

OCCURRENCE AND MORPHOLOGICAL DESCRIPTION OF SEAGRASSES FROM PULAU REDANG, TERENGGANU, MALAYSIA

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Abstract. The occurrence of seagrasses was surveyed around the Pulau Redang water from April 1996 to September 1998. Seagrasses were observed at four locations; Cagar Hutang, Sungai Redang estuary, Pasir Panjang and Teluk Dalam. Three species; *Halophila decipiens* Ostenfeld, *Halophilaminor* (Zoll.) den Hartog and *Halodule pinifolia* (Miki) den Hartog were recorded around Pulau Redang. All species were thriving in the sub-tidal areas; monospecific patches of *H. pinifolia* grew on sandy substratum at depth of 2.5–5.0 m at Pasir Panjang and Teluk Dalam, and a population of *H. minor* on similar substrate at depth of 6 m at Sungai Redang estuary. Meadows of *H. decipiens* on silty substratum were observed at Sungai Redang estuary (depth 6 m) and Cagar Hutang (depth 24 m). Morphological plasticity due to varied depth distribution was detected in the seagrass, *H. decipiens*. The descriptions on general and reproductive morphologies are given.

Key words: diversity, seagrass, ecology, morphology, Pulau Redang

Abstrak. Tinjauan kehadiran rumput laut di kepulauan Pulau Redang telah dijalankan dari April 1996 hingga September 1998. Rumput laut telah dijumpai di empat kawasan; Cagar Hutang, muara Sungai Redang, Pasir Panjang dan Teluk Dalam. Tiga spesies; *Halophila decipiens* Ostenfeld, *Halophilaminor* (Zoll.) den Hartog dan *Halodule pinifolia* (Miki) den Hartog telah direkodkan di perairan Pulau Redang. Kesemua spesies tumbuh subur di kawasan sub-tidal: kelompok monospesifik *H. pinifolia* tumbuh di atas substrat berpasir pada kedalaman 2.5–5.0 m di Pasir Panjang dan Teluk Dalam, dan populasi *H. minor* di atas substrat yang sama pada kedalaman 6 m di muara Sungai Redang. Hamparan *H. decipiens* tumbuh di atas substrat berlumpur dijumpai di muara Sungai Redang (kedalaman 6 m) dan Cagar Hutang (kedalaman 24 m). Perbezaan morfologi dalam *H. decipiens* dapat dikesan dan ini disebabkan kedalaman dimana spesies ini didapati. Keterangan dan perbincangan tentang morfologi keseluruhan dan pembiakan disertakan.

Kata kunci: diversity (kepelbagaian), rumput laut, ekologi, morfologi, Pulau Redang

1.0 INTRODUCTION

Seagrasses are unique amongst flowering plants as they are the only ones able to live submerged in the marine environment [1]. The important ecological and economic

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function of seagrass meadows have been recognized for example in stabilizing sediments, as substratum for many epiphytes and as feeding and nursery areas for many fishes and crustaceans [2,3,4]. In our biogeographical studies, collections have been made of plants particularly seagrasses in coastal waters around the mainland Peninsular Malaysia and off-shore islands. The attention paid to the last decades has led to many records of species in areas where they had not been known before. In Malaysia, 13 species of seagrasses belonging to 8 genera, 3 families and 2 orders distributed over wide areas of Peninsular Malaysia (western, eastern and southern coasts) and East Malaysia [5,6,7,8,9] have been recorded. In this paper the occurrence, some aspects on ecology and morphology of seagrass species encountered around the waters of Pulau Redang, Terengganu is reported.

2.0 MATERIALS AND METHODS

Field surveys were undertaken from 1996 to 2001 along the coastal areas of Pulau Redang by Scuba diving. Four locations were identified; Cagar Hutang, Sungai Redang estuary, Pasir Panjang and Teluk Dalam (Figure 1). Habitat type, depth, sediment for

