ISSN 1880-7682
Volume 20, No. 2 **July 2022**

Botany, distribution, phytochemistry and bioactivities of mangrove plants VI: *Avicennia rumphiana*

Eric W.C. Chan[1*], Joseph Tangah[2], Mio Kezuka[3] & Hung Tuck Chan[3]

[1]*Faculty of Applied Sciences, UCSI University, 56000 Cheras, Kuala Lumpur, Malaysia.*
[2]*Forest Research Centre, Sabah Forestry Department, 90009 Sandakan, Sabah, Malaysia*
[3]*Secretariat, International Society for Mangrove Ecosystems (ISME), c/o Faculty of Agriculture, University of the Ryukyus, Okinawa, 903-0129 Japan*

[*]*E-mail address: chanwc@ucsiuniversity.edu.my, erchan@yahoo.com*

Background

Globally, there are eight species of *Avicennia* with five species (*A. alba, A. integra, A. marina, A. officinalis* and *A. rumphiana*) in East Africa and Indo-Pacific, and three species (*A. bicolor*, *A. germinans* and *A. schaueriana*) in the New World and West Africa (Duke, 1991; Spalding *et al*., 2010). *Avicennia* species occur in tropical, subtropical including temperate tidal habitats. Found on the mudflats of the foreshore, *Avicennia* species are the most widely distributed among the mangrove species. Among species of this genus, the geographical distribution of *A. marina* is the broadest due to its ability to adapt a wide range of environmental conditions (Baba *et al.*, 2016).

Trees of *Avicennia* are generally 10−25 m tall with some reaching up to 30 m. Leaves are simple, opposite, oval to pointed in shape, and have glands to secrete salt. Their pencil-like pneumatophores protrude above the ground, sprouting from underground cable roots. Inflorescences produce small clustered yellow flowers. Propagules are small, vary in shape, and are semi-viviparous with single seeds germinating promptly upon dispersal. Botanical descriptions of *Avicennia* are from Tan (2013). The wide spectrum of medicinal and non-medicinal uses of *Avicennia* species has been reviewed by Thatoi *et al*. (2016).

Botany and Uses

Avicennia rumphiana Hallier f. (synonyms: *A. officinalis* var. *spathulata* and *A. lanata*) belongs to the family Avicenniaceae. The species can grow up to 30 m tall with bole diameter reaching 30 cm. The trunk is straight and cylindrical when growing gregariously. The bark is smooth and dark grey. Pneumatophores are short and pencil-like that emerge from the ground. Twigs are quadrangular and covered with dense tomentose when young. Leaves are simple, opposite, ovate or elliptic with a slightly pointed apex. They are thick, entire, dark green above, and covered with dense, fawn-colored velvety hairs beneath. Flowers are orange-yellow, fragrant, clustered. Propagules resemble little almonds, broadly ovoid, compressed, and are covered by dense woolly tomentose. Botanical descriptions of *A. rumphiana* are from Duke (1991) and Giesen *et al.* (2007).

Distribution

In the World Atlas of Mangroves, *A. rumphiana* is distributed in the Asia-Pacific countries of Indonesia, Malaysia, Papua New Guinea and Philippines (Spalding *et al*., 2010). In the study on the relation between amino acids profiles and recalcitrancy of cell growth or salt tolerance, propagules of *A. rumphiana* were collected from Thailand, confirming its occurrence in the country (Tsuchiya *et al*., 2013). In Singapore, *A. rumphiana* has been encountered at Sungai Mandai (Tan *et al.*, 1989) and Pasir Ris (Lee *et al.*, 1996). In East Malaysia, the species is recorded in Sematan, Sarawak, while there are no records in Sabah. In West Malaysia, the species has been encountered in the east coast at Kemaman (Sulong *et al*., 2002) and Setiu Wetlands (Salim *et al*., 2020) in Terengganu, and in the west coast at Sungai Benut in Johor. The species is not widely distributed but localized.

In this article, Bagan Lalang (2°35'N, 101°41'E), Selangor, in the west coast, is another location where *A. rumphiana* is encountered (Chan *et al.*, 2017). The site is a coastal beach located in the Sepang District at the state boundary of Selangor and Negeri Sembilan. At Bagan Lalang, the species grows gregariously further inland unlike the other mangrove tree species such as *Sonneratia alba*, *Rhizophora apiculata*, *R. stylosa* and *A. alba*, that grow at the seafront. A characteristic feature of *A. rumphiana* are the dense, velvety and fawn-colored under-surface of leaves. Its short and cylindrical pneumatophores differ from those of other *Avicennia* species that are thin and long. Morphological features of pneumatophores, leaves and flowers of *A. rumphiana* are shown in Figure 1.

Figure 1 Trees of *A. rumphiana* at Bagan Lalang showing their leaves, flowers and pneumatophores.

According to IUCN Red List of Threatened Species, *A. rumphiana* is at high risk of being endangered in the wild, and is categorized under Vulnerable (Criterion A) (Duke *et al.*, 2010). The population trend of this species is decreasing and the mangrove habitat within this species range has declined at least 30% from 1980 to 2005. No data to estimate the decline of population are available and there are no conservation measures for this species, but continued monitoring and research are recommended, as well as the inclusion of this species in marine and coastal protected areas.

Phytochemistry

From leaves of *A. rumphiana* in Vietnam, terpenoids (ursolic acid, lupeol and botulin), sterols (sitosterol and sitosterol 3-*O*-β-D-glucopyranoside), and flavonoid (tectochrysin) have been reported (Khanh *et al.*, 2013). Recently, from methanol extracts of twigs from *A. rumphiana* in Malaysia, new (glycosemiquinone and hydroxyavicenol C) and known (avicenol C, avicequinone C and glycoquinone) naphthofuranquinones have been isolated (Mazlan *et al.*, 2020a). From endophytic fungi of *A. rumphiana*, naphthofuranquinones (anhydrofusarubin, javanicin, dihydrojavanicin and solaniol) and dihydroisocoumarins (mullein and its three derivatives) were identified (Mazlan *et al.*, 2020b).

Bioactivities

Anti-quorum sensing: Leaves and pneumatophores of *A. rumphiana* have been reported to possess anti-quorum sensing (anti-QS) activity (Chan *et al.*, 2017). Anti-QS activity was tested against *Chromobacterium violaceum*, a Gram-negative bacterial strain that synthesizes a purple pigment called violacein. QS is an important feature of pathogenesis of some pathogenic bacteria and QS inhibition can result in a significant decrease in the virulence of these bacteria (Tan *et al.*, 2015; Lim *et al.*, 2021). Other mangrove species having anti-QS activity are the stem and stilt root of *Rhizophora apiculata* and the pneumatophore of *Sonneratia alba* (Chan *et al.*, 2017).

Antioxidant: Total phenolic content and free radical scavenging antioxidant activity of leaves of *A. rumphiana* were 3.0 and 2.1 times those of stems, and 3.7 and 3.6 times those of roots, respectively (Chan *et al.*, 2017). Similar observations were made in wild and cultivated species of ginger plants, where significantly higher phenolic contents and antioxidant activities were found in the leaves than in the rhizomes (Chan *et al*., 2007, 2008). A likely explanation is that *A. rumphiana* leaves are exposed to more sunlight than stems while roots are unexposed below the soil surface.

Antibacterial: Leaves and pneumatophores of *A. rumphiana* possess antibacterial activity against Gram-positive *Bacillus cereus* and *Staphylococcus aureus* with minimum inhibitory dose (MID) of 1.0 and 0.5 mg/disc (Tan, 2016). Leaves inhibited the growth of *S. aureus* with MID of 0.5 mg/disc.

Anti-trypanosomal: All five naphthofuranquinones from the twigs of *A. rumphiana* and all eight compounds from the endophytic fungi of *A. rumphiana* showed significant anti-trypanosomal activity on *Trypanosoma brucei brucei* with minimum inhibitory concentration (MIC) of 3.12–12.5 µM (Mazlan *et al.*, 2020a, 2020b).

Anti-cancer: The polyisoprenoid leaf extract of *A. rumphiana* exhibited moderate anticancer activity against WiDr colon cancer cells. The activity of *A. rumphiana* was two times weaker than that of *A. marina* (Illian *et al.*, 2018), but comparable to that of *A. alba* (Qurrohman *et al.*, 2020). Although the anticancer activity may involve inhibition of the cell cycle and induction of apoptosis, the molecular mechanisms require further studies.

Conclusion

Among the *Avicennia* species, *A. rumphiana* is localized in its distribution, reported in the Asia-Pacific countries of Indonesia, Malaysia, Papua New Guinea, Philippines, and Singapore. Thailand is the latest country where *A. rumphiana* occurs. Chemical compounds isolated from *A. rumphiana* include terpenoids, sterols and flavonoids. Recently, new and known naphthofuranquinones have been reported. From endophytic fungi, naphthofuranquinones and dihydroisocoumarins have been identified. Pharmacological properties of *A. rumphiana* include anti-quorum sensing, antioxidant, antibacterial, anti-trypanosomal and anti-cancer activities.

References

Baba, S., Chan, H.T., Oshiro, N., Maxwell, G.S., Inoue, T. & Chan, E.W.C., 2016. Botany, uses, chemistry and bioactivities of mangrove plants IV: *Avicennia marina*. *ISME/GLOMIS Electronic Journal* 14(2): 5-10.

Chan, E.W.C., Lim, Y.Y. & Lim, T.Y., 2007. Total phenolic content and antioxidant activity of leaves and rhizomes of some ginger species in Peninsular Malaysia. *Gardens' Bulletin Singapore* 59: 47-56.

Chan, E.W.C., Lim, Y.Y., Wong, L.F., Lianto, F.S., Wong, S.K., Lim, K.K., *et al*., 2008. Antioxidant and tyrosinase inhibition properties of leaves and rhizomes of ginger species. *Food Chemistry* 109(3): 477-483.

Chan, E.W.C., Ng, S.M., Sim, B.W., Tan, H.C. & Lo, Z.L., 2017. Antioxidant, anti-tyrosinase and anti-quorum sensing activities of four mangrove tree species vs. green tea. *Journal of Applied Pharmaceutical Science* 7(7): 225-229.

Duke, N.C., 1991. A systematic revision of the mangrove genus *Avicennia* (Avicenniaceae) in Australasia. *Australian Systematic Botany* 4(2): 299-324.

Duke, N., Kathiresan, K., Salmo, S.G., Fernando, E.S., Peras, J.R., Sukardjo, S., *et al*., 2010. *Avicennia rumphiana*. *The IUCN Red List of Threatened Species* e.T178809A7613129. DOI: 10.2305/IUCN.UK.2010-2.RLTS.T178809A7613129.en.

Giesen, W., Wulfraat, S., Zieren, M. & Scholten, L., 2007. *Mangrove Guidebook for Southeast Asia*. FAO, Bangkok, Thailand and Wetlands International, Wageningen, Netherlands.

Illian, D.N., Basyuni, M., Wati, R. & Hasibuan, P.A., 2018. Polyisoprenoids from *Avicennia marina* and *Avicennia lanata* inhibit WiDr cells proliferation. *Pharmacognosy Magazine* 14(58): 513-518.

Khanh, L.P., Truc, H.K., Kim, N.T.T., Phung, N.P.K. & Thu, N.T.H., 2013. Chemical constituents from leaves of *Avicennia lanata* non-Ridley, Phamhoang (Avicenniaceae). *Science and Technology Development Journal* 16(2): 20-25.

Lee, S.K., Tan, W.H. & Havanond, S., 1996. Regeneration and colonisation of mangrove on clay-filled reclaimed land in Singapore. *Hydrobiologia* 319(1): 23-35.

Lim, C.S.S., Chan, E.W.C., Wong, C.W., Tan, J.B., Anggraeni, V.S., Loong, Z.J., *et al*., 2021. Anti-quorum sensing and antibiotic enhancement of allylpyrocatechol and methyl gallate. *Jurnal Teknologi* 83(3): 101-106.

Mazlan, N.W., Clements, C. & Edrada-Ebel, R., 2020a. Targeted isolation of anti-trypanosomal naphtho furan-quinone compounds from the mangrove plant *Avicennia lanata*. *Marine Drugs* 18(12): 661.

Mazlan, N.W., Tate, R., Yusoff, Y.M., Clements, C. & Edrada-Ebel, R., 2020b. Metabolomics-guided isolation of anti-trypanosomal compounds from endophytic fungi of the mangrove plant *Avicennia lanata*. *Current Medicinal Chemistry* 27(11): 1815-1835.

Qurrohman, T., Hasibuan, P.A., Nuryawan, A., Sumaiyah, S., Siregar, E.S. & Basyuni, M., 2020. Effects of polyisoprenoids from *Avicennia lanata* and *Avicennia alba* leaves on the gene expression of PI3K, Akt1, mTOR, P53, and EGFR in human colorectal adenocarcinoma WiDr cells. *F1000 Research* 9: 182.

Salim JM, Lee GE, Salam MR, Shahimi S, Pesiu E, Jani JM, *et al*., 2020. A checklist of vascular plants and uses of some species for livelihood-making in Setiu Wetlands, Terengganu, Malaysia. *PhytoKeys* 160: 7-43.

Spalding, M., Kainuma, M. & Collins, L., 2010. World Atlas of Mangroves. Earthscan, London, U.K. and Washington, D.C., U.S.A., 336 pp.

Sulong, I., Mohd-Lokman, H., Mohd-Tarmizi, K. & Ismail, A., 2002. Mangrove mapping using Landsat imagery and aerial photographs: Kemaman District, Terengganu, Malaysia. *Environment, Development and Sustainability* 4(2): 135-152.

Tan, H.C., 2016. Antioxidant, antibacterial, anti-tyrosinase and anti-quorum sensing properties of *Avicennia rumphiana*. B.Sc. thesis, Faculty of Applied Sciences, UCSI University, Kuala Lumpur, Malaysia.

Tan, R., 2013. *Avicennia* sp. Wild Fact Sheets. Accessed from www.wildsingapore.com.

Tan, T.K., Leong, W.F. & Jones, E.B., 1989. Succession of fungi on wood of *Avicennia alba* and *A. lanata* in Singapore. *Canadian Journal of Botany* 67(9): 2686-2691.

Tan, Y.P., Chan, E.W.C. & Lim, C.S.Y., 2015. Potent quorum sensing inhibition by methyl gallate isolated from leaves of *Anacardium occidentale* L. (cashew). *Chiang Mai Journal of Science* 42(3): 650-656.

Thatoi, H., Samantaray, D. & Das, S.K., 2016. The genus *Avicennia*, a pioneer group of dominant mangrove plant species with potential medicinal values: A review. *Frontiers in Life Science* 9(4), 267-291.

Tsuchiya, S., Ogita, S., Kawana, Y., Oyanagi, T., Hasegawa, A. & Sasamoto, H., 2013. Relation between amino acids profiles and recalcitrancy of cell growth or salt tolerance in tissue and protoplast cultures of three mangrove species, *Avicennia alba*, *Bruguiera sexangula*, and *Sonneratia alba*. *American Journal of Plant Sciences* 4(7): Article ID 33987, 9 pp.

How to cite this article:
Chan, E.W.C., Tangah, J., Kezuka, M. & Chan, H.T., 2022. Botany, distribution, phytochemistry and bioactivities of mangrove plants VI: *Avicennia rumphiana*. *ISME/GLOMIS Electronic Journal* 20(2): 13-16.