RHIZOPHORACEAE (Ding Hou, Leyden)[1]

Evergreen trees or shrubs, mangrove species with various remarkable root formations. Branching (in the mangrove genera) mostly sympodial; branchlets swollen at the nodes, solid and pithy, hollow in *Crossostylis*, *Gynotroches*, and *Pellacalyx*. Innovation continuous, but flushwise in *Anisophyllea*. *Leaves* decussate and stipulate, rarely alternate and exstipulate (*Anisophyllea* and *Combretocarpus*), usually isomorphic, rarely dimorphic (*Anisophyllea spp.*), gland-like cork warts sometimes occurring as small black spots on the lower surface; young leaves involute or convolute. Nervation generally pinnate, more rarely curvinerved and with 1–2 intramarginal veins (*Anisophyllea*). *Stipules* conspicuous, interpetiolar, caducous, opposite, except in *Pellacalyx* overlapping each with one free margin, in Malaysia with colleters at the base inside, leaving an *annular* scar. *Inflorescences* axillary, simple or branched, usually cymose (lax or condensed and cluster-like), racemose or fascicled, rarely consisting of a solitary flower. *Flowers* usually bisexual, rarely unisexual or polygamous and plants monoecious (*Anisophyllea* and *Gynotroches*), sustained at the base by connate or cupular bracteoles or ebracteolate. *Calyx* 3–16–lobed, lobes valvate, persistent. *Petals* free, equal in number to the calyx lobes and alternating with them, usually fleshy and conduplicate, sometimes embracing 2 (*Bruguiera*) or 1 stamen, entire, 2-fid, lacerate or fringed with appendages at the apex, usually clawed, caducous during or after anthesis, rarely persistent. *Stamens* free or epipetalous ones adnate to the petals in *Anisophyllea sp.* (or adnate to the calyx tube in *Pellacalyx*), in one whorl (except in *P. symphiodiscus*), usually twice the number of the petals and one opposite and one alternating with the petals, in *Bruguiera* in pairs opposite and embraced by the petals, in *Rhizophora apiculata* 3 times and in *Crossostylis spp.* 3–4 times as many stamens as petals, in *Kandelia* indefinite in number, in some species some stamens may be aborted and staminodial, free or connate at the base; anthers typically 4-celled, rarely multi-locellate (*Rhizophora*), dorsifixed, dehiscing longitudinally and introrse, in *Rhizophora* opening with a large ventral valve. Disk fleshy, annular, and crenate or flat, or lobed, rarely absent. *Ovary* inferior, rarely semi-inferior or superior (*Gynotroches*, *Cassipourea*), 2–12-celled, rarely 1-celled by suppression of the septa; style simple with simple or ± lobed stigma, or styles free, persistent. *Ovules* (1–)2–∞ in each cell, pendulous, attached axile or in 1–celled ovaries on the columella-like axis running from base to apex, anatropous with micropyle upward and outward. *Fruit* always bearing the persistent calyx and often other floral remains, a berry or a drupe or dry and rather hard-shelled (*Anisophyllea*), indehiscent, rarely (in extra-Mal. *spp.*) a capsule and dehiscent, winged in *Combretocarpus*. *Seeds* pendulous, 1–∞, sometimes (in extra-Mal. *spp.*) arillate, viviparous in mangroves, germinating in the ordinary way in inland species; albumen fleshy or small and soon obsolete (in *Rhizophoreae*); embryo straight or curved.

Distribution. Mainly in the Old World, 16 genera[2] with an estimated 120 *spp.*

Four mangrove genera are restricted to the littoral zone of the tropics extending slightly into the

(1) The introductory matter on ecology by C. G. G. J. VAN STEENIS.

(2) Recently ARÈNES has described two new genera from Madagascar (Not. Syst. 15, 1954, 2–3; Fl. Madag. fam. 150, 1954, 4 & 6, f. I 5–11). *Petalodactylis* differs merely from *Cassipourea s.l.* by 2 short styles and cannot be maintained. *Richeopsis* has been reduced to *Scolopia* (*Flac.*) by CAPURON (Ess. Intr. Fl. For. Madag. 1957, p. 123).

Fig. 1. Inside the *Rhizophora* mangrove forest at low tide at the mouth of the Pahoturi R., Western Division, Papua: *Rh. mucronata* LAMK (dark stems), *Rh. apiculata* BL. (pale stems). The dark horizon on the roots is caused by the mud and marks the high tide level. April 1936 (L. J. BRASS, Archbold Expeditions).

subtropics: *Rhizophora* is pantropical, *Bruguiera* and *Ceriops* occur from tropical Africa through Malaysia to Australia and the Pacific (Micronesia and Samoa), *Kandelia* is restricted to SE. Asia and West Malaysia.

The other genera occur all inland as constituents of the tropical rain-forest, only very occasionally occurring also in the seasonal forest (*Carallia brachiata*). Among them *Anisophyllea* is pantropical (very rare in America and absent from Australia and the Pacific), and *Cassipourea* nearly so (absent E of Ceylon to W. America). *Carallia* occurs from Madagascar to S. China and Australia, *Gynotroches* and *Pellacalyx* are restricted to SE. Asia and Malaysia. The others possess a still more restricted area *viz Macarisia* in Madagascar, *Poga* and *Anopyxis* in tropical W. Africa, *Blepharistemma* in India, *Combretocarpus* in W. Malaysia, *Sterigmapetalum* in tropical S. America, and *Crossostylis* in Melanesia and Polynesia. The latter genus might also occur in E. Malaysia and has, for that reason, been entered in the key without being described further.

Most genera are small and some of them, for instance *Kandelia, Combretocarpus, Blepharistemma, etc.* are even monotypic. The largest genus is *Cassipourea* with about 70 *spp.* (*cf.* ALSTON, Kew Bull. 1925, 241–276). The distribution towards the north and south shows the family to be restricted to the tropical zone and the warm subtropical zone both in the inland genera and the mangroves.

On the northern hemisphere the mangroves extend on *all* coasts north to latitudes varying between 24° and 31° N:

In the Riukius and S. Japan mangrove go north as far as 31° 20′ N, according to ITO (Ann. Bot. 13, 1899, 465) (*Kandelia, Bruguiera, Rhizophora*).

In Florida and Bermuda they extend to *c.* 28° N, in California to 24° 38′ N.

In the southern hemisphere the situation is very different between the west coasts of the continents and the east coasts.

On the east coast of S. America they go south to about the tropic of Capricorn. On the east coast of Africa[1] *Rh. mucronata* extends to 30° S, *Bruguiera gymnorrhiza* to 30° (or even 32°?) S and *Ceriops tagal* to 26° S. In East Australia mangrove *Rhizophoraceae* go as far south as the far northern corner of New South Wales at 29° S.

On the westcoast of South America *Rhizophora* seems only to extend south as far as 4° S. On the west coast of Africa *Rh. racemosa* G. F. W. MEY. goes to 6° S and *Rh. harrisonii* LEECHM. and *Rh. mangle* L. to 9° S. From West Australia I have no data but I would not be surprised that it will be found there also at small southern latitude. In all these cases the west coasts are very dry or even arid caused by northern directed cold oceanic currents.

Ecology (inland species). They represent constituents of the mixed Malaysian rain-forest, generally avoiding the seasonal areas and rarely found on the mountains above the upper limit of the tropical zone at 1000 m. The (extra-Malaysian) *Pellacalyx parkinsonii* and *P. axillaris* have been found up to 1200 m and 1300 m respectively, *Anisophyllea grandis* up to 1250 m, *A. disticha, Carallia brachiata,* and *C. eugenioidea* up to 1800 m, and *Gynotroches axillaris* up to 2250 m.

Though many species are common they are generally of humble size and either shrubs or small or medium-sized trees of the substage. Only a few *spp.* reach the upper canopy and sizes between 40–50 m have been recorded for *Carallia brachiata, Gynotroches axillaris, Pellacalyx lobbii,* and *Anisophyllea sp.* They may flower and fruit from a very early age onwards and share this tendency with the mangrove genera (see under *Carallia* and *Gynotroches*).

In contrast with the mangrove species none of the inland species occurs gregariously with the exception of *Combretocarpus rotundatus* which is a typical constituent of the lowland swamp- and peat-forests of Sumatra and Borneo.

Germination of representatives of the inland genera has not yet been described. The structure of the seeds in *Anisophyllea* and *Combretocarpus* is even not known with certainty. The seeds in the large-fruited species, for instance *A. grandis* and *A. griffithii*, must be a very curious one, as their enormous seeds are enveloped in exceedingly hard and woody pericarps. The structure of the seeds is in the dry state almost woody, including both embryo and its thick envelop which we assume to represent endosperm and which forms one solid whole with the embryo. In *Gynotroches* and *Carallia* the embryo is almost filiform extending from one end of the seed to the other. Germination experiments are urgently needed for getting a clear picture of both structure and mode of germination.

Ecology (mangrove species). By their wide distribution, their gregarious coastal occurrence and practical application, and their morphological and biological peculiarities, the four littoral genera deserve a more ample treatment in this Flora than is usual in the general paragraphs preceding the taxonomic revision. These four genera, *Rhizophora, Bruguiera, Ceriops,* and *Kandelia,* form a considerable part of the tropical and semi-tropical forest fringe along the shores called at variance *mangrove, bakau* (M) or *tidal forest* (*vloedbos,* N)[2].

(1) Precise data on African mangroves were kindly supplied by Mr J. R. LAUNDON.

(2) The main works on the Malaysian mangrove are:

BECKING, J. H., L. G. DEN BERGER & H. W. MEINDERSMA: Vloed- of mangrovebosschen in Ned.-Indië (Tectona 15, 1922, 561–611).

(cntd. next page)

Mangroves[1] form a rather uniform, evergreen fringe of forest which is most profusely developed on low muddy shores, in estuaries and lagunes and is less abundant along sandy or rocky beaches and on old coral-reefs covered with a thin sheet of sand or mud. In the latter localities the height of the stands is low, trees are dwarfed and crooked, and the fringe is often narrow and sparse. This is in part due to the poor soil of these habitats and in part to the fact that different species are concerned. Whereas for example *Rh. apiculata* BL. and *Rh. mucronata* LAMK may attain a height of 35–40 m in favourable localities in lagoons and estuaries, with straight stems (fig. 1, 7), *Rh. stylosa* GRIFF., which is bound to the sandy beach, is always a small insignificant tree (fig. 5, 13).

It should be added here at once, in order to avoid confusion with field-workers, that in very many places mangroves are poor at present due to excessive cutting by man (fig. 3). After excessive cutting they may also change their composition and clear fellings of *Rhizophora* are sometimes replaced by regrowth of *Avicennia*, commercially an inferior timber. In many localities, notably near the larger towns, the mangroves have almost disappeared or/and degraded into low, seral thickets of *Acanthus, Clerodendron*, and *Acrostichum*. In other cases the destruction has even gone further and mangroves have been replaced by fish-ponds or stands of naturalized exotics, as for example in many places along Manila Bay by *Prosopis*, a spiny leguminous tree doubtless imported from Mexico.

In the field it should therefore always been verified whether a poor mangrove is due to natural factors or in minor or major degree to previous anthropogenous destruction.

The number of trees and shrubs participating in the mangrove forest is a very limited one and reversely the mangrove plants are generally bound to this habitat and are not found inland. BACKER (Krakatao 1929, 174) and I (Tijd. K.N.A.G. 52, 1935, 381) have given a list of the Malaysian mangrove species, the total being approximately 60.