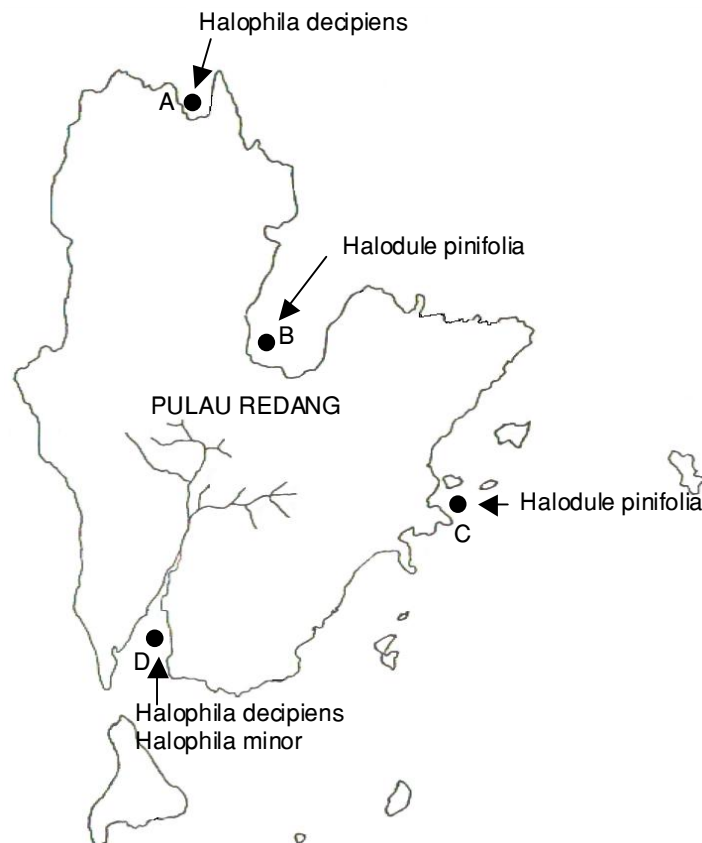


Figure 1 The location of seagrass species around Pulau Redang, Terengganu. A-Cagar Hutang, B-Teluk Dalam, C-Pasir Panjang and D-Sungai Redang estuary

each location as well as water temperatures and salinity where possible, were recorded. The identity of the seagrasses was ascertained by referring to den Hartog [1] and Japar Sidik *et al.* [8,10]. Vegetative (leaf length, leaf width, petiole length, rhizome diameter and rhizome internode length) and reproductive (male and female flowers and fruit) dimensions were recorded. The data were analyzed to test the significant variance (t-test, $p < 0.05$) to compare vegetative and reproductive structures between locations (SPSS for Windows Release 7.5). Materials were processed for herbarium specimens as described by Menez *et al.* and some were preserved as wet specimens in 4% formalin in saline water [11].

3.0 RESULTS AND DISCUSSION

3.1 Occurrence and ecology

The waters of Pulau Redang with little variation in salinity of 28.0–32.3 ppt and temperature 27.0–30.2°C harboured three species of seagrasses: *Halophila decipiens* Ostenfeld, *H. minor* (Zoll.) den Hartog and *Halodule pinifolia* (Miki) den Hartog (Figure 1). All species were thriving in the sub-tidal areas with silty or sandy substrates (Table 1). *Halodule pinifolia* at Teluk Dalam and Pasir Panjang, and *H. minor* at Sungai Redang estuary inhabited depth of 2.5–5 m. Meadows of *H. decipiens* on silty substratum at 6 m depth were observed at Sungai Redang estuary and at depth of 24 m at Cagar Hutang. No other seagrass species such as *H. ovalis* (R. Br.) Hook. f. which is common in the east coast such as Pulau Perhentian, Kuala Setiu, Pulau Tengah, Pulau Besar, Pulau Tinggi down to Pulau Sibul was encountered [12] Phang mentioned that *Halodule uninervis* (Forssk.) Aschers. occurred in the estuary of Sungai Redang

Table 1 Location and habitat characteristics of seagrass around Pulau Redang

Location	Seagrass species	Zone and depth (m)	Habitat Characteristics		
			Substrate type	Water temp. (°C)	Water salinity (ppt)
Cagar Hutang	<i>Halophila decipiens</i>	Sub-tidal 24 m	Silt	29.2–30.1	29.3–32.0
Teluk Dalam	<i>Halodule pinifolia</i>	Sub-tidal 2.5–5 m	Sand	29.0–30.2	29.5–32.3
Pasir Panjang	<i>Halodule pinifolia</i>	Sub-tidal 2.5–5 m	Sand	29.4–29.6	29.0–32.0
Sungai Redang estuary	<i>Halophila decipiens</i>	Sub-tidal 6 m	Silt	27.0–30.1	28.0–32.0
	<i>Halophila minor</i>	Sub-tidal 2.5–5 m	Sand		

