Journal of Tropical Agriculture 54 (2) : 115-119, 2016

Ecoanatomical characterisation of a true mangrove, *Aegiceras corniculatum* Blanco, found in the West Coast of India

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Received 6 December 2016; received in revised form 28 December 2016; accepted 30 December 2016

Abstract

Aegiceras corniculatum Blanco is one of the important true mangrove species of the western coast of India. Wood as well as increment core samples were collected from trees having GBH ≥10cm, from three sites in the western coast of India and wood anatomical features were recorded in the laboratory. The results indicate simple, alternate, diffuse porous vessels; both diffuse and scanty axial parenchyma, homogeneous type III rays, vestured pits, helical thickening, sheath cells, breakdown areas in ray cells and vessel inclusions. A comparison of ecoanatomical characters of this true mangrove species was made with its nearest upland relative belonging to the same family viz., *Myrsines andwicensis* A. DC. In contrast to its upland relative, *Aegiceras corniculatum* recorded short vessels with smaller diameter, exceptionally high vessel frequency and high vessel grouping. The vulnerability and mesomorphy ratio of *Aegiceras corniculatum* were 0.27 and 80, respectively, which showed the xeromorphic nature of wood. Modification of hydraulic architecture of *Aegiceras corniculatum* as response to ecological condition might be the reason for its survival towards the seaward line of mangrove succession and is hence, less vulnerable to cavitation. This causes a safer sap flow in this species.

Keywords: *Aegiceras corniculatum,* Ecoanatomy, Hydraulic conductivity, Mangroves

Introduction

Mangroves are a tropical and sub tropical woody ecosystem which is found in the interface of sea and land. In India, mangroves are seen in both east and west coasts. Out of the 32 true mangroves (FAO, 2007), 20 were reported in west coast of India by several workers (Kathiresan and Bingham, 2001). *Aegiceras corniculatum* Blanco is a true mangrove species that belongs to the family Myrsinaceae (Lens et al., 2005). *Aegiceras corniculatum* normally occurs along the seaward line of mangrove succession. Most of the investigations carried out along these lines are restricted to eco-physiology of mangrove vegetation and only limited studies are available on eco-anatomical features of mangrove wood. The effect of ecological parameters on wood anatomical features is defined as the 'eco-anatomy' of wood (Lindorf, 1994). The ecoanatomical wood features such as vessel diameter, vessel frequency, and vessel length affect the hydraulic efficiency and safety of a tree in its habitat, in interaction with the environment. Carlquist (1988) asserts that short and narrow vessels are valuable because they localize air embolism to a greater extent than long ones. He coined the two ecological indices viz., vulnerability (vessel member diameter divided by vessel frequency) and mesomorphy (vulnerability multiplied by mean vessel member length). A low value of vulnerability indicates a greater redundancy of vessels and mesomorphy value expresses the conductive safety of a wood. Because of saline environmental conditions prevailing in mangrove ecosystem, the xylem sap is at negative absolute

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pressures. This increase in xylem sap tension induces cavitation, which results in the formation of gas bubbles (embolism). Embolism reduces hydraulic transport efficiency and finally leads to the death of the plant. Mangrove woods have been found to have specialized ecoanatomical features to overcome stressful environment (Tomlinson, 1986; Anoop et al., 2013). In this background, the present study was formulated with the objectives of studying the wood anatomy of *Aegiceras corniculatum* and elucidating its eco-anatomical wood features.

Materials and Methods

The present study was conducted in the Wood Science department of the College of Forestry, Kerala Agricultural University, Vellanikkara. Wood samples, which included blocks as well as increment cores of the *Aegiceras corniculatum* were collected from three sites in the Western Coast of India viz. Kodibag ($14^0$50 17.6" N and $74^0$07 57.1" E) in Karnataka, Chettuva ($10^0$31’51.6" N and $76^0$02’55.1"E) and Ayiramthengu (9' 073’2.6" N and 76^0 28' 47.8" E) in Kerala. The core samples were collected using an increment borer (Haglof; 2 thread 10 mm increment borer). Wood anatomical studies were conducted using wood microtomy and maceration. Wood specimens of size 1.0 cm^3 and core samples of size 1cm were chiselled out from each sample and anatomical features were studied. The specimens were then softened by keeping in water bath (Rotex water bath) kept at 100^0C. Transverse Sections (TS), Tangential Longitudinal Sections (TLS) and Radial Longitudinal Sections (RLS) of 10-15 μm thickness were prepared using a Leica sliding wood microtome (Leica SM 2000R). The sections were stained and mounted to prepare permanent slides (Johansen, 1940). Maceration of the wood samples was done using Jeffrey’s method (Jeffrey, 1917). Microscopic examination and quantification of sections were undertaken using an Image Analyzer (Labomed-Digi 4). The important ecoanatomical wood features recorded for the study were vessel length, vessel diameter, vessel frequency and solitary vessel percentage of the mangrove species. These were compared with the nearest terrestrial relative *Myrsines andwicensis* belonging to the same family (Weerdt, 2010; Lindorf, 1994). Data of the nearest terrestrial relative were taken from other published literature. The phylogenetic relationship between the mangrove genera and their upland relative were based on molecular genes viz. *atpB, ndhF* and *rbcL* and *DNA* through Maximum Parsimony (MP) method (Hilu and Borsch, 2003; Kallersjo et al., 2000). Wood anatomical indices of vulnerability (vessel member diameter divided by vessel frequency) and mesomorphy (vulnerability multiplied by mean vessel member length) were calculated from species means following the formulae provided by Carlquist (1977).

Results and Discussion

Wood anatomical characters of Aegiceras corniculatum Blanco

An examination of the wood anatomical properties of *Aegiceras corniculatum* indicated that growth ring boundaries were indistinct or absent. Perforation plates were simple, transverse end had tail and lateral wall showed alternate pitting (Fig. 1a). Two cells per parenchyma strand and four (3-4) cells per parenchyma strand were also observed (Fig. 1b). Breakdown areas were present in rays and sclereid-like substance was deposited in this area (Fig. 1c). Vessels in diagonal or radial multiples of 4 or more were common with round to oval shape and 36-40% were solitary (Fig. 1d). Helical thickenings were observed adjacent to the vessel element (Fig. 1e).

Vestured pits were also present (Fig. 1f).Vessel frequency ranged between 66-170 mm^{-2}. Non septate fibre with simple to minutely bordered pits were also observed. Fibres were thin walled with mean fibre length of 482 μm and mean diameter of 27 μm. Fibre tracheids were also present. Gums and globular starch deposits were observed in vessels

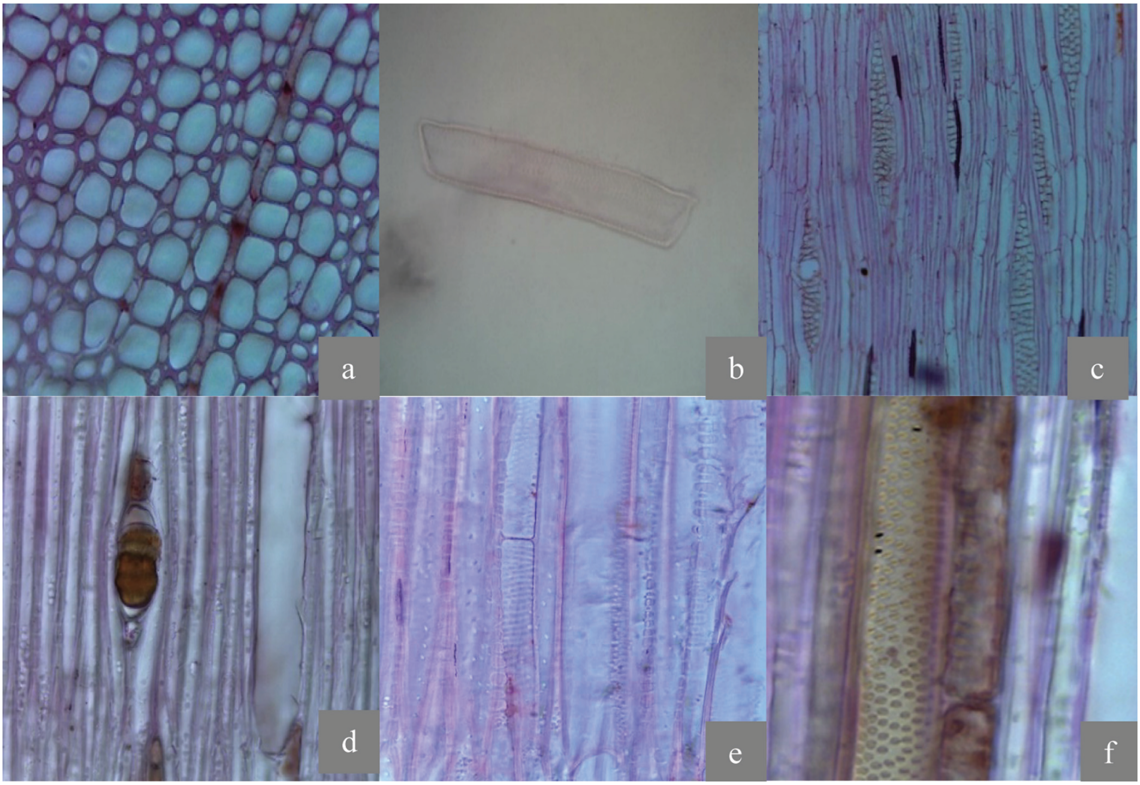

Figure 1. Wood anatomical features of *Aegiceras corniculatum* showing vessels in diagonal or radial multiples (1 a) vessels with simple perforation plates and transverse end tail (1b); rays of homogeneous type II with frequency of 6 mm^{-2} (1c); break down areas in rays with sclereid-like substance (1d); helical thickenings adjacent to vessel elements (1e) and vestured pits in vessels (1f).

and ray cells. Both apotracheal diffuse and paratracheal scanty axial parenchyma were present. Rays were homogeneous type II with frequency of 6 mm^{-2}. Ray width of small rays were 1-3 cells wide and of large rays were 4-10 cells with an average ray diameter of 43 µm, and ray height was upto 521 µm.

Ecoanatomical wood characters of Aegiceras corniculatum

Vulnerability and Mesomorphy

According to Carlquist (2001) 'vulnerability' is the ratio of vessel frequency and vessel diameter. A low value for this ratio could indicate safety of vessels. Vulnerability ratio is also said to be indicative of sensitivity of a species to the risks of embolism. Notably, the vulnerability ratio of *Aegiceras corniculatum* was found to be 0.27 (Table 1). The vessel frequency, vessel diameter and vessel length were recorded as 165 mm^{-2}, 36 µm and 280 µm respectively (Table 1). This species is mostly found in the saline swampy stressful environment where there are more chances for cavitation and embolism. *Aegiceras corniculatum* has numerous short narrow vessels (Table 1). More numerous the vessels per sq. mm, less is the chance of disabling a given number of vessels by air embolisms formed under water stress and serious impairment of conduction in a plant. Carlquist (1977) reported the vulnerability value of xeric species would be in the range 1.0 to 2.5.

Mesomorphy is obtained when vulnerability ratio is multiplied with vessel length. Mesomorphy is said to be the measure of water availability of the species

Table 1. Comparison of eco-anatomical characters of mangrove species *Aegiceras corniculatum* and its terrestrial relative *Myrsines andwicensis*

Species	Vessel frequency (no./mm^2)	Vessel diameter (µm)	Vessel length (µm)	Solitary vessel percentage (%)	References
Aegiceras Corniculatum	165	36	280	36-40	Present study
MyrsineSandwicensis	18-29	47-50	350-680	Mostly solitary	Lens et al.,2005

with high values being typically for the species related to mesic ecology (Givinish, 1986; Carlquist, 2001). The mesomorphic value of *Aegiceras corniculatum* was found to be 80 (Table 1). According to Carlquist (1977), xerophytes would have mesomorphic value near to 75. The mesomorphic value of *Aegiceras corniculatum* is more or less similar to this value. According to mesomorphic ratio of *Aegiceras corniculatum,* the wood is more xeric in nature. Plasticity of wood anatomical characters with respect to fluctuation in mangrove ecological condition might be one of the physiological adaptations of mangrove species *Aegiceras corniculatum* to withstand the change in climatic conditions such as altering hydrological regimes and occurrence of natural calamities.

Helical thickenings

The helical thickenings in mangrove species *Aegiceras corniculatum* might help to store more water during saline stress conditions in mangrove ecosystem (Fig. 1d). This might aid in refilling of embolized vessels or in some way might diminish danger of cavitation or increase the wall strength. The citation of helical thickenings in desert and chaparral shrubs by Webber (1936) underlines the relationship between helical thickenings and drought.

Vessel grouping

High vessel grouping in *Aegiceras corniculatum,* more probable with high vessel frequency (Table 1), can also bring a functional advantage in saline condition. This stressful environment creates more negative pressure inside the xylem sap leading to cavitation and vessel blockage. Vessel grouping is advantageous because it allows water to bypass air-filled vessels by alternative pathways created by the intervessel pits of adjoining vessels in a vessel group.

Inclusions

Inclusions like gums and other deposits in vessels and rays were also recorded in *Aegiceras corniculatum* (Fig. 1c, 1f). These vessel inclusions prevent the spread of embolism which occur during the stressful condition in mangrove environment.

Vestured pit

Vestured pits are small lip like structures present in alternate pits (Fig. 1f).The vestures might help to prevent rupturing of the deflected pit membranes when pressure drops occur between adjacent vessel elements after air embolism during physiological drought condition typical of mangrove ecosystems. These vestures would also trap the bubble formation due to embolism and restore the normal water transport inside the xylem sap.

Comparison of Aegiceras corniculatum with upland terrestrial relative Myrsines andwicensis.

The vessel frequency of mangrove species *Aegiceras corniculatum* was recorded as 165 mm^{-2} in the present investigation (Table 1) and that of its terrestrial relative *Myrsines andwicensis* was found to be in the range 18-29 mm^{-2} (Lens et al., 2005). The vessel diameter and vessel length of *Aegiceras corniculatum* was found to be 36 µm and 280 µm in the current investigation whereas *Myrsines andwicensis* has been reported to have vessel diameter in the range 35-60 µm and vessel length between 350 and 680 µm (Lens et al., 2005). It was observed that the mangrove species *Aegiceras* can easily be distinguished from its upland relative *Myrsines andwicensis*, due to the presence of relatively narrow vessels, high vessel frequency, short vessel elements and high vessel grouping. These eco-anatomical wood features would be helpful for *Aegiceras* to withstand saline stressful environment. Tomlinson (1986) also noted that the wood of mangrove species typically has a high number of narrow vessels, which are less vulnerable to cavitation, causing a safer sap stream.

In the present investigation it was found that *Aegiceras corniculatum* has simple, alternate pitting with both diffuse and paratracheal axial parenchyma. Advanced features such as helical thickening, vestured pitting, vessel inclusion and vessel grouping assisted in safer hydraulic transport. The vulnerability and mesomorphy ratio of *Aegiceras corniculatum* were 0.27 and 80 respectively. Due to the presence of relatively narrow vessels, high vessel frequency, short vessel elements and high vessel grouping, *Aegiceras* can be easily distinguished from its upland relative *Myrsines andwicensis*. The wood anatomical features would modify according to ecological conditions. The negative pressure prevailing in the xylem sap creates cavitation and leads to embolism formation. These wood anatomical parameters helps to diminish or refill the embolism and maintain the hydraulic conductivity in xylem vessels. A safe hydraulic architecture is only one of the alternative ways for a plant to be able to survive in water stress situations. The modification of xylem hydrological structure of mangrove wood helps to balance safety versus efficiency of water transport system.

References

Anoop, E.V., Job, J.N. and Fasil, M.M. 2013. Eco-anatomical characteristics of the wood of certain selected mangrove species of Kerala. In: Bhatt, J.R., Ramakrishna, M., Sanjappa, M., Ramadevi, O.K., Nilaratna, B.P. and Venkitaraman, K. (eds.), Mangroves in India: their Biology and Uses. Zoological Survey of India, Kolkata, pp. 445-456.

Carlquist, S. 1977. Ecological factors in wood evolution: A floristic approach. Am. J. Bot., 64: 887-896.

Carlquist, S. 1988. Comparative Wood Anatomy. Springer-Verlag, Berlin & Heidelberg, 460p.

Carlquist, S. 2001. Comparative Wood Anatomy (2nd Ed.). Berlin: Springer-Verlag, 460 p.

Carlquist, S. 1977. Ecological factors in wood evolution: A floristic approach. Am. J. Bot., 64: 887-896.

Givinish, T.J. 1986. Optimal stomatal conductance, allocation of energy between leaves and roots, and the marginal cost of transpiration. In: Givnish, T.J (ed.), On the Economy of Plant Form and Function, Cambridge University Press, Cambridge, pp.171–213

Hilu, K. and Borsch, T. 2003. Angiosperm phylogeny based on mat K sequence information. Am. J. Bot., 90: 1758-1766.

Jeffrey, E.C.1917. The anatomy of woody plants. University of Chicago Press, Chicago, Illinois 150p.

Johansen, D. A. 1940. Plant Microtechnique. McGraw-Hill Book Company, New York. 502p.

Kallersjo, M., Bergqvist, G. and Anderberg, A.A. 2000. Generic realignment in primuloid families of the Ericales: a phylogenetic analysis based on DNA sequences from three chloroplast Genes and morphology. Am. J. Bot., 87(9): 1325–1341.

Kathiresan, K. and Bingham, B. 2001 Biology of mangroves and mangrove ecosystems. Adv. Mar. Biol., 40, 81-251.

Lens, F. 2005. Systematic significance of wood anatomical characters in Ericales. PhD Thesis. Laboratoriumvoor Systematiek, K. U. Leuven, Belgium, 290 pp.

Lindorf, H. 1994. Ecoanatomical wood features of species from a very dry tropical forest. IAWA15 (4): 361-376.

Tomlinson, P.B. 1986. The Botany of Mangroves. Cambridge University Press, Cambridge, 419p.

Webber, I. E. 1936. The woods of sclerophyllous and desert shrubs and desert plants of California. Am. J. Bot., 23:181-188

Weerdt, J.D. 2010. Is the wood hydraulic structure contributing to mangrove survival? A wood anatomical comparison with upland relatives. PhD thesis, Vrije University, Brussel, 93 p.