A Comparative Study of Indian Species of Avicennia

BY

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WITH PLATES CCXLIII–CCXLVI.

The genus *Avicennia* belongs to the family Verbenaceae and is characterised by opposite coriaceous leaves with short rather stout petioles; three-bracteate, capitate or rarely spicate inflorescences; subregular flowers; five-lobed calyx, the lobes ciliate along their margins, not enlarged in fruit; four-lobed corolla, corolla lobes yellow; stamens 4, alternating with the corolla lobes; superior ovary, imperfectly four-celled; ovules four in number; style short or somewhat long, rarely nearly absent; stigma bifid; fruit a leathery, bivalved capsule, opening dorsally; seeds viviparous; pneumatophores abundant, rather uniform in thickness.

While working out specimens from the Chakaria Sundarbans, Chittagong, my attention was drawn by Dr. J. M. Cowan to the confusion among the Indian species of *Avicennia*. At his suggestion a comparative study of the genus was undertaken with a view to separate clearly the Indian plants belonging to this genus. The work has been greatly facilitated by the co-operation of Babu B. C. Sarkar, Range Officer, Chakaria Sundarbans, Chittagong.

Of the twenty-two species mentioned in the Index Kewensis, only nine, viz., *A. officinalis* Linn., *A. nitida* Jacq., *A. floridana* Rafin., *A. sphaerocarpa* Stapf; *A. spicata* Kuntze, *A. lanata* Ridley, *A. bicolor* Standley, *A. Rumphiana* H. Hallier, *A. mindanaensis* Elmer, have not been reduced. Some of the Indian species show considerable variation in their morphological characters, especially in the leaves, but their separation on herbarium material is very difficult, although they are readily distinguished in the field as observed by Dr. J. M. Cowan and the writer. The cumulative evidence shows that there are undoubtedly at least three separate Indian species—*A. officinalis* Linn., *A. alba* Bl., and *A. tomentosa* Jacq. The different forms and varieties of *A. marina* (Forsk.) Vierh. (enumerated in Denkschr. Kais. Wiss. Akad., Math.-nat., Bd. lxxi, Teil I (1907), by Dr. Fritz Vierhapper), reported to occur along the coast of the

[Notes, R.B.G., Edin., No. LXXXIX, April 1934.]

Malayan Archipelago and Philippines and recorded by Gamble from the east coast of Madras, have been found to be different forms of *A. alba* and *A. officinalis*.

Roxburgh (Flora Indica, p. 487) mentions *A. tomentosa* but not *A. officinalis*. Although he notes the main points of Jacquin's description of this species, his own description includes both *A. officinalis* and *A. tomentosa*. Dr. Wallich, while supporting Roxburgh, gives a detailed and accurate description of a typical specimen of *A. tomentosa*, illustrated with beautiful coloured sketches, in Plantae Asiaticae Rariores (iii, pp. 44–45, Tab. 271). Wallich's description of *A. tomentosa* includes Hamilton's *A. Oepata*. Kurz, agreeing with Roxburgh, describes *A. tomentosa* in his Forest Flora of British Burma (ii, p. 276), and also records *A. officinalis*. From his description of the latter species, however, it appears that he considers *A. alba* Bl. to be a form of *A. officinalis*. In 1825, C. L. Blume (in Bijdragen tot de Flora van Nederlandsch Indië, p. 821) mentions only *A. tomentosa* and *A. alba*, distinguishing them by their leaves, the former having obovate, cuneate, obtuse, grey tomentose leaves and the latter oblong, lanceolate, white tomentose leaves. Wight confirms Blume's view and describes and draws *A. tomentosa* and *A. alba*. In the Flora of British India (iv, p. 604), C. B. Clarke reduced *A. tomentosa* Jacq. to *A. officinalis* Linn. and *A. alba* to a variety of *A. officinalis*. The main characters by which he distinguishes his var. *alba* are as follows : var. *alba* has " lanceolate acute " leaves, and " style short or hardly any." Engler and Prantl in Pflanzenfamilien have reduced *A. alba* to *A. officinalis*. Wight is of opinion that *A. tomentosa* Linn. is equal to *A. officinalis*, and draws and describes it under that name (Icon. Plant. Ind. Or., iv, pt. 3, p. 12, Pl. 1481). On the other hand, Sir David Prain (Bengal Plants, ii, p. 838) has considered *A. alba* Bl. a distinct species on account of its having a " narrow capsule," a permanent character which certainly entitled him to do so. Specimens of *A. alba* collected by Sir David Prain from the Sundarbans and others from Chittagong and elsewhere have invariably more or less narrow conical capsules as opposed to the almond-shaped, compressed, broadly ovate capsules of *A. officinalis*. Hence there is no doubt that *A. alba* is a distinct species. Further, Sir David Prain's note on *A. alba* (Rec. Bot. Sur. Ind. iii, pp. 330–331) strongly supports his view, reinstating *A. alba* as a separate species. He suggests the occurrence of three species, but definitely recognises only two, viz., *A. officinalis* and *A. alba*, reducing *A. tomentosa* to *A. officinalis*. Later systematists follow Prain, as does J. G. Watson, who has given a splendid account of the Malayan Avicennias (Mangrove Forests of the Malay Peninsula, 1928). My examination of the Herbarium material of *A. officinalis*, *A. intermedia*, *A. alba*, and others, however, leads me to conclude that *A. intermedia*, as Griffith remarks, is intermediate between *A. officinalis* and *A. alba* and may be merged in the former as has been done in the Index Kewensis. From a careful

