Sains Malaysiana 46(1)(2017): 1–7
*http://dx.doi.org/10.17576/jsm-2017-4601-01*

# Biodiversity of Macroalgae in Blue Lagoon, the Straits of Malacca, Malaysia and Some Aspects of Changes in Species Composition

(Kepelbagaian Biologi Makroalga di Blue Lagoon, Selat Melaka, Malaysia dan Beberapa Aspek Perubahan dalam Komposisi Spesies)

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ABSTRACT

*This research was conducted to study the biodiversity status of marine macroalgae (seaweeds) in Blue Lagoon, Port Dickson and assess the changes in species composition in the area. The sampling site is located in the west coast of Peninsular Malaysia, which has been regarded as one of the Malaysia's popular beach resort destinations. This tourist spot has seen major physical changes over the last few decades. Despite habitat disturbance, our study recorded 44 species of macroalgae with* Sargassum asperifolium *noted as a new record for this area. Brown seaweeds (Phaeophyta) and green seaweeds (Chlorophyta) dominated the sampling areas with each division recorded 19 and 16 species, respectively. Change to species composition was evident for the common genus* Sargassum *(Sargassaceae, Fucales). Chlorophyta was mostly found in the upper intertidal to subtidal zones while Phaeophyta proliferated in the mid-tidal areas. The red seaweeds (Rhodophyta) were distributed and grew better in lower light intensity in the subtidal zone. This study will contribute to the seaweed database of Malaysia for future reference and this may help in the conservation of seaweeds.*

*Keywords: Biodiversity; checklist;* Sargassum*; species composition; tropical seaweeds*

ABSTRAK

*Kajian kepelbagaian biologi rumpai laut telah dijalankan di Blue Lagoon, Port Dickson bagi menilai perubahan komposisi spesies rumpai laut di kawasan kajian. Lokasi pensampelan terletak di bahagian pantai barat Semenanjung Malaysia yang dikenal pasti sebagai salah satu pantai peranginan yang terkenal di Malaysia. Sejak beberapa dekad yang lepas, Port Dickson telah mengalami perubahan fizikal yang pesat. Walaupun terdapat gangguan habitat, kajian ini telah merekodkan sebanyak 44 spesies rumpai laut dengan satu spesies (*Sargassum asperifolium*) sebagai rekod baharu bagi Port Dickson. Rumpai laut perang (Phaeophyta) dan rumpai laut hijau (Chlorophyta) mendominasi kawasan kajian dengan masing-masing 19 dan 16 spesies. Perubahan dalam komposisi rumpai laut dapat dilihat secara jelas bagi genus* Sargassum *(Sargassaceae, Fucales). Cholophyta mendominasi zon intertidal dan subtidal manakala Phaeophyta tumbuh dengan banyak di zon mid-tidal. Rumpai laut merah (Rhodophyta) pula tumbuh dengan baik di bahagian bawah zon tidal yang mempunyai pencahayaan yang rendah. Kajian ini menyumbang kepada pangkalan data rumpai laut di Malaysia untuk dijadikan sebagai rujukan pada masa hadapan dan ini boleh membantu dalam pemuliharaan rumpai laut.*

*Kata kunci: Kepelbagaian biologi; komposisi spesies; rumpai laut tropika;* Sargassum*; senarai semakan*

## INTRODUCTION

Seaweeds are generally classified into three main divisions, namely Chlorophyta, Phaeophyta and Rhodophyta, based on their pigmentation (John et al. 2002; Lee 2008). Most green algae (Chlorophyta) are found in the ocean surface and marine sediments. Phaeophyta, the brown algae, can be found mostly on the rocky intertidal shore. The red algae (Rhodophyta) usually inhabit warmer waters and tropical seas. The green algae appear green due to the presence of chlorophyll $\alpha$ and $\beta$. All green algae are photosynthetic, including single-celled, sheet like, tubular, filamentous and colonial forms (Starr & Taggart 2004). The brown algae normally appear brown or yellowish brown and they contain xanthophyll pigments called fucoxanthin. Some species of Phaeophyta appear olive-green, golden or dark brown depending on the pigments (Ismail & Tan 2002). Brown algae are distributed from the intertidal zone to the open ocean. The red algae appear red due to the dominance of the pigments phycoerythrin and phycocyanin. They are normally found in deep clear waters (Druehl 2000). Biodiversity studies of tropical seaweeds are currently gaining attention. However, more efforts are needed to understand its status. The biodiversity of seaweeds in the Straits of Malacca was reported by Phang et al. (2008) on the marine algae of Pulau Jarak, Sembilan Group of Islands and Pulau Perak. According to Phang et al. (2007), the marine algae in Malaysia comprise of 381 taxa with 105 taxa are from Chlorophyta, 186 taxa from Rhodophyta, 73 taxa from Phaeophyta and 17 taxa from Cyanophyta. The neighbouring countries Indonesia and the Philippines have been actively recording the biodiversity of seaweeds (Gerung 2004; Trono & Fortes 1998). Port Dickson is located on a busy waterway along the Straits of Malacca and this directly and indirectly harmed the seaweed habitats (Tan & Yap 2006). Therefore, effort has to be made to investigate the diversity of seaweeds in this area and the data obtained is of much use for future reference and comparison study. The objectives of this study were to record the biodiversity of seaweeds in Blue Lagoon, Port Dickson and determine the species composition and distribution on tidal zones.

