

Distribution and Rarity of Rhizophoraceae in Peninsular Malaysia

W. A. Wan Juliana, M. S. Razali and A. Latiff

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Abstract This paper attempts to review the distributions and rarity of Rhizophoraceae in Peninsular Malaysia. Results presented were from plot studies (11 sites), random field surveys (3 sites) and previously published reports. The primary data were from four sites in Johor (Belungkor Forest Reserve, Pulau Forest Reserve, Santi Forest Reserve and Tanjung Piai), four in Langkawi (Ayer Hangat, Sungai Kilim, Kisap Forest Reserve and Selat Tuba), two in Matang Forest Reserve (Compartment 49 and VJR), one in Selangor (West Port, Klang), one in Terengganu (Kuala Kemaman Forest Reserve), and one each in Melaka (Tanjung Tuan) and

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Negeri Sembilan (Port Dickson), respectively. Secondary data were obtained from reports of studies at Sungai Merbok Forest Reserve in Kedah, Matang mangrove forest in Perak, Sementa mangrove forest in Selangor, Kuala Sedili Forest Reserve, Johor, Terengganu mangrove forest, Terengganu and also a general survey throughout Peninsular Malaysia. All trees at 5 cm and above diameter were recorded in plot studies. A total of seven species from the family Rhizophoraceae were sampled at the study plots, the number of which ranged from two to six. The most common and highly abundant species in the study sites was *Rhizophora apiculata* with an estimated total of 1,184 trees (51.2 % of the total). Other abundant species were *R. mucronata* (25.5 %) and *Ceriops tagal* (12.2 %). The less abundant and restricted species in the study sites were *Bruguiera cylindrica* (3.80 %), *B. gymnorrhiza* (2.94 %), *B. parviflora* (4.06 %) and *B. sexangula* (0.30 %). *Rhizophora stylosa*, *Ceriops decandra*, *Kandelia kandel* and *Bruguiera hainesii* were only found from random surveys and not in plot studies and are considered rare species. The *Rhizophora x lamarckii* and *R. x annamalayana* are considered very rare and endangered and were only found in Selat Kuah, Langkawi and Pulau Forest Reserve and Merbok Forest Reserve, respectively.

1 Introduction

Mangrove trees are a major component of a mangrove ecosystem. According to Duke (1992), mangrove has been defined as a “community of trees, shrubs, palms or ground ferns, generally exceeding more than half a meter in height, and which normally grows above mean sea level in the intertidal zones of marine coastal environments, or estuarine margins.” There are three components of a mangrove habitat: plants, aquatic animals and terrestrial animals.

2 Mangrove Forest in Malaysia

According to Japar Sidik (1994), a mangrove forest developed best in Malaysia where the highest number of species occur and is favoured by a humid tropical climate and high rainfall, which are usually accompanied by silt-laden rivers forming suitable mudflats. These mangrove forests are also found to develop further inland, up to where the tidal influence of the sea can be felt in the rivers or streams. The Malaysian mangrove is the third largest mangrove forest in the Asia-Pacific region after Indonesia and Thailand. It could be found mainly in the states of Perak, Kedah and Johor. Smaller mangrove areas are found in Kelantan, Terengganu and Pahang. In Sarawak, mangroves are found along the coastlines and estuaries of the Sarawak River, the Rajang Delta and the Trusan River and in Sabah they are found in the eastern and northern coastal areas of the state (Table 1).

In the case of Peninsular Malaysia, mangrove forests are well developed in the west due to relatively sheltered coasts. The seas of the west coast are calmer due to

Table 1 Occurrences of mangrove by state in Peninsular Malaysia, Sabah and Sarawak. (Source: Shaharuddin et al. 2005)