examination of the material and descriptions of *A. nitida* and *A. africana* available at Calcutta, including Beauvois' authentic specimens, I am of opinion that *A. africana* may be better reduced to *A. nitida* than to *A. officinalis*.

In the Flora of the Chakaria Sundarbans (Rec. Bot. Sur. Ind. xi, 1928) Dr. J. M. Cowan briefly discussed the systematic position of the three species of *Avicennia*—*A. officinalis*, *A. tomentosa*, and *A. alba*. He distinguishes them by their local names and indicates certain characteristics, both structural and ecological, by which they may be separated. My observations and data collected in the field and Sarkar's reference to the vernacular names lead me to accept that *Boro* or *Tia* Baen is *A. officinalis*, *Dulia* or *Dudhi* Baen is *A. tomentosa* and *Kala* or *Narcha* Baen is *A. alba*. Griffith mentions four species, namely: (1) *A. tomentosa*, his description tallying with that of *A. tomentosa* Wallich. (2) *A. resinifera*, which is evidently nothing but *A. alba*, and is better reduced to *A. alba* than to *A. officinalis*. (3) *A. obovata*, which agrees to a certain extent with *A. tomentosa* Roxb., but can now be regarded as *A. officinalis*. (4) *A. intermedia*, which is simply a form of *A. officinalis*.

The different opinions of some of the well-known authors regarding the systematic position of *A. officinalis*, *A. tomentosa*, and *A. alba* can be summarised thus :—

Specific Names.	Authors' Names.
A. officinalis Linn.	Hooker, Prain, Cooke, Ridley, Gamble, Watt, Kurz.
A. tomentosa Jacq.	Roxburgh, Wallich, Kurz, Watt, Blume, Wight, Griffith.
A. alba Bl.	Prain, Cooke, Brandis, Gamble, Ridley, Blume, Wight.
A. officinalis=*A. tomentosa*, Jacq.	Hooker, Prain, Cooke, Gamble.
A. alba=*A. officinalis*	Watt, Kurz, Engler & Prantl.
A. officinalis var. *alba*	Hooker.
A. tomentosa=*A. officinalis* Linn. (Schauer).	Roxburgh, Wight, Kurz.

Turning to the morphology of the capsules, seedlings, and germinating seeds, and also to the leaves, we find strong corroboration of our opinion that *A. officinalis* Linn., *A. alba* Bl., and *A. tomentosa* Jacq. are separate species.

MORPHOLOGY OF CAPSULES :

A. officinalis Linn. bears capsules which are more or less shortly almond-shaped, compressed, with somewhat acute erect tips about 20 to 25 mm. in width and 25 to 30 mm. in length, the surface grey tomentose.

