

## Survey of *Rhizophora stylosa* populations in Peninsular Malaysia

### Introduction

In Peninsular Malaysia, *Rhizophora apiculata* Bl. and *Rhizophora mucronata* Lamk. are widely distributed mangrove species. *Rhizophora stylosa* Griff. is rare and reportedly occur at locations associated with rocky and sandy shores (Mohd Nasir & Safiah Yusmah, 2007). Eight sites where *R. stylosa* populations occur have been identified. In March 2012, we conducted a field survey in four of these sites, namely, Bagan Lalang in Selangor, Pulau Burung in Negeri Sembilan and Pulau Besar in Melaka on the west coast, and Pulau Mawar in Johor on the east coast. Trees of *R. stylosa* were flowering and/or fruiting (Fig. 1). At each site, the relative abundance of *Rhizophora* species was determined based on transect counts and their leaf dimensions measured.



Fig. 1. Leaves, flowers and propagules of *R. stylosa*

### Description of sites

Bagan Lalang (2°35'N, 101°41'E) is a popular beach resort in Sepang, Selangor. At the end of the beach east of the Golden Palm Tree Resort, scattered trees of *R. stylosa* were found growing on sand flats at the seafront (Fig. 2), interspersed with trees of *Avicennia* and *Sonneratia*. At the landward side, *R. stylosa* occurs with *R. apiculata* and *R. mucronata* in mixed stands.

Pulau Burung (2°32'N, 101°47'E) is a small islet off the coast of Si Rusa in Port Dickson, Negeri Sembilan. An elaborate wooden bridge and walkway provide access from the mainland to the islet. *Rhizophora* species, including hybrid(s), dominate the islet. The morphological features of the hybrid *Rhizophora x lamarckii* and its putative parents *R. stylosa* and *R. apiculata* have been described by Chan (1996), Chan & Wong (2009), and Ng & Chan (2012). The features of *R. stylosa* are summarised in Box 1. Other mangrove species included *Bruguiera gymnorhiza*, *Ceriops tagal* and *Sonneratia alba*.



Fig. 2. A solitary *R. stylosa* tree in Bagan Lalang

Pulau Besar (2°06'N, 102°19'E) is an island about 10 min by speed boat from the mainland Umbai, Melaka. Trees of *R. stylosa* occur as pure stands on muddy sand flats at rocky promontories of the eastern and southern shores of the island. The stands were confined to the promontories (Fig. 3), suggesting that protection from waves and currents may be crucial for their establishment. Growing amongst the *R. stylosa* stands were scattered individuals of *Avicennia* and *Sonneratia*. Along the sandy beaches are *Hibiscus tiliaceus*, *Calophyllum inophyllum*, *Anacardium occidentale*, *Ficus microcarpa*, *Casuarina equisetifolia*, *Eugenia grandis*, *Casuarina equisetifolia*, *Terminalia cattapa*, *Pandanus odoratissimus* and *Casuarina equisetifolia*. In recent years, the development of several beach resorts has altered the pristine coastal environment.



Fig. 3. Stand of *R. stylosa* at a promontory on Pulau Besar

Pulau Mawar (2°36'N, 103°46'E) is an island off Kampung Mawar, in Endau, Johor. It is connected to the mainland by a sand bar, enabling access during the low tide. On the island, *R. stylosa* and *R. apiculata* grow luxuriously on muddy sand flats. Other coastal plant species present included the true mangrove species *S. alba* and *C. tagal*, as well as mangrove associates such as *Pongamia pinnata*, *H. tiliaceus*, *C. inophyllum*, *T. cattapa*, *C. equisetifolia*, *S. taccada* and *P. odoratissimus*. The presence of gigantic trees of *S. alba* at the seaward flats suggests that the island flora is relatively pristine.

### Relative abundance

In Bagan Lalang, enumeration of trees within a 20 × 200 m transect showed that *R. stylosa* constituted 33% of all mangrove trees (Mohd Nasir & Safiah Yusmah, 2007). On Pulau Burung, counts in six 10 × 45 m transects showed that the relative abundance of *Rhizophora* species was of the order: *Rhizophora* hybrid(s) = 50 (69.4%) > *R. stylosa* = 12 (16.7%) > *R. mucronata* = 6 (8.3%) > *R. apiculata* = 4 (5.6%). The predominance of *Rhizophora* hybrid(s) and the presence of putative parents on Pulau Burung make the islet an interesting and valuable site for research on population genetics. On Pulau Mawar, counts in three 10 × 45 m transects showed that the relative abundance of *R. stylosa* was 25 (55.6%) and *R. apiculata* was 20 (44.4%). On Pulau Besar, *R. stylosa* was the only *Rhizophora* species found.