Seen from a distance the mangrove makes the impression of a dark-green more or less monotonous type of forest. On entering it on foot with ebb its eerie aspect appears at once from the oppressing heat, the damp atmosphere, the bare, stinking mud, covered with stilt-rooted trees (fig. 1, 2, 7), and several kinds of other root formations (knee-like roots (fig. 16, 22), knobs, snake-like roots, erect peg- or torpedo-shaped pneumatophores), the mud teeming with crabs, fishes, shells, worms and their holes, mud-heaps and shallow pools, the air with plenty mosquitoes, the silence only interrupted now and then by the sudden rush of monkeys through the gloomy foliage, the thud of a fruit falling in the mud, or the forlorn cry of a passing seabird. For a tourist the place is singularly uninviting, but for the biologist it is a most fascinating biotope and the secrets of its life and life conditions are certainly far from being exhausted. Entering the mangrove on board a small prahu during high tide (fig. 4), gliding through the silent waters of the creeks, bordered now by the flooded forest which is nearly submerged up to the flattish underside of the tree crowns, the aspect is less fascinating and appears more monotonous, as the foliage of the trees is much alike even of representatives of very different families, all of them having dark-green, elliptic to obovate, medium-sized blades of the laurel type but rather coriaceous and slightly fleshy. Flowers are not particularly striking, and those which are, as *e.g.* of *Sonneratia* and *Dolichandrone*, are nocturnal.

On closer observation, however, it appears that each mangrove species has its own niche in accordance with its own claims to habitat and life cycle. Hence, mangroves differ in composition from place to place.

As in these low coastal regions and deltas there is always an intricate mosaic surface relief with deeper and more shallow places, higher grounds are interspersed with creeks, and soil types vary from place to place from more sandy and firm to muddy and less firm or deep soft mud, the particular niches for the species are also available in a mosaic-like pattern. Moreover, rapid changes may occur in these coastal areas where creeks may be silted up, lagoons may be shut off from the open sea by bars, and deposits of silt may be replaced or covered by those of sand.

BROWN, W. H. & A. F. FISCHER: Philippine mangrove swamps (Philip. Bur. For. 17, 1918; 22, 1922); reprinted in Minor Forest Products Philippines vol. 1.
HAAN, J. H. DE: De Tjilatjapsche vloedbosschen (Tectona 24, 1931, 39–76).
KARSTEN, G.: Über die Mangrove Vegetation im malayischen Archipel (Bibl. Bot. Heft 22, 1891).
LUYTJES, A.: De vloedbosschen van Atjeh (Tectona 16, 1923, 575-601).
MEAD, J. P.: The mangrove forests of the Westcoast of the Federated Malay States. 1912.
SCHIMPER, A. F. W.: Die Indo-malayische Strandflora. 1891.
WATSON, J. G.: Mangrove swamps of the Malay Peninsula (Mal. For. Rec. 6, 1928).

(1) In the following publications identification keys are given to the species of the mangrove formation, either based on vegetative or floral characters or on both. Unfortunately none is complete for the whole of Malaysia:

BECKING, J. H., L. G. DEN BERGER & H. W. MEINDERSMA (Tectona 15, 1922, 569-573, trees only).
BROWN, W. H. & A. F. FISCHER: Minor For. Prod. Philippines (For. Bull. 22) 1 (1920) 30–32.
FLOYD, A. G. in WOMERSLEY, J. S. & J. B. MCADAM: For. & For. Conditions in the Territ. of Papua & New Guinea (1957) 56–59.
MEINDERSMA, H. W.: Trop. Natuur 12 (1923) 73–77 (trees only).
WATSON, J. G.: Mal. For. Rec. 6 (1928) 22-23.

The main factors responsible for the ecological preference of the mangrove species are the following three which may occur combined in a limited number of combinations:

(1) *Soil type*, firm or soft, sandy or clayey in various proportions.

(2) *Salinity* and its variation both daily and to yearly average, roughly corresponding to the frequency, depth, and duration of being flooded.

(3) *Resistance to currents and surf of the mangrove species.*

From the side of the species conditions involved are the *conditions of germination and upgrowth of seedlings* and various degree of resistance (ecological amplitude) to these single factors, some being more restricted (stenecous), others allowing for a wider range (euryecous).

Fig. 2. *Rhizophora* along a creek near Pasuruan (NE. Java), about low tide. Between the root systems abundant regeneration (JESWIET).

Preference for *soil types* is markedly shown in the genus *Rhizophora*, *Rh. mucronata* being typical in general for deep soft mud, *Rh. apiculata* ('*conjugata*') being rather intermediate or indifferent, and *Rh. stylosa* being bound to sandy beaches and coral reefs (eventually covered by a thin sheet of mud or sand). Fig. 5, 13. BÜNNING (Flora 137, 1944, 341–342) rightly concluded that the major factor for the zonation of the mangrove is caused by the soil types (their mineralogical and physical condition), but not primarily by salinity.

Preference to *salinity* or inundation is illustrated by the fact that if the free connection with the sea (hence the tides) of estuaries or lagoons is suddenly shut off by a bar and the salinity decreases through water from the inland, *Rhizophora* forest may suddenly die off and its regeneration prohibited to be replaced by a less saline species typical for the back-mangrove, *e.g.* by *Lumnitzera* (LUYTJES *l.c.*, p. 580). WATSON observed a case of suffocation of *Bruguiera cylindrica* on stiff clays in Malaya and its dying off over a considerable surface, see p. 467.

Along coasts before a hinterland which is subject to a seasonal climate, coastal waters receive during the rainy season a large amount of freshwater diminishing salinity in the littoral zone considerably in the vicinity of the mouths of large rivers.

Possibly the salinity which is naturally closely bound to the rhythm of inundation is not the primary factor as it is interwoven with the amount of oxygen brought in by freshly oxygenated surface water of the tides which, as just shown above, is necessary for the root system prohibiting suffocation.

Preference to *water current velocity* can easily be observed along creeks with the daily recurrence of the rush of the tides. They are often fringed with *Nypa*, the massive and dense root-system of which is better fitted to resist erosive forces of swift running water than that of most other mangroves; from this it derives its advantage in these places, from which it must not be rashly inferred that *Nypa* is bound to such localities, which is by no means the case. The phenomenon may also easily be observed in the bends of the creeks where water velocity is higher in the outward bend than along the inner bend, and where consequently one species may be gregarious along the inner bends and another along the outer bends. Current and soil type go here naturally hand in hand, as silt deposits will be more coarse-grained (sandy) along the outer bend.

Along the tropical shores the three factors mentioned, soil type, salinity & inundation, and resistance against currents are running roughly parallel with the main shore and those of the islands, and are responsible for the ecological preference, manifesting itself in a *girdling* or *zonation* of the mangrove species. WATSON gave an instructive map of how such a zonation may be observed in a tidal estuary (*l.c.* p. 128, map).

The circumstances concerned with tides are naturally different in different localities: maxima and minima of the tides, their average values, turbulence of waters by wind and currents, soils, and other physical fore-shore conditions.

Schemes trying to identify conditions for the species which are responsible for the zonation are therefore apt to be of local value.

In Malaya WATSON (*l.c.* p. 129 *seq.*) attempted to avoid to form inundation classes based on the actual number of times or even days that the ground is flooded in each month, and adopted a classification based rather on the *nature of the tide* that inundates the area. For Port Swettenham he distinguished the following five classes:

Class:	Flooded:	Height above Admiralty Datum	Days flooded p/month
1	All high tides	– 8′	56–62
2	Medium high tides	8–11′	45–59
3	Normal spring tides	11–13′	20–45
4	Spring high tides	13–15′	2–20
5	Abnormal or equinoctial tides	15–	0–2

He correlated the species typical for the different tidal classes with the following (here abbreviated) comment:

Class 1: *Inundated by all high tides.*—It is unlikely that any species can survive complete daily inundation except, perhaps, *Rhizophora mucronata* on the banks of streams, and then only if its head remains above water. On the sea this class is sterile.

Class 2: *Inundated by medium high tides.*—Here belong the *Avicennias* and *Sonneratias*. Bordering the river *Rh. mucronata* predominates.

Class 3: *Inundated by normal high tides.*—Includes the greater part of the mangrove area and the majority of the species will thrive under these conditions, but the *Rhizophoras* predominate, *Rh. mucronata* being found near the streams and, on firm soils, often associated with *Ceriops tagal*. *Rh. apiculata* reaches its optimum development and forms pure stands. *Bruguiera parviflora* grows well, often in mixture with *Rhizophora*.

Class 4: *Inundated by spring tides.—Rhizophoras* are replaced by *Bruguieras*. On particularly stiff soil *B. cylindrica* forms dense pure stands. On the better drained soils, particularly near the rivers, *B. parviflora* is common, with occasional *B. sexangula*, the latter rarely gregarious. Prawn heaps result in better aeration and the bringing to the surface of shell remains and sand.

Class 5: *Occasionally inundated by exceptional or equinoctial tides.—Bruguiera gymnorrhiza* is definitely established here, often with a dense growth of the mangrove fern. *Rh. apiculata* is sometimes present as an old tree. On the land side bordered by pure growth of *Oncosperma filamentosa*.

The subject has in Java specially been studied by DE HAAN *l.c.* in Segara Anak near Tjilatjap (S. Java). Salinity is naturally varying both daily and with the seasons. In the dry season it is higher than in the wet season; and during the daytime it is highest at ebb when it increases in proportion to evaporation to decrease again with flood. Different species are different in their tolerance against these rather sudden changes in salinity; samples examined in Dec. 1928 (wet season) at high tide gave for *Rh. mucronata*, *Rh. apiculata*, *Bruguiera gymnorrhiza*, and *B. parviflora c.* 10–30‰ NaCl, for *Xylocarpus* and *Nypa* 1–30‰, and for *Bruguiera eriopetala* (= *B. sexangula*) 1–10‰. It appears that *Xylocarpus* and *Nypa* are rather indifferent to salt percentage.

As to inundation frequency DE HAAN *l.c.* distinguished 6 classes, namely: *A.* salinity 10–30‰ (1) Soils flooded 1–2 times per day, at least 20 days per month total, (2) *Ditto*, 10–19 days per month, (3) *Ditto*, 9 days per month or less, (4) Only a few times each year;—*B.* salinity 0—10‰ (5) Soils slightly influenced by the tides, (6) Soils only subject to seasonal water levels in the wet period. Species tolerance to inundation by sea-water decreases hence from class 1 to class 6, that is from the outer mangrove to the inner.

And the species concerned are in this sequence: outer zone: either *Avicennia* or *Sonneratia* on soft-muddy young silts or *Rhizophora* on rather firmer silts, middle zone: *Bruguiera gymnorrhiza*, third zone: *Xylocarpus*, *Heritiera*, inner zone: *Bruguiera caryophylloides* (= *B. cylindrica*), *Scyphiphora*, *Lumnitzera*.

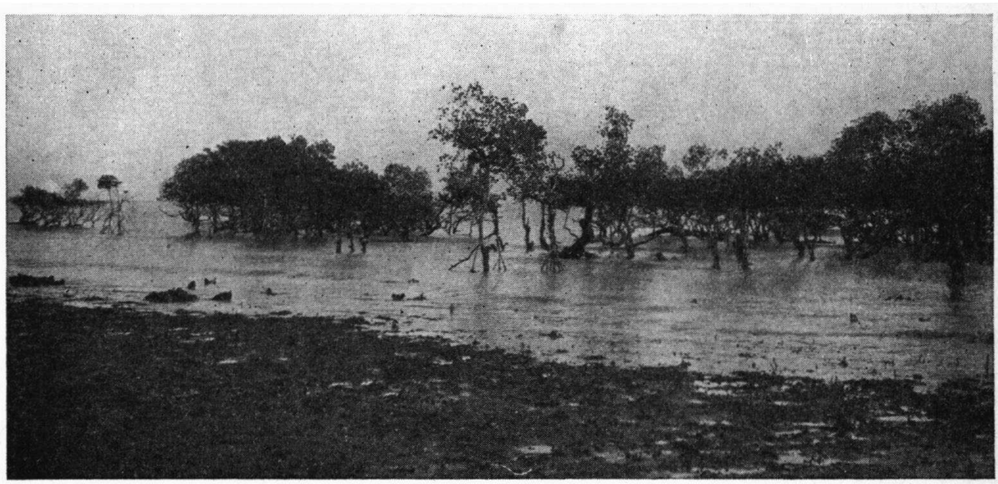

Fig. 3. Degraded type of mangrove through cutting, mostly consisting of *Sonneratia caseolaris* (L.) ENGL. and some *Rhizophora*, at low tide, near the river mouth of K. Pasuruan (NE. Java) (JESWIET).