## MATERIALS AND METHODS

### SAMPLING LOCATION

The sampling area was located in Blue Lagoon, approximately 15 km off Port Dickson and approximately 60 km from the capital city of Malaysia, Kuala Lumpur (Figure 1). Located on the west coast of Peninsular Malaysia along the Straits of Malacca, this sampling location is at risk to water pollution due to busy water traffic along the narrow channel between Peninsular Malaysia and Indonesia. Blue Lagoon is one of the popular tourist spots, therefore fast growing development is inevitable. These physical changes will, one way or another, change the species composition of marine algal flora in this area. The fieldwork was conducted in January 2008, which involved seaweed sampling at four stations (Figure 1) during the low tide when the shore was exposed. The intertidal and subtidal zones were represented by two stations each. The seaweeds were collected along the coastal area between 2°25’06.5”N 101°52’11.8”E to 2°25’03.7”N 101°52’32.1”E.

### SPECIMEN SAMPLING

Seaweeds specimens were collected along the intertidal and subtidal zones of the sampling location by snorkelling and wading through the shallow water. Complete structure of macroalgal specimens was detached from their substratum and put into plastic bags. Small and fragile specimens were


FIGURE 1. Location of sampling (in red tear drop) in Blue Lagoon, Port Dickson. Four sampling stations marked with blue dots (intertidal zone) and red dots (subtidal zone)

kept in specimen vials. Specimens were then cleaned by removing any attached debris or epiphytes using small brushes. Cleaning process was done in a herbarium tray containing seawater. Data such as the shape and colour of the specimens were recorded on-site. These data will assist in species identification. Images of the specimen were captured using a Sony Cybershot digital camera. Examination in the laboratory was done using a Brunel digital light microscope with an LCD screen. For preservation purpose, specimens were kept in 10% formalin-seawater solution and stored as wet specimens. Specimens were subjected to morphological and anatomical examinations (where necessary) for identification. Identification of species was based on published dichotomous keys in Gan et al. (2011), Geraldino et al. (2005) and Phang et al. (2008).

## Results

Seaweeds in Blue Lagoon comprised of three main divisions namely Chlorophyta, Phaeophyta and Rhodophyta (Figure 2). The most dominant division with the highest species richness was Phaeophyta, with 19 species representing 44% of the total seaweed species recorded (Table 1). This was followed by Chlorophyta with 16 species making up 36% of the total species richness. Rhodophyta which was represented by nine species contributing 20% of the total species richness.

Even though Phaeophyta showed the highest species richness, it was only represented by two families: Dictyotaceae and Sargassaseae. Both families had similar species richness, of which Dictyotaceae was represented by 10 species and Sargassaceae by nine species. *Sargassum* and *Dictyota*, both from the order Fucales, were the common species of Phaeophyta recorded from the sampling location. Another member of Phaeophyta, *Padina australis* (Sargassaceae, Dictyotales) with a soft thallus with rhizoidal holdfast, was attached mainly to the sandy substrate. However, a small amount of *P. australis* was found on rocky substrate. Other genera of this division recorded in this study were *Turbinaria* and *Lobophora*.

