Coastal Marine Science 34(1): 108–112, 2010

Special Section "Oceanography"

Morphological characteristics, shoot density and biomass variability of *Halophila* sp. in a coastal lagoon of the east coast of Malaysia

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Received 20 December 2009; Accepted 18 February 2010

Abstract — This study in a coastal lagoon of Merchang Terengganu, east coast of Peninsular Malaysia evaluated the morphological characteristics, shoot density and biomass for *Halophila* in pure and mixed population with *Halodule pinifolia* (Miki) den Hartog. Both species inhabited the silt and sand substrates at depth of about 1.9 m to 2.0 m. They are well adapted and tolerated a range of micro-ecology; pH of 6.57–7.32, wide salinity differences of 9.42–34.47 psu, conductivity 16.14–52.27 ms/cm, and light availability of 446.63–624.1 lux. Morphologically, there are two forms for *Halophila* (a) small-leaved in pure population and those mixed with the short-leaved, (b) big-leaved with the long-leaved *Halodule pinifolia*. Both forms have variable leaf shapes, a respond to the wide and frequent fluctuation in water salinity. Leaves possessed red or purplish spots or blotches with more spots and blotches in leaves of *Halophila* in pure population. These spots or blotches are believed to be UV-blocking pigments for protection of plants exposed directly to strong sun-light during low tides. Shoot density of 79.08 ± 38.02 shoots/100 cm^2; is comparatively higher in pure *Halophila* population compared with 26.33 ± 13.20 shoots/100 cm^2 and 64.00 ± 17.09 shoots/100 cm^2 for small-leaved and big-leaved *Halophila* sp. respectively. *Halophila* biomass (AG and BG) exhibit similar trend as those observed for shoot density. In pure or mixed *Halophila* population the majority of the biomasses (63–77% of the total) were in the below-ground parts (rhizome and roots). Although *Halophila* sp. is a smaller size seagrass, for propagation they would need extensive rhizome networks buried in the substrates.

Key words: Seagrass, *Halophila*, morphology, shoot density, biomass, Malaysia

Introduction

Seagrass is considered as productive in tropical ecosystem (Bronwyn 2006) and act as shelter and food for shore fisheries, marine reptiles and mammals. They influenced the physical, chemical and biological environment in which they grow by acting as ecological engineer (McKenzie 2008). The distribution and abundance of seagrasses is controlled by range of environmental conditions including light availability (Dennison and Alberte 1985, Dennison 1987), nutrient availability (Short 1987), water motion (Fonseca and Kenworthy 1987) and grazing (Longstaff and Dennison 1999). Light availability controlled the depth to which seagrasses can grow (Abal and Dennison 1996). The reduced availability of light can also be caused by bigger and taller seagrass species shading the understory species e.g. in a mixed seagrass population of *Enhalus acoroides* (L.*f.*) Royle, *Halophila ovalis* (R.Br.) Hook. *f.* and *Cymodocea serrulata* (R.Br.) Aschers. & Magnus (Japar Sidik et al. 2001a). A considerable part of morphological variability is due to environmental circumstances and therefore merely phenotypical. However, one can often find in the same habitat two morphologically quite distinct forms growing together. In such a case the differences might be genotypically determined. Seagrass plants in mixed population e.g. in the Merchang lagoon, depending on their habits of growth forms, tall versus short or those growing overlying the substrates under the canopy of other seagrass species may have different light requirement and simultaneously compete for space and nutrients. The response to low light and acclimatization towards such conditions may be expressed in the plant morphology e.g. the leaf dimension, the nervation (leaf cross veins number in *Halophila*), the length of the petiole and the rhizome length and biomasses. This present study in a coastal lagoon of Merchang Terengganu, east coast of Peninsular Malaysia evaluate the morphological characteristics, shoot density and biomass for *Halophila* pure population and those growing in association with *Halodule pinifolia*.

Materials and Methods

The *Halophila* plants were sampled during low tides, on 13th September 2007 and 8th November 2007 from different sites in Merchang coastal lagoon (Lat. 5°02′15.0″N, Long. 103°17′53.0″E, Fig. 1), Terengganu, east coast of Malaysia. At the same site, water temperature, salinity, depth, pH where possible, were recorded using Hydrolab Surveyor 4a or SCT meter and light availability using Li-Cor model 250 Quantum Light Meter.