State	State land mangrove (ha)	Permanent reserve forest (ha)	Total area (ha)
Kedah	150	8,257	8,407
Pulau Pinang	494	376	870
Perak	122	41,302	41,424
Selangor	4,606	14,897	19,503
Negeri Sembilan	–	204	204
Melaka	–	80	80
Johor	3,348	17,832	21,180
Terengganu	692	1,130	1,822
Sub-total	9,412	84,078	93,490
Sarawak	93,200	33,200	126,400
Sabah	23,266	317,423	340,689
Total	125,878	434,701	560,579

the protection accorded by Sumatera and bordered by the Strait of Malacca that has a limited wind fetch, whereas the east coast is exposed to the South China Sea that has larger and more energetic waves (Aldrie 2002). Mangrove forest developments are inhibited by strong currents and wave action, especially due to the monsoon season (Gong et al. 1984; Mohd. Lokman and Yaakob 1995). About 96 % of these forest reserves are located on the west coast while only 4 % are located on the east coast. There are small patches of mangrove area on the east coast of Peninsular Malaysia and they are confined to river mouths in the states of Pahang, Terengganu and Kelantan. However most of these mangrove reserves are situated in Pahang, with 11 locations, compared to three locations in Terengganu, and no mangrove forest is set aside as a reserve in Kelantan (Japar Sidik 1994).

In Peninsular Malaysia, the total extent of mangrove forest reserve in 2005 was estimated to be about 102,541 ha. When compared to the total forest area of about 4,639,981 ha and total land area of about 13,167,245 ha, mangrove forests amount to only 2.2 % and 0.79 %, respectively (JPNT 2005). The largest mangrove forest in Peninsular Malaysia is the Matang Mangrove (covering about 41,000 ha), which has been managed for charcoal, firewood and poles by the Forestry Department since 1904. Studies on forest composition are very important as a part of the present environmental impact assessment and, more importantly, for management of natural resources, especially for monitoring changes in ecosystem quality.

3 Research on the Mangrove Forest in Malaysia

Published works on estuary mangrove swamps on the east coast of Peninsular Malaysia are scanty. On the other hand, in other states on the west coast of Peninsular Malaysia, mangrove areas have been well studied. The first study on floristic composition, structure and potential net primary production of mangrove forest in Kuala Kemaman was done by Soepadmo and Pandi Mad Zain (1989). This study

surveyed the mangrove of Kuala Kemaman and Kampung Pantai Tinggi, Kemaman where only 24 species of plants are recorded. The dominant species were *Rhizophora apiculata* and *Bruguiera gymnorhiza*.

Norhayati (1995), who studied the biomass and species composition in 1 ha stand of mangrove forest in Kisap Forest Reserve, Langkawi, recorded a total of 849 trees comprising nine mangrove tree species from four families. The dominant species is *Rhizophora apiculata* (65.5 %) followed by *Xylocarpus granatum* (10.6 %) and *Bruguiera parviflora* (9.8 %). Sulong and Ismail (1990) identified the species groups of mangrove forest from Kemaman to Kuantan and they recognized three mangrove forest types, namely, the *Rhizophora* type, *Avicennia/Sonneratia* type, and the mixed-mangrove type. An area of 2,214 ha is covered by mangrove forest, of which 2 % is the *Avicennia/Sonneratia* type, 24 % the *Rhizophora* type and 74 % the mixed-mangrove type. *Avicennia/Sonneratia* is found to have the highest stand density with 13,348 trees/ha, followed by *Rhizophora* with 6,697 and mixed-mangrove forest with 1,997.

The study conducted by Hafizah Seman (2004) in the Kisap Forest Reserve, Langkawi in the 0.25 ha plot area found six species from four families, namely, *Rhizophora mucronata*, *R. apiculata*, *Xylocarpus moluccensis*, *Ceriops tagal*, *Lumnitzera littorea* and *Avicennia marina*. The most dominant species was *R. mucronata* (45.2 %), followed by *R. apiculata* (30.4 %) and *C. tagal* (14.2 %). The other study in Langkawi was conducted by Fera Fizani (2004) in the Ayer Hangat Forest Reserve, whereby 230 mangrove trees in the 0.25 ha plot area were sampled comprising seven different species from five families, namely, Rhizophoraceae, Meliaceae, Avicenniaceae, Combretaceae and Sonneratiaceae. The result showed that the dominant species is *Rhizophora mucronata* (58.7 %), followed by *Sonneratia alba* (14.9 %) and *Rhizophora apiculata* (13.4 %).

