

## RESEARCH ARTICLE

# MORPHOLOGICAL STRUCTURES OF *RHIZOPHORA APICULATA* BLUME and *RHIZOPHORA MUCRONATA* LAM.

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## ABSTRACT

Research on the morphological structures of *R. apiculata* and *R. mucronata* was carried out in three different regions from July to December 2018. The research aimed at observing and documenting the morphological structure of *R. apiculata* and *R. mucronata*. Samples were collected from selected locations in Peninsular Malaysia. Subsequently, samples were processed as herbarium vouchers. The vegetative and reproductive structures of both species were observed and identified. 55 morphological features were recorded and annotated as result of this research. The research revealed that vegetative and reproductive structures could differentiate *R. mucronata* from *R. apiculata*. According to this research, there were no significant differences in the morphological structures of *R. apiculata* and *R. mucronata* from three different locations. As a consequence, the data acquired in this research would be valuable for future studies on *Rhizophora* species.

## KEYWORDS

Morphology, *Rhizophora*, *apiculata*, *mucronata*.

## 1. INTRODUCTION

The mangrove forest is one of the plant ecosystems that thrive in the moist soil of tidal zones. A group researchers identified over 30 families of mangrove plants (Minobe et al., 2010). They acknowledged their ecological and economic values in a multitude of aspects, including timber and firewood sources, ideal habitats for diverse wildlife, biological defense from tsunami and storm, and erosion mitigation (Ong et al., 2004; Hashim et al., 2010). The mangrove ecosystem is found along the intertidal areas with high salinity and high tidal conditions (Sheue et al., 2013). Due to extreme high salinity conditions and tidal water in the coastal areas, the mangrove forests have evolved, making them unique mangrove species with adaptation abilities that can withstand the harsh conditions (Mohd-Arrabe and Noraini, 2013; Samaddar and Jayakumar, 2015). The mangrove family, Rhizophoraceae, consists of 16 genera and 149 species worldwide that tend to thrive in tropical and subtropical coastal mangrove ecosystems (Balasubramanian et al., 2015). Rhizophoraceae is the most diverse mangrove family, consisting of four exclusive genera: *Rhizophora*, *Bruguiera*, *Ceriops* and *Kandelia*. They are classified as true mangrove species, distributed mainly in the intertidal zones (Sheue et al., 2013; Setyawan and Ulumuddin, 2012). *Rhizophora* is the largest genus in the Rhizophoraceae family, consisting of three main species: *R. mucronata*, *R. stylosa* and *R. apiculata*, as well as two hybrids species: *R. x lamarckii* and *R. x annamalayana* (Setyawan and Ulumuddin, 2012).

Previous research on the medicinal value and usefulness of *R. apiculata* has been extensively published, as reported, that communities in Malaysia utilized *R. apiculata* with high tannin content to cure immunological disorders (Balasubramanian et al., 2015). Furthermore, as mentioned that the leaves of *R. mucronata* were utilized by the Indian Sundarban communities residing near mangrove areas to relieve angina (Abdul-Malik

et al., 2015). This species is also economically significant as commercial mangrove wood and timber supplies in the Asia-Pacific regions. Its timber is primarily utilized to produce fishing stakes, wood pilings, charcoals, and wood chips, which are then converted into rayon (Ong et al., 2004). *Rhizophora* species is easily recognized morphologically by apparent features of its viviparous seed and pneumatophore roots. The viviparous seed is the most distinct characteristic of true mangrove species that allows it to adapt to water with high saline conditions.

For adaptation purposes, the genus *Rhizophora* also possesses unique features that distinguish it from terrestrial plants, such as stilt root, succulent leaves with black dots beneath the leaves, and viviparous fruits (Mohd-Arrabe and Noraini, 2013). Morphological characteristics are among the most significant components considered by biologists in plant identification and classification for systematic studies. It is the simplest conventional method, performed based on observation on parameters such as root habit, stem habit, in addition to leaf, flower and fruit variations. *Rhizophora* species appears to be well-known; nevertheless, there is insufficient information on its distribution in Peninsular Malaysia in terms of morphological structures. Thus, the purpose of this research was to record and observe the morphological variations of *R. apiculata* and *R. mucronata* in selected locations across Peninsular Malaysia.

## 2. MATERIALS AND METHODS

The plant samples were collected in three different locations in Peninsular Malaysia: (1) Sungai Kong Kong, Masai, Johor, (2) Sungai Kemaman, Kemaman, Terengganu, and (3) Cherating and Sungai Pahang, Pahang. The collected sample processed as voucher herbarium specimen. The morphological structures of *R. apiculata* and *R. mucronata* were studied based on the descriptions provided (Duke and Bunt, 1979; Mathew, 1994;

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Ragavan, 2015).

### 3. RESULTS AND DISCUSSION

The vegetative and reproductive structures of *R. apiculata* and *R. mucronata* from three locations were recorded and annotated. The recorded parameter was summarised in (Table 1 and Table 2). Following rigorous examinations, it was determined that morphological structures or features could be utilized to distinguish *R. apiculata* (Figure 1) from *R. mucronata* (Figure 2). According to the available data, both species may

reach a height of 30 metres in all study locations. *R. apiculata* and *R. mucronata* have fissure stem habit. However, the distinction between these two is that fissure in *R. apiculata* is vertical but horizontal as far as *R. mucronata* is concerned. Furthermore, *R. apiculata* has a dark grey stem, but *R. mucronata* has a dark black stem, which distinguishes them (Setyawan and Ulumuddin, 2012). Morphological studies on the tree stem habit are prominent in taxonomy; studied plant structured to identify woody plant species (Cantrill and Poole, 2005; Yunus et al., 1990). In terms of locations, there were no variations in the parameter for both species.

**Table 1: Morphological structure of *Rhizophora apiculata***

	Johor	Terengganu	Pahang
<b>TREE</b>	Up to 30 m high	Up to 20 m high	Up to 30 m high
<b>STILT ROOT</b>	Present to support the tree growth	Present to support the tree growth	Present to support the tree growth
<b>BARK</b>	Dark grey with vertical fissure	Dark grey with vertical fissure	Dark grey with vertical fissure
<b>LEAF</b>	Simple leaf with petiole, oppositely arranged, average leaf size 11.60 cm long and 4.50 cm wide, narrowly elliptic-oblong, apex acute, base cuneate, entire margin with leathery surface, penni-veined but venation barely visible, dark green and presence of black dotted underneath the leaf surface	Simple leaf with petiole, oppositely arranged, average leaf size 13.70 cm long and 5.20 cm wide, narrowly elliptic-oblong, apex acute, base cuneate, entire margin with leathery surface, penni-veined but venation barely visible, dark green and presence of black dotted underneath the leaf surface	Simple leaf with petiole, oppositely arranged, average leaf size 14.00 cm long and 5.30 cm wide, narrowly elliptic-oblong, apex acute, base cuneate, entire margin with leathery surface, penni-veined but venation barely visible, dark green and presence of black dotted underneath the leaf surface
<b>INFLORESCENCE</b>	2-flowered cymes	2-flowered cymes	2-flowered cymes
<b>FLOWER</b>	Actinomorphic and polypetalous, 4-yellow sepals, 4-white petals, lanceolate shape, hairless surface, 10-12 stamen	Actinomorphic and polypetalous, 4-yellow sepals, 4-white petals, lanceolate shape, hairless surface, 10-12 stamen	Actinomorphic and polypetalous, 4-yellow sepals, 4-white petals, lanceolate shape, hairless surface, 10-12 stamen
<b>FRUIT</b>	Solitary fruit, brown when ripe, pear shape	N/A	Solitary fruit, brown when ripe, pear shape
<b>PROPAGULE</b>	Cylindrical-clavate hypocotyl, 25 cm long, 0.8 cm wide, smooth surface	N/A	Cylindrical-clavate hypocotyl, 28 cm long, 0.8 cm wide, smooth surface

**Table 2: Morphological Structure Of *Rhizophora mucronata***

	Johor	Terengganu	Pahang
<b>TREE</b>	Up to 21 m high	Up to 25 m high	Up to 23 m high
<b>STILT ROOT</b>	Present to support the tree growth	Present to support the tree growth	Present to support the tree growth
<b>BARK</b>	Dark black with horizontal fissure	Dark black with horizontal fissure	Dark black with horizontal fissure
<b>LEAF</b>	Simple leaf with petiole, oppositely arranged, average leaf size 17.90 cm long and 9.40 cm wide, broadly elliptic-oblong, apex acute, base cuneate, entire margin with leathery surface, penni-veined with deep pattern, dark green and presence of black dotted underneath the leaf surface	Simple leaf with petiole, oppositely arranged, average leaf size 15.40 cm long and 8.40 cm wide, broadly elliptic-oblong, apex acute, base cuneate, entire margin with leathery surface, penni-veined with deep pattern, dark green and presence of black dotted underneath the leaf surface	Simple leaf with petiole, oppositely arranged, average leaf size 15.00 cm long and 8.30 cm wide, broadly elliptic-oblong, apex acute, base cuneate, entire margin with leathery surface, penni-veined with deep pattern, dark green and presence of black dotted underneath the leaf surface
<b>INFLORESCENCE</b>	2-5-flowered cymes	2-5-flowered cymes	2-5-flowered cymes
<b>FLOWER</b>	Actinomorphic and polypetalous, 4-creamy white sepals, 4-creamy white petals, lanceolate shape, densely hairy surface, 8 stamens	Actinomorphic and polypetalous, 4-creamy white sepals, 4-creamy white petals, lanceolate shape, densely hairy surface, 8 stamens	Actinomorphic and polypetalous, 4-creamy white sepals, 4-creamy white petals, lanceolate shape, densely hairy surface, 8 stamens
<b>FRUIT</b>	Solitary fruit, dull brown when ripe, pear shape	Solitary fruit, dull brown when ripe, pear shape	Solitary fruit, dull brown when ripe, pear shape
<b>PROPAGULE</b>	Cylindrical hypocotyl, 44 cm long, 1.8 cm wide, rough surface	Cylindrical hypocotyl, 25 cm long, 1.0 cm wide, rough surface	Cylindrical hypocotyl, 60 cm long, 1.4 cm wide, rough surface

*R. apiculata* in Pahang has the largest average leaf size, measuring 14.13 cm long and 5.47 cm wide. On the other hand, *R. apiculata* in Johor has the smallest average leaf size, measuring 11.60 cm long and 4.57 cm wide. *R. mucronata* in Johor has the largest size, measuring 17.90 cm long and 9.47 cm wide. However, *R. mucronata* collected in Pahang has the smallest size. In terms of species, *R. mucronata* has bigger leaves compared to *R. apiculata*. The leaf shape of *R. mucronata* is broadly elliptic-oblong, while

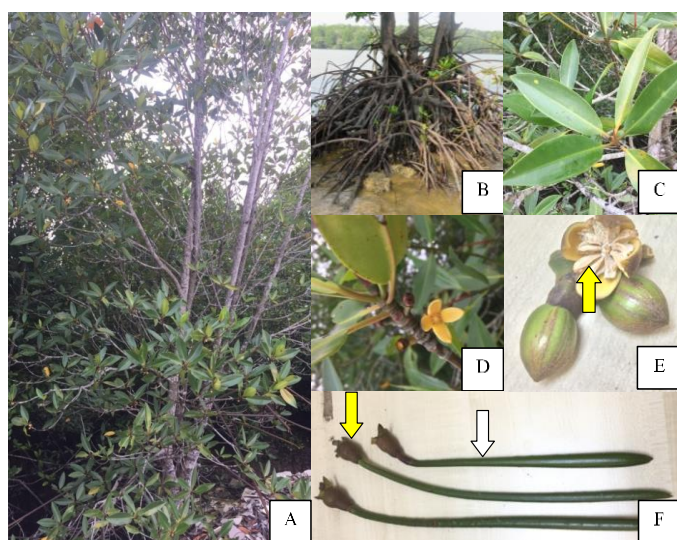
*R. apiculata* has a narrowly elliptic-oblong leaf shape. These findings were consistent with (Haining and Boufford, 2007; Ragavan, 2015).

Stipules serve as sturdy enclosures for young shoots in Rhizophoraceae species. This structure is crucial in plant identification and classification. According to a study, the morphology of stipules may be utilised to differentiate plant species in the Rhizophoraceae family from other plant genus and to classify all *Rhizophora* species owing to stipule variations

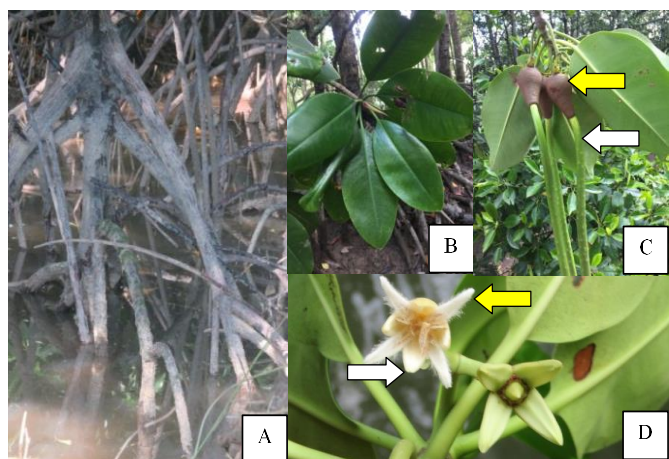
(Sheue et al., 2012). This research discovered that *R. apiculata* and *R. mucronata* had distinct coloured stipules. Thus, the colour of stipules distinguished them. Based on the observations, *R. apiculata* had red stipules, but *R. mucronata* had light green stipules, and this finding was supported (Sheue et al., 2012). The stipule and its morphological characteristics are important in the taxonomic study; investigated stipules in the Coccocypseleae and Kandelina genus studies, respectively (Piesschaert et al., 2000; Sheue et al., 2003).

*R. apiculata* has 2-flower cymes per peduncle in terms of inflorescence, but *R. mucronata* has 2-5-flower cymes per peduncle. Both species have four sepals and four petals per flower; however, the colours of the sepal distinguish these two species. *R. apiculata* has yellow sepals, but *R. mucronata* has creamy white sepals. Some researchers supported the comparison of flower characteristics between *R. apiculata* and *R. mucronata* (Setyawan and Ulumuddin, 2012; Ragavan, 2015). The significance of flower morphological characteristics in the systematic study, nevertheless, was not only limited to *Rhizophora* species.

In fact, according to some study also, the floral structure of Zingiberaceae was the most significant plant part for observation and analysis (Box and Rudall, 2006; Sakai and Nagamasu, 2000). One of the distinguishing features of the *Rhizophora* genus is that it is viviparous (Tomlinson and Cox, 2000). *R. mucronata* was recorded to have a bigger hypocotyl size compared to *R. apiculata*. *R. mucronata* may grow and reach approximately 60 cm long, whereas *R. apiculata* may grow to be 35 cm long. The morphology shape of hypocotyl varies for *R. apiculata* and *R. mucronata*. *R. apiculata* was confirmed to have a cylindric-clavate shape, but it was a long cylindrical shape for *R. mucronata* (Setyawan and Ulumuddin, 2012; Ragavan, 2015).



**Figure 1:** Morphological features of *Rhizophora apiculata*. (A) Habit, tall form; (B) Aerial and stilt root; (C) leafy rosette; (D) fertilized flower with bright yellow sepals; (E) stamen of flower (arrow) and mature bud (arrow); (F) fruit (yellow arrow)



**Figure 2:** Morphological features of *Rhizophora mucronata*. (A) Aerial and stilt roots; (B) leafy rosette; (C) fruit (yellow arrow) and hypocotyl (white arrow); (D) flower (yellow arrow) and hypocotyl (white arrow)

arrow); (D) creamy white flower (yellow arrow) and fertilized flower with creamy white sepals (white arrow).

#### 4. CONCLUSION

These findings supported the hypothesis that morphological structures were beneficial in identifying, classifying, and differentiating *R. apiculata* and *R. mucronata*. Both exhibit morphological variations in selected vegetative and reproductive features such as stem, leaf, and flower parts. This research established that there were no distinguishing characteristics of morphological structures of *R. apiculata* and *R. mucronata* collected from three locations. However, the data revealed quantitative data variations in morphological structures, such as the height and width of the species samples. In conclusion, the data presented in this study could be utilised to supplement future *Rhizophora* species studies.

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