Chlorophyta was represented by six families, namely Ralfsiaceae, Caulerpaceae, Cladophoraceae, Codiaceae, Udoteaceae and Ulvaceae. This division was recorded as the most diverse in terms of the number of family. Caulerpaceae dominated the green algae with seven out of 16 species while the other families were represented by one or two species. Other genera of Chlorophyta recorded in this area were *Ulva*, *Udotea* and *Enteromorpha*.

The red algae (Rhodophyta) were represented by families Rhodomelaceeae, Solieriaceae, Gracilariaceae, Corallineaceae and Hypneaceae. As expected for tropical marine waters, *Gracilaria* was the most diverse genus of this division. It was represented by four out of nine species, namely *G. blodgetii, G. vermiculophylla, G. foliifera* and *G. arcuata*. The remaining five species of Rhodophyta were represented by *Acanthophora, Euchema, Jania, Lithophyllum* and *Laurencia*.

## Discussion

Blue Lagoon, Port Dickson is dominated by the brown seaweeds from two genera, *Dictyota* and *Sargassum* (Table 1). Alongside the brown seaweeds, the green seaweeds from the family Caulerpaceae also recorded high in species richness. Seaweeds from this family are usually large with thick blade and coarse branch (van den Hoek et al. 1995). It has chemical defence which prevents predators and grazers such as sea urchin and fish from feeding on them. According to Amade and Leme (1998), caulerpenyne, a toxin produced by *Caulerpa,* is the major secondary metabolite. This defensive mechanism has allowed this family to successfully colonize many habitats and substrates. Not only the Caulerpaceae widely distributed in tropical seas, the macroalgae have also invaded the Meditteranean (Piazzi et al. 2001, 1994).

The green seaweed *Udotea* is not an unfamiliar sight in Malaysian marine waters. This genus normally has erect thallus with calcified blades that forms a shape of a fan or a funnel. Its stipes and rhizoids are also calcified. This genus can be found globally in tropical and subtropical marine waters. Green algae of warmer tropical waters are similar around the world but in colder regions, the northern and southern green seaweeds are markedly different (Costa et al. 2002; Tan & Yap 2006). Thus, seaweeds of the Indo-Pacific region are more similar to the macroalgae of Malaysia (Phang et al. 2008).

The most diverse seaweed division in Blue Lagoon was Phaeophyta, represented by *Sargassum*, *Dictyota* and *Padina*. *Padina* has concentric circles of tiny hairs which bear its reproductive structure in alternate bands

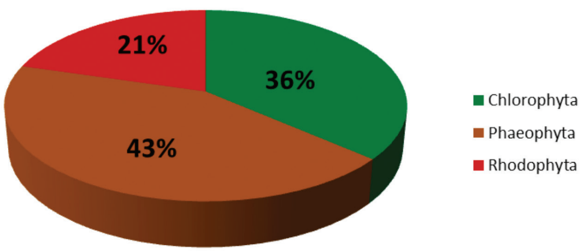


FIGURE 2. The percentage of seaweeds according to the divisions

TABLE 1. Seaweed species composition in Blue Lagoon

| Family | Species | Zone | |
|---|---|---|---|
| Division Chlorophyta | | Intertidal | Subtidal |
| Ralfsiaceae | *Analipus japonicus* | ✓ | |
| Caulerpaceae | *Caulerpa sertularioides* | ✓ | |
| | *Caulerpa racemosa* | ✓ | |
| | *Caulerpa lentillifera* | ✓ | |
| | *Caulerpa serrulata* | ✓ | |
| | *Caulerpa microphysa* | ✓ | |
| | *Caulerpa subserrata* | ✓ | |
| | *Caulerpa verticillata* | ✓ | |
| Cladophoraceae | *Chaetomorpha* sp. | ✓ | |
| Codiaceae | *Codium yezoense* | ✓ | |
| Udoteaceae | *Udotea argentea* | ✓ | |
| Ulvaceae | *Udotea javensis* | ✓ | |
| | *Ulva fasciata* | ✓ | |
| | *Ulva lactuca* | ✓ | |
| | *Enteromorpha clathrata* | ✓ | |
| | *Enteromorpha intestinalis* | ✓ | |
| Division Phaeophyta | | | |
| *Dictyotaceae* | *Dictyota dichotoma* | ✓ | |
| *Sargassaceae* | *Dictyota ciliolata* | ✓ | |
| | *Dictyotaceae* sp. | ✓ | |
| | *Dictyopteris delicatula* | ✓ | |
| | *Dictyota dentata* | ✓ | |
| | *Lobophora variegata* | | ✓ |
| | *Padina japonica* | ✓ | |
| | *Padina minor* | ✓ | |
| | *Padina tetrastomatica* | ✓ | |
| | *Padina australis* | ✓ | |
| | *Sargassum polycystum* | | ✓ |
| | *Sargassum siliquosum* | | ✓ |
| | *Sargassum cristaefolium* | ✓ | |
| | *Sargaasum ilicifolium* | ✓ | |
| | *Sargassum asperifolium* | ✓ | |
| | *Sargassum oligocystum* | ✓ | |
| | *Turbinaria conoides* | ✓ | |
| | *Turbinaria ornata* | ✓ | |
| | *Turbinaria luzonensis* | ✓ | |
| Division Rhodophyta | | | |
| Rhodomelaceae | *Acanthophora spicifera* | | ✓ |
| Solieriaceae | *Eucheuma alvarezii* | ✓ | |
| Gracilariaceae | *Glacilaria blodgettii* | ✓ | |
| | *Gracilaria vermiculophylla* | ✓ | |
| | *Gracilaria foliifera* | ✓ | |
| | *Gracilaria arcuata* | ✓ | |
| Corallineaceae | *Jania decussata-dichotoma* | | ✓ |
| | *Lithophyllum pygmaeum* | | ✓ |
| Hypneaceae | *Laurencia cartilaginea* | | ✓ |

