b) stolon with tuft rhizoid, c) fronds

long and measuring 1-2 mm in diameter. Each of the frond measuring 1 - 3 mm in diameter consists of an irregularly branched but more often unbranched cylindrical axis, completely and usually densely covered by sub-spherical or more or less club-shaped branchlets. *Caulerpa lentillifera* is usually found on rocks, coral reefs and sand-mud substrates in the littoral zone.

Figures 3a and 3b show *Caulerpa microphysa* with a green thallus of about 15 cm in length. The stolon is less than 1 cm in diameter, sparsely ramified, bears short-stalked upright fronds, composed of a group of 4 - 15 spherical ramuli each with a diameter of 2 mm. *Caulerpa microphysa* grows on rocks surfaces at the littoral and sublittoral zones.

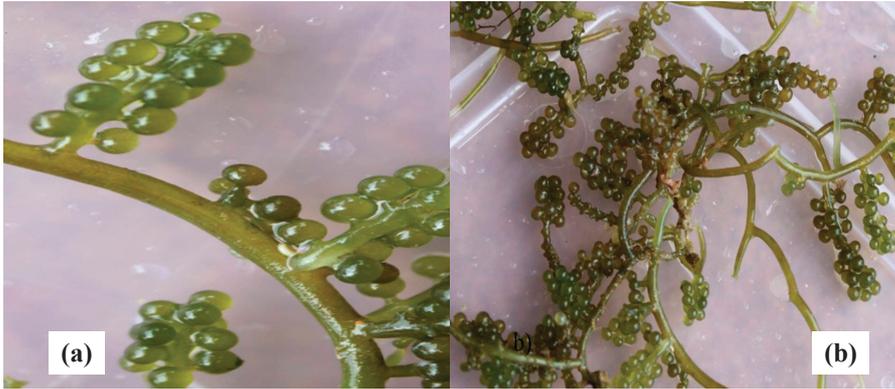


Figure 3 *Caulerpa microphysa*; a) & b) thallus with fronds composed of a group of 4 -15 spherical ramuli

Caulerpa prolifera has a creeping stolon with rhizoids which branch at the lower surface while assimilator vertical branches appear in the distance about 0.5 – 1 cm forming green colonies (Figure 4). The assimilator branch has a short stalk of about 2 - 5 cm long. The branch is linear like a narrower band, usually less than 5 mm wide and emerges from a single stem. The branches always have smooth edges. *Caulerpa prolifera* grows on rocks in shallow intertidal areas.



Figure 4 *Caulerpa prolifera*; branch shaped in linear and narrow band

Caulerpa racemosa has a light green thallus with 1- 3 cm tall assimilators (Figure 5a). The small axis is only 1 mm thick comprising a compact clusters of plants with imbricately arranged top-shape ramuli. On the average the ramuli is 1.5 - 2 mm in diameter (Figure 5b). The stolon has a small diameter at the base and gradually increases in size towards apex. Stolon branching is thin and less than 1 mm in diameter. Its habitat is on rocks and sands in the littoral zone of the beach (Figure 5c).

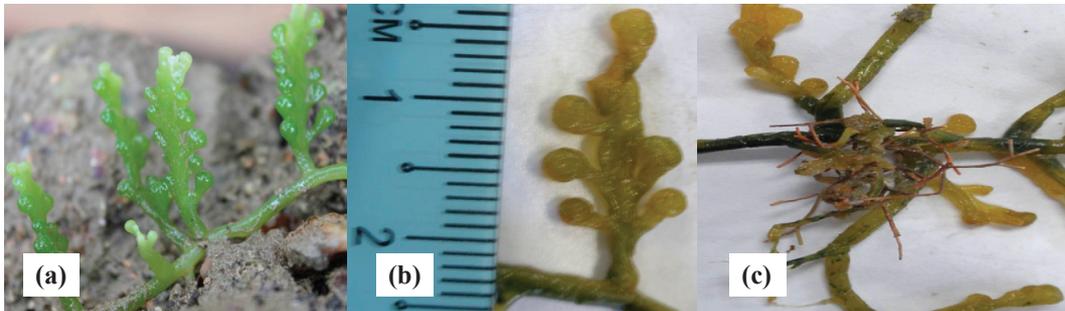


Figure 5 *Caulerpa racemosa*; a) thallus with assimilators, b) ramuli imbricate arrangement, c) stolon branching