A. tomentosa has capsules which are broadly ovate-elliptic to rather

oblong, typically beaked, about 25 mm. to 30 mm. in width and 40 to 45 mm. in length, and somewhat densely grey tomentose.

A. alba Bl. bears narrow oblong capsules more or less conical, tapering into an acute point, 5 to 6 mm. in width and 40 to 45 mm. in length, and grey tomentose.

Hence from the examination of the capsules alone the three species can readily be separated.

GERMINATION :

The seeds of all the three species are more or less viviparous, testa and tegumen adhere rather loosely to the cotyledons. When the seeds are mature, the cotyledons, with the covering of testa and tegumen, still retain their greenish colour, but the seed-cover becomes yellowish-grey tomentose. The dorsal sides of the cotyledons have an irregular, M-shaped notch at the point of contact between the axis and the outer lobes of the cotyledons. Germination tends to be more or less epigeal, a character much pronounced in *A. alba* (see Pl. CCXLV *d*). The cotyledons are thick, leathery, and longitudinally plicate, the radicle is furnished with a tuft of hairs which helps the seedling to adhere more firmly to the muddy soil. Rootlets diverge from around the radicle, prop-root fashion, penetrating very soon into the soil and thus sufficiently fix the growing seedling.

Experiments showed clearly the difference between the germination of the three species. Seeds were sown in pots, three of which contained pure river soil from the Hooghly and three others ordinary garden soil mixed with 2·5 to 3 per cent. common salt. Water from the Hooghly was used for watering the plants twice a day.

The period of germination in *A. tomentosa* in artificial conditions, as in its natural habitat, was found to vary from three to four days. The first pair of leaves are linear, acute to acuminate, slightly tapering at both ends, 5 to 8 cm. × 5 to 7 mm. The leaves of plants three to four months old (which have attained a height of 1 ft. 6 in. to 2 ft.) are 10 to 15 cm. × 10 to 12 mm., becoming darker with age. The stem is then reddish-brown.

The germination of *A. officinalis* followed two days later. The first pair of leaves were ovate, elliptic, subacute or obtuse, or sometimes obtusely rounded about 5 to 6 cm. long and 2 to 3 cm. broad. Leaves of plants three months old (9 in. to 1 ft. in height) were 6 to 7 cm. long and 3 to 4 cm. wide. The stem is then green in colour.

The germination of *A. alba* began after a period of eight to twelve days. The first pair of leaves were elliptic, 3 to 4 cm. in length and 2 cm. in width, and leaves of plants three to four months old (which were rather dwarf, being 2 to 6 inches in height) were 4 to 5 cm. × 2 cm. The tomentum on the undersides of the leaves was white. It is interesting to note that the shapes of the leaves of *A. alba* in the experiment were similar to those of Southern Indian forms in their natural habitat.

Leaves :

Bengal forms of *A. alba*, specially in Chittagong (see Pls. CCXLV–CCXLVI) have narrow juvenile leaves which, when they mature, become lanceolate and tapering at both ends with acute to acuminate tips, and this character is retained through life.

A. tomentosa, on the other hand, develops linear-lanceolate leaves in the seedling stage both in nature and under artificial conditions, but the mature leaves become broadly ovate-elliptic and broadly rounded at the apices, resembling to a certain extent the adult leaves of *A. officinalis*. The white tomentum on the dorsal surface of the leaves of this species in the mature stage, as well as the linear or linear-lanceolate leaves in the younger and seedling stage, are such fixed characters (as observed in the field) that there is not much difficulty in separating the two species just mentioned on the basis of leaf characters. (See Pl. CCXLIII.)

As already pointed out, the local people readily distinguish the three species of *Avicennia* by the colour, size, and shape of their leaves, which in fact give rise to the vernacular names. *A. officinalis*, *Boro* (large) Baen or *Tia* (Rupee) Baen, leaves rounded like the shape of a rupee ; and *A. alba*, *Kala* (black) Baen or *Narcha* (Jute) Baen, colour of the bark of stems and shape of the leaves like those of Jute plant.