[13]. The range of depth limit of 2.5–5 m for *H. pinifolia* and *H. minor* were similar to other areas in Malaysia [9,10]. In clear water, *H. decipiens* thrive at depth of 8-18 m at Pulau Sulug, Sabah, Malaysia [8]. Elsewhere around the world it occurred at similar depth or deeper and on variety a of substrates; at depth of 19–23 m on clayed sand at Tenerife, Canary Islands [14], 11–23 m depth on soft mud with fine sand and silty sediments in the southern Philippines [11], 15–18 m depth on flat sandy coralline at Okinawa Island [15], 58 m depth on carbonate mud in Northeastern, Australia [16]. In turbid water it was found at 2 m depth on muddy coral sand at Tuticorin, Southern India [17] and 1.5 m at Teluk Kemang, Port Dickson on sandy-muddy substrate [6, 18]. Altered depth of *H. decipiens* may be the ‘indicator’ on water quality changes that caused changes in light penetration and consequently affected its depth distribution pattern. Changes in seagrass depth distribution such as those found in Chesapeake Bay, U.S.A. was the result of runoff-impacts on water quality [19].

3.2 Morphological description of seagrasses

Dimension analysis of vegetative components such as leaf length, leaf width, rhizome internode length, rhizome diameter and reproductive components, flowers and fruits if available are presented in Tables 2 and 3 and the descriptions are given below.

Table 2 Summary of dimension analysis (given in mm) of vegetative structures of seagrasses (*Halophila decipiens*, *H. minor* and *Halodule pinifolia*) around Pulau Redang. N is the number of measurement taken, different letters indicate significant differences at $p < 0.05$ (t-test), i.e. $a > b$, values in parenthesis are the ranges

Vegetative	<i>H. decipiens</i>		<i>H. minor</i>	<i>H. pinifolia</i>
	Sungai Redang estuary (at 6 m depth)	Cagar Hutang (at 24 m depth)	Sungai Redang estuary	Sungai Redang estuary/Pasir Panjang/Teluk Dalam
Leaf length	11.51 ± 0.15 ^b (8.69–13.60) N=56	14.05 ± 0.18 ^a (10.59–18.01) N=81	13.62 ± 0.18 (11.14–17.98) N=74	53.73 ± 1.24 (41.00–80.00) N=80
Leaf width	4.53 ± 0.06 ^b (3.09–5.46) N=57	5.90 ± 0.07 ^a (4.50–7.23) N=81	8.25 ± 0.12 (5.73–10.52) N=75	0.45 ± 0.01 (0.40–0.50) N=80
Leaf length: Leaf width	2.54 ± 0.04:1 ^a (1.82–3.14:1) N=56	2.39 ± 0.03:1 ^b (1.71–2.99:1) N=81	1.67 ± 0.02:1 (1.27–2.35:1) N=74	–
Petiole length	3.02 ± 0.10 ^b (1.89–5.13) N=57	4.82 ± 0.13 ^a (2.18–8.10) N=82	11.86 ± 0.46 (3.74–20.88) N=77	–