between the lines of hairs (Geraldino et al. 2005). Strong wave action helps to loosen and distribute their spores. The most diverse and abundant genus was *Sargassum*. *Sargassum* can be found abundantly in Malaysian coastal waters (Phang 1998; Wong & Phang 2004b). They are robust macroalgae with strong stipes and holdfast. These distinctive characteristics make it possible for *Sargassum* to withstand strong wave action and predators contributing to the survival of the taxa. Phang (2006) stated that the west coast of Peninsular Malaysia consist of a mixture of seaweeds from many divisions. Among the genera known from the west coast include 18 genera of Cholorophyta (*Enteromorpha, Ulva, Anadyomene, Boodlea, Cladophoropsis, Dictysphaeria, Struvea, Valonia,* *Chaetomorpha, Cladophora, Cladophoropsis, Bryopsis, Caulerpa, Codium, Halimeda, Avrainvillea, Udotea* and *Rhipidosiphon*), 40 genera of Rhodophyta (*Gelidium, Pterocladia, Gelidiella, Gracilaria, Gracilariopsis, Cryptonemia, Grateloupia, Halymenia, Hildenbrandia, Amphiroa, Corallina, Jania, Mesophyllum, Catenella, Caulacanthus, Chondracanthus, Hypnea, Sarcodia, Titanophora, Champia, Botryocladia, Ceratodictyon, Anotrichium, Ceramium, Griffithsia, Spyridia, Wrangelia, Dasya, Heterosiphonia, Hypoglossum, Martensia, Taenioma, Acanthophora, Bostrychia, Herposiphonia, Laurencia, Leveillea, Neosiphonia, Polysiphonia* and *Tolypiocladia*) and 14 genera of Phaeophyta (*Ectocarpus, Feldmannia, Sphacelaria, Dictyopteris, Dictyota, Lobophora, Padina, Chnoospora, Colpomenia, Hydoclathrus, Rosenvingea, Hormophysa, Sargassum* and *Turbinaria*). The study of Phang (2006) was conducted in numerous habitats and multitudes of substratum including coral, driftwood, epiphytes, mud, mangroves, rock, bedrock, sand, wood, fish cage, fishing lines and fish nets. Our study in the Blue Lagoon was considerably a small fraction of the west coast of Peninsular Malaysia. However, we recorded seven Chlorophyta genera, eight Phaeophyta genera and six Rhodophyta genera.

In this study, changes to species composition were focused on the most common seaweeds in Malaysia - *Sargassum* (Sargassaceae, Fucales). Published reports and records stated that there are 25 *Sargassum* species throughout Malaysia. Wong and Phang (2004b) reported five species of *Sargassum* (*S. baccularia, S. binderi, S. myriocystum, S. oligocystum* and *S. ciliquosum*) in Port Dickson including in Cape Rachado, an area adjacent to Blue Lagoon (Table 2). The present study recorded six *Sargassum* species, all but one (*S. asperifolium*) are common to Malaysia. *S. asperifolium* was not reported from the coastal waters of Malaysia in previous published reports, therefore it is a new record for this area. *S. baccularia* was reported only in Port Dickson, but it was not sampled in the present study. *S. binderi* and *S. myriocystum* previously reported from Port Dickson (Wong & Phang 2004a) was also absent in the present study.