The three plants can easily be distinguished with the help of the following descriptive key.

I. Fruit ovoid ; style rather long.

(*a*) Tree, 20–60 ft. Young branches green ; leaves, both young and old, elliptic to oblong, tip acute, obtuse or rarely more or less rounded, grey tomentose beneath ; seed almond-shaped, not distinctly beaked . . . . . *A. officinalis* Linn.

(*b*) Tree, 15–30 ft. in height, young branches reddish-brown. Young leaves linear-lanceolate, tapering at both ends, tip acute, rarely acuminate, mature leaves much larger, broadly ovate-elliptic to widely rounded, yellowish-white or brownish, sometimes greyish tomentose beneath, seed distinctly beaked *A. tomentosa* Jacq.

II. Fruit narrow, oblong ; conical, style rather short.

Leaves when young linear, when mature lanceolate, acute to acuminate, white tomentose beneath . . *A. alba* Bl.

The species are described in detail as follows :—

1. **Avicennia officinalis** Linn.

A tall shrub or large or medium-sized tree varying from 15 ft. to 40 ft., sometimes 60 ft., in height ; girth of the trunk 6 in. to 1–2 ft., sometimes 3 ft., rarely 5 ft. ; leaves at all ages elliptic-oblong to ovate, base tapering, tip broadly rounded, rarely subacute, shining above,

lamina about 6 to 8 cm. long and 3 to 4 cm. wide, veins indistinct on the upper side, but more or less prominent on the under side, pale grey tomentose beneath ; flowers sessile, about 4 to 5 mm. in diameter, in small axillary or terminal somewhat crowded heads on thick, angled peduncles ; bracts three in number ; receptacle fleshy, concave, shorter than the sepals ; sepals five in number, ovate or orbicular, more hairy than the bracts with longer marginal, hyaline cilia ; corolla lobes four, subequal, elliptic, acute or subacute, silky, minutely hairy outside ; stamens four, shorter than the petals ; pollen grains when fresh spherical, 28 to 30μ in diameter with the three hyaline protuberances ; ovary villous, irregularly celled, style rather long, equal to or sometimes shorter than the ovary, slender, when longer about 2 to 2·3 mm. ; stigma bifid, acute ; capsule almond-shaped, almost as long as broad, always distinctly smaller than that of *A. tomentosa*, not distinctly beaked, densely grey tomentose. (See Pl. CCXLIII, figs. 3 and 4.)

2. **Avicennia tomentosa** Jacq.

A small to medium-sized tree, 20 to 30 ft. in height ; leaves of seedlings, or of young plants, long, linear, lanceolate, slightly tapering at both ends ; leaves on mature trees obovate, elliptic-oval, broadly rounded, tapering into a short, thick peduncle, 7 to 10 mm. long, lamina 6 to 12 cm. long and 3·6 to 6·5 cm. wide, densely grey, yellowish, or brownish-white tomentose beneath, coriaceous, smooth and glossy above ; panicles terminal, trichotomous, bearing the flowers in single terminal rigid heads, peduncle terete ; flowers 9 to 10 mm. in diameter ; bracts three, concave, smaller than the sepals ; calyx five-lobed, lobes more or less rounded, strongly concave, glabrous or silky-pubescent, ciliate ; corolla tube short, lobes four large irregularly rounded ; stamens four, filaments arising from the sinuses of the corolla ; pollen grains similar to those of *A. officinalis* ; ovary densely downy, style long, shorter than or equal to the ovary, 3 to 4 mm. long ; stigma bifid with two acute points ; capsules broad, large, distinctly beaked, grey tomentose. (See Pl. CCXLIV, figs. 2 and 3.)

3. **Avicennia alba** Bl.