Halophila plants were sampled from pure population and those in association with *Halodule pinifolia* within 5 0.5 m×0.5 m quadrat with sub-divisions of 25 units. Both plants and substrates were taken within the three sub-division of each quadrat. Samples were carefully sieved using soil sieve with a mesh size of 0.45 mm (which retained seed c. 0.5 mm). The number of shoot (for *Halophila* in Merchang, a shoot is a pair of leaves) in each sample was recorded. The plants were placed in a labeled plastic bag and kept in an ice chest before processing in the laboratory. In the laboratory each sample was then rinsed in 5% v/v o-phosphoric acid for 3–4 minutes (Parthasarathy et al. 1988) to remove calcareous epiphytes and washed with distilled water and carefully observed for leaf length, width, petiole length, distance between intra-marginal vein to leaf edge, paired cross vein number and distance between cross-veins that were used for taxonomic identification of *Halophila ovalis* (den Hartog 1970) and *H. minor* (Zoll.) den Hartog (Kuo 2000). In addition the *Halophila* plants' rhizome length was recorded. All plant dimensions were measured using Mitutoyo Digimatic Vernier Caliper (measured to two decimal points) and plant habits were recorded digitally using Nikon Coolpix 995 Digital Camera. After plant dimensions and characteristics were recorded they were then separated into leaves, male and female flowers and fruits (assigned as above ground, AG), rhizomes and roots (assigned as below ground, BG). Seagrass fractions were dried at 80°C in an air-circulating oven to constant weight (approximately 5 days). Biomasses of AG, BG and T (total) biomass were determined by weighing the material on a Sartorius chemical balance. Analysis of variance (ANOVA, $p<0.05$) and post-hoc Duncan's Multiple Range Test (DMRT, $p<0.05$) were used to compare the vegetative parts dimensions, shoot density and biomasses of *Halophila* between stands.

Results and Discussion

Habitat type

A coastal lagoon comprising of pure and mixed patches of two seagrass species, the dominant *Halodule pinifolia* interspersed with *Halophila* sp. The *Halophila* sp. based on leaf dimension (leaf length and leaf width), the number of cross-veins and the ascending angles from cross-vein to the mid-vein, showed overlapping characters with most of the descriptive morphology used in the taxonomy of *Halophila ovalis* (den Hartog 1970) and *Halophila minor* (Kuo 2000). They inhabited the silt and sand substrates at depth of about 1.9 m to 2.0 m from the highest high water level. Both species are well-adapted and tolerated a range of micro-ecology; pH of 6.57–7.32, wide salinity differences of 9.42–34.47 psu, conductivity 16.14–52.27 ms/cm, and light availability of 446.63–624.1 lux.

Leaf and rhizome dimension

There are two categories for *Halophila* (a) small-leaved as pure population and those mixed with the short-leaved *Halodule* species (b) big-leaved mixed with the long-leaved *Halodule pinifolia*. Leaf dimensions varied in pure and

Fig. 1. Merchang coastal lagoon during low tide. Site A-a mixed population, *Halophila* with long-leaved *Halodule pinifolia*, Site B-pure population of short-leaved *Halodule pinifolia*, Site C-a mixed population of *Halophila* with short-leaved *Halodule pinifolia* and Site D-a pure population of *Halophila*.

Table 1. Leaf and rhizome dimensions of *Halophila* plants from Merchang, Terengganu. Means with the same alphabet (a–d) are not significant different (ANOVA, $p<0.05$).