Caulerpa sertularioides is dark green and grows in colonies of densely branched stolons. *Caulerpa sertularioides* anchors itself with the help of rhizoids branching at the bottom and assimilators branching vertically at the top. The assimilator branch is flat, approximately 15 cm in length. The branching system is rarely simple with pinnate meeting. Pinnates are contrary and cylindrical with slightly curved at the tip (Figure 6) about 1 - 2 cm in diameter and 3 - 5 cm in length. Pinnate is broader at the base than the apex. Its habitat is in the shallow area substrates of sands and rocks.



Figure 6 *Caulerpa sertularioides*; branching system with pinnate

Cladophora sp. grows as thin and hair-like threads up to 10 cm long (Figures 7a and 7b). These hair-like threads form slippery mats that are attached to rocks (Figure 7c) and

other solid objects at or just below the water line. The genus *Cladophora* contains many species that are rather difficult to separate and classify because of the great variation in their appearances due to being influenced by habitat, age and environmental conditions.

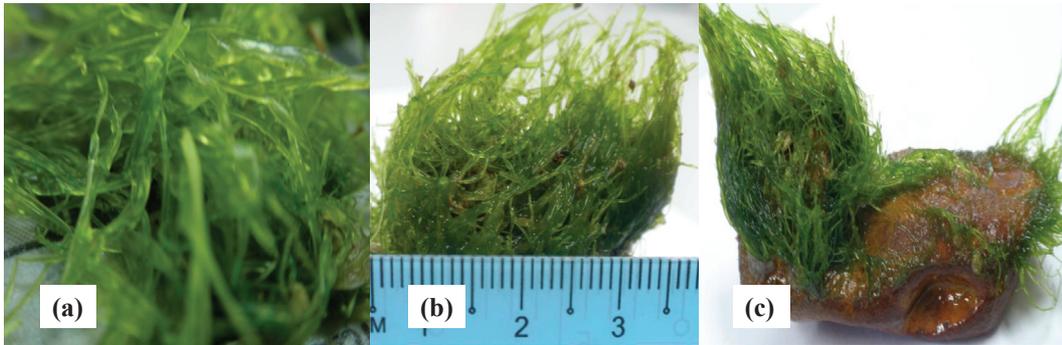


Figure 7 *Cladophora* sp.; a) & b) hair-like threads, c) hair-like threads attached to rocks

Species of the genus *Sargassum* are generally brown to dark green in colour and consist of a holdfast, a stipe, and a frond. Oogonia and antheridia occur in conceptacles embedded in receptacles on special branches. Some species have berrylike gas-filled bladders which help keep the fronds afloat closer to the sunlight to promote photosynthesis. Thus, long pieces often form floating rafts even after they had been broken off from their holdfast. Many have a rough sticky texture, together with a robust but flexible body that helps it to withstand strong water currents. The stems grow to about 10 cm or longer (Figure 8a). Attached to the stem are inflated air bladders (Figure 8b) and leaf-shaped blades (Figure 8c). The leaves may be narrow, broad or small measuring 1-5 cm in length. Although these plants appear to have the same morphological features as the root, stems and leaves of terrestrial plants, their cells are simpler and not organized in the same degree of complexity.

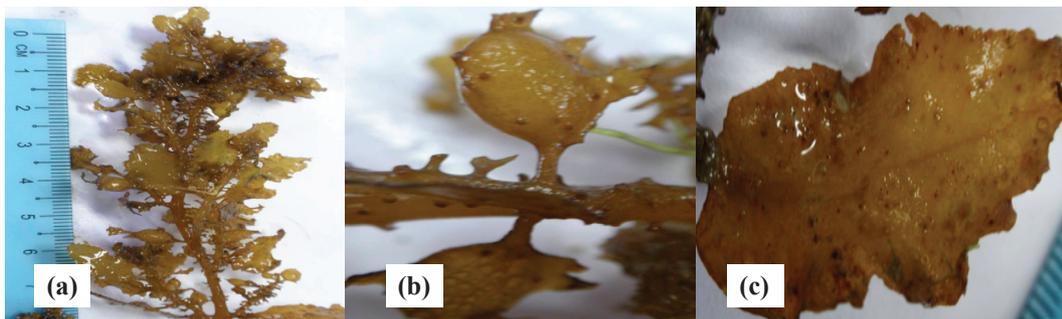


Figure 8 *Sargassum polycystum*, a) 'stems' grow to about 10 cm or longer, b) 'stem' inflated air bladders, c) leaf-shaped blades

Padina minor is a species of marine brown algae with frond or flabellate thallus that is divided into lobes. It is yellowish brown when dry and reaches a height of 7 cm (Figure 9a).