The 5th and 6th class are rather gradual transitions to the ± freshwater swamp forest at the back of the inner mangrove proper, with *Cerbera* and *Oncosperma*. Of course the soil increases in firmness going inland.

Depending on the physiographical structure of the coast the mangrove will differ from place to place and it will be much broader in one place than in another. Along straight coastlines and absence of streams the mangrove fringe is mostly rather narrow, 25–50 m; where there are streams and deltas bringing abundant clay and sand it may be much wider and in lagoons it may attain many km in depth, depending on the gradient of the sloping land.

The zonation depends on the circumstances: very often either *Sonneratia* or *Avicennia* are the pioneers, but in places as inside estuaries which are protected from turbulent water and surf *Rhizophora* belongs to the first colonists. Fig. 1, 2, and 7.

On reefs and rocky shores seeds and seedlings are deposited in crevices and between boulders and grow where they can attain foothold and are sufficiently sheltered against heavy surf. This biotope is therefore very heterogenous and shows no or less distinct zonation. This is the situation prevailing in many Pacific islands.

With large estuaries and low gradient where rivers are sluggish, the influence of the tides goes far up river and specially the inner mangrove species are able to disperse and grow upstream fringing the banks of the creeks and river itself to considerable distances inland, gradually thinning out in quantity and in number of species, sorted out according to capacity to stand freshwater conditions. In S. Sumatra for example mangroves are found upstream the Musi as far as Palembang. Mr BRASS records to have found mangrove vegetation 85 miles upstream the Kikori River in Papua in a straight line! In the Fly River he found mangrove from the coast as far as Ellengowan Isl. 320 km upstream!, *viz Bruguiera* and *Sonneratia*. The tidal portion of the Hooghly River near Calcutta is also about 300 km long.

It has not been exactly examined whether the roots of these upstream mangrove fringes are growing under pure freshwater conditions all the year round. And this would be interesting since it has been shown by HARDENBERG (Natuurwet. Tijd. Ned. Ind. 104, 1948, 341, fig. 2) that these large, sluggish, tropical rivers contain far upstream a bottom layer of salt or brackish water. This is caused by a natural bar of sand and mud, convex towards the open sea, before the river mouth; this bar is gradually sloping down seaward and steep towards the river mouth. With each high tide sea-water is driven behind it and extends, through its higher gravity, below the upper sheet of seaward bound freshwater. It is most remarkable that these sheets of different salinity do not get mixed immediately but are separated by rather sharp 'spring horizons'. It has been found that in some Bornean rivers the brackish lower sheet may extend upstream over a considerable distance.[1] The brackish sheet will follow the lowest course of the river bottom, *i.e.* that of the main current, coming closest to the river banks along the outer bends. Additional field observations must show whether indeed the upstream mangrove is found specially along these bends and whether their roots are in contact with brackish bottom water.

In passing it may be remarked here that mangrove plants are decidedly not absolutely bound to salt or brackish water; *Acanthus ilicifolius* and *Acrostichum aureum* are occasionally found inland in pure freshwater (analyzed!) (*cf.* VAN STEENIS, Arch. Hydrobiol. Suppl. 11, 1932, 262–263; Trop. Natuur 26, 1937, 206). And it has been reported and is still observable in various temperate greenhouses that man-

Fig. 4. *Rhizophora* forest from the seaside at high tide, some seedlings in front. Otimmer, Tenimber Isl. (BUWALDA).

groves are cultivated under freshwater conditions, as for example shown in the Hamburg Botanic Gardens by HANS WINKLER (Ber. Deut. Bot. Ges. 49, 1931, 87), *n'en déplaise* the negative results with *Rhizophora* obtained by BENECKE and ARNOLD in Münster i/W who maintain that *Rhizophora* is an obligatory halophyte (Planta 14, 1931, 471–481).

Already a century ago TEYSMANN planted and maintained many mangrove species with success in a freshwater swamp and along the ponds in the Bogor Botanic Gardens at 250 m above sea-level and at *c.* 70 km distance from the sea (*cf.* Nat. Tijd. Ned. Ind. 14, 1857, 368), anticipating VON FABER's statement that the mangroves are facultative halophytes. *Sonneratia caseolaris, Bruguiera gymnorrhiza, B. sexangula,* and others are still cultivated in Kebun Raya Indonesia, Bogor, where they flower and fruit freely and even regenerate. Fig. 23.

In mapping mangroves it appears sufficiently clear that they avoid coastal areas with strong wave action and those which are subject to strong tidal currents. This is natural as frequently agitated waters prohibit generally a stable accumulation of mud or sand, hence a stable soil for the seedlings to grow up and *ditto* for the mature trees to maintain themselves. In other words, mangroves prefer shore conditions

(1) Accordingly HARDENBERG points to the well-known fact that marine fishes are found in abundance far upstream in these rivers.

which are favourable for accretion (accumulation and extension of soil and land). Their rather superficial root system does not allow otherwise and they follow rather than precede soil accumulation. This can be easily read from the mangrove map of Malaysia drawn by FOXWORTHY (Ann. Bot. Gard. Btzg Suppl. 3 1910, 319–344).

Heavy surf through wave action and wind cause a great difference between the shore vegetation of the ocean-facing S. and SW. sides of Java and Sumatra and the Java–South-China Sea shores on the N. and NE. sides of the same islands. On open ocean-faced sides mangrove is very scarce and found only in closed estuaries or on leeward sides of islands.

Recently HOSOKAWA demonstrated this also with a mapping of mangrove in Micronesia where it is specially developed on the leeward side of the islands (Mem. Fac. Sc. Kyushu Un. E2, 1957, 106, f. 1–2).

WATSON (*l.c.* p. 5) observed the same in Malaya. He says: —"There is a distinct difference between the west and east coasts of Malaya, silting conditions being more favourable along the west coast. On the more exposed east coast wave action is more severe, particularly during the north-east monsoon, so that any fresh water brought down by the rivers is more speedily dispersed. Mangrove forms are, therefore, unable to establish themselves along the beach and are confined to the river mouths, whilst the sandy beaches themselves are flanked by a narrow belt of *Casuarina equisetifolia* which extends practically unbroken from Singapore northwards to far beyond the limits of Malayan territory."

"Where the flow of the river is sluggish the tendency is for banks of sand to be deposited at the mouth through the combined action of the currents and the north-east monsoon, the channel being forced thereby further and further south. The newly formed natural breakwater is speedily covered on its seaward edge with a dense growth of *Casuarina*, and subsequently on its protected side by mangrove forms brought down by the river. The bank continues to advance in a southerly direction, until exceptional circumstances breach it and allow the water to escape by a new mouth. The old channel then rapidly silts up and soon becomes stocked with mangrove species which persist until a new bank is formed and again breached. The new channel is then in its turn converted into a mangrove swamp and the old one is invaded by inland forms."

"Nearly all of the east coast rivers show this tendency. It is most marked at Rumpin, Merchong, and Bebar, where successive folds in the ground running parallel to the coast and bearing a few straggling *Casuarina* on the ridges and decadent mangrove in the hollows, provide unmistakable evidence of former banks and swamps. The last mentioned river demonstrates this process particularly clearly, the abnormal floods at the beginning of 1927 having broken through the *Casuarina* bank about 5 miles above the mouth of the previous channel, which is now beginning to silt up and be invaded by mangrove."

"On the west coast the mangrove is almost continuous from Kedah to Singapore. It varies in width from a few chains to a maximum of *c.* 19 km at the mouth of the Larut River in the Matang District of Perak; but the mangroves follow the rivers much further inland, extending along the banks of the Perak River up to Telok Anson, at *c.* 50 km from the sea."

"Changes of current and unusually heavy seas may sweep away the mud banks before the forest is fully formed, or even the mature forest may be eroded."

WATSON reported (*l.c.* p. 157): —"that disastrous floods on the east coast of the Malay Peninsula in the beginning of 1927 did considerable damage to the mangrove growing in the rivers, much of which was washed away or killed by excessive deposits of sand or silt. Large numbers of trees died as a result of prolonged inundation by practically fresh water, specially of *Bruguiera gymnorrhiza*. It is assumed to be a simple case of drowning; *Nypa* scarcely suffered from either immersion or silt."

FOXWORTHY recorded from Manila Bay also that seedlings of *Rhizophora* are occasionally killed by excess of fresh water.

Land reclamation capacity has been attributed to the stilt-roots and pneumatophores and other root formations projecting above the soil, attributing to them not only the faculty of calming waters and favouring thus precipitation of mud and holding back (accumulating) debris from the retreating flood water, but also attributing to them to act in this manner on *any* coast line.

This idea has been defended by H. H. M. BOWMAN (Proc. Am. Phil. Soc. 66, 1917, 667–670) who claims to have projected dikes, jetties, *etc.* in Florida and Venezuela by planting mangroves on the foreshore as ballast retainers. Recently J. H. DAVIS (Carnegie Inst. Wash. Publ. 517, 1940, 303–412) stated "that it may be possible to use mangrove, by means of plantings, to extend the coast and form islands."

Already a century ago JUNGHUHN (Java 1, 1853, 255) showed that the *mangrove follows the silting up of a coastal area rather than precedes and initiates the accumulation of mud or other soil, and that it establishes itself merely on accrescent coasts.*

BISSCHOP GREVELINK (Pl. Ned.-Ind. 1883, p. 166) pointed out that cause and condition should not be confounded and that mangrove settles only in places outside the heavy surf and current in the quiet bays, estuaries, lagoons; the same opinion is held by BACKER (Schoolfl. 1911, cliv, p. 478), F. C. VAN HEURN (Studiën, 1923, p. 65–71), MEAD (*l.c.* p. 1), WATSON (*l.c.* p. 1, 5), BROWN & FISCHER (*l.c.* p. 17), BECKING *c.s.* (*l.c.*) and has been explained by myself (Natuurwet. Tijd. N.I. 101, 1941, p. 82–85). WATSON observed: —"that as silt deposits remain bare until they have attained a definite condition of elevation and consistency, it is scarcely correct to regard the mangrove as the causative agent in the silting process. The large expanse of unclothed mud of shoals and banks exposed at low water suggests that it is necessary for the banks to remain uncovered for several days together before any form of land vegetation can establish itself. It is considered that the limit of tree growth is to be found round about the neap high-water mark, above which the ground remains unsubmerged for at least two days in every month. In rivers and sheltered situations the *Rhizophoras* may occupy flats that are covered by even the lowest neap tides, but here the superior length of the radicle enables them even the seedlings to keep their heads above water."

This observation fits also with the practical experience of engineers who, in the thirties, tried to prevent the silting up of the Deli River channel in the harbour of Belawan (Deli) by building a dam (dike) from dredged mud. This was regularly damaged and washed away by the heavy surf and current and had to be paved ('metalled'). For further protection the foreshore of the dam was planted on both sides with a fringe of mangrove seedlings but this succeeded only on the side of the silted channel. It appeared impossible to force an accumulation of silt by mere planting of mangrove.

It is of course true that in many places the mangrove has been devastated by man's cutting of firewood and that in those places replanting of mangrove will generally have success.

It is also true that the underwater foreshore conditions may change and may turn a formerly regressing part of the shore into an accrescent one enabling mangrove to settle. The reverse may also happen. In delta areas the underwater surface relief of shoals and gullies may vary and change from place to place on the same coast and may vary in the course of time in one place. It is comparable to the situation on the sand beach where similar conditions, accretion or regression, will be responsible for the origin of dunes: here also the wealth of the pescaprae beach flora is dependent on the supply of sand deposits and not reversely the amount of accumulated sand to the presence of sand-catching beach plants.

It should be admitted that where silt or sand are accumulating by the grace of suitable foreshore conditions plants may accelerate the process by adding mechanically towards a favourable upsilting through quieting waters and acting as a barrier during ebbing time; this is practized in the N. of the Netherlands by building palissades on accrescent muddy coasts. The similar function of the mangrove root formations is, obviously, a secondary one.