Table 2 *Continued*

Rhizome diameter	0.65 ± 0.02^b (0.45–1.05) N=45	0.73 ± 0.02^a (0.48–1.05) N=48	0.92 ± 0.02 (0.67–1.17) N=56	0.89 ± 0.02 (0.62–1.28) N=61
Rhizome internode length	13.38 ± 0.71^b (4.00–21.73) N=48	18.01 ± 1.20^a (5.63–33.72) N=53	22.99 ± 0.67 (11.41–36.44) N=57	22.93 ± 0.87 (10.77–35.48) N=65
Erect stem length	–	–	–	2.48 ± 0.16 (0.59–6.31) N=48
Sheath length	–	–	–	10.82 ± 0.2 (5.00–15.17) N=55
Cross vein number	–	–	9.00 ± 0.16 (7.00–11.00) N=49	–
Space between two cross veins	–	–	0.70 ± 0.02 (0.57–1.00) N=27	–
Space between intramarginal vein and blade margin	–	–	0.18 ± 0.01 (0.14–0.29) N=22	–
Upper scale length	2.46 ± 0.07^a (2.00–3.18) N=17	2.68 ± 0.10^a (2.27–3.64) N=16	2.94 ± 0.08 (2.14–3.57) N=23	–
Upper scale width	2.37 ± 0.06^a (2.00–2.73) N=16	2.16 ± 0.07^b (1.82–2.73) N=16	2.83 ± 0.10 (1.71–4.00) N=23	–
Lower scale length	2.99 ± 0.08^a (2.09–3.64) N=21	3.19 ± 0.11^a (2.64–4.09) N=16	2.81 ± 0.08 (2.14–3.71) N=23	–
Lower scale width	1.97 ± 0.05^a (1.27–2.18) N=20	1.92 ± 0.05^a (1.64–2.18) N=16	2.57 ± 0.10 (1.71–3.43) N=23	–

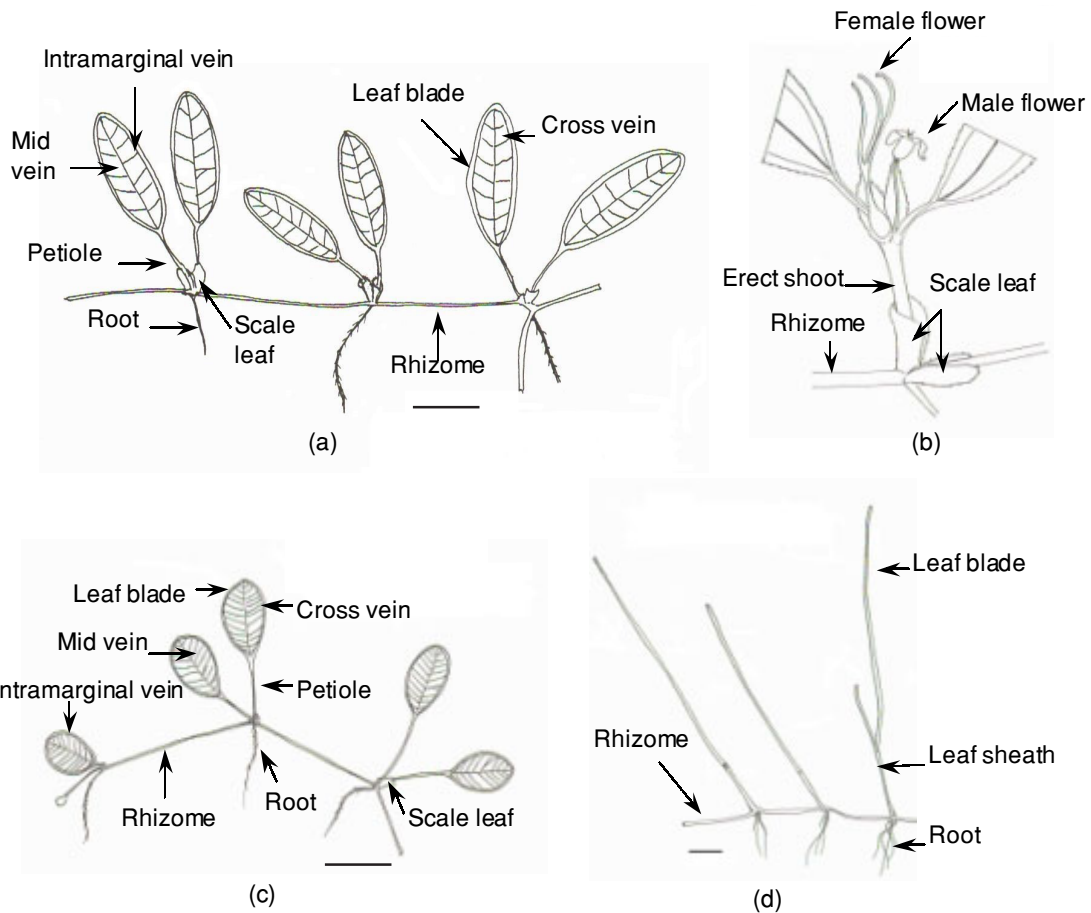


Figure 2 The habits of seagrasses at Pulau Redang. (a) *Halophila decipiens*, scale bar 10 mm. (b) *H. decipiens* exhibits monoecy where male and female flowers are found on the same plant. (c) *H. minor*, scale bar 10 mm. (d) *Halodule pinifolia*, scale bar 10 mm