### Leaf dimensions

Leaves of *R. stylosa* in all four sites showed no significant difference in mean blade length (BL), mean blade width (BW), mean petiole length (PL) and mean mucronate length (ML) (Table 1). Values ranged from 10.0 ± 1.4 to 12.3 ± 1.3 cm, 4.9 ± 0.6 to 5.4 ± 0.8 cm, 2.5 ± 0.3 to 3.3 ± 0.6 cm and 4.0 ± 0.8 to 5.0 ± 0.5 mm, respectively. When the leaf dimensions of *R. stylosa* are compared with those of *R. apiculata* and *R. mucronata*, a consistent trend emerged. In Bagan Lalang and Pulau Burung, mean BL of *R. apiculata* and *R. mucronata* was significantly longer than *R. stylosa*. Mean BW of *R. mucronata* was significantly wider than *R. stylosa* and *R. apiculata*. Mean PL of *R. apiculata* was significantly shorter than *R. stylosa* and *R. mucronata*. Mean ML of *R. stylosa* and *R. mucronata* was significantly longer than *R. apiculata*. On Pulau Mawar, as in Bagan Lalang and on Pulau Burung, mean BL of *R. stylosa* was shorter than *R. apiculata*, mean BW was comparable, and mean PL and ML were longer.

### Other morphological features

In Bagan Lalang, the length of five mature propagules of *R. stylosa* measured ranged from 31 to 32 cm (mean = 31.2 ± 0.4 cm). They are slightly longer than those of *R. apiculata* (25 to 30 cm) but much shorter than those of *R. mucronata* (50 to 70 cm) (Chan & Baba, 2009). Trees of *R. stylosa* in Bagan Lalang were shorter in height (mean = 3.1 m) compared to those on Pulau Burung (mean = 3.9 m), Pulau Besar (mean = 4.7 m) and Pulau Mawar (mean = 5.3 m).

One key morphological feature of *R. stylosa* leaves is the presence of fine black dots at the under surface. On Pulau Mawar, however, we found that the spots were brown in colour, different from those collected from the other three sites. This may indicate a possible difference in phenotypic expression between *R. stylosa* populations on the east and west coast of Peninsular Malaysia. Physical barriers are known to impede gene flow between isolated populations, resulting in intra-specific differentiation over time (Ge & Sun, 2001; Inomata *et al.*, 2009; Minobe *et al.*, 2010).

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Table 1. Leaf dimensions of *Rhizophora stylosa* at four sites, in comparison with those of *Rhizophora apiculata* and *Rhizophora mucronata*

Site	Species	N	Mean BL (cm)	Mean BW (cm)	Mean PL (cm)	Mean ML (mm)
Bagan Lalang	<i>R. stylosa</i>	45	10.0 ± 1.4b	4.9 ± 0.6b	2.6 ± 0.6a	4.0 ± 0.8a
	<i>R. apiculata</i>	12	13.2 ± 1.2a	5.0 ± 0.6b	1.9 ± 0.3b	2.0 ± 0.8b
	<i>R. mucronata</i>	9	14.8 ± 1.7a	7.8 ± 0.6a	2.9 ± 0.5a	4.0 ± 1.4a
Pulau Burung	<i>R. stylosa</i>	27	10.7 ± 1.0b	5.1 ± 0.5b	2.5 ± 0.3a	5.0 ± 1.2a
	<i>R. apiculata</i>	6	13.6 ± 0.8a	5.1 ± 0.4b	1.4 ± 0.1b	2.0 ± 0.0b
	<i>R. mucronata</i>	9	14.6 ± 1.4a	7.2 ± 0.7a	2.7 ± 0.8a	4.2 ± 1.8a
Pulau Besar	<i>R. stylosa</i>	33	11.5 ± 1.5	5.4 ± 0.8	3.3 ± 0.6	4.6 ± 0.6
Pulau Mawar	<i>R. stylosa</i>	45	12.3 ± 1.3b	5.3 ± 0.6a	3.2 ± 0.5a	5.0 ± 0.5a
	<i>R. apiculata</i>	15	14.8 ± 1.1a	5.6 ± 0.6a	2.2 ± 0.2b	2.5 ± 0.5b

Three leaves per tree were sampled and measured. For each column, different letters (a-b) are significantly different at  $P < 0.05$ , as measured by the Tukey HSD test. ANOVA does not apply between sites. Abbreviations: N = number of leaves measured, BL = blade length (measured from the base to the tip of leaf blade), BW = blade width (measured at the widest point of leaf blade), PL = petiole length, ML = mucronate length, and HSD = honestly significant difference.



**Tree:** Gnarled form with multiple stems and extensive reddish brown stilt roots, 3-5 m in height, produces aerial roots from branches

**Bark:** Reddish brown with no fissures

**Leaf:** Stalk 2.5-3.5 cm, midrib pale green at under surface, blade broadly elliptic (blade length 10.0-12.5 cm, blade width 5.0-5.5 cm, petiole length 2.5-3.5 cm), apex with prominent mucronate spike (4.0-5.0 mm), prominent black dots at the under surface

**Inflorescence:** Branched 2-4 times, 4-8 buds borne on elongated peduncle

**Flower:** Inverted, petals hairy, elongated style 4-5 mm

**Fruit:** Dark brown when ripe, ovate, 2 cm long

**Propagule:** Hypocotyl cylindrical, warty with pointed tip, 30-32 cm, collar yellow in colour and slightly swollen

Box 1. Morphological features of *Rhizophora stylosa*