The differences in species richness between sampling sites could be attributed to the different in sampling frequency and time of collecting, changes in water physicochemical parameters and predator and prey relationship. Most diversity studies of seaweeds in the past did not record the specific location of the sampling sites (with GPS coordinates) but generally marked the sites on a map. Therefore, to conduct a similar biodiversity study in the same location would be challenging. Thus researchers tend to conduct fieldwork in the same general area, albeit inaccurate, but generally acceptable as representative of the previously reported study sites. In terms of habitat preference, there are marked differences of seaweed composition between the intertidal and subtidal zones. On a smaller scale, we found that there is a distinctive difference in species composition of the seaweeds of subtidal and intertidal zones in Blue Lagoon. Chlorophyta was mostly found in the upper intertidal to subtidal zones while Phaeophyta proliferated in the mid-tidal zone. Both divisions are known to thrive in habitats having high light intensity. Naturally, Rhodophyta with phycoerythrin as their pigments grows well in lower light intensity in the subtidal areas where the water is much deeper.

We revisit data collected and compiled by Wong and Phang (2004b) to detect any changes in terms of species composition. The spatial and temporal species list in Table 2 which lists the absence and presence of *Sargassum* in Port Dickson and other places in Malaysia helps us to see the changes between the previous and current species inhabiting the area. *S. asperifolium* which has not yet been recorded in previous surveys could be endemic and exclusive to Blue Lagoon. However, it could only be confirmed with further explorations and extensive field samplings as the *Sargassum* species are known to exhibit seasonal polymorphism (Wong & Phang 2004b). A part from high species richness, these macroalgae also exhibit variability under seasonal changes due to varying nutrient availability that impacts the growth of the seaweeds (Elser et al. 2007). In Malaysia, genus *Sargassum* consists of 25 species (Wong & Phang 2004b). We hypothesize that the shift in species composition could be due to many concurrent changes such as water physicochemical

TABLE 2. *Sargassum* species reported in Port Dickson and other places in Malaysia. + indicates presence

| No. | *Sargassum* species | Port Dickson (Wong & Phang 2004b) | Other sites in Malaysia (Wong & Phang 2004b) | Present study |
|---|---|---|---|---|
| 1 | *S. baccularia* | + | + | + |
| 2 | *S. binderi* | + | + | + |
| 3 | *S. myriocystum* | + | + | + |
| 4 | *S. oligocystum* | + | + | + |
| 5 | *S. siliquosum* | + | + | + |
| 6 | *S. polycystum* | | + | + |
| 7 | *S. cristaefolium* | | + | |
| 8 | *S. ilicifolium* | | | |
| 9 | *S. asperifolium* | | | |

components, light intensity and the predator and prey interactions which need to be tested further. The rapid development within the proximity of the sampling sites has most probably triggered changes to the physicochemical parameters of the adjacent coastal waters.

## CONCLUSION

Blue Lagoon is diverse in seaweed diversity. With 44 species of seaweeds comprising three divisions, Blue Lagoon can be considered as a highly reputable area. Unlike other places, this location was dominated by brown algae rather than green algae. Even though there is only a slight difference in terms of species richness between the two divisions, the result reflects the character of the habitat. This could be due to high turbidity, an implication from bad weather and sediments. Thus, it may not be the best habitat for the proliferation of green algae, but instead it gives rise to a good number of brown seaweeds. We suggest larger sampling locations in the future to fully understand the species composition of seaweeds in this area. A good systematic method to record the seaweeds should be conducted. Spatial and temporal studies on marine flora in this area will help us to gain insight to this marine macroalgae.

## ACKNOWLEDGEMENTS

Authors would like to thank staff of Phycology and Aquatic Plant Laboratory, UKM for their assistance and guidance. This work was funded by the Ministry of Education, Malaysia and Universiti Teknologi MARA under Research Acculturation Grant Scheme (RAGS) 600-RMI/RAGS 5/3 (8/2013) and Fundamental Research Grant Scheme 600-RMI/FRGS 5/3 (145/2013).

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Received: 14 June 2013
Accepted: 1 August 2016