Research on the conservation value of mangrove has been carried out by Ashton and Macintosh (2001) at Semantan mangrove forest, Sarawak. They found that the uniqueness in the Semantan mangrove is related to the large strand of mature *X. granatum* that dominates the forest. Research about forest composition and biomass estimation of the mangrove at west Port, Klang, Selangor by Norhayati et al. (2007) determined that the total number of individual trees recorded in all ten plots was 222 from ten species of three families, namely, Rhizophoraceae, Avicenniaceae and Meliaceae. *Rhizophora apiculata* was the most dominant tree species (34.7 %) followed by *Ceriops tagal* with 58 trees forming 26.1 % of all trees. This study also found 26 trees of *Bruguiera cylindrica*, 11.7 % *R. mucronata*, 8.1 % *B. gymnorhiza* and 0.9 % of *B. parviflora*.

Another study in Belungkor Reserve Forest, Johor conducted by Intan et al. (2003) sampled 196 trees in 0.1 ha. It included eight mangrove species from three families, namely, Rhizophoraceae, Euphorbiaceae and Meliaceae. From the total individuals, 168 trees are in the family Rhizophoraceae. *Rhizophora apiculata* was the dominant species, which covers 30.1 % (59 trees), followed by *R. mucronata* with 53 trees (27 %) and *Ceriops tagal* with 45 trees (23 %) (Table 2).

Table 2 Location of sampling plots in Peninsular Malaysia (areas in ha)

Location	Size	Plot size	Date	Sources
Sungai Pulai, Johor	7,600	0.1	12-16/07/2002	Jamaliah et al. (2003)
Sungai Belungkor, Johor	1,600	0.1	12-15/07/2002	Intan et al. (2003)
Sungai Santi, Johor	3,028	0.1	13-14/07/2002	Sariah (2003)
Matang: VJR C49	110	0.06	20-25/10/2002	Juliana and Nizam (2005)
Ayer Hangat, Langkawi	555	1.0	21-27/12/2003	Fera Fizani (2004)
Sungai Kisap, Langkawi	1,464	0.25	21-27/12/2003	Hafizah Seman (2004)
West Port, Klang	10,817	0.4	10/2003	Norhayati et al. (2007)
Port Dickson & Tanjung Tuan	60.7	0.06	25-27/08/2005	Juliana et al. (2007)
Kuala Kemaman F.R	816	1.0	2007	Ida Suzilawate (2007)

4 Study Sites & Methods

4.1 Southern Part of Peninsular Malaysia

The southern part of Peninsular Malaysia is located at the confluence of the South China Sea and the Strait of Malacca tidal regimes, leading to complex and strong tidal processes. The largest river discharging into the Johor Strait at the eastern side is Sungai Johor, while Sungai Pulai is the largest river on the western side. Sungai Santi is located at the southeast of Sungai Johor, near the southeastern tip of the peninsula and part of Kota Tinggi District, Johor.

4.2 Sungai Pulai Forest Reserve

The Sungai Pulai Forest Reserve is the largest forest reserve in South Johor (7,600 ha), stretching from Jeram Batu in the north to Tanjung Piai in the southwest and Tanjung Pelepas in the southeast. This reserve is also managed by the Johor State Forestry Department for sustainable forestry production, especially to supply wood for the charcoal industry.

4.3 Western Part of Peninsular Malaysia

At Matang, many big rivers discharge their water and effluents into the Malacca Strait, including Sungai Sangga Besar for the compartment 49 Virgin Jungle Reserve (VJR).

4.4 Matang Forest Reserve, Compartment 49

The VJR of compartment 49 covers a total area of 110 ha, which include the protective forest (85 ha) and dryland forest (25 ha). A plot of 30m × 20m was established at compartment 49.

4.5 *Northern Part (Langkawi) of Peninsular Malaysia*

In Langkawi, the major rivers that discharge into the Pulau Peluru Strait are Sungai Kisap and Sungai Kilim.

4.6 *Ayer Hangat Forest Reserve*

Gua Cherita Forest Reserve is located at Tanjung Rhu, Langkawi, and there are eight compartments in this reserve, which are located at the northeastern part of the main island of Langkawi. This study was conducted in compartments 3, 4, and 5. This reserve is managed by the Forestry Department of Kedah State. The sampling areas consisted of 50m × 10m plots, located randomly.

4.7 *Sungai Kisap Forest Reserve*

The Kisap Forest Reserve is located on the northeastern coast of Pulau Langkawi. Its border extends for about 27.5 km covering an area of 1,464 ha from a total of 3,270 ha or 45 %. The Kisap FR contains the largest mangrove area on the island. There are 17 compartments, six of which are under mangroves. These compartments are numbered 4, 5, 6, 7, 8 and 9. Two plots were set up in compartment 16 and one each in compartments 14, 15, and 17. The sampling plots consisted of five 50m × 10m plots, located randomly.

4.8 *Mangrove in West Port, Klang*

Plot establishment and field surveys on tree species composition and other measurements were conducted in October 2003. The first site was located at Pulau Che Mat Zin in compartment 35 of Che Mat Zin Forest Reserve, while the second site was at Pulau Indah, partly in compartments 10 and 3 of Pulau Indah Forest Reserve. Pulau Che Mat Zin is located between Pulau Selat Kering, Pulau Kelang and Pulau Indah. This island comprised mainly mangrove forest with some intertidal mudflats to the west and east. Pulau Indah is located in the innermost of the Klang Islands. The sampling plots consisted of five plots of 10m × 10m arranged along a line-transect at each site.

4.9 Mangrove Forest in Port Dickson, Negeri Sembilan and Tanjung Tuan, Melaka

Mukim Pasir Panjang is located 16 km from Port Dickson and 130 km from Kuala Lumpur. Tanjung Tuan is bordered with Port Dickson and located 16 km from this town. The total area of Tanjung Tuan is 60.7 ha. Plot studies for species composition and biomass was 0.06 ha with six quadrats of 10m × 10m at Sungai Menyala. All trees in the study plot at 5 cm and above diameter were recorded.

Secondary data were also included from Sungai Merbok Reserve Forest, Kedah, Matang Mangrove Forest, Perak, Sepang kecil, Selangor, Kuala Sedili Reserve Forest and Mangrove Flora of Tanjung Piai, Johor and also Terengganu Mangrove Forest.

4.10 Sampling Methods

Measurements of DBH involved marking a tree ≥ 5 cm DBH, at its point of measurement (p.o.m) 1.3 m above ground level or 20 cm above its buttress. Measurements were made by using fiberglass diameter tape. Standard procedures suggested by Lugo and Snedaker (1974) when measuring tree diameter were followed. When a stem forks below breast height, each branch was measured as a separate stem. When a stem forks at breast height or slightly above, the diameter was measured at breast height or just below the swelling caused by the fork. For stems with swellings, branches or abnormalities at the p.o.m., the diameters were measured slightly above the irregularity where it stopped affecting the normal form. Field survey on tree species composition and other measurements were also conducted at the studied sites.

5 Results and Discussion

The information of mangrove species in this study was collected from Japar Sidik (1994) who recorded 11 species of Rhizophoraceae present in Malaysia including: *Bruguiera cylindrica*, *B. gymnorrhiza*, *B. hainesii*, *B. parviflora*, *B. sexangula*, *Ceriops tagal*, *C. decandra*, *Kandelia candel*, *Rhizophora apiculata*, *R. mucronata* and *R. stylosa*. The number of individuals of all species in the mangrove study site was shown in Appendix 1.

A total of seven species of mangrove plants was recorded at the study sites and the distribution of Rhizophoraceae was shown (Appendix 2). The number of species at the 11 sites ranged from as low as two to the highest of six species. *Rhizophora apiculata* was the most common species, and was mostly present at all sites (Appendix 2). There was an estimated total of 1,184 (51.2 %). The other abundant species were *R. mucronata* (25.5 %), which appeared at 11 sites, and *Ceriops tagal* (12.2 %), which also appeared at ten sites. Five species were classified as restricted because only 0.3 % – 4.0 % were present at the study site. They were *B. cylindrica*, *B. parviflora*

B. gymnorhiza, and *B. sexangula*. Another species like *B. hainesii*, *C. decandra*, *R. stylosa* and *K. candel* were classified as restricted and rare species at 12 study sites around Peninsular Malaysia.

The mangrove species composition of the west coast and east coast is different. For example, from the Sementa mangrove forest, Soepadmo and Pandi Mat Zain (1989) reported a total of 32 species found there, of which 18 are considered as principal mangrove species. On the east coast, especially in Terengganu mangroves, Mohd Lokman and Sulong (2001) listed a total of 55 species, with 29 exclusive mangrove species and a further 26 species as being non-exclusive.

Hafizah Seman (2004) and Fera Fizani (2004) had recorded a similar number of species—six species and seven species, respectively—and only three species from the family Rhizophoraceae. Another study by Norhayati (1995) recorded nine species in the area of the Kisap Forest Reserve. The species composition of these three studies was also similar. The scenario could be explained by the location of these three study sites as they were carried out in the west coast. In Matang Mangrove forest, Wan Juliana et al. (2005) established a seaward plot and an inland plot. This study only recorded four species and three families of mangrove species. The species composition is much lower compared to the other studies because the area of the study was a pure stand of *R. apiculata*. Studies at Merbok Forest Reserve, Kedah had also recorded a large number of species. This is because the sampling method used in this study was transects. It can be concluded that the study methods influence the species composition because the mangrove areas have zonation patterns in species composition.

The species *R. apiculata* and *R. mucronata* are widely distributed throughout mangrove forest areas in Peninsular Malaysia. Both species are of economic importance in forestry and fisheries industries. There is little information about the other species, *R. stylosa* or locally named as *Akik jalar* or *Bakau pasir*. This species does not grow extensively in all mangrove areas in Peninsular Malaysia and can only be found in very restricted locations, though it has a wide distribution in the Indo-Pacific region. It stretches from the Queensland coast to as far as Taiwan (Ding Hou 1960). It has been reported that in the peninsula, *R. stylosa* was only found in Pulau Langkawi, Melaka and Johor (Kochummen 1989). Other than these areas, our survey carried out in 2001 and 2002 showed that the species is also found in Sungai Kurung Tengar, Perlis, Bagan Lalang mangrove, Sepang, Selangor, Pulau Besar, Melaka, Pulau Burung, which is small rocky island off the coast of Port Dickson, two sites at Sungai Mawar, Endau, Johor, and Pulau Sibul and Pulau Tinggi, both islands of which are off the coast of Mersing, Johor (Nasir & Safiah 2007). *R. stylosa* grows best in hard sandy soil substrate or even on rocky islands. Its occurrence in muddy areas has rarely been reported. The species is not found in Matang mangrove areas which have soft muddy alluvial soil. Soil samples were collected from Bagan Lalang mangroves where *R. stylosa* was present. The soil was analyzed and results showed that this species grows best in areas with higher contents of sandy materials compared with other soil components such as silt and clay.

A total of 26 species in 12 families were found and 25 of them are exclusive mangrove species, that is, 66 % of all exclusive mangrove species found in Malaysia

(Japar Sidik 1994). All five members of *Bruguiera* were found in the Sungai Santi. One rare species, namely, *B. hainesii*, probably is a new record to Johor (Chan 1999). Previously in Peninsular Malaysia, *B. hainesii* was only found in the Matang forest reserve (Gan 1995). Other than *B. hainesii* *B. sexangula* and *C. decandra* are also rare species.

As a comparison, a study by Intan et al. (2003) at Hutan Simpan Belungkur, reported a total of 16 mangrove species from nine families. Johor Forestry Department (1999) recorded a total of 26 exclusive mangrove species were found from four separate studies in Johor. One of the exclusive species from the family Rhizophoraceae is *Kandelia candel*. Absence of this species from this survey cannot be ignored. A total of 35 species and a hybrid from 26 genera and 19 families of mangrove flora were collected during the survey on Tanjung Piai and Sungai Pulai, Johor. The Tanjung Piai mangrove species is represented 35 % taxa of Malaysia's mangrove species (Japar Sidik 1994) and 31 % of the world's mangrove plant. Out of the total mangrove flora recorded, 23 species were classified as exclusive species. A total of 15 mangrove species and a hybrid found in this survey were not recorded by Jamaliah et al. (2003) in their mangrove species survey in Pulau Reserve Forest, Johor. The survey has added a new record where a sterile hybrid between *R. stylosa* and *R. apiculata*, i.e. *R. x lamarckii*, was discovered. The *R. stylosa* is considered rare and endangered and the *R. x lamarckii* is considered very rare and endangered.

A report about the Biodiversity Audit and Conservation Plan for the Mangroves of Johor, which was collected from research on the mangrove at Johor (Sungai Sedili Kecil and Sungai Sedili Besar), revealed that along the eastern banks of the mouth of Sungai Sedili Kecil is a fringing belt of the tidal mangrove. The most common mangrove from the family Rhizophoraceae is *R. apiculata*. The other tree species include *B. cylindrica* *B. gymnorrhiza* and *R. mucronata*. Mangrove fringing rocky and sandy shores are encountered at Teluk Merbok, situated between the estuary of Sungai Sedili Kecil and Tanjung Sedili Kecil, which are located between the rocky promontories of the bay area along stretches of sandy beach with pockets of mudflats. Mangrove trees found include *B. cylindrica* *B. gymnorrhiza*, *R. apiculata* and *R. mucronata*. Sungai Sedili Besar is unique in that it contains mangroves (a restricted habitat on the east coast) and close association of mangroves with riverine (a severely threatened habitat in Peninsular Malaysia) and coastal forests upstream of the current Kuala Sedili Forest Reserve.

Kandelia candel occurs sporadically along banks of tidal rivers on the east coast but it is very rare on the west coast. During the survey it was found in Muar as well as in Sungai Sedili Besar. During the survey it was found in Sungai Sedili Besar that *B. sexangula* is the only species that sometimes forms stilt roots. It occupies the more inward parts of the mangrove and is less common than the similar *B. gymnorrhiza*. It has an ornamental potential. It was noted in Sungai Santi but also found in Sungai Pulai and at Muar, Johor.

Studies at Merbok Forest Reserve, Kedah had recorded a large number of species. Ong et al. (1980; 2003) made a comprehensively study at Merbok Reserve Forest and stated that forest is one of the mangrove forests with the highest density of plants. These forests have not less than 30 true mangrove species. Ong (2003)

recorded 53 species from 25 families and Rhizophoraceae is the most abundantly distributed. The species of Rhizophoraceae presented were *B. cylindrica* *B. gymnorrhiza*, *B. parviflora* *B. sexangula* *C. tagal* *R. apiculata* *R. mucronata* and *R. x annamalayana*.

An inventory on mangrove flora was conducted around Pulau Tuba, Pulau Dayang Bunting, Pulau Ular and Pulau Singa Besar which represent Selat Kuah (Razali Salam et al. 2005). Random walk and boat surveys were employed to document all mangrove species found. In this survey, there are 15 species and a hybrid which was not recorded by Norhayati and Latiff (2001) in their survey of mangrove species in Kisap Forest Reserve. The study has also added three new records for the Kilim-Kisap area (Wan Juliana et al. 2005), namely, *Xylocarpus mekongensis*, *R. stylosa* and a sterile hybrid between *R. x lamarckii*. Selat Kuah is a suitable habitat for *R. apiculata* and *R. stylosa*. The mangrove forest in Selat Kuah is considered as having a high density of mangrove plants, followed by the Pulau Forest Reserve and Merbok Reserve Forest.

From the preliminary assessment of the flowering plant diversity of Matang mangrove forest (Shamsul et al. 2005.), seven species of Rhizophoraceae were present, namely, *B. cylindrica* *B. gymnorrhiza* *B. parviflora* *B. sexangula* *R. apiculata* *R. mucronata* and *C. tagal*. All the species are abundant at the Sungai Derhaka Besar, Jebong Forest Reserve. Importantly, *R. apiculata* dominated the area of study.

Through the observation in the Terengganu Mangrove Forest, there are 29 exclusive and 26 non-exclusive mangrove species in Terengganu. In contrast, Malaysia has 38 exclusive and 57 non-exclusive mangrove species. Thus, more than 50 % of the mangrove species of Malaysia are available in Terengganu. For Rhizophoraceae, *B. cylindrica* *B. gymnorrhiza*, *B. parviflora* *B. sexangula* *C. decandra*, *K. candel*, *R. apiculata* and *R. mucronata* were recorded.

6 Conclusion

From this study, Rhizophoraceae were distributed all over Peninsular Malaysia and *R. apiculata* was the dominant species in all areas followed by *R. mucronata*. *R. apiculata* dominated the mangroves on the east and west coasts of Peninsular Malaysia. *B. sexangula* *R. stylosa* *C. decandra*, *K. candel*, and *B. hainesii* were restricted species in Peninsular Malaysia and hybrids, i.e *R. x lamarckii* and *R. x annamalayana*, were the rare and endangered species. In conclusion, all Rhizophoraceae are present in Perlis, Kedah, Perak, Selangor, Negeri Sembilan, Melaka, Johor, Terengganu and Kelantan.

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