Along certain mud shores, notably the west coast of Malaya and the east coast of N. Sumatra there occurs a narrow strip of sand beach on the mud where the surf strikes the coast. This fan of sand is sometimes slowly rolled landwards while the mangrove mud is exposed on the seaward side: in fact here we have simply a narrow belt of sand piled up on top of the mangrove mud, the mud being never more than a few feet below the surface of the sand even at the top of the beach. By this slow retreat of the sand fan mangroves are buried by sand. I found this remarkable situation near Pantatjermin, E of Medan (Deli), and it has also been reported by CHAPMAN (1940, p. 323) from Jamaica. From the air the foreshore of such a coast with a sand beach might be interpreted as sandy, though the sands represent only a very narrow strip of sand veneer. This misinterpretation, I am told by Mr CORNER, has proved to be disastrous in landing attempts of tanks by Allied Forces on the west coast of Malaya at the end of the last world war, the tanks finding a soft mud instead of a firm, sandy bottom.

Mangrove and climate.—It has been considered occasionally (SCHIMPER *l.c.* p. 87–88) that mangrove, being little or not developed in arid or seasonal areas, would require ombrophilous conditions for its full development. The largest development of mangroves is indeed found in the everwet parts of Malaysia.

Besides, as has been mentioned on p. 431 mangrove is absent before the arid *west* coasts of the *S.* hemisphere tropics of America and Africa (and probably Australia).

The correlation between mangrove growth and climate is still often interpreted as a *direct* one, but this rash conclusion is essentially wrong. *The arid climate is not the cause of the absence of mangrove but merely the condition.*

This follows partly from the observation that not in *all* ombrophilous tropics mangroves are found; they are absent from steep shores or those with turbulent coastal waters, *etc.*

For the explanation why they avoid arid shores we have to consider that the occurrence of mangrove is primarily controlled by accretion of silt or sand and this again is controlled by the winds, the tides, the currents before the coast, the foreshore underwater relief and its shoals, and in no mean degree by the amount of silt transported by the rivers to the shore where it is deposited by its gravity and through the coagulating power of the sea-water on soil particles. Inadequacy of any of these factors will prohibit or limit growth of mangrove. Coasts which offer suitable conditions but fall off steeply towards the deep sea can only bear a very narrow fringe. Coasts along shallow seas but without accretion of silt or big rivers bringing silt will possess a poor mangrove development or none.

The situation in the seasonal parts of Malaysia, for instance the Lesser Sunda Islands, is a generally poor development of mangrove but not on account of the dry climate, but on account of the deficiency of the other conditions. In the first place this area is generally provided with steep coasts and a heavy surf. Besides, during the dry monsoon the coasts are subject to strong winds and consequently have agitated coastal water. Finally, in these islands large streams which transport a regular supply of silt to the coast are absent; most rivers are 'flood-rivers' filled only during the rainy season.

If under seasonal conditions there are, however, local sheltered bays and estuaries where silt is deposited in sufficient quantity, the mangrove may appear in luxuriant stands not falling short of those found under ombrogenous conditions, *e.g.* in the south of Central Java (Tjilatjap), the southeast of Java

(Gradjagan & Pampang Bays), SW. Timor (Kupang), and the Fly River delta, E. New Guinea.

WATSON rightly remarked (*l.c.* p. 1) that the absence of mangroves along arid shores is due to the absence of rich silt carrying rivers in such places.

The conclusion is that *Rhizophoraceae* and other mangroves follow the coastal silt deposits independent of the dryness of the climate.

Characteristics of mangrove.—As has been alluded to above the characteristic appearance of the mangrove is in part due to the remarkable *root formations* which are obviously tolerant to withstand the peculiar conditions for nutrition, assimilation of water and oxygen in anaerobic mud, besides serving

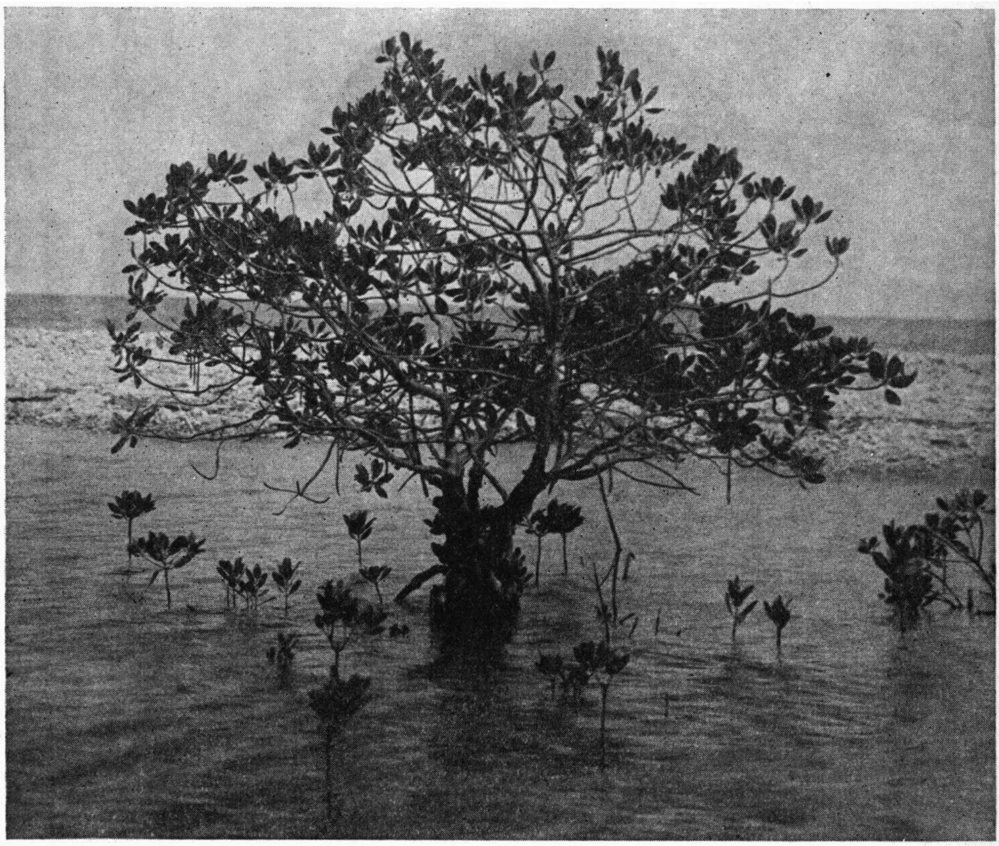

Fig. 5. *Rhizophora stylosa* GRIFF. at high tide in the small lagoon sheltered behind the lee of the shingle-wall on the coralreef island Leyden, Bay of Djakarta, surrounded by seedlings, Nov. 1927 (DOCTERS VAN LEEUWEN).

for anchorage on an unstable substratum. *Rhizophora* stems are provided with a cone of branched stilt- or prop-roots (fig. 12), and generally additional similar, also forked aerial roots stick out or hang down to reach eventually the soil (fig. 11); the stembase is obconical and a taproot is absent or feebly developed (fig. 7). *Sonneratia* and *Avicennia* possess a horizontal root system provided with erect, asparagus-, peg-, or torpedo-shaped 'pneumatophores' (fig. 23), *Bruguiera* and *Lumnitzera* show upward knee-like bends in the roots (fig. 16, 22), in *Xylocarpus moluccensis* the horizontal roots possess knobs producing thick-conical 'pneumatophores', in *X. granatum* these roots have an upper thickening which appears as a sharp ridge above the silt. *Ceriops*, however, does not very much show in the way of root formations save for large lenticels in the uncovered parts of the roots and stem base.

An other characteristic, unique in the plant world, is the frequent occurrence of *vivipary* in mangrove trees in which either the fruit is enlarged (*Aegiceras*) or the elongating hypocotyl pierces the apex of the fruit in the 4 genera of *Rhizophoraceae:* Fig. 6, 9, 17, 18, 24, and 26.

Further features differentiating the mangrove vegetation from the rain-forest is the *paucity of species* *and their gregarious occurrence* which can easily be observed both in the field and from aerial photographs, the absence of palms (save the stemless *Nypa*), the almost absence of lianas, the general scarcity of epiphytes and parasites, the almost absence of undergrowth, and the absence of storeys with substage layers. These characteristics hold for the proper mangrove and are generally less well pronounced towards the inner transition to the coastal forest behind.

Epiphytes and undergrowth.—Though it should be admitted that mangroves have, in general, less epiphytes if compared with rain-forest, SCHIMPER's assumption that they would be deficient in them is erroneous. BECCARI already mentioned their occurrence in Sarawak (*cf.* Wanderings p. 83, amongst others of *Rhododendron brookeanum* LOW), RUTTEN in E. Borneo (Tijd. K.N.A.G. 28, 1911), and HUB. WINKLER in SE. Borneo (Bot. Jahrb. 50, 1914, Suppl. 190–191). RIDLEY described many epiphytic orchids from the mangrove in Malaya. I found some in the Anambas Isl. mangrove (Bull. Jard. Bot. Btzg III, 12, p. 162) and STEUP mentioned them from the Riouw mangroves (Trop. Nat. 30, 1941, 90). From Java they were mentioned by BEUMÉE (Exc. guides 4th Pac. Sc. Congr. 1928, C 3, p. 11–13) to occur in Segara Anak near Banjumas; BACKER & POSTHUMUS (Varenfl. Java 1939, 325) emphasized that the occurrence of epiphytic ferns in the mangrove is restricted to areas which are not subjected to a rather strong to strong dry annual period and lack, for that reason, near Djakarta, Pasuruan, *etc.* From East New Guinea and Melanesia mangrove epiphytes (mosses, pteridophytes, orchids, *etc.*) were recorded by SCHLECHTER (1914) and from West New Guinea by KOCH. BROWN & FISCHER *l.c.* p. 24 found epiphytes fairly common in Philippine mangroves. HOSOKAWA found a similar condition in Micronesia. I have tried to give a preliminary enumeration (Tijd. K.N.A.G. 52, 1935, 382).

There seems no doubt that the typical mangrove with epiphytes is bound to ombrogenous conditions. Within these the (older) inner mangrove is richer than the (younger) outer one. Epiphytes may grow very close above the waves and subject to salt spray with wind at high tide.

Also ant-inhabited epiphytes occur in the mangrove (*Hydnophytum*, *Myrmecodia*, *Pachycentria*, *Polypodium sinuosum*).

Some epiphytic plants are even restricted to the mangrove, as for example *Humata parvula* (WALL.) METT. on 'old mossy mangrove' in S. Malaya and Borneo, and orchids as *Dendrobium rhizophoreti* J.J.S., *D. prostratum* RIDL., *D. callibotrys* RIDL., and *Bulbophyllum xylocarpi* J.J.S., and a Melastomatacea *Plethiandra sessilifolia* RIDL.

The only parasites I know from the mangrove are *Viscum orientale* and *Amyema gravis*, both *Loranthaceae*. As far as known the latter species is confined to this formation. More loranthaceous representatives will occur in the mangrove, as they also freely occur on trees of the *Barringtonia* formation; their exact number is difficult to ascertain from DANSER's works on that family as he omitted to mention the host plants save in certain exceptional cases.

Among the lianas the only true ones of the outer mangrove are *Derris heptaphylla* and *D. heterophylla*; in the inner mangrove several representatives are found of the *Asclepiadaceae* (*Cynanchum carnosum*, *Finlaysonia maritima*, *Gymnanthera paludosa*, and *Sarcolobus banksii*).

Undergrowth may consist in local, open places of few grasses (*Xerochloa imberbis*, *Diplachne polystachya*) or sedges (*Fimbristylis ferruginea*, *Cyperus malaccensis*). A submerged water-plant of the pools and creeks is *Cryptocoryne ciliata*.

Low shrubs or tall herbs appearing in open places are *Acanthus spp.*, *Acrostichum aureum*, and *Clerodendron inerme*. These may gain ground in clearings and cuttings, specially invading the colossal mud heaps accumulated by mangrove crabfish and finally form dense thickets in which regeneration of the mangrove proves difficult.

According to measurements by BÜNNING (Flora 137, 1944, 342) inside well-developed mangrove the light intensity at the bottom is about 1–5% of the open.