The genus *Padina* is widely distributed throughout the tropics and very easily recognized in the field. Its frond typically consists of two or more layers of cells while the stipe is composed of four or more layers. The upper surface is calcified to varying degrees, covered by white chalky substances arranged in bands that function as their reproductive structures occurring sometimes on the lower surface. Below the surface, it is divided into concentric zones of equal distance and width of line capillary (Figure 9b and 9c). *Padina minor* is usually found on rocks and sands in the shallow littoral zone.



Figure 9 *Padina minor*; a) flabellate thallus, b) & c) thallus surface is divided into concentric zones of equal distance and width of line capillary

Acantophora spicifera has a root-like shape (Figure 10a) holdfast for attachment to hard bottoms such as rocks, basalt ledges or dead coral heads. From the holdfast, erect fronds branch out with solid cylindrical branches. The main branches have short, determinate branchlets that are irregularly shaped and spinose. Branchlets are hook-like, brittle and fragment easily under heavy wave action. *Acantophora spicifera* in intertidal, high motion areas are often very dark in colour. Usually, it is of lighter colour in shallow areas with low water motion and reflective sandy or silty bottoms. *Acantophora spicifera* grows upright to approximately 8 - 15 cm (Fig 10b).

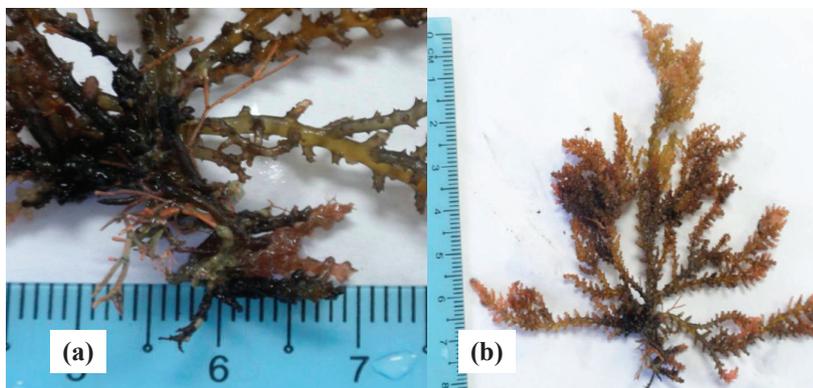


Figure 10 *Acantophora spicifera*; a) & b) holdfast with root-like shaped and fronds with solid cylindrical branches

The diversity of marine macroalgae at Sri Rusa beach, Port Dickson is represented by the presence of nine different species (Figure 1) dominated by the species from Phaeophyta of the families Sargassaceae and Dictyotaceae. The dominant and most common species are *Sargassum polycystum* and *Padina minor*. Similar results were obtained in previous studies by Mijan Uddin *et al.* (2007) whereby, besides *Sargassum polycystum* and *Padina minor*, other dominant species, such as *S. ilicifolium* and *S. siliquosum* were reported. Bymers *et al.* (2005) also reported fleshy canopy seaweeds such as *Sargassum* dominated the shallow areas of the shore, typical of foliose algae that only grow at the lowest level on the shores. The rocky and fine sand shallow areas of Port Dickson beach had provided suitable habitats for the *Sargassum* species. In addition, wave action also plays an important role in controlling seaweed recruitment.