A large tree, 30 to 40 or even 70 ft. in height, girth 2 to 3, rarely 4½, ft. ; leaves in the seedling stage all more linear than lanceolate, mature leaves long, lanceolate, rarely short, ovate-elliptic, acute or acuminate, 3·5 to 13 cm. long and 1·5 to 4 cm. broad, sometimes suddenly tapering at the base, glabrous and glossy above, white tomentose beneath ; flowers small, about 4 to 5 mm. across, sessile, in a short subpinnate compact panicle, often interrupted, rarely in dense heads, peduncles terete, very rarely somewhat angled ; bracts small, concave, orbicular ; calyx five-lobed ; corolla sparingly hairy, lobes four, similar to those of *A. officinalis* ; stamens 4 ; pollen grains and ovary as in *A. officinalis*, but style stouter, sometimes hardly any ; stigma bifid, capsule

oblong, narrow, more or less conical, never beaked, grey tomentose. (See Pl. CCXLVI, figs. *d* to *g*.)

The flowering periods of all three species vary from April to June, and seeds generally ripen from August to September.

Avicennia officinalis Linn. and *A. tomentosa* are very common constituents of the littoral forests of the tropics. They occur abundantly in the mangrove swamps of the Deccan Peninsula and Ceylon. They are generally distributed along the coast of Malay, Burma, Bengal, Malabar, Andamans, and shores of the Indian and Pacific Oceans.

A. alba, found in South India, Malay, and along the shores of south-east Asia and Australia, is the predominant species along the margins of creeks, khals, and rivers in Chittagong.

Economically the Avicennias are not of much importance. The wood, which is very brittle, is chiefly used for fuel and sometimes for house-making. The fruits are bitter and can be used medicinally as a poultice. The bark is employed as a tanning material.

EXPLANATION OF PLATES.

Plate CCXLIII (*A. officinalis*).

a, Ripe seed. × ½.
b, Germinating seed. × ½.
c, Young seedling grown in the Royal Botanic Garden, Calcutta. × ½.
d, Young seedling growing wild in Chakaria Sundarbans. × ½.
e, Mature leaf from a wild tree. × ¼.
f, An apical leaf. × ¼.
g, Dissected flower. × ½.
h, Ovary with elongated style and bracts. × ½.
i, Ovary with long style and recurved stigma. × ½.
k, Pollen grain, from dried material, magnified.

Plate CCXLIV (*A. tomentosa*).

a, Mature leaf from an adult tree growing wild. × ¼.
b, Ripe seed. × ½.
c, Germinating seed. × ½.
d, Basal portion of a seedling, about 15 days old, showing the dorsal incision of the cotyledons. × ½.
e, Seedling about 12 days old grown in the Royal Botanic Garden, Calcutta. × ½.

f, Single leaf of *d* flattened out. × ½.
g, Mature wild seedling, about 1 month old, from the Chakaria Sundarbans. × ½.
h, Different views of an open flower. × ½.
i, Dissected flower. × ½.
k, Dissected flower. × ½.
l, Pistil with rather long style and pointed stigmatic lobes. × ½.
m, Deformed pollen grains, magnified.

Plate CCXLV (*A. alba*).

a, Ripe seed. × ½.
b, Germinating seed, grown in the Royal Botanic Garden, Calcutta. × ½.
c, Young seedling, about 1½ months old, grown in the Royal Botanic Garden, Calcutta. × ½.
d, Young wild seedling from the Chakaria Sundarbans, about 2 months old. × ½.
e, Seedling about two months old, grown in the Royal Botanic Garden, Calcutta. × ½.
f, Leaf of *e* spread out. × ½.
g, Mature leaves from adult trees in the Chakaria Sundarbans. × ¼.

Plate CCXLVI (*A. alba*).

a, Form of leaf common in healthy middle-aged plants. × ½.
b, A small dwarf form common on plants growing along the Southern Indian coastal regions. × ½.
c, Common form of leaf in adult trees in the Sundarbans area.
d, Part of apical shoot with young fruits attached to the inflorescence. × ½.
e, Part of inflorescence. × ½.
f, Flower opened out. × ¼.
g, Dissected flower. × ½.
h, Anther. × ½.
i, Deformed pollen grains, magnified.
k, Fertile pollen grains from fresh flowers.
l, Mature ovary longitudinally cut. × ½.
m, Young fruits. × ½.