The mangrove as a primary vegetation type.—The thesis is defended here that the mangrove cannot merely be subordinated as an edaphic (seral) subtype of the tropical rain-forest on the argument that the back-mangrove may sometimes contain an increasing number of coastal trees if one proceeds inland. There is only a narrow transition zone, in Sumatra characterized by a strip of a tall, spiny palm: *Oncosperma horrida.*

It is certainly interesting that several mangroves (with the exception of *Rhizophora*?) can successfully be planted and grown in freshwater mud in greenhouses. In Kebun Raya Indonesia at 250 m there is an artificial freshwater swamp where *Bruguiera gymnorrhiza*, *Sonneratia caseolaris*, *&c.* flower and fruit freely and produce natural regeneration (fig. 23). This might induce the viewpoint that their restricted occurrence in the littoral zone is merely a question of resistance against the extreme littoral environment combined with low competitive power as compared with the freshwater swamp forest trees immediately behind the coast. But this argument derived from cultivated plants holds for representatives of nearly all vegetation types for which the range of edaphic tolerance is always much wider than that exhibited under natural conditions.

Mangroves are certainly bound to specific edaphic conditions, but as I have tried to demonstrate (Proc. Int. Bot. Congr. Stockholm 1950, p. 638, 1954) all vegetation types are, in last instance, edaphic.

Structurally the mangrove forest differs markedly from both the dryland rain-forest and from the freshwater swamp- and peat-forest in that *it lacks substage strata* and in that its subtypes, when fully developed mostly consist of *one or a few dominant species*. In this the mangrove forest structure approaches that of some forest types of the temperate and cold zones.

The second important reason why the mangrove cannot be considered to represent an edaphic subtype of the rain-forest is because *it is independent of the climate* and is found under both everwet and seasonal conditions, though it should be admitted that under the latter the mangrove is generally poorer and more stunted, but as has been shown above for other than climatical reasons.

An additional argument, significant but not conclusive for assigning primary rank to the mangrove, is the high percentage of genera and species confined to it and provided with a unique set of structures, morphological and physiological, fitting to the environment.

By some authors it has been held that the mangrove is a pioneer forest only, preceding the stable rain-forest. This is inferred from the fact that certain coasts show a very rapid land increase (for human concepts of time) in which the mangrove fringe is continuously pushed seaward, sending out its pioneer specimens forward while the back-mangrove is simultaneously gradually replaced by the mixed coastal rain- or swamp-forest. This land increase may average a dozen or several dozen metres per year (E. Sumatra, N. Java, S. New Guinea), leaving the hinterland interspersed with old, ± parallel strand dikes.

Elsewhere land is secularly sinking and the rain-forests are drowned and replaced by a landwards retreating mangrove; this process goes sometimes at such a rate that even the peat-forest, which bordered the mangrove on the land side, is gradually washed away by the sea.

Many are the vicissitudes of this shore vegetation and in Malaya it has been found that freshwater swamp forest has (probably often) replaced mangrove, as shown by subfossil mangrove timber and by marine diatoms in Telok Forest Reserve (WYATT-SMITH, Mal. For. 17, 1954, 25–26).

But there are also coasts which are, at present, stable and neither regressive nor accrescent, and there the mangrove behaves not different from other climax types and comes up fully to the age class criterion which is the test for a climax: in the full grown stand all year classes of all species are present, with no further potential participiants (LUYTJES *l.c.* p. 580; WATSON *l.c.*; NOAKES, Mal. For. 18, 1955, 26).

It is true that many (specially outer) stands of mangroves are about even-aged and represent a pioneer stage of the mangrove itself, but that is no proof for accepting the mature mangrove forest as consisting of nomad species. These pioneer stands mostly consist of one species in an immature environment: there will always be an immature environment fringing the seaside with a border of pioneer stands.

It is due to the bare-soil habitat, the very restricted number of species, and their rapid growth, that the stabilization of a mature mangrove forest on a stable soil type is performed in a very much shorter period than for example a climax of the very much mixed rain-forest.

The mangrove forest formation is a type *sui generis* with its own stable type of regeneration.

Morphology. (1) *Root system.* As alluded to above the mangroves present a number of remarkable root structures worthy of special mention. A taproot is generally insignificant or absent. In *Rhizophora* the root system is mainly consisting of lateral adventitious prop-roots; they originate from the hypocotyl and later the stem in an upward sequence (fig. 9, 10, 11 and 12), sticking obliquely down or hanging down as rather thick, repeatedly di- or trichotomously branched aerial roots finally striking ground and rooting. The highest of these branched adventitious roots may originate on the lower branches of the crown and may attain more than 10 m in length! According to GOEBEL and WARMING extreme heat and drought would be responsible for the dying of the tips of the stilt-roots. These would then in a subsequent growth period be replaced by secondary adventitious roots originating somewhat above the dead root tip. And this process would be repeated, resulting in the sympodially branched stilt-roots. DOCTERS VAN LEEUWEN (Ber. Deut. Bot. Ges. 29, 1911, 476–478) has offered a much more reasonable, though very curious explanation of the dying of the root tips which he observed to be damaged by a boring beetle of the *Scolytidae*! Normal stilt-roots should remain unbranched. Fig. 11.

In *Bruguiera* the horizontal cable roots produce knee- or elbow-shaped, negative-geotropical, supraterranean bends acting as 'pneumatophores'. *Ceriops* does not have much in the way of special root structures, but may occasionally have stilt-roots at the stem base. *Kandelia* has merely a thickened stem base, but with pneumatophores and true buttresses. It is worthy of note that the inland *Carallia brachiata* sometimes produces stilt-roots (fig. 32) at the stem base under marshy conditions!

Seedlings and very young trees of *Rhizophora* have some coppicing power, but contrary to what some believe the aerial roots from the branches play no part in reproduction. *Bruguiera spp.* do not coppice. This capacity is, however, strongly developed in *Combretocarpus* (*cf.* p. 481).

The underground root system of all mangroves is flat, densely branched, and superficial, the horizontal main roots (cable roots) are anchored by vertically descending small lateral roots (anchor roots); besides they (or the pneumatophores respectively) produce an extensive net of very fine nutrition ('absorption') roots in the uppermost mud stratum. The structure differs from species to species in detail, but the scheme is apparently not essentially different from that worked out by TROLL for *Sonneratia* (*cf.* vol. 4, p. 281, fig. 1). The cable and anchor roots give the tree mechanical fastening in the substratum, the fine nutritional roots serve for nutrition and assimilation of oxygen from the uppermost silt layer which is distinctly better aerated than the silt lower down. If the substratum is silted up, new nutritional roots are produced above the old ones, thus keeping pace with the accumulation of silt. The results obtained by TROLL with *Sonneratia* in Malaysia (*cf.* vol. 4, p. 281–282, fig. 2) are in general corroborated by CHAPMAN for *Avi-*

cennia in Jamaica (J. Linn. Soc. Lond. Bot. 52, 1944, p. 407–533) and there seems good reason to assume the general validity for various root formations of other mangroves.

(2) *Foliage and stipules.* The foliage of the mangroves is generally dark green and glossy, more or less coriaceous to fleshy, elliptic to obovate as common to the laurel type of rain-forest. They are said to have frequently a downward hanging position, specially in the daytime, which is assumed to be an ecological adjustment to avoid overheating. No critical experiments or observations are known to me to sustain this idea.

The leaves of *both* the mangrove and inland *Rhizophoraceae* show the occurrence of characteristic dark glandlike dots which appear to be corked epithem cells. The vernation of the leaves in the Malaysian *Rhizophoraceae* is either convolute (fig. 6j) in the genera *Bruguiera* and *Rhizophora* or involute (fig. 6i) in the genera *Ceriops, Carallia, Gynotroches,* and *Pellacalyx*. In *Kandelia* it could not be examined due to lack of adequate material.

The interpetiolar stipules of the mangrove *Rhizophoraceae* are large and caducous and are cigar-like clasping one another, each having one free margin (fig. 6k). It has sometimes been assumed that they serve for bud protection but this again has, as far as I know, not been verified by some simple experiments: it would be easy for people on the spot to cut away stipules in various stages of development to see whether the terminal bud will succeed without them.

A peculiar phenomenon is the occurrence of glandular emergences (*colleters*) in the axil of the stipules; they were first described by ALSTON in African *Cassipourea*, later by METCALFE & CHALK in *Carallia*, but appear to occur in all Malaysian genera, both of the mangrove and inland. The resin exuded by them during the time the flush expands lends a certain varnish to the innovations which is specially conspicuous in *Carallia brachiata*.

(3) *Branching.* The mode of branching is often sympodial which adds to a flat undersurface of the crown; with low tide this flattened appearance is very distinct.

(4) *Flowering* of mangrove trees takes often place at an early stage (3–4 years) if sufficient light is available in seedling trees of all genera. This capacity is shared by the inland genera.

(5) *Vivipary* and *embryology.* Among mangrove plants, both of the *Rhizophoraceae* and belonging to taxonomically quite different families, there is a distinct tendency towards a viviparous development of the seed, which finds its extreme in the *Rhizophoras*. The endosperm plays only a short role and is soon obsolete. In the myrsinaceous *Aegiceras corniculatum* the embryo ruptures the testa and fills the pericarp which then starts to enlarge in proportion to the growth of the embryo; after the enlarged fruit is fallen the embryo pierces the pericarp. In the verbenaceous *Avicennia* there is a similar development, but the embryo may or may not pierce the pericarp while the fruit is still on the tree. In *Bruguiera* the apex of the

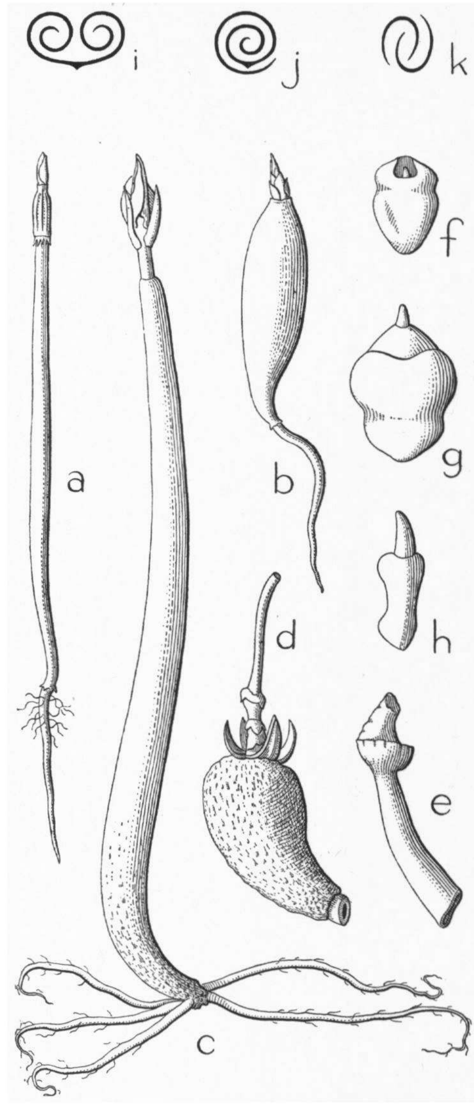

Fig. 6. *a. Bruguiera parviflora* (ROXB.) W. & A. seedling, the pericarp + calyx are pierced at both sides, × 1/2, *b. Br. sexangula* (LOUR.) POIR., young seedling, × 1/2, *c. Rhizophora mangle* L., *ditto*, × 1/2, *d. Rh. mucronata* LAMK, fruit from which the seedling has fallen out, the basis of the cotyledonar body just protruding from the fruit calyx, × 1/2, *e. ditto*, cotyledonar body removed, in the same position, × 1/2, *f. ditto*, developing seed with widely opened micropyle, × 2, *g. ditto*, older stage, × 2, *h.* young germlet with the dumb-bell shaped cotyledonar body, × 2.—Vernation of *i.* involute leaves, *j.* convolute leaves, *k.* clasping stipules (all in schematic cross section) (*a–h* after SCHIMPER).

hypocotyl pierces the fruit apex and the hypocotyl grows cigar-like out of it, to fall together while still attached. In *B. parviflora* the fruit base is frequently pierced by the growing plumule, the pericarp persisting as a cuff round the seedling (fig. 6a). In *Bruguiera* the cotyledons are only connate at the base but they serve by their glandular epidermal tissue for assimilating nutrients from the pericarp and feeding the hypocotyl. In *Rhizophora* vivipary has advanced so far that the hypocotyl may attain a considerable length and when ripe fall out of the fruit; its plumule is entrenched in a single, club-shaped cotyledonar body (fig. 6d–e), formed by the fleshy connate cotyledons. This serves for sucking nutrients from the pericarp for the growth of the hypocotyl; it often protrudes from the fruit and is demarcated against the hypocotyl by an articulation. When mature this articulation is ruptured and the hypocotyl crowned by the plumule (fig. 6c) falls out of the fruit (*Rhizophora, Ceriops*) or the hypocotyl falls together with the fruit (*Bruguiera, Kandelia*). Fig. 6a, 17l, 26e.

In *Avicennia* TREUB (Ann. Jard. Bot. Btzg 3, 1883, 79–85, t. 14–15) observed one enormous, branched cell performing this assimilatory function retained in the embryo which for the greater part escapes very early from the integuments.

It is current usage to accept, teleologically, the striking vivipary of the mangroves as a 'special adaptation' to the environment, though what 'profit' is exactly meant by this trend of thought is not disclosed. It is termed 'adaptation' as it is exhibited in one environment by various not related plants. As a matter of fact vivipary with such intricate designs is not found in any other vegetation type. But on the other hand it appears that certainly not all mangroves possess it; none of these remarkable features occurs for example in *Sonneratia* which is, among the mangroves, taxonomically the closest ally of the *Rhizophoraceae* and ecologically a pioneer! Also none of these characters is found among the representatives of the *Barringtonia* formation which grows under rather similar conditions of the shore, though not under permanent inundation, and none is found among the trees of the swamp- and peat-forests which are often found immediately behind the mangrove. Consequently a generalization seems out of question and the term 'adaptation' seems rather an excuse for ignorance than explanatory.

Seedling stage and dispersal. As is usual among shore plants dispersal is mainly waterborne. Drift capacity over relative short distances is undeniable. The idea that the hypocotyls would fall from the seed tree (at ebb tide) torpedo-like penetrating into the mud and grow into seedlings in that same place is a popular opinion, but seems to be wrong and to happen only in exceptional cases. To my knowledge there have been made no pertinent observations in nature to the effect that one has actually seen fruits falling, sticking in the mud, remaining in a vertical position, and growing up. The 'torpedo-act' would only be possible in very soft exposed mud and then the chance that they will soon sag sideways is likely. On stiff clays and on sand (*Rhizophora stylosa*) it seems out of question that it may happen even occasionally. Furthermore all fruits falling when the mud is covered with a good sheet of water will not have the force to penetrate into the mud as the water will act as a distinct brake on their falling speed. C. D. DE LA RUE & T. J. MUZIK have made a plea to the contrary (Science 114, 1951, 169) and assume *Rhizophoras* mainly 'plant themselves' but they counted the erect seedlings as being borne from 'self-planting' and those which are curved they assumed derived from fruits which took root while lying flat. It is quite possible, however, that the latter may get an erect position and remain straight by the uplifting power of the water in conjunction with their own drifting capacity. I agree entirely with the excellent observations and considerations by EGLER (Carib. For. 9, 1948, *no* 4) and by B. D. LAWRENCE (Am. J. Bot. 36, 1949, 426–427) on the self-erecting habit of *Rh. mangle* which seems the usual way of seedling growing up. As a matter of fact hypocotyls are dispersed by floating horizontally in the water (though some have been observed floating in a vertical position). It is true that sometimes a seed tree is surrounded by seedlings as children under a mother (fig. 5), but we should not jump to the conclusion that they are *per se* its own children. The observation is that the hypocotyls drift freely in the water; the hypocotyl produces small roots near its tip and they get attached to the mud during ebb tide in a horizontal position. When the anchorage is obviously firm enough, the hypocotyl bends itself upwards and soon gains the erect position (fig. 6c). That this happens often nearly an already existing tree is due to the fact that this offers obviously a suitable ecology for growth of mangrove, and secondly in that mature hypocotyls are easily caught between the projecting root structures of existing trees with other drifting debris. Spring ebb is possibly the most suitable time for the hypocotyls to fasten their rootlets for anchorage. For no obvious reason the main root of the seedling in *Rhizophora* and *Ceriops* is abortive and lateral roots take its function (fig. 9–10).

According to GUPPY fruits or seedlings may drift for several months and retain their vitality. In Malaya, however, it is maintained (Res. Pamphl. For. Res. Inst. Mal. 15c, 1957, 7) that observations on natural regeneration in the mangrove indicate that recruitment of seedlings of *Rhizophora*, *Bruguiera*, and *Ceriops* species, in deep flooding blanks of the Perak mangrove, proceeds slowly with seed from nearby trees and not from seed which has been waterborne for any distance. Recruitment of *Sonneratia* and *Avicennia* species may occur with seed which has been waterborne for a considerable distance.

CHAPMAN *c.s.* have pointed out (Geogr. J. 76, 1940, 320) that a successful colonization of seedlings depends either upon a very shallow sea in those cases where there is only a small tidal rise, otherwise there must be a considerable tidal rise and fall so that they are exposed for some hours during the day, as unless the small shoot portion is out of the water the seedling soon dies.

Accordingly the *length of the hypocotyl* must play a considerable role in the colonization and is obviously responsible for the fact that *Rhizophora mucronata*, the hypocotyls of which may attain 60 cm in length (according to CORNER even 3 feet!), are able to grow in the deepest water (or places subject to deepest fall and rise of the water level with the tides), and is henceforth the principal seaward pioneer.

The waterborne dispersal is certainly one of the factors responsible for the generally wide distribution of mangroves. Obviously the megatherm character of the *Rhizophoraceae* has prohibited species to migrate freely between oceans which are separated by N–S directed continents, as Indo-Pacific species do not occur in the Atlantic, *vice versa*, but those of the Caribbean occur also in West Africa. SCHIMPER (*l.c.* p. 193) has already pointed to the agreement between the littoral flora of the Caribbean and West Africa and the marked difference between the West African and East African coastal floras, the latter being a depauperated Indo-Malaysian one. The situation is obviously radically different from that found in the distribution of the seagrasses (see p. 382).

The relation between the mangroves of the Caribbean and those of the Pacific coast of North America are less clear and can not be explained before a critical detail identification of Pacific *Rhizophoras* has been undertaken. If the tentative assumptions made under the genus *Rhizophora* (see p. 450) are right it would seem that at least two Caribbean *Rhizophoras* occur on the Pacific American coast and their distribution must have been effected before the closing of the isthmus of Panama.

From the rather restricted area of a few rhizophoraceous mangrove species we also may infer that there are limitations to either the long-distance dispersal capacity or the ecology. It is for example difficult to explain why *Kandelia candel* is so extremely rare in Malaysia, as the number of ecological niches offered by Malaysian coastal areas certainly includes the one suitable for *Kandelia. Bruguiera exaristata* and *B. hainesii* are other examples of geographically relatively restricted species.

Another argument for the relative difficulty in dispersal for the seaborne mangroves is the remarkable fact that *no* mangroves are known to occur native in the Hawaiian islands, although they can grow there in certain localities, as has been shown by extensive planting experiments initiated by the Hawaiian Sugar Planters' Association in 1922. This peculiarity is even more remarkable if it is remembered that of the *inland* genus *Crossostylis* representatives have been found eastwards in the Pacific in truly oceanic islands as far as southeast Polynesia, although their means of dispersal would appear far inferior to those of the mangroves!

Physiology. The extreme habitat of the mangrove vegetation has led to several assumptions, some of which have been mentioned in passing in the foregoing paragraphs. SCHIMPER (Pfl. Geogr. 1898) classified the mangroves among the 'xerophytes', accepting a low rate of transpiration and growth. His (± teleological) argument was that this must be so in order to avoid too high salt concentration in the tissues. He believed to have circumstantial evidence for this viewpoint in morphological 'adaptations' to xerophily, *viz* fleshy or lepidote leaves, hairy leaves, isolateral leaves, thickened epidermis and cuticle, slime cells and thin-walled water tissue, sunken stomata, *etc.*. HOLTERMANN (Einfl. Klimas, *&c.* 1907), and specially VON FABER (Proc. 4th Pac. Sc. Congr. 1929, 3, 1930, 113–120) have shown, however, that mangroves are strong transpirators and besides show abundant guttation. Concentration of salt is avoided by exuding it and the water supply and water stream through the plant consists of salt water.

As has been shown by Mrs REINDERS-GOUWENTAK in an excellent digest of later literature in this Flora (vol. 4, p. 513–515) on the relation between wood anatomy and water relations later authors are not in full agreement with VON FABER's results and are of opinion that his evaporation figures are overestimated. But growth measurements by silviculturists have shown mangroves to be not particularly slow growers. And it can be maintained that their classification with xerophytes is definitely erroneous.

It would be most interesting to make a comparative study of the physiology of the mangrove *in situ* and that in the Botanic Gardens, Bogor, where the same species have grown up in fresh-water.

It seemed an attractive idea of SCHIMPER to base a wholesale ecological classification of the plant kingdom on correlating the water supply of substratum and climate with the morphology of plants, but it appears more and more that this simple device has to be abandoned, both for the halophytes, mangroves, and desert plants themselves, some of which show a high rate of transpiration.

In the foregoing paragraphs the other major physiological problem of the *Rhizophoraceae*, *viz* their respiration under anaerobic soil conditions has already been touched upon and reference has been made to the work of TROLL and CHAPHAM who I believe have found a reasonable explanation for the way how the root systems of *Sonneratia* and *Avicennia* are provided with sufficient oxygen, from which it follows that the respiratory function of the supraterranean 'breathing roots' has formerly been exaggerated. This pattern will, *mutatis mutandis*, probably hold in its basic design for other mangroves; there is here a need for further investigation.

Galls. DOCTERS VAN LEEUWEN (Zoocecidia Neth. Ind. 1926, 402, fig. 746–747) reported a leaf-gall caused by a gall-midge in *Anisophyllea disticha* and a flower-gall caused by a gall-midge in *Carallia lucida* (= *C. brachiata*). I have also seen those two kinds of galls in the above-mentioned species. Besides, I have found a fruit-gall in *Anisophyllea beccariana* where the ovary is swollen into a fruit-like body.

Flower biology. Though the flowers are, for example in *Bruguiera*, *Kandelia*, and *Rhizophora*, not small, very little actual observation has been recorded and this remains an urgent desideratum.

Many representatives possess a distinct disk and their flowers will contain honey. Further there are in certain genera unisexual or polygamous flowers which might require insect pollination.

GEHRMANN (Ber. Deut. Bot. Ges. 29, 1911, 308–318) and PORSCH (Jahrb. Wiss. Bot. 63, 1924, 611) assume occasional visits by birds in addition to anemophily in *Bruguiera*. The first author studied in the Botanic Gardens, Bogor, March 1911, the structure of the flowers of *B. gymnorrhiza*. He found the anthers pressed between the petal lobes with a tension in the snakelike curved filaments. This tension can be released by touching with a needle or hair the sensitive inner basis of the petal after which the anther comes forward and explodes into a cloud of powdery pollen. This can also be attained by shock. The cupular calyx basis is filled with honey. No flower visitors were observed.

DOCTERS VAN LEEUWEN (Ann. Jard. Bot. Btzg 37, 1927, 11) did not observe bird's visits, though the red calyx and abundance of honey would suit them. But visits by *Xylocopa* (wood bees) and wind might also be capable of setting free the pollen. In the flowers of *Rhizophora stylosa* he observed once a small bee (*l.c.* p. 24).

Wood anatomy. DEN BERGER, Med. Proefstat. Boschw. 13 (1926) 138, Determinatietabel Malesië, Veenman, Wageningen (1949) pp. several & 71; DESCH, Mal. For. Rec. 15[II] (1954) 447; REYES, Dep. Agr. & Comm. Manila, Techn. Bull. 7 (1938) 354 (hand lens). JANSSONIUS, Key to Jav. woods, Brill, Leiden (1952) 16, 22; MARCO, Trop. Woods 44 (1935) 1; METCALFE & CHALK, 1 (1950) 605; MOLL & JANSSONIUS, Mikr. 3 (1918) 323; PANSHIN, Philip. J. Sc. 48 (1932) 143; PEARSON & BROWN, 1 (1932) 486. For review of anatomical structure and water relations: REINDERS-GOUWENTAK, Fl. Mal. I, 4 (1953) 513.