Halophila decipiens is a monoecious plant (Figures 2a, 2b) with a creeping fragile narrow rhizome, 0.45–1.05 mm thick, rhizome internode length, 4.00–21.73 mm (Sungai Redang estuary) to 5.63–33.72 mm (Cagar Hutang). One unbranched root with numerous root hairs is present below each erect shoot. Erect shoot is up to 2.78 mm long arising from each node, bearing a pair of leaves. The erect stem and the immediate rhizome are enveloped by a pair of obovate, keeled, transparent scales, with short stiff hairs on the margin and the outside, upper scale, 2.00–3.64 mm × 1.82–2.73 mm, lower scale, 2.09–4.09 mm × 1.27–2.18 mm. Leaf blade is pale green in colour, distinctly elliptic, obtuse at the apex, margin finely serrated, 10.59–18.01 mm long, 4.50–7.23 mm wide (Cagar Hutang; Figures 3a, 3b) 8.69–13.60 mm long, 3.09–5.46 mm wide (Sungai Redang estuary; Figures 3c, 3d). The mid-vein is conspicuous, united apically with intramarginal veins, cross veins 5–10 pairs, sub-opposite to alternate, occasionally

forked. The adaxial and abaxial leaf surfaces are with dense, short, stiff unicellular hairs, almost evenly distributed; petioles slender, 1.89–5.13 mm long (Sungai Redang estuary) to 2.18–8.10 mm (Cagar Hutang).

Halophila decipiens from Cagar Hutang (at depth of 24 m) have longer leaf, petiole and rhizome internode length, wider leaf width, rhizome diameter and narrow upper scale leaf when compared to plants from Sungai Redang estuary (at depth of 6 m) (t-test, $p < 0.05$; Table 2). The leaf length:leaf width ratio of *H. decipiens* from Sungai Redang estuary was higher (1.82–3.14:1) than plants from Cagar Hutang (1.71–2.99:1). This provides evidence of the relationship between depth and the morphological plasticity of *H. decipiens*. Adaptation to the low light (deeper water or turbid water) by *H. decipiens* might induce and increase in dimension of the above parameters. It has been reported that *H. decipiens* adaptation to low light include a high ratio of leaf tissue to non-photosynthetic tissue, low leaf area index to reduce self-shading, high turn over of leaf materials and ability to rapidly colonize soft bottom when light conditions are suitable [20].

For both areas, size dimensions of the inflorescences (reproductive structures) are similar with the exception of hypanthium length, which is longer at Cagar Hutang when compared to Sungai Redang estuary (Table 3). Inflorescence, a pair of flowers on the same or lateral erect shoots; one male and one female flower, subtended by 2 overlapping scarious, transparent spathes with finely serrulate margins, 1.82–3.36 mm long (Sungai Redang estuary) to 2.27–3.64 mm long (Cagar Hutang). A male flower

Table 3 Summary of dimension analysis (given in mm) of reproductive structures of seagrasses *Halophila decipiens* at different depths at Sungai Redang estuary and Cagar Hutang. N is the number of measurement taken, different letters indicate significant differences at $p < 0.05$ (t-test), i.e. $a > b$, values in parenthesis are the ranges