Vegetative dimension and characteristic Site	*Halophila* population					
	Pure			Mixed with short-leaved *Halodule*		Mixed with long-leaved *Halodule*
	Area D-1	Area D-2	Area D-3	Area C1	Area C2	Area A
Leaf dimension	Mean±s.d Range (mm) N	Mean±s.d Range (mm) N	Mean±s.d Range (mm) N	Mean±s.d Range (mm) N	Mean±s.d Range (mm) N	Mean±s.d Range (mm) N
Leaf length	9.36 ± 2.13^{bc} 4.56–14.02 82	8.91 ± 1.76^{ab} 5.74–12.82 79	10.05 ± 2.58^{cd} 5.90–16.20 74	10.41 ± 1.47^{d} 6.90–14.06 43	8.35 ± 2.26^{a} 4.90–14.30 97	14.59 ± 1.14^{e} 12.00–16.30 18
Leaf width	4.33 ± 1.24^{b} 1.55–7.40 82	4.42 ± 1.19^{b} 1.95–7.43 79	4.72 ± 1.47^{b} 1.70–8.40 74	4.44 ± 1.07^{b} 1.58–7.00 43	3.73 ± 1.14^{a} 1.60–7.00 97	6.40 ± 0.42^{c} 5.60–7.20 18
Petiole length	12.95 ± 3.86^{ab} 3.28–21.71 82	10.86 ± 4.01^{a} 4.24–19.36 79	14.52 ± 5.33^{bc} 4.10–26.00 74	16.21 ± 5.84^{c} 3.21–28.19 43	12.07 ± 6.02^{a} 3.00–33.00 95	26.33 ± 8.08^{d} 9.30–36.90 18
Rhizome length	10.09 ± 5.09^{a} 1.98–22.95 66	11.17 ± 5.75^{a} 2.53–23.80 76	10.30 ± 6.29^{a} 2.60–33.80 209	9.83 ± 2.74^{a} 4.47–15.78 76	9.27 ± 3.47^{a} 3.20–20.20 106	13.22 ± 3.92^{b} 5.90–19.60 27
A-distance between cross-vein	1.15 ± 5.24^{a} 0.30–81 347	0.57 ± 0.25^{a} 0.16–1.32 223	1.31 ± 2.56^{a} 0.64–1.92 50	0.91 ± 4.47^{a} 0.10–79.00 309	1.15 ± 0.43^{a} 0.43–2.38 42	1.38 ± 0.40^{a} 0.50–2.55 227
B-distance between intra-marginal vein to leaf edge	0.26 ± 0.07^{a} 0.10–0.47 160	0.56 ± 0.25^{c} 0.18–1.47 115	0.69 ± 0.07^{d} 0.61–0.88 14	0.67 ± 0.33^{d} 0.19–1.63 154	0.44 ± 0.07^{b} 0.35–0.58 21	0.47 ± 0.01^{b} 0.23–0.76 125
Number of cross-vein	8.94 ± 1.76^{ab} 3–14 122	10.60 ± 1.75^{c} 6–13 40	10.61 ± 1.71^{c} 7–14 72	9.59 ± 1.79^{b} 6–13 39	8.33 ± 1.90^{a} 4–13 72	10.97 ± 1.19^{c} 9–13 32

mixed population. Bigger leaves, longer petioles and rhizomes were observed particularly in *Halophila* growing with long-leaved *Halodule pinifolia* (Table 1, Site A, Fig. 1). Morphological variability occurred among *Halophila* associated with the short-leaved and long-leaved *Halodule pinifolia*, and those as a pure populaton. *Halodule pinifolia* being common, a larger and taller seagrass have its leaves raised or extended above that of smaller understory seagrass, *Halophila.* The canopy formed by *Halodule pinifolia* caused shading of the understory species. *Halophila* has to compete for light and habitat because leaves as well as roots are position at similar level in the water column and sediment respectively (Duarte 1991). The understory *Halophila* responded or acclimatized to shading by morphological responses through altered growth pattern of leaf size by having longer leaf length, petiole length and horizontal rhizome length as opposed to the one in pure population. The morphology differences in the forms of *Halophila* sp. have selective significance in adapting to habitats of varying light (shaded or unshaded) availability. The big-leaved and long-petiolate *Halophila* has selective advantage in habitats with low light e.g. created by *Halodule pinifolia*, can also survive in turbid water and subtidal zone (Japar Sidik et al. 2001b). The short-petiolate *Halophila* sp. may be confined to unshaded sites or higher light conditions.

Leaf shape and characteristic

Leaf variants occurred in pure or mixed populations (Site A-a mixed population, *Halophila* associated with long-leaved *Halodule pinifolia,* Site C-a mixed population of *Halophila* with short-leaved *Halodule pinifolia* and Site D-a pure population of *Halophila*, Fig. 2). Den Hartog (1970) regarded such observations as the respond to environmental modifications. The variability in *Halophila*'s leaf shapes in Merchang lagoon is regarded as a respond to the wide (9.42 to 34.47 psu) and frequent fluctuation in water salinity.

Irrespective of pure or mixed population, *Halophila* leaves possessed red or purplish spots or blotches with more

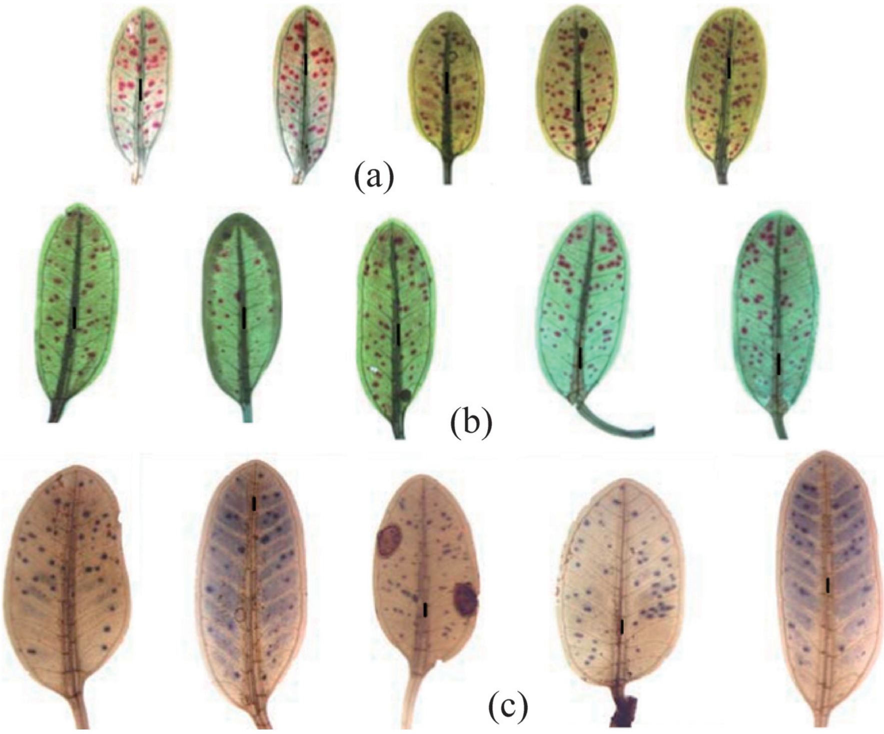

Fig. 2. Red or purplish spots or blotches were more in leaves of (a)-*Halophila* in pure populations, compared with leaves of *Halophila* in population mixed with (b)-short-leaved *Halodule* and (c)-long-leaved *Halodule*.

Table 2. Shoot density and biomass in an area of 100 cm^2 (N=15) for the three *Halophila* populations.

Halophila population	Shoot density	Biomass (gram dry weight) AG	BG	Total
Pure	79.08±38.02 (41–155)	0.0956±0.0404 (0.0490–0.1745)	0.3241±0.3636 (0.0865–1.2955)	0.4197±0.3670 (0.1355–1.4060)
Mixed with short-leaved *Halodule*	26.33±13.20 (12–38)	0.03±0.0128 0.0153–0.0375	0.0512±0.0356 (0.0128–0.0830)	0.0813±0.0477 (0.0281–0.1205)
Mixed with long-leaved *Halodule*	64.00±17.09 (48–82)	0.0873±0.0179 (0.0680–0.1034)	0.1829±0.0823 (0.1152–0.2745)	0.2702±0.0821 (0.2186–0.3649)

spots and blotches in leaves of *Halophila* in pure population (Sites A, C, D, Fig. 2). We believed these spots or blotches are UV-blocking pigments (Hemminga and Duarte 2000) formed as a response for protection of pure stand *Halophila* to direct exposure to strong sun-light during the low tides. *Halophila* in mixed populations have less spots in their leaves as they were partially protected by shading afforded by the *Halodule pinifolia*.

Shoot density and biomass

Shoot density is comparatively higher in pure *Halophila* population. In pure population plants propagated without competing for light, space (substrate) and nutrients. Shoot density was 79.08±38.02 shoots/100 cm^2 (Table 2). *Halophila* plants in mixed populations required more energy for propagation as they were competing for light, space and nutrient under the canopy of *Halodule pinifolia* hence less shoot density compared with those from pure population.

Halophila biomass (AG and BG) exhibit similar trend as those observed for shoot density. Leaves of *Halophila* is the part which up-take the nutrient in the sea-water. The highest level in up-taking the nutrient from the environment was from plants that have higher shoot density. These would definitely contribute to the significant contribution to higher above ground biomass. In pure or mixed *Halophila* population, the majority of the biomasses (63–77% of the total) were in the below ground parts (rhizome and roots). Although *Halophila* sp. is a smaller seagrass species, for propagation *Halophila* sp. would need prostate stems or extensive rhizome networks buried in substrate similar to those observed for larger seagrasses such as *Thalassia hemprichii* (Ehrenb.) Aschers., *Halodule uninervis* (Forssk.) Aschers. *Cymodocea serrulata*, and *Syringodium isoetifolium* (Aschers.) Dandy (Norhadi 1993, Japar Sidik et al. 1996).

References

Abal, E. G. and Dennison, W. C. 1996. Seagrass depth range and water quality in Southern Moreton Bay, Queensland, Australia. Mar. Freshwater Res. 47: 763–771.

Bronwyn, G. M. 2006. Seagrasses, fish and fisheries. *In* Seagrasses: Biology, Ecology and Conservation. Larkum, A. W. D., Orth, R. J. and Duarte, C. M. (eds.), pp. 503–536. Dordrecht, Springer.

den Hartog, C. 1970. The sea grass of the world. North Holland and Publishing Company Amsterdam, London.

Dennison, W. C. 1987. Effects of light on seagrass photosynthesis, growth and depth distribution. Aquat. Bot. 27: 15–26.

Dennison, W. C. and Alberte, R. S. 1985. Role of daily light period in the depth distribution of *Zostera marina* (eelgrass). Mar. Ecol. Prog. Ser. 25: 51–62.

Duarte, C. M. 1991. Seagrass depth limits. Aquat. Bot. 40: 363–377.

Fonseca, M. S. and Kenworthy, W. J. 1987. Effect of current on photosynthesis and distribution of seagrasses. Aquat. Bot. 27: 59–78.

Hemminga, M. A. and Duarte, C. M. 2000. Seagrass ecology. Cambridge University Press. Cambridge.

Japar Sidik, B., Arshad, A., Hishamuddin, O., Muta Harah, Z. and Misni, S. 1996. Seagrass and macroalgal communities of Sungai Pulai estuary, south-west Johore, Peninsular Malaysia. *In* Seagrass biology: Scientific discussion from an International Workshop, Rottnest Island, Western Australia. Faculty of Science. Kuo, J., Walker, D. I. and Kirkman, H. (eds.), pp. 3–12. The University of Western Australia, Nedlands, Western Australia.

Japar Sidik, B., Muta Harah, Z. and Arshad, A. 2001a. Responses of *Halophila ovalis* and *Cymodocea serrulata* under the shade of *Enhalus acoroides. In* Aquatic resource and environmental studies of the Straits of Malacca: Current research and reviews. Japar Sidik, B., Arshad, A., Tan, S. G., Daud, S. K., Jambari, H.A. and Sugiyama, S. (eds.), pp. 111–115. Malacca Straits Research and Development Centre (MASDEC), Universiti Putra Malaysia, Serdang, Malaysia.

Japar Sidik, B., Muta Harah, Z., Kanamoto, Z. and Mohd. Pauzi, A. 2001b. Seagrass communities of the Straits of Malacca. *In* Aquatic resource and environmental studies of the Straits of Malacca: Current research and reviews. Japar Sidik, B., Arshad, A., Tan, S. G., Daud, S. K., Jambari, H. A. and Sugiyama, S. (eds.), pp. 81–98. Malacca Straits Research and Development Centre (MASDEC), Universiti Putra Malaysia, Serdang, Malaysia.

Kuo, J. 2000. Taxonomic notes on *Halophila ovata* and *Halophila minor*. Bio. Mar. Medit. 7(2): 79–82.

Longstaff, B. J. and W .C. Dennison. 1999. Seagrass survival during pulsed turbidity events: The effects of light deprivation on the seagrasses *Halodule pinifolia* and *Halophila ovalis*. Aquat. Bot. 65: 105–121.

McKenzie, L. 2008. Seagrass educator's hand book. Seagrass-Watch HQ/DPI & F. Queensland, Australia.

Norhadi, I. 1993. Preliminary study of seagrass flora of Sabah, Malaysia. Pertanika J. Trop. Agri. Sc. 16: 111–118.

Parthasarathy, N., Ravikumar, K. and Ramamurthy, K. 1988. Floral biology and ecology of *Halophila beccarii* Aschers. (Hydrocharitaceae). Aquat. Bot. 31: 141–151.

Short, F. T. 1987. Effect of sediment nutrients on seagrass: literature review and mesocosm experiment. Aquat. Bot. 24: 41–57.