The largest family in Chlorophyta was Caulerpaceae of which *Caulerpa* was the largest genus represented by five species, namely, *C. racemosa*, *C. prolifera*, *C. microphysa*, *C. lentillifera* and *C. sertulariodes*. A high diversity of Caulerpaceae was the result of sedimentation, an important physical factor affecting benthic communities at coastal areas (Piazzini *et al.*, 2007). Sediments that accumulate on rocky substrate are important agents of stress and disturbance. They can cause burial, scour and profound modifications to the characteristics of the bottom surface, and interact with other important physical and biological processes. The effects of sedimentation are complex, because they involve both direct outcomes on settlement, recruitment, growth and survival of individual species, and indirectly through mediation of competitive and/or predator-prey interactions. The ability to trap sediments can enhance the spread, avoiding predation and favouring the competitiveness of these species (Airoldi *et al.*, 2005).

CONCLUSION

This study revealed that the Sri Rusa beach, Port Dickson has a diversity of marine macroalgae that consisted of nine species, six from the Chlorophyta, two from Phaeophyta and one from Rhodophyta. From the division of Chlorophyta, the genus *Caulerpa* presented the most number of species. *Sargassum polycystum* and *Padina minor* from Phaeophyta were the dominant species in this study area. It is hoped that the results would be useful in extending the biogeographical distribution studies of the macroalgae in the seashore of Port Dickson.

REFERENCES

- Airoldi, L., Abbiati, M., Beck, M.W., Hawkins, S.J., Jonsson, P.R., Martin, D., Moschella, P.S., Sundelöf, A.S., Thompson, R.C. & Aber, P. (2005). An ecological perspective on the deployment and design of low-crested and other hard coastal defence structures. *Coastal Engineering*, 52 (10-11): 1073-1087.
- Bymers, L., Glenn, E.P., Nelson, S.G. & Fitzsimmons, K. (2005). Diversity and biomass dynamics of marine algae in Biosphere II's tropical reef macrocosm. *Ecological Engineering*, 25: 442-456.
- Chee, S.Y., Wong, P.K. & Wong, C.L. (2011). Extraction and characterisation of alginate from brown seaweeds (Fucales, Phaeophyceae) collected from Port Dickson, Peninsular Malaysia. *Journal of Applied Phycology*, 23: 191-196.

- Gibson, R. & Atkinson, R. (2003). The effects of sedimentation on rocky coast assemblages. *Oceanography and Marine Biology: An Annual Review*, 41: 161-236.
- Mijan Uddin, S.M., Ismail, A. & Ismail A. (2007). Species composition of seaweeds in Port Dickson, Peninsular Malaysia. *Malaysian Applied Biology*, 36: 69.
- Nirmal-Kumar, J.I., Kumar, R.N., Amb, M., Bora, A. & Chakraborty, S. (2010). Variation of biochemical composition of eighteen marine macroalgae collected from Okha coast, Gulf of Kutch, India. *Electronic Journal of Environmental, Agricultural and Food Chemistry*, 9: 404-410.
- Phang, S.M. (1995). Distribution and abundance of marine algae on the coral reef at Cape Rachado, Port Dickson, Peninsular Malaysia. *Malaysia Journal of Science*, 16A: 23-32.
- Piazzzi, L., Balata, D., Foresi, L., Cristaudo, C. & Cinelli, F. (2007). Sediment as a constituent of Mediterranean benthic communities dominated by *Caulerpa racemosa* var. *cylindracea*. *Scientia Marina*, 71: 129-135.
- Raven, J.A. (2011). Effects on marine algae of changed seawater chemistry with increasing atmospheric CO₂. In *Biology & Environment: Proceedings of the Royal Irish Academy*, 111(1):1-17. The Royal Irish Academy, Ireland.
- Sharif Hossain, A.B.M., Salleh, A., Boyce, A.N., Chowdhury, P. & Naquiuddin, M. (2008). Biodiesel fuel production from algae as renewable energy. *American Journal of Biochemistry and Biotechnology*, 4: 250-254.
- Su, C.S.C. & Tse-Min, L. (2007.) Nutrients, temperature, and salinity as primary factors influencing the temporal dynamics of macroalgal abundance and assemblage structure on a reef of Du-Lang Bay in Taitung in southeastern Taiwan. *Botanical Studies*, 48: 419-433.
- Teo, L.W. & Wee, Y.C. (1983). *Seaweeds of Singapore*. Singapore: NUS Press, 4 pp.
- Wong, C.L. & Phang, S.M. (2004). Biomass production of two *Sargassum* species at Cape Rachado, Malaysia. *Hydrobiologia*, 512:79-88.