NOTE

Ceriops zippeliana Blume (Rhizophoraceae), a New Record of a Mangrove Species in Singapore

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ABSTRACT: *Ceriops zippeliana* Blume is here reported as a new record for the mangrove forests in Singapore. The botanical description of this new record with color plates and a key to the two *Ceriops* species in Singapore are provided. It is noteworthy that *C. tagal* (Perr.) C. B. Rob. is rarer than *C. zippeliana* in Singapore. Thus, special attention for conservation should be focused on *C. tagal* and a further survey of this genus would provide valuable information to better manage Singapore's mangrove plant biodiversity.

KEY WORDS: C*eriops decandra* (Griff.) Ding Hou, *Ceriops tagal* (Perr.) C. B. Rob., *Ceriops zippeliana* Blume, Mangroves, Rhizophoraceae, Singapore.

INTRODUCTION

'Mangroves' are the intertidal plants, mostly trees and shrubs, distributed in regions of estuaries, deltas and riverbanks or along the coastlines of tropical and subtropical areas. Various terms have been used to describe mangroves, such as coastal woodland, mangal, tidal forest or mangrove forest. It is noted that 'mangrove' has two different interpretations: it can refer to an individual plant or to an assemblage of plants that contains many species (Tomlinson, 1986; Saenger, 2002).

The members of mangroves consist of various kinds of plants from different genera and families, many of which are not related closely to one another phylogenetically. However, it is difficult to delineate precisely what constitutes the mangrove species (Tomlinson, 1986). The difficulty comes from the delimitation of its transition to terrestrial and other seashore communities, since mangroves are an ecological assemblage, and many of the processes of the land-sea interface regulating them have their origin elsewhere (Saenger, 2002). Therefore, a number of definitions have been given in past years. Based on their fidelity to the mangrove environment, structural and physiological specialization and the ability to form a conspicuous element, Tomlinson (1986) set limits between three groups: major elements of mangal (or known as 'strict mangrove' or 'true mangroves') with 9 genera and 34 species of 5 families, minor elements of mangal with 11 genera and 20 species of 11 families and mangal associates with 46 genera and 60 species of 27 families. Nevertheless, it contained errors and omissions. Duke (1992) provided an updated list, which addressed the omissions. Field (1995) made a consensual list based on IUCN (the International Union for Conservation of Nature) and Duke (1992). In Field's list, 25 genera and 66 species out of 19 families were included as the members of mangroves (Field, 1995). Saenger (2002) provided an updated list of mangroves of the world, consisting of 84 species of plants belonging to 39 genera in 26 families. However, the mangroves species on a cosmopolitan basis is up to 87 species with the additional newly reported taxa (Sheue et al., 2003; Sheue et al., 2009a, 2010).

According to Tomlinson's definition (1986), 19 major species belonged to six families and nine minor species of seven families were recorded in the mangroves of Singapore in 1999 (Ng and Sivasothi, 1999). Recently, a rare mangrove species, *Bruguiera hainesii* C. G. Rogers, was added to the mangrove flora of Singapore (Sheue et al., 2005), thus, 20 major components of Singapore mangrove forest are recognized now (Tan et al., 2007).

In 1999, the first two authors discovered an uncertain taxon of *Ceriops* at Pasir Ris Park, which was

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morphologically different from *C. tagal* (Perr.) C. B. Rob. in Singapore. At first, this taxon was identified as the so-called *C. decandra* (Griff.) Ding Hou according to Flora of Malesiana (Hou, 1958). However, the first author noticed that it is morphologically and anatomically different from the *C. decandra* collected from India (Sheue, 2003). It was then considered as an uncertain species by the first author awaiting further taxonomic research (Sheue, 2003). Recently, the authors have come to realize that the uncertain species should be *C. zippeliana* Blume, and this species also occurs in areas of southeastern Asia as well (Sheue et al., 2009a). However, the collection was not first made by the first two authors in Singapore, because several previous collections of *C. zippeliana,* misidentified as *C. tagal*, were found in SING herbarium. In this report, the botanical description with photos of the new record and a key to differentiate the species of *Ceriops* with a discussion in Singapore are provided.