The group of the tidal genera is readily separated from the 3 groups (see MARCO, METCALFE & CHALK) of inland genera by the heavy-barred scalariform perforations of the vessels, the scalariform intervascular pitting, the libriform fibers, the scanty (except in *Kandelia*) vasicentric parenchyma, and the structure of the fine-celled rays (JANSSONIUS, MARCO, METCALFE & CHALK). Four of the 5 inland genera are rather readily separated from the *Macarisieae* (MARCO) but METCALFE & CHALK do not quite agree. *Pellacalyx* cannot be placed satisfactorily into any group of the family (MARCO, METCALFE & CHALK).—C.A.R.-G.

Taxonomy. The family was established by R. BROWN as order *Rhizophoreae* including *Rhizophora* L., *Bruguiera* LAMK, and *Carallia* ROXB. (in Flinders' Voy. II, 1814, App. iii, p. 549).

ENDLICHER separated two inland genera *Cassipourea* and *Dryptopetalum* (= *Gynotroches*) from the mangrove genera and accommodated them in a subdivision *Legnotideae* (Gen. Pl. 1840, p. 1184), but he left *Carallia* in the *Rhizophoreae sens. strict.* He maintained this division in his Enchir. Bot. (1840) 634–635, where he added that the *Legnotideae* differed from the *Rhizophoreae* by albuminous seeds and superior ovary.

These two subdivisions were raised to family rank by BLUME (Mus. Bot. 1, 1849, 126, 131), followed by MIQUEL (Fl. Ind. Bat. 1, 1, 1855, 581, 591), but *Carallia* was (rightly) transferred to the *Legnotideae* which then consisted merely of inland genera.

BENTHAM & HOOKER *f.* maintained the two groups *Rhizophoreae* and *Legnotideae* as tribes of one family but added a third tribe, *Anisophylleae*, including two inland genera *Anisophyllea* and *Combretocarpus* (Gen. Pl. 1, 1865, 687).

This system was recently still followed by RIDLEY, who raised these three tribes each to family rank (Fl. Mal. Pen. 1, 1922, 692, 696, 700).

It was also followed by BAILLON who, however, split the *Legnotideae* into two separate tribes ('series') (Hist. Pl. 6, 1876, 284–304).

CORNER distinguished the same three groups as BENTHAM & HOOKER *f.* but was of opinion that the *Anisophylleae* deserved family rank against the *Rhizophoraceae* proper, subdividing the latter into two subfamilies *Rhizophoreae* and *Legnotideae* (Ways. Trees 1940, 122, 520).

SCHIMPER had a quite different opinion as compared with preceding authors, in assuming that the remarkable structure of the fruit and mode of germination of the mangrove genera were mere adaptations to the tidal habitat, which would represent therefore artificial characters. He suggested a different system and rearranged the genera according to what he assumed to represent 'natural relationships'; he kept the subfam. *Anisophylloideae* in the circumscription of BENTHAM & HOOKER *f.* and kept also one inland tribe *Macarisieae* in about the circumscription of BAILLON, but he assembled *Carallia* and *Pellacalyx* with *Bruguiera* in a subtribe and added *Gynotroches* and *Crossostylis* to the *Rhizophora-Ceriops-Kandelia* affinity (in Engl. & Pr. Nat. Pfl. Fam. 3, 7, 1898, 49–50).

This mixing of inland and mangrove genera in both tribes and subtribes as advocated by SCHIMPER is not sustained by the wood anatomy and other anatomical characters, as pointed out by SOLEREDER (Syst. Anat. Dicot. 1908, 384, Ergänz. Bd 1908, 137), MOLL & JANSSONIUS (Mikr. Holz. Jav. 3, 1918, 323), and DEN BERGER (Hand. 4e N.I. Nat. Congr. 1926, 403–404, 1927). SCHIMPER's clearly wrong classification provides again a good example of what danger is involved if a taxonomist introduces preoccupied theoretical ideas in a classification.

MARCO (Trop. Woods 44, 1935, 1–21) in a comprehensive study of the wood anatomy classified the family into 3 divisions, leaving *Pellacalyx* and *Poga* unclassified, as he could not refer them to any of these divisions. He considered the mangrove division, *Rhizophoreae*, to form wood-anatomically, a well-defined, homogeneous, natural division readily separable from other groups of this or any other family;

it might even deserve family rank. In his opinion BENTHAM & HOOKER's *Legnotideae* are, wood-anatomically, heterogeneous and unnatural. Therefore he split it into two divisions, *Gynotrocheae* and *Macarisieae*, adding the *Anisophylleae* (*Anisophyllea* & *Combretocarpus*) to the *Gynotrocheae*, as a separate section.

METCALFE & CHALK (Anat. Dic. 1, 1950, 610) confirmed in general MARCO's scheme, but remarked that the material they examined provided less convincing evidence of the clear distinction between *Gynotrocheae* and *Macarisieae*. They confirmed also that MARCO's unclassified genera *Poga* and *Pellacalyx* do not fit very well into any of their proposed groups though these genera have many characteristics in common, even in detail, with other members of the *Rhizophoraceae*.

DESCH had a similar opinion (Mal. For. Rec. 15^2, 1954, 447–454) and assumed that *Pellacalyx* shows wood-anatomically a distinct alliance with both *Carallia* and *Gynotroches*, all belonging together to the *Legnotideae sens. lat.*

Affinities with other families. R. BROWN, *l.c.*, BENTHAM (J. Proc. Linn. Soc. Bot. 3, 1859, 65), LINDLEY (Veg. Kingd. 1846, 726), BAILLON, *l.c.*, and HUTCHINSON (Fam. Fl. Pl. 1, 1926, 185) have discussed the multiple affinity of this family. It shows relationships with *Myrtaceae*, *Lythraceae*, *Cunoniaceae*, *Combretaceae*, and *Melastomataceae* in one way or another.

ERDTMAN (Pollen Morph. & Pl. Tax. 1952, 379) has examined pollen grains of 12 species from 10 genera of *Rhizophoraceae*. He stated that "grains ± similar to those in *Rhizophoraceae* occur for instance in certain *lythraceous* genera (*cf.* also *Dialypetalanthaceae* and *Santalaceae*). The grains in *Combretaceae*, *Cunoniaceae*, *Lecythidaceae*, *Melastomataceae*, *Sonneratiaceae*, *etc.* are ± different." The pollen structure gives obviously no clear conclusion either for the subdivision of the family or for its affinity. *Anisophyllea* has no aberrant pollen type justifying a separate rank.

Resemblance with Rubiaceae. There is an astonishing outward, vegetative morphological resemblance between *Rhizophoraceae* and *Rubiaceae*, both families sharing in the majority of genera, decussate leaves, interpetiolar stipules provided with colleters, and an inferior ovary.

In *Rhizophoraceae* the caducous stipules have overlapping margins (except in *Pellacalyx* where they are flat), each stipule having one free margin (fig. 6k). In *Rubiaceae* they are generally flat, often persistent, and not overlapping, though in *Mastixiodendron* the situation is exactly the same as in *Rhizophoraceae* (except that each stipule is inserted between the leaves and besides intra-axillary in one axil!); in *Timonius spp.* the situation varies with the *spp.* and may be overlapping as in the *Rhizophoraceae*, or one stipule may embrace entirely the other, or the stipules may be connate and are cucullately caducous, or they may be valvate.

The families can of course easily be distinguished by the structure of the corolla (sympetalous in *Rubiaceae* and choripetalous in *Rhizophoraceae*) and the androecium (isomerous in *Rubiaceae* and twice or more the number of flower parts in *Rhizophoraceae*). Besides the petals of *Rhizophoraceae* have a distinct tendency to produce fringes or appendages and are generally erose, emarginate, or 2-lobed.

Uses. Nearly all *Rhizophoraceae* have a heavy, dense, and hard, often red timber, but none of them seems to be capable to withstand use in the open, except for the proper heart-wood of some mangroves which is said to be durable in the soil below the water level.

The timber of some inland genera seems to be of better quality for building purposes and cabinet work.

Mangrove timber is frequently used for short time purposes, poles in fisheries, piles for mining, for tobacco drying sheds, *etc.*

Its main use is for fire-wood, fuel in locomotives, *etc.* and for making charcoal. Chinese coastal people in Malaya and Sumatra (*e.g.* on Rupat Isl. near Bengkalis and in Aru Bay) are using large, stone-built permanent kilns of which the filling and burning takes one month, one filling delivering nearly 8000 piculs charcoal. NOAKES described the charcoal industry in the Matang mangrove and recorded that the art of building good brick kilns was introduced by the Siamese (Mal. For. 13, 1950, 80–83).

The bark of nearly all species of mangrove species is used for tanning purpose (bakau: *Rhizophora*, *Bruguiera;* tĕngar: *Ceriops*) and may contain up to more than 40% tanning substance in air-dry bark. The tannin is sometimes extracted and concentrated into cutch. In general the impression of HEYNE is (Nutt. Pl. 1927, 1162 *seq.*) that the quality of the tan is less good than that derived from *Acacia* bark, partly caused by the red colour of leather tanned with bakau bark. The bark is also used for tanning nets and fishing lines but is not judged of excellent quality. Large studies on the use of mangrove have been published by R. WIND (Med. Proefst. Boschwezen Ned. Ind. *no* 9, 1924) and T. A. BUCKLEY (Publ. Dep. For. Malaya *no* 7, 1929).

Tĕngar bark is also used for the purpose of dyeing, phlobaphene colouring-matter being associated with the tan, and has been used in the batik industry; it is preferred for black colours to *Melastoma*.

For more details and for minor uses (as food or medicinal purposes) see under the species.

The mangrove forests are of distinct value for the timber industry in the widest sense for various reasons: species are few and gregarious, the terrain is not fit for many other purposes (save in some cases for fish-ponds[1], the coastal situation near large towns and harbours needing timber and fuel is favourable, and extraction and transport is relatively easy.

The total surfaces covered by mangrove are rather considerable; in Malaya (West Coast) estimated at

(1) In North Java these fish-ponds ('tambaks') cover *c.* 75.000 ha.

about 1400 sq. km, in Riouw-Indragiri at 1750 sq. km, in Papua the area from the Purari mouth to the Turama River is estimated to contain 800–1200 sq. km mangrove forest.

The stands are often heavy: a good mangrove forest may contain in certain cases, according to MERRITT (in Mindoro) 500–1000 trees per ha 10–30 cm thick and 6–14 m high. In Subuguey Bay (Mindanao) FOXWORTHY found in 1912 old stands to contain the enormous amount of 300–650 m^3/ha (stacks), and also in Mindanao he found virgin mangrove forest to contain 149 trees per ha over 25 cm diam. with a cubic content of 130 m^3/ha. According to WATSON (*l.c.* p. 167) the average yield of 250 m^3/ha (stacks) is optimistic for future yield of productive areas; in Riouw it is according to JONKER (Tect. 26, 1933, 730) 100–200 m^3; planted forest 40 years old would yield 400 m^3.

The rotation period in Malaya was originally estimated at 20 years, later 40 years, but the latest and obviously final working plan by NOAKES is set at 30 years.

Cutting and management of mangrove must be planned from place to place in accordance with available rejuvenation, the course of the creeks, occurrence of *Acrostichum* and *Acanthus* which may hamper upgrowth of seedlings or sometimes be favourable for nursing them. Care should be taken that a felling is not followed by a succession of the inferior *Avicennia* or *Bruguiera parviflora*. Sometimes it is advisable to leave seed trees ('standards'). The planting of mangroves can be performed both by using young seedlings or fruits (DE JONG, Tect. 27, 1934, 290). Extraction of timber is sometimes done by rail but mostly by water transport. Drainage ditches or canals are sometimes necessary for improving stands or specific composition.

KEY TO THE GENERA

Based on fertile material

1. Plants of mangrove forests. Seeds germinating in the fruit while the latter is still attached to the tree; hypocotyl protruding from the fruit.
 2. Calyx always 4–lobed. Petals entire, without appendages. Anthers multi-locellate, finally dehiscing with a large ventral valve . . . . **1. Rhizophora**
 2. Calyx 5–16-lobed. Petals 2-lobed, multifid, or with apical appendages. Anthers 4-locular, dehiscing with lengthwise slits.
  3. Calyx 8–16-lobed, lobes subulate-lanceolate, pointed. Petals bilobed or emarginate **2. Bruguiera**
  3. Calyx 5- or 6-lobed, lobes ovate or linear-oblong, acuminate or obtuse. Petals fringed with apical appendages or multifid.
   4. Calyx lobes ovate, 2½–3½ mm long. Petals less than ½ cm long. Stamens 10–12. Hypocotyl ridged . . . . **3. Ceriops**
   4. Calyx lobes linear-oblong, *c.* 15 mm long. Petals *c.* 1½ cm long. Stamens indefinite. Hypocotyl smooth . . . . **4. Kandelia**
1. Plants of inland habit. Seeds not germinating in the fruit when the latter is still attached to the tree.
 5. Leaves alternate, exstipulate. Styles free.
  6. Flowers usually polygamous, 4-merous. Fruits not winged. Leaves usually 3–5-plinerved. **5. Anisophyllea**
  6. Flowers bisexual, 3-merous. Fruit 3-winged. Leaves pinnate-nerved . . . **6. Combretocarpus**
 5. Leaves decussate, stipulate. Styles simple.
  7. Free part of the calyx divided to the base, inside glabrous in the lower part. Disk annular or cup-shaped surrounding the base of the style. Stamens attached to the disk. Stipules imbricate and overlapping.
   8. Fruits globose to ellipsoid, indehiscent. Seeds not embedded in a thin pulp. Petals erose, fimbriate, or fringed with filamentous appendages in the upper part. Stamens always twice the number of petals.
    9. Branchlets solid. Flowers usually in peduncled rarely in sessile cymes, pedicelled or not, not articulate. Petals erose or fimbriate. Persistent calyx lobes terminating the fruit . **7. Carallia**
    9. Branchlets hollow. Flowers in fascicles; pedicels with distinct articulation. Petals fringed with filamentous appendages. Persistent calyx lobes at the base of the fruit . . **8. Gynotroches**
   8. Fruits ovoid, dehiscent. Seeds embedded in a thin pulp (aril?). Petals entire. Stamens usually three or more times the number of petals . . . . **Crossostylis**[1]
  7. Free part of the calyx forming a distinct tube and divided only at the upper part; lower part of the tube hairy inside. Disk none. Stamens attached to the mouth of the calyx tube. Stipules flat, not imbricate . . . . **9. Pellacalyx**

KEY TO THE GENERA

Mainly based on vegetative characters

1. Leaves decussate. Stipules interpetiolar.
 2. Stipules imbricate, one margin of each free. Free part of the calyx not forming a tube or forming an obscure one much shorter than the lobes.
  3. Branchlets solid. Pedicel without articulation.

(1) See footnote on p. 448.

4. Leaves acute or pointed at the apex, lower surface usually with scattered black dots.
5. Leaf tip mucronate by the extending midrib. Trees supported by conspicuous stilt roots. Calyx lobes always 4. Anthers multilocellate . . . . **1. Rhizophora**
5. Midrib not mucronate. Stilt roots absent or occasional and small. Calyx lobes 5–16. Anthers 4-locular.
6. Flowers ebracteolate. Calyx lobes 8–16, lobes subulate-lanceolate, pointed. Petals fringed with white hairs on the margins sometimes also on the dorsal surface, each embracing 2 stamens. Mangrove trees . . . . **2. Bruguiera**
6. Flowers bracteolate. Calyx lobes 5 or 6(–7), lobes deltoid, acute to acuminate. Petals glabrous, each embracing 1 stamen. Inland trees . . . . **7. Carallia**
4. Leaves obtuse or slightly notched at the apex, lower surface without black dots.
7. Calyx lobes ovate, $2^1/_2$–$3^1/_2$ mm long. Petals entire, with 3 or many appendages at the apex. Stamens 10–12. Hypocotyl ridged. Stem-base flanged . . . . **3. Ceriops**
7. Calyx lobes linear-oblong, *c.* 15 mm long. Petals multifid without appendages. Stamens ∞. Hypocotyl smooth. Stem-base conical, not flanged . . . . **4. Kandelia**
3. Branchlets hollow. Pedicel with distinct articulation.
8. Fruits globose or subglobose, indehiscent. Seeds not embedded in a thin pulp. Upper part of the petals split into filamentous appendages. Stamens always twice the number of petals **8. Gynotroches**
8. Fruits ovoid, dehiscent. Seeds embedded in a thin pulp (aril?). Petals entire. Stamens usually three or more times the number of petals . . . . **Crossostylis**[1]
2. Stipules flat, not imbricate. Free part of the calyx forming a distinct tube much longer than the lobes . . . . **9. Pellacalyx**
1. Leaves alternate. Stipules none.
9. Leaves 3–5-plinerved, or at least (in *A. griffithii*) with a distinct regular intramarginal vein. Leaves without scale-like dots underneath. Flowers usually polygamous, 4-merous. Fruits not winged . . . . **5. Anisophyllea**
9. Leaves pinnate-nerved, intramarginal vein indistinct and irregular. Leaf surface underneath with very minute scale-like dots. Flowers bisexual, 3-merous. Fruit 3-winged . . **6. Combretocarpus**

1. RHIZOPHORA

LINNÉ, Gen. Pl. ed. 5 (1754) 202; Sp. Pl. (1753) 443; LAMK, Encycl. Méth. Bot. 6 (1804) 187; SALVOZA, Nat. Appl. Sc. Bull. Un. Philip. 5 (1936) 207; KEAY, Kew Bull. (1953) 121–127.—*Mangle* PLUKENET *ex* ADANS. Fam. 2 (1763) 445, *nom. illeg.*—*Mangium* RUMPH. *ex* SCOP. Introd. Hist. Nat. (1777) 218.—**Fig. 1–13.**

Trees. Stems supported by numerous, branched stilt-roots provided with a root cap; tap-root abortive. *Leaves* decussate, entire, coriaceous, petioled, usually black-dotted below, glabrous; midrib protruding at the tip into a (caducous) mucro; nerves and veinlets obscure beneath, visible or distinct above. Stipules lanceolate, more or less red when fresh. *Inflorescences* peduncled, simple or di- to trichotomously branched cymes. *Flowers* bisexual, bracteolate. *Calyx* deeply 4-lobed, coriaceous, accrescent and reflexed in fruit, surrounded at the base by cup-shaped bracteoles. *Petals* 4, lanceolate, caducous, inserted at the base of the disk. *Stamens* 8–12, sessile or with very short filaments, inserted on the margin of the crenulate disk; anthers areolate, elongated, pointed, triangular in cross section, multilocellate, opening with a large ventral valve. *Ovary* semi-inferior, 2-celled; each cell with 2 ovules; style obscure to 6 mm long, stigma simple or obscurely 2-lobed. *Fruits* ovoid with a granular or roughened surface. *Seeds* 1, very rarely 2–3. Cotyledons connate into a fleshy body continuous with but set off from the hypocotyl, in old fruits protruding from the fruit; *hypocotyl* clavate, elongate, perforating the apex of the fruit and falling out of it.

Distr. About 6(–?9) *spp.*, widely distributed along tropical coasts, throughout *Malaysia.*

Ecol. In coastal swamps and along tidal streams; the most important and widest spread of the man-

(1) The genus *Crossostylis* FORST. (*Haplopetalum* A. GRAY) has also been entered in the key though it is hitherto only recorded from Melanesia (Solomons, New Hebrides, New Caledonia, Fiji, and Samoa) as far east as the Marquesas in Polynesia. It might occur in East Malaysia.

Fig. 7. Forest of *Rhizophora apiculata* BL., with falling tide, at Pangkalan Susu, Aru Bay, in the estuary of the Besitang River, NE. Sumatra, April 1937.

grove genera. Several botanists have said that the *Rhizophoras* occur to the exposed sea-face; this is not so, and they are generally found well behind the *Avicennias*, which are the pioneers extending into the sea. Only *R. stylosa*, occurring on sandy reefs and sandy beaches, faces the open sea. The *Rhizophoras* make in Malaya about 70–90% of the stock of the mangrove belt, filling the estuaries with a closed forest of straight cylindric boles and compact ellipsoid crowns, raised commonly about 20 m from the ground; exceptional trees are sometimes over 30 m tall, with a clear bole of 25 m and a maximum diameter of 60 cm.

NOAKES (Work. Plan Matang 1952, 59) recorded that "regeneration is always present beneath mature bakau, whether or not there has been a regeneration felling, but little of it survives the final felling."

Morph. According to DOCTERS VAN LEEUWEN (Ber. Deut. Bot. Ges. 29, 1911, 476–478) the branching of the stilt-roots seems to be abnormal and caused by a Scolytid beetle damaging the root tips; above the hole one or more adventitious roots develop, the tips of which may be attacked in turn, and so forth, giving a sympodial branching.

Uses. The wood is used for timber, fire-wood, and the making of charcoal. The bark contains up to 30% tannin of its dry weight. BROWNE (1955, p. 297) cited some chemical analysis from bark which appears to contain high percentages of pentosans and furfurol, the ash consisting mostly of lime and $CaCO_3$.

In Java *Rhizophora* is sometimes planted along littoral fishponds for protecting the dykes and banks by the extensive root system.

Taxon. *Rhizophora* is subdivided into two sections:

1. *sect.* **Rhizophora.**—*sect. Mangle* BL. Bot. Mus. 1 (1849) 132.—Peduncles longer than the petiole, bi-trifid or dichotomously branched. Flowers pedicelled. Petals with involute and villous margins. Stamens 8, 4 epipetalous, 4 episepalous (in Malaysia *R. mucronata* and *R. stylosa;* type species: *R. mangle* L.).

2. *sect.* Aërope BL. Bot. Mus. 1 (1849) 134.—*Aerope* ENDL. *ex* RCHB. Nomencl. (1841) 171, *n.* 6618. —Peduncles shorter than the petiole, undivided. Flowers sessile. Petals flat, glabrous. Stamens normally 12, 4 epipetalous, 8 episepalous, in some flowers 1–2 of the latter absent by abortion (in Malaysia *R. apiculata;* type species: *ditto*).

Specific distinction.—As to the species of *Rhizophora* it is very clear that in the E. African–Indo-Australian area there are three well distinguished species. In the Atlantic Ocean tropics there are also three (other) good species (KEAY *l.c.*) which all occur also in the Caribbean as recently found by Dr JONKER.

Specific identification of the *Rhizophoras* of the Pacific Ocean as far West as Fiji is still unsatisfactory. Formerly it was held that there would be only *R. mangle* the area of which would then touch the areas of *R. mucronata* and *R. stylosa* in Fiji.

SALVOZA (*l.c.* 225) recorded in the Pacific *R. mangle* only from Hawaii as introduced!

In the Pacific Ocean he distinguished *R. brevistyla* SALV. (obviously closely allied to the Caribbean *R. harrisonii* (*cf.* KEAY; *non sens.* SALVOZA) from the Pacific coast of America.

The second species he distinguished in the Pacific basin, ranging from the Pacific coast of America westwards to Polynesia and Melanesia is *R. samoensis* SALV. put in the key close to *R. mangle.*

Finally he distinguished a third Pacific species *R. lamarckii* MONTR. from New Caledonia which he puts very close to *R. apiculata;* this is known only from very few specimens.

I have some doubt about these distinctions; it may well appear that two of the Caribbean species (*R. mangle* and *R. harrisonii*) occur also on the Pacific coasts of America (in slightly different forms).

It falls beyond the scope of this revision to make a closer study of the situation in the Pacific which should preferably be performed in a combined study of living plants and adequate herbarium material.

Nomencl. In the Species Plantarum LINNAEUS inserted 5 species among *Rhizophora*, 4 of which have later been transferred to *Bruguiera* and *Kandelