*Hydrobiologia* **352:** 61–66, 1997.
*Y.-S. Wong & N. F.-Y. Tam (eds), Asia–Pacific Conference on Science and Management of Coastal Environment.*



# Wood structure of *Aegiceras corniculatum* and its ecological adaptations to salinities

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*Key words: Aegiceras corniculatum*, wood structure, quantitative characters, soil salinities

## Abstract

We describe the wood structure of *Aegiceras corniculatum* and its differences under various soil salinities. This species had diffuse-porous wood with poorly defined growth rings. Vessels which had single perforations occurred abundantly and in multiples and were storeyed. Intervascular pits between contiguous vessels were alternate bordered ones while half-bordered pit-pairs existed between both vessel-ray and vessel-parenchyma. Homogenous xylem rays were multiseriate and uniseriate. Fiber-tracheids with bordered pits often had thinner walls. Xylem parenchyma cells were scant and distributed diffusely and paratracheally. Differences in the structural and quantitative characters of vessels, xylem rays and fiber-tracheids under diverse soil salinities are described.

## Introduction

Mangroves are communities of woody plants distributed in coastal intertidal strips of tropical and subtropical zones. They are special ecosystems appearing in vulnerable coastal strips all over the world. In recent decades, research on mangroves has been focused on the diversity of species, resources, flora, physiological ecology, matter recycling and energy flow in their ecosystems. However, as far as ecological anatomical research is concerned, little work has been done (Janssonius, H. H., 1950; Lin, P., 1988; Panshin, A. J., 1932; Tomlinson, P. B., 1986). *Aegiceras corniculatum* is a widespread mangrove species and one of major species of mangroves in Fujian Province. We studied this species at Jiulongjiang Estuary, Fujian Province, China, concentrating on its wood structure and the differences of wood structure under various salinities, so as to have a better understanding of the characters and ecological adaptations of wood structure in mangrove plants.

## Materials and methods

### *Materials and sample plots*

The materials in this paper were all the trunk wood of *Aegiceras corniculatum,* which grew naturally in five different sample plots from the northen coast of Jiulongjiang Estuary to Xiamen Harbour, Fujian Province, China. Details of research materials and sample plots could be got from Figure 1 and Table 1.

### *Methods*

We adopted the following two methods to treat the trunk wood:

a. Sectioning (Miksche, 1976): cut the trunk wood into blocks of 1 $cm^3$, soften them in hot water, then section them with a sliding microtome in transverse, radial and tangential directions. Keep sections with the thickness of 15 $\mu$m.

b. Maceration (Miksche, 1976): divide the trunk wood into slivers thinner than a toothpick, boil in water, then macerate in a solution of glacial acetic acid and hydrogen peroxide. Wash them in water.

Take some of the above treated materials, stain with safranin, dehydrate through an ethyl alcohol series,

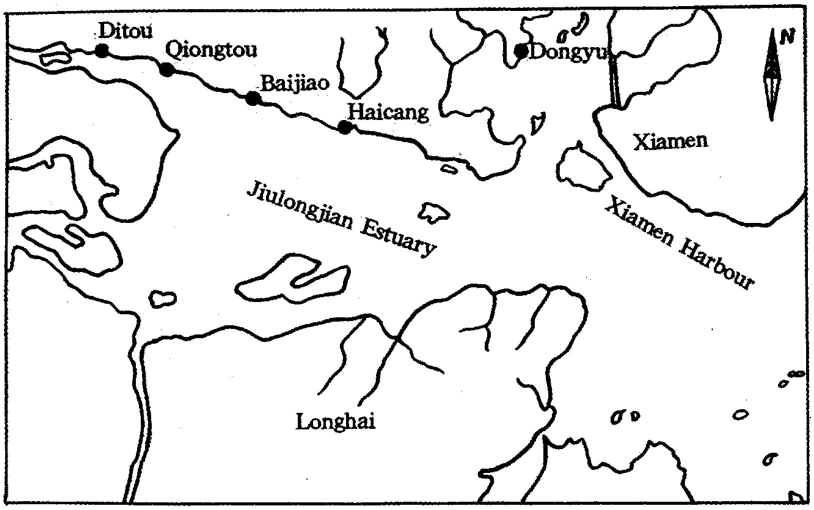


*Figure 1.* The map illustrating the distribution of sample plots (•).

*Table 1.* The heights and diameters of plant body of *Aegiceras corniculatum* and soil salinities in different sample plots

| Item | Sample plot Ditou | Qiongtou | Baijiao | Haicang | Dongyu |
|---|---|---|---|---|---|
| Height of plant body(m) | 1.6 | 1.5 | 1.8 | 1.8 | 1.6 |
| Diameter of trunk(cm) | 3.0 | 2.8 | 3.2 | 3.0 | 2.9 |
| Soil salinity (‰)∗ (20∼40 cm soil layer) | 3.5 | 12.7 | 19.2 | 20.0 | 23.0 |

∗ mean values of monthly soil salinities from January 1988 to December 1992, measured by $AgNO_3$Methods (Chen, G.Z., 1965) at ebb tide of spring tide.

then clear in xylene and mount for observations under a light microscope. Also take other of the above treated materials, dehydrate through an ethyl alcohol series to absolute alcohol, dry, then coat with gold for observation in the scanning electron microscope (SEM).

Densities of vessels and xylem rays were measured and analysed in 10 fields of view selected randomly. 30 values of other anatomical structures, also selected at random, were measured and analysed.

## Results

### *Wood structure and its differences under various salinities*

*Aegiceras corniculatum* had diffuse-porous wood with poorly defined growth rings. The vessels in transverse section appeared polygonal, round or elliptical, with 273–488 per square millimeter. The length and diameter of vessel elements were 159.6–205.9 $\mu$m and 30.7–39.2 $\mu$m respectively. In wood which grew in lower salinities (lower than 19‰), almost all vessels formed multiples on a large scale, with scanty solitary vessels (Figure 2); while in higher soil salinities (higher than 19‰), they mainly formed multiples of three to seven cells, but there were some solitary vessels (Figure 3). In this species, vessels exhibited a storeyed arrangement in longitudinal section (Figures 4, 5). Vessel elements had level or oblique end walls with simple perforations (Figure 6). Intervascular pits were alternate bordered ones whose apertures appeared elliptical or extendedly elliptical in transverse direction (Figures 7, 8, 9). Half-bordered pit-pairs, which were of the same size as intervascular pits, existed between both vessel-ray and vessel-parenchyma.

Xylem fibers in this species were fiber-tracheids, whose length and diameter were respectively 234.5–316.1 $\mu$m and 17.3–22.3 $\mu$m. Their pits were round or elliptical bordered ones (Figure 10). In wood which grew in lower salinities, fiber-tracheids were of thinner

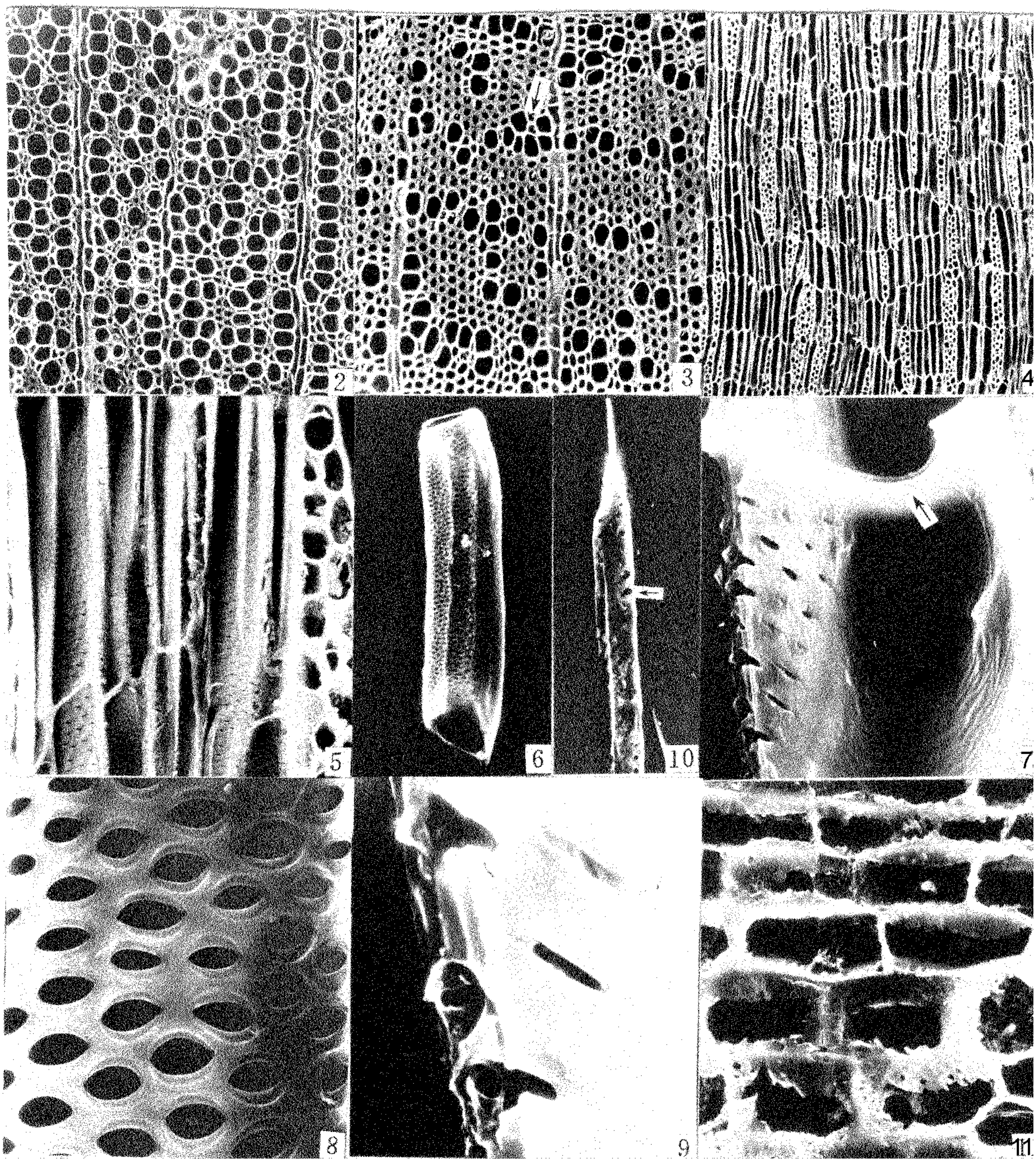


*Figure 2-11*. SEM micrographs of wood structure of *Aegiceras corniculatum*. 2. Transverse section of wood grown in lower soil salinity, showing diffuse-porous wood and vessel multiples on a large scale × 150. 3. Transverse section of wood in higher soil salinity (20‰), showing vessel multiples consisting of fewer cells (arrowed) × 150. 4. Tangential section of wood, showing the storeyed arrangement of vessel elements and uniseriate and multiseriate rays × 69. 5. Tangential section of wood, showing the shape of the pits × 300. 6. Vessel element, showing simple perforation and alternate pits × 500. 7. Half of a simple perforation (arrowed) and elliptical bordered pits × 3000. 8. Bordered pits between contiguous vessels × 5000. 9. Surface view of a vessel element, showing alternate elliptical bordered pits × 10 000. 10. Fiber-tracheid, showing round bordered pits (arrowed) × 500. 11. Homogenous xylem ray consisting of procumbent ray cells × 700.

*Table 2.* Comparison of quantitative characters of secondary xylem of *Aegiceras corniculatum* under various soil salinities (mean value ± standard error)

| Item | | Soil salinity (‰) 3.5 | 12.7 | 19.2 | 20.0 | 23.0 | r(1) |
|---|---|---|---|---|---|---|---|
| Vessel element | Density (/mm$^2$) | 488 ± 14.7 | 413 ± 11.1 | 345 ± 19.9 | 310 ± 13.1 | 273 ± 18.5 | −0.9849** |
| | Diameter (μm) | 36.7 ± 1.2 | 39.2 ± 1.6 | 39.0 ± 1.2 | 30.7 ± 0.9 | 35.9 ± 0.7 | −0.2908 |
| | Length (μm) | 205.9 ± 5.1 | 190.6 ± 4.0 | 172.7 ± 3.7 | 163.6 ± 3.6 | 159.6 ± 3.6 | −0.9811** |
| Fiber-tracheid | Diameter (μm) | 22.3 ± 0.6 | 19.9 ± 0.6 | 17.9 ± 0.7 | 17.8 ± 0.7 | 17.3 ± 0.5 | −0.9972** |
| | Length (μm) | 267.8 ± 6.5 | 234.5 ± 5.0 | 276.2 ± 8.5 | 241.8 ± 6.1 | 316.1 ± 4.7 | 0.3677 |
| Xylem ray | Density (/mm$^2$) | 11.0 ± 0.2 | 9.0 ± 0.6 | 12.3 ± 0.6 | 10.5 ± 0.5 | 13.6 ± 0.5 | 0.5023 |
| | Height (μm) | 366.8 ± 26.9 | 323.9 ± 23.9 | 301.2 ± 19.4 | 292.6 ± 19.6 | 237.4 ± 21.2 | −0.9337* |
| | Uniseriate ray ratio (%) | 45.0 ± 5.1 | 39.5 ± 6.0 | 38.8 ± 3.4 | 36.2 ± 5.7 | 25.1 ± 3.7 | −0.8280 |

(1) correlation coefficient with soil salinity; ** significant at 1% level; * significant at 5% level.

wall with many pits, while in higher salinities they were of thicker wall with fewer pits.

Xylem parenchyma cells were scanty. They were distributed paratracheally and diffusely in lower salinities, and often paratracheally in higher salinities.

Xylem rays in this species had two types: multiseriate and uniseriate. Both of them were homogenous and consisted of procumbent ray cells (Figure 11). The height and number of rays were 237.4–366.8 μm and 9–13 per square millimeter respectively. Most ray cells contained tannin and resin, but crystals were not observed.

*Relationship of quantitative characters of wood structure and soil salinities*

We investigated the quantitative characters of vessel, fiber-tracheid and xylem ray of the trunk wood in *Aegiceras corniculatum* which grew naturally under five different soil salinities. We also assessed correlation between them and soil salinity and made a linear regression analysis on those characters with significant correlation. The above data were handled and listed in Table 2 and made into Figure 12.

From Table 2 and Figure 12, it could be seen that these quantitative characters of wood structure varied under various soil salinities. By comparing the diameters, lengths and densities of vessel elements under various soil salinities, it was revealed that, the density (Figure 12A) and length (Figure 12B) of vessel elements were significantly correlated with soil salinity at 1% level and had negative correlation, while between diameter and soil salinity there was no significant correlation and the correlation coefficient was especially low. These meant that, with the increase of soil salinity, density and length decreased proportionally on a large scale, but diameter changed irregularly.

As for xylem rays, only height and soil salinity had significant negative correlation at 5% level (Table 2, Figure 12D), which indicated that ray height was also in inverse proportion with soil salinity, but no significant correlation occurred between the uniseriate ratio and density of ray and soil salinity (Table 2). Furthermore, density had weaker correlation with soil salinity, showing no regular relationship.

Comparison of the relationship of diameters and lengths of fiber-tracheids and soil salinities showed that the former pair was significantly and negatively correlative at 1% level (Figure 12C), while the latter (Table 2) had no significant correlation with only irregular variation.

## Discussion

The relationship between quantitative characters of wood struture and habitat factors has received considerable attention in ecological wood anatomy. However, because of the complicated roles that environment plays upon wood, the data are far from enough to offer an overall understanding of this relationship. How water affects the quantitative characters of vessels is one of the most important problems in this field. It is generally believed that the diameter and length of vessels in the xylem of xerophytes tend to be smaller while their density greater (Bass, et al., 1983; Carlquist, 1975; Fahn, 1964). Mangrove plants grow in salinized soil from which water is scarcely available. Thus, they actually grow in drought habitats which have a physiological influence on the plants. With increase in

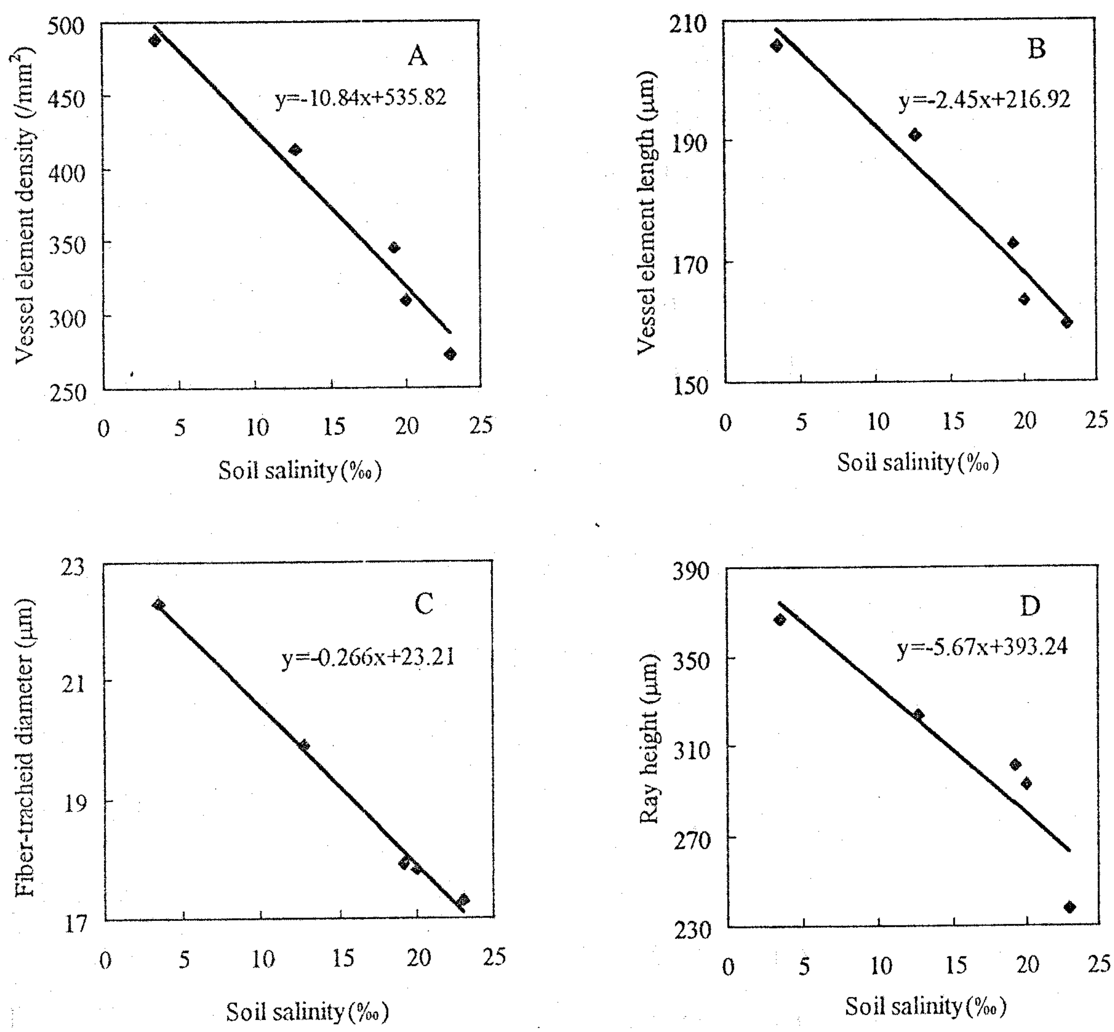


*Figure 12.* Relationship of some quantitative characters of wood structure and soil salinities.

soil salinity, available water becomes less and drought more serious. Panshin (1932) and Janssonious (1950) who studied the wood structure of mangrove species and non-mangrove species of Rhizophoraceae also discovered that the former had smaller vessels in diameter. But our research showed that, with increase of soil salinity, density and length of vessels decreased proportionally while diameter varied irregularly. So, in our paper, only the variation of vessel length was in accordance with the above trend, and the other two items did not have any connection with it.

Quantitative characters of xylem fibers were often affected by both genetic and habitat factors, though the former was greater than the latter in some plants (Metcalf, et al., 1983). The observation and analysis of fiber-tracheids in this paper revealed that, under lower soil salinities, fiber-tracheids had greater diameters and thinner walls with more pits, while, under higher soil salinities, they had small diameters and, in general, thicker walls with fewer pits. The fact that fiber-tracheids had smaller diameters and thicker walls was conducive to strengthening their mechanical support. It might have resulted from the long-period adaptation of this plant growing on the coast (higher soil salinities) to tidal force. The present study also showed that, there was siginificant and negative correlation between the diameter of fiber-tracheids and soil salinity, but the lengths of fiber-tracheids varied irregularly under various soil salinities, which had no direct connection with soil salinity.

Xylem rays are the radial transporting system in wood. Their quantitative characters are mainly decided by genetic factors, though their density and height are inevitably affected by environment (Metcalf, C. R. et al., 1983). This paper made clear that, with the increase of soil salinity, the height of rays in the wood of *Aegiceras corniculatum* decreased, while there was no significant correlation between the soil salinity and the uniseriate ratio and density of rays.

## References

Bass, P., E. Werker & A. Fahn, 1983. Some ecological trends in vessel characters. IAWA Bull. n.s. 4: 141–159.

Carlquist, S., 1975. Ecological strategies of xylem evolution. University of California Press, Barkley, 1–31.

Chen, G. Z., 1965. Analytical chemistry of seawater. China Science Press, Beijing: 11–60.

Fahn, A., 1964. Some anatomical adaptations of desert plants. Phytomorphology 14: 93–102.

Janssonius, H. H., 1950. The vessels in the wood of Javan mangrove trees. Blumea 6: 465–469.

Lin, P., 1988. Mangrove vegetation. China Ocean Press, Beijing: 16–27.

Metcalf, C. R. & L. Chalk, 1983. Anatomy of the dicotyledons (2nd ed.) Clarendon Press, Oxford, Volume II: 1–156.

Miksche, J. P., 1976. Botanical microtechnique cytochemistry. The Iowa State University Press, Iowa: 54–129.

Panshin, A. J., 1932. An anatomical study of the woods of the Philippine mangrove swamps. Philipp. J. Sci. 48: 143–205.

Tomlinson, P. B., 1986. The botany of mangroves. Cambridge University Press, Cambridge: 89–95.