TAXONOMIC TREATMENTS

Key to the species of *Ceriops* in Singapore

1a. Petal apex with 3 clavate appendages; inflorescence axis relatively long and slender (10-30 mm × 2 mm), bending downwards; inflorescence compound bifurcate cyme; hypocotyl 15-25 cm long at maturity, cotyledon collar yellow to yellowish green ……..…… ……. *C. tagal* (Tengah)

1b. Petal apex fringed with multi-cilia (13-17); inflorescence axis relatively short and stout (3-10 mm × 3-4 mm), erect; inflorescence simple head-like; hypocotyl 9-17 cm long at maturity, cotyledon collar scarlet ……...…….. *C. zippeliana*

Ceriops zippeliana Blume, Mus. Bot. 1: 143. 1849. (named after Zippelius) (line illustration see f. 2 in Sheue et al., 2009a) Figs. 1 & 2

Ceriops decandra auct. non (Griff.) Ding Hou (1958) 471. *pro part*.

Small tree or shrub up to 12 m tall; bark brownish with some protruding lenticels, flaky at base. Leaves oval to elliptical-oval, 5.5-11 cm x 3-7.5 cm, apex obtuse, rounded to emarginate, base cuneate to attenuate; petiole 1-2.5 cm long. Stipules 1.5-2.5 cm long, with 18-20 layered colleters inside adaxial base. Inflorescence head-like, usually bearing at the uppermost three nodes of a branch, axillary, 3-5(-7) flowered. Bracteole 2-lobed, disc-like, sessile, 2.6 mm in length, apex rounded, with 2-8 colleters at adaxial base of each lobe. Calyx lobes 5, erect while in flowering and in fruiting, ovate, acute, 2-3 mm x 2 mm. Petals 5, white, turning brownish, linear-rectangular, 3-3.5 mm x 1.8 mm (including terminal cilia), with broad base, slightly folded longitudinally, margins hairless, apex multiciliate with 13-17 cilia, 0.5-0.8 mm long. Stamens 10, almost equal in size; filament 1 mm long; anther 1 mm long, ovoid, dorsifixed, with one short connective protrusion. Ovary inferior, 3 chambered, 2-ovules in each chamber, style 2 mm long, stigma 1, very shortly trifid. Persistent calyx tube shallow disc, 3 mm in height, persistent lobes 5, 2-2.5 mm x 1-1.5 mm, slightly obliquely erect or patent. Fruit ovoid-conical, 1.2-1.5 cm x 1.0 cm, with reticulate ornament. Hypocotyl clavate, 9-17 cm x 0.7-0.8 cm, width unequal, gradually thickening with an acute sharp apex (root tip), sharply ridged and sulcate, erect to pendant; epicotyl 2-3 mm long.

Specimens examined: SINGAPORE: Sungei Buloh Nature Reserve: Sheue 30-31 (CHIA); Jurong River: M. Ismail S-14 (SING); Changi: M. Shah MS868 (SING); Khatib Bongsu: J. Lai LJ58, LJ126 (SING); Pulau Ubin: E. Tang & H. Sidek 302 (SING); Pasir Ris Park: Sheue 46 (CHIA).

Ceriops zippeliana was discovered by the authors along the boardwalk at Pasir Ris Park (1°22'52.8"N, 103°57'7.2"E) at the north-eastern part in Singapore. This is a five-hectare patch of mature mangrove forest preserved during land reclamation and development (Ng and Sivasothi, 1999). Diverse species of mangrove members could be found in this area, including the more common species of *Avicennia alba* Blume, *A. rumphiana* Hallier f., *Bruguiera cylindrica* (L.) Blume, *B. gymnorhiza* (L.) Sav., *Ceriops tagal*, *Rhizophora mucronata* Lam., *R. apiculata* Blume, *Scyphiphora hydrophyllacea* C. F. Gaertn., the ferns of *Acrostichum* L. and the shrubs of *Acanthus* L.; and the relative rare species of *Aegiceras corniculatum* (L.) Blanco, *Bruguiera parviflora* (Roxb.) Griff. and *Rhizophora stylosa* Griff. (Ng and Sivasothi, 1999). *Ceriops zippeliana* is a shrub about 2-4 m in height commonly found under the mangrove canopy of inner mangroves and growing with *Bruguiera*, *Rhizophora* and *Lumnitzera*. The leaf shape may appear more oval while it occurs at deep shade habitat.

DISCUSSION

This is an interesting and important botanical discovery despite significant decrease of mangrove land area from 13% in 1820's (Corlett, 1987) to only 0.5% in 1993 (Hilton and Manning, 1995) and where seven mangrove species had been lost in Singapore during the past years (Turner and Yong, 1999). Our study may imply that a further extensive study of the mangrove ecosystem in Singapore (especially the offshore islands) is still warranted.

Despite the morphological similarity of the two species of *Ceriops* in Singapore, *C. zippeliana* can be differentiated from *C. tagal* by reproductive characteristics. The inflorescence has an important

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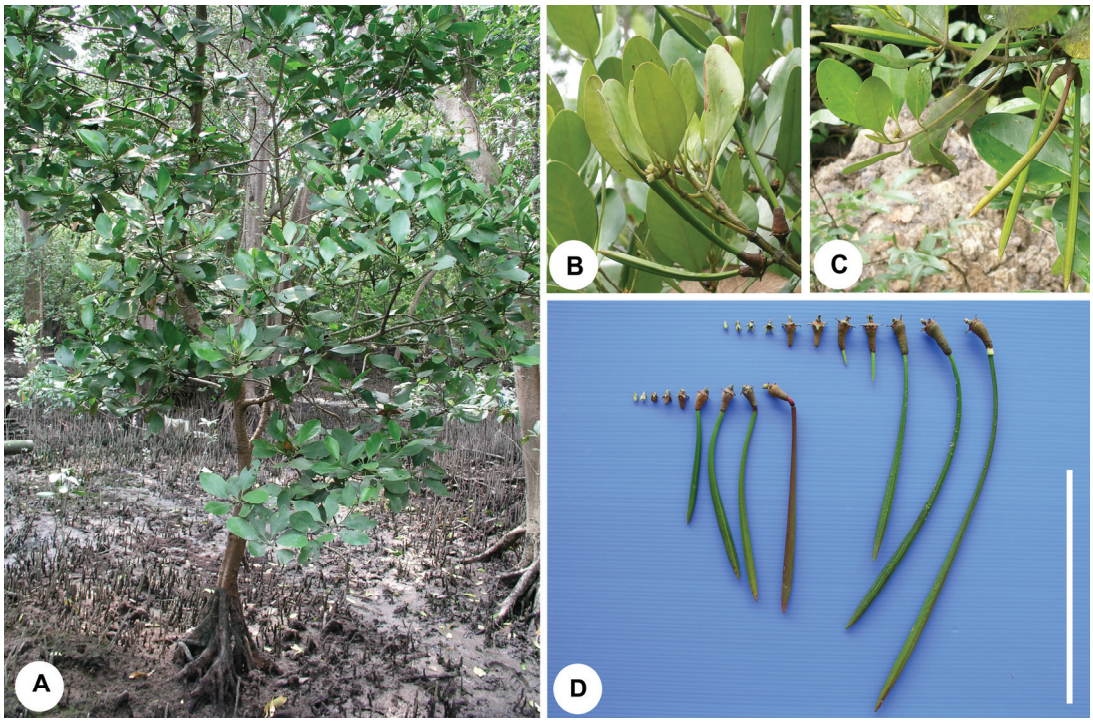


Fig. 1. The newly recorded mangrove species of *Ceriops zippeliana* Blume with the comparison of reproductive organs with *C. tagal* (Perr.) C. B. Rob. in Singapore. A: An individual tree of *C. zippeliana* with compressed stilt-roots in the Lim Chu Kang mangroves, Singapore. B: A shoot of *C. zippeliana* with inflorescences, fruit and erected hypocotyls (Pasir Ris Park, Singapore). C: A shoot of *C. zippeliana* with elongated hypocotyls toward different directions. D: The reproductive organs from flower buds to a mature viviparous seedlings at different stages of *Ceriops*, *C. zippeliana* (left) and *C. tagal* (right).

diagnostic value for differentiating the two groups of *Ceriops*, namely *C. australis* (Sheue et al., 2009b) and *C. tagal*, and *C. decandra*, *C. pseudodecandra* (Sheue et al., 2010) and *C. zippeliana* (Sheue et al., 2009a). The former group has relatively long and slender peduncles and the latter group has short and stout ones. Moreover, for the genus *Ceriops*, the inflorescence of *C. zippeliana* is a simple head-like structure with a primary bract. Petal morphology and the inflorescence features can be used to divide the genus into the same two groups as mentioned above. The apex of petal of *C. tagal* has 3 clavate appendages (see f. 4e, Sheue et al., 2009b) while that of *C. zippeliana* has finger-like fringes containing 13-17 sinuate cilia (see f. 3d,, Sheue et al., 2009a). Furthermore, the different open extent of sepals of *Ceriops* during flowering could be observed in the field. The flowers of *C. zippeliana* never open widely while blooming.

Different pollination systems were noted in the mangrove Rhizophoraceae (Tomlinson, 1986). Similar to those of the species of *Bruguiera*, the stamens of *C. tagal* with relatively long filaments are enclosed in pairs under tension within petals, and pollen grains are released when the flower is triggered by the pollimator (i.e. explosively). However, *C. zippeliana* is similar to *Kandelia* and *Rhizophora* which release pollen non-explosively. This phenomenon is related to the morphology of petal. There is a group of intertwined helical trichomes located at each middle margin of the petal of *C. tagal.* Thus, the entire petals of *C. tagal* link together strongly by these trichomes and they are sensitive to be triggered (Sheue, 2003). On the contrast, the petal margins of *C. zippeliana* are hairless (Fig. 2C) (Sheue et al., 2009a). In addition, *C. tagal* has long filament type (25 mm) with a terminal hook structure while *C. zippeliana* has short filament type (1 mm). These structures are associated with the two different blooming mechanisms mentioned above.

The ovoid fruit of *Ceriops* also has persistent calyx tubes and lobes. Although the fruits of the species in this genus are very similar, the detailed morphological features (including surface ornamentation patterns) can be used for interspecific differentiation (Sheue, 2003). The fruit with generally lift calyx lobes above the residue structure of floral disc of *C. tagal* is larger than that of *C. zippeliana* with ascending calyx lobes and netted decoration on fruit surface. The color of cotyledon collar seems quite constant of the mature

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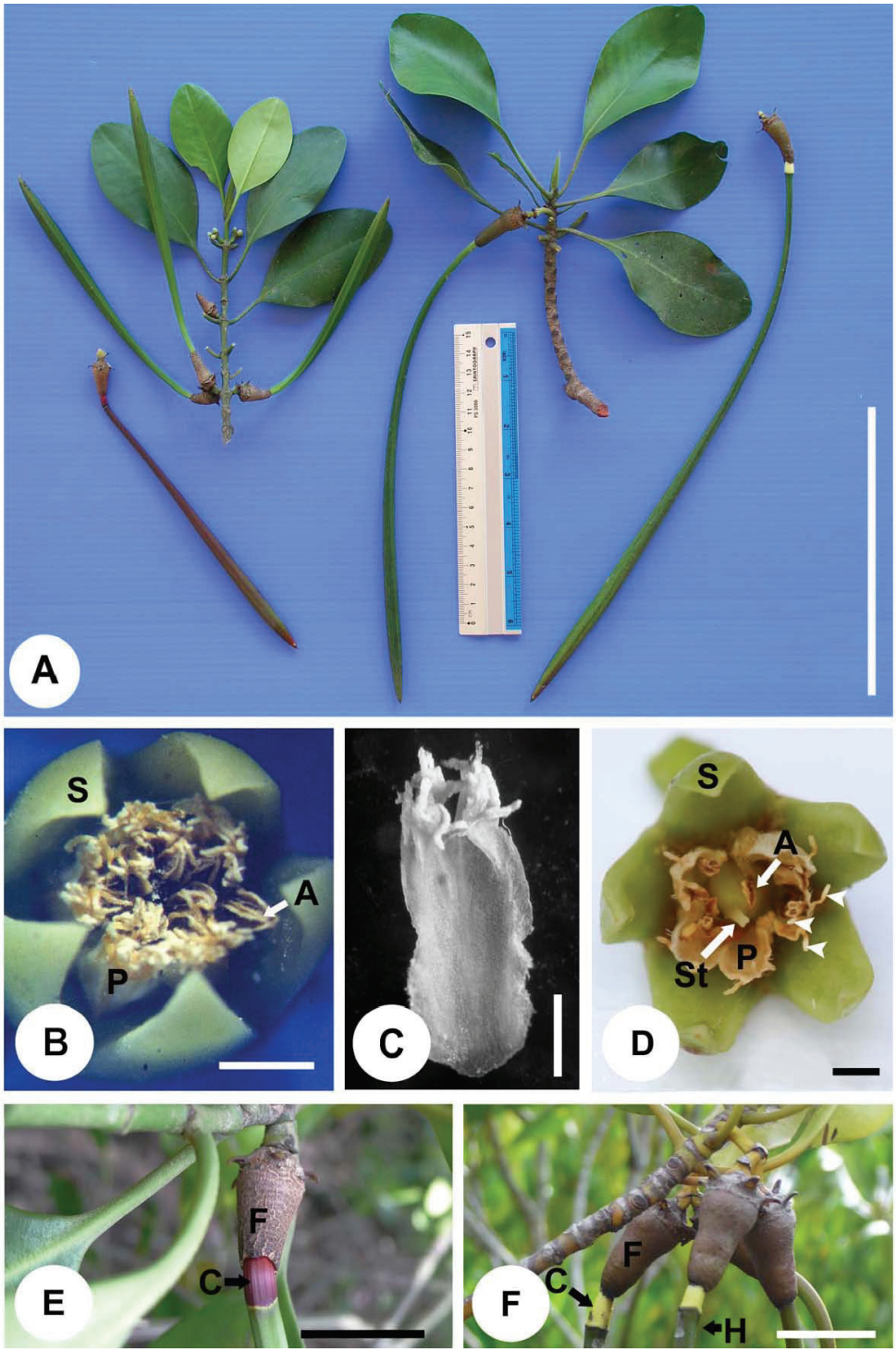


Fig. 2. Diagnostic characters of *Ceriops* in Singapore. Abbreviations: A: Anther. C: Cotyledon collar. F: Fruit. H: Hypocotyl. P: Petal. S: Sepal. St: Style. A: Branchlets with mature viviparous seedlings of *C. zippeliana* Blume (left) and *C. tagal* (Perr.) C. B. Rob. (right). B-C. Flower surface view and a petal of *C. zippeliana* showing multi-cilia (13-17) of petal apex. D: Flower surface view of *C. tagal* showing three clavate appendages on the apex of a petal (arrow heads). E: The fruit of *C. zippeliana* with netted surface decoration, ascending persistent calyx lobes and a scarlet hypocotyl collar. F: The fruit of *C. tagal* with generally lifted persistent calyx lobes and a yellow to yellowish green hypocotyl collar. Scale bars: A = 15 cm; B-D = 1 mm; E-F = 2 cm.

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viviparous seedlings. The mature collar color of *C. tagal* appears yellow to yellowish green while that of *C. zippeliana* always shows scarlet (reddish). In addition, *C. zippeliana* has propagules pointing towards different directions while attached to the parent tree, whereas *C. tagal* propagules usually tend to point downwards (Sheue, 2003). These features could be confirmed from a recent Singapore's mangrove book (Ng et al., 2008) photographic record.

According to the recent Singapore Red Data Book (Davison et al., 2008), seven species of the mangrove Rhizophoraceae were included, including *C. tagal* (remarked as vulnerable) and *C. zippeliana* (it was noted as *Ceriops sp. nov.*, designated as endangered). Similarly, *C. zippeliana* was reported as rarer than the *C. tagal* in Malaysia (Kochummen, 1989; Madani and Wong, 1995). However, according to the field observations of the authors, *C. zippeliana* is not a rare member at the Pasir Ris Park, especially when compared with *C. tagal*. Several field trips to the current mangrove forests in Singapore revealed that *C. zippeliana* were also found in Sungei Buloh Wetland Reserve, Changi Creek, Pulau Semakau, Woodlands Town Gardens Park, Lim Chu Kang, Sungei Seletar Reservoir causeway mangroves, Pandan mangroves (off Jalan Buroh), Pulau Ubin and Pulau Tekong. The previous collections of *C. zippeliana* deposited at SING herbarium (misidentified as *C. tagal*) were collected from Changi, Jurong River, Khatib Bongsu and Pulau Ubin.

It is not surprising that *C. zippeliana* occurs in Singapore; since the island of Singapore is separated from the Malay Peninsula by a narrow Johor Strait and the flora of Singapore naturally is a natural floristic extension of the southern part of the Malay Peninsula (Keng, 1990). Nevertheless, a detail field and population survey of this genus would provide more adequate information to better manage Singapore's mangrove biodiversity. Moreover, further attention for conservation of this genus in Singapore may need to be focused on *C. tagal.*

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LITERATURE CITED

Corlett, R. T. 1987. Singapore. In: Umali, R. M., P. M. Zamora, R. R. Gotera, R. S. Jara and A. S. Camacho (eds.), Mangroves of Asia and the Pacific: status and management, 211-218. Technical Report of the UNDP/UNESCO Research and Training Pilot Programme on Mangrove Ecosystems in Asia and the Pacific (RAS/ 79/ 002). UNDP/ UNESCO, Manila, The Philippines.

Davison, G. W. H., P. K. L. Ng and H.-H. Chew. 2008. The Singapore Red Data Book: threatened plants & animals of Singapore. 2nd ed. The Nature Society (Singapore), Singapore. 285pp.

Duke, N. C. 1992. Mangrove floristics and biogeography, Chapter 4. In: Robertson, A. I. and Alongi, D. M. (eds.), Tropical Mangrove Ecosystems, **41**: 63-100. Coastal and Estuarine Studies Series, American Geophysical Union, Washington, D.C., 329 pp.

Field, C. D. 1995. Journey amongst Mangroves. Okinawa, Japan: International Society for Mangrove Ecosystems. 137pp.

Hilton, M. and S. S. Manning. 1995. Conservation of coastal habitats in Singapore: indications of unsustainable development. Environmental Conservation **22**: 307-322.

Hou, D. 1958. Rhizophoraceae. In: van Steenis, C. G. G. J. (ed.), Flora Malesiana, ser. 1, **5**: 429-493. Noordhoff-Kolff N. V., Djakarta, Indonesia.

Keng, H. 1990. The Concise Flora of Singapore: gymnosperms and dicotyledons. Singapore University Press. 222pp.

Kochummen, K. M. 1989. Rhizophoraceae. In: Ng, F. S. P. (ed.), Tree Flora of Malaya. A Manual for Foresters. **4**: 302-323. Longman Malaysia, Kuala Lumpur, Malaysia.

Madani, L. and K. M. Wong. 1995. Rhizophoraceae. In: E. Soepadmo and K. M. Wong (eds.), Tree Flora of Sabah and Sarawak. **1**: 321-349. Ampang Press Sdn. Bhd., Kuala Lumpur, Malaysia.

Ng, P. K. L. and N. Sivasothi. 1999. A Guide to the Mangroves of Singapore 1: the ecosystem and plant diversity. Singapore Science Centre, Singapore. 160pp.

Ng, P. K. L., W. L. Keng and K. K. P. Lim. 2008. Private Lives: an exposé of Singapore's mangroves. The Raffles Museum of Biodiversity Research, Department of Biological Sciences, National University of Singapore. 249pp.

Saenger, P. 2002. Mangrove Ecology, Silviculture and Conservation. Kluwer Academic Publishers, The Netherlands. 360pp.

Sheue, C.-R. 2003. Comparative Morphology and Anatomy of the Eastern Mangrove Rhizophoraceae. Ph. D. Dissertation. National Sun Yat-sen University, Kaohsiung, Taiwan. 228pp.

Sheue, C.-R., H.-Y. Liu, C.-C. Tsai, S. M. A. Rashid, J. W. H. Yong, and Y.-P. Yang. 2009a. On the morphology and molecular basis of segregation of two species *Ceriops zippeliana* Blume and *C. decandra* (Griff.) Ding Hou (Rhizophoraceae) from southeastern Asia. Blumea 54: 220-227.

臺灣大學學術期刊資料庫

Sheue, C.-R., H.-Y. Liu, C.-C. Tsai, and Y.-P. Yang. 2010. Comparison of *Ceriops pseudodecanda sp. nov.* (Rhizophoraceae), a new mangrove species in Australasia, with related species. Botanical Studies 51 (in press).

Sheue, C.-R., H.-Y. Liu and J. W. H. Yong. 2003. *Kandelia obovata* (Rhizophoraceae), a new mangrove species from Eastern Asia. Taxon **52**: 287- 294.

Sheue, C.-R., Y.-P. Yang, H.-Y. Liu, F.-S. Chou, S.-C. Chang, P. Saenger, C. Mangion, G. Wightman, J.W. H. Yong and C.-C. Tsai. 2009b. Reevaluating the taxonomic status of *Ceriops australis* (Rhizophoraceae) based on morphological and molecular evidence. Botanical Studies **50**: 89-100.

Sheue, C.-R., J. W. H. Yong and Y.-P. Yang. 2005. The *Bruguiera* (Rhizophoraceae) species in the mangroves of Singapore, especially on the new record and the rediscovery. Taiwania **50**: 251- 260.

Tan, H. T. W., L.-M. Chou, D. C. J. Yeo and P. K. L. Ng. 2007. The Natural Heritage of Singapore (2nd ed.). Prentice Hall, Singapore. 271pp.

Tomlinson, B. P. 1986. The Botany of Mangroves. Cambridge Univ. Press, Cambridge. 419pp.

Turner, I. M. and J. W. H. Yong. 1999. The coastal vegetation of Singapore. In: C. Briffett and H. H. Chew (eds.), State of the Natural Environment in Singapore, 5-23. Nature Society (Singapore), Singapore.

新加坡紅樹林植物的新紀錄種－齊氏細蕊紅樹

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摘要：本文報導作者於 1999 年於新加坡採集到的一種新紀錄之紅樹林植物。經數年的分類研究後，作者確認本種為 *Ceriops zippeliana* Blume (此譯為齊氏細蕊紅樹)，除新加坡外，本種亦分布於東南亞一帶。文中提供本種植物描述、含鑑別特徵的彩色圖片及新加坡當地本屬植物的檢索表，以供鑑定，並和原已知產於該地的細蕊紅樹 (*C. tagal* (Perr.) C. B. Rob.) 比較與分辨之。值得注意的是原產於新加坡的細蕊紅樹之族群比本新紀錄種相對地更加稀少。建議未來進一步廣泛調查本屬植物，並對細蕊紅樹特別加以關注，將有助於新加坡地區紅樹林植物多樣性之保育工作。

關鍵詞：印度細蕊紅樹 (*Ceriops decandra* (Griff.) Ding Hou)、細蕊紅樹 (*Ceriops tagal* (Perr.) C. B. Rob.)、齊氏細蕊紅樹 (*Ceriops zippeliana* Blume)、紅樹林、紅樹科、新加坡。

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