Reproductive structure	N	Sungai Redang estuary (at 6 m depth)	N	Cagar Hutang (at 24 m depth)
Male flower				
Pedicel length	13	2.54 ± 0.17 (1.36 – 3.36)	4	3.00 ± 0.25 (2.27 – 3.45)
Tepal length	38	0.89 ± 0.02 (0.73 – 1.09)	12	0.86 ± 0.02 (0.73 – 1.00)
Tepal width	38	0.45 ± 0.01 (0.36 – 0.55)	12	0.45 ± 0.02 (0.36 – 0.55)
Anther length	3	0.42 ± 0.03 (0.36 – 0.45)	3	0.42 ± 0.03 (0.36 – 0.45)
Female flower				
Style length	31	2.87 ± 0.15 (0.91 – 3.91)	6	3.06 ± 0.17 (2.55 – 3.64)
Ovary length	10	0.94 ± 0.05 (0.55 – 1.09)	2	1.00 ± 0.09 (0.91 – 1.09)
Ovary width	10	0.57 ± 0.02 (0.45 – 0.73)	2	0.50 ± 0.05 (0.45 – 0.55)
Hypanthium length	17	1.12 ± 0.07^b (0.45 – 1.55)	12	1.39 ± 0.08^a (0.91 – 1.91)
Fruit length	7	1.31 ± 0.12 (1.00 – 1.91)	10	1.59 ± 0.13 (1.09 – 2.27)
Fruit width	7	0.97 ± 0.13 (0.55 – 1.55)	10	1.12 ± 0.09 (0.64 – 1.55)

comprised of a whitish pedicel, 1.36–3.45 mm long; three whitish, oblong-elliptic, convex tepals, 0.73–1.09 mm × 0.36–0.55 mm and three fused anthers, 0.36–0.45 mm long. A Female flower comprised of a sessile, ovoid ovary, 0.55–1.09 mm × 0.45–0.73 mm; a hypanthium 0.45–1.55 mm long (Sungai Redang estuary) to 0.91–1.91 mm long (Cagar Hutang); three to four styles, with glandular inner surfaces, of unequal length of 0.91–3.91 mm long (Figure 2b). Fruits broadly ellipsoid, 1.00–2.27 mm long, 0.55–1.55 mm wide. Seeds 20–30, ellipsoid to spherical, bluntly beaked at both ends, testa reticulate.

Halophila decipiens previously recorded only from the west coast of Peninsular Malaysia [6] and in Sabah [8], is now known also from the east coast at Cagar Hutang and Sungai Redang estuary, Pulau Redang. This species grows as a monospecific meadow or growing in association with other seagrasses. Deep water *H. decipiens* have been used as feeding ground by dugong for example at Lookout Point to Barrow Point northern Australia. Numerous dugong feeding trails were found at depth down to 23 m which indicated the for first time the importance of these deep water *Halophila* meadows as food for dugong [21]. Similarly, Cagar Hutang is known for the nesting ground of turtles and the *H. decipiens* meadow in the vicinity may serve as feeding ground.

Halophila minor is a petiolate seagrass (Figure 2c) with creeping horizontal rhizome, 0.67–1.17 mm in diameter, rhizome internode length, 11.41–36.44 mm long, an unbranched root with numerous root hairs at each node. Two scales; transparent, convex or folded, suborbicular to transversely elliptic, acute, rounded or emarginate at the apex, auriculate at the base. The upper scale is 2.14–3.57 mm × 1.71–4.00 mm and the lower scale, 2.14–3.71 mm × 1.71–3.43 mm. Leaves in pairs, with petiole, 3.74–20.88 mm long. Leaf blade ovate or obovate, green, entire; apex rounded; base obtuse or shortly cuneate and contracted near the petiole, 11.14–17.98 mm in length and 5.73–10.52 mm in width, with a L:W ratio of 1.27–2.35:1; cross veins 7–11 pairs, space between two cross veins, 0.57–1.00 mm, space between intramarginal vein and blade margin narrow, 0.14–0.29 mm (Table 2; Figures 3e, 3f). Male and female flowers were not found.

The *H. minor* identified in this study is based on the recent taxonomic reexamination of *H. ovata*-*H. minor* complex, where *H. ovata* and *H. minor* are under separate distinct species [22]. The previous classification by den Hartog [1] and Sachet and Fosberg [23], assumed that *H. ovata* and *H. minor* are identical. Kuo [21] in his examination of other materials reported that *H. minor* is widely but disjunctionly distributed in the tropical Indian Ocean, and Western Pacific Ocean, including Kenya, India, Malaysia and Northern Australia while *H. ovata* has been collected from Saipan, Guam in the northern Mariana Islands, Yap or Micronesia Islands and Manila Bay in the Philippines in the western Pacific Ocean.

Halodule pinifolia is a small seagrass (Figure 2d) with creeping rhizome, 0.62–1.28 mm thick with 1–3 roots and a short erect stem, 0.59–6.31 mm long at each node.

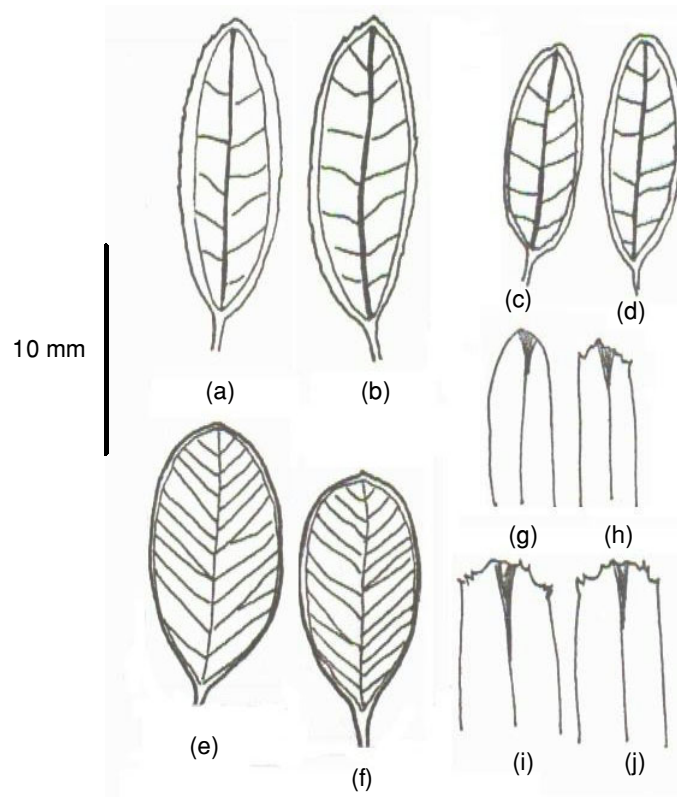


Figure 3 The morphology of seagrass leaves at Pulau Redang. Leaves with serrated margin of *Halophila decipiens* from Cagar Hutang (a, b). Leaves with serrated margin of *H. decipiens* from Sungai Redang estuary (c, d). Leaf variation of *H. minor* from Sungai Redang estuary (e, f). Leaf tip round or with serratures in young leaf of *Halodule pinifolia* (g, h). Leaf tip with numerous serratures in mature or old leaf of *H. pinifolia* from Sungai Redang estuary, Pasir Panjang and Teluk Dalam (i, j). In the case of *H. pinifolia* the leaves are not drawn to scale.

Rhizome internode length is 10.77–35.48 mm long. There are 2–3 leaves per shoot and 5.00–15.17 mm long leaf sheaths, leaf blades 41.00–80.00 mm long and 0.40–0.50 mm wide (Table 2). The leaf tips are obtuse with irregular serration; lateral teeth are temporarily developed or totally absent (Figures 3g, 3h, 3i, 3j). Midrib conspicuous, sometimes bifurcate at the apex. Intramarginal veins inconspicuous, both end in a very small tooth. Male and female flowers were absent.

In Malaysia, *H. pinifolia* have been classified as long leaved variant (mean leaf length range 83.91–102.52 mm, leaf length range 60–166 mm) and short leaved variant (mean leaf length range 49.70–57.43 mm, leaf length range 40–80 mm). The Pulau Redang population belongs to the *H. pinifolia* short leaved variant [10]. This species can be mistaken for *H. uninervis* narrow leaved variant where mature leaf-tip is tridentate with the median tooth as long as or even shorter or longer than the lateral (Figures 3i, 3j). It is easily distinguished from *H. uninervis* broad leaved species that are found in

other areas in Malaysia, where the leaf blade is generally wider (mean leaf width ranged 2.16–3.21 mm, leaf width range 1.5–4.0 mm) and leaf-tips with an obtusely rounded or pointed median tooth in which the midrib ends, usually as long as and rarely longer than the 2 lateral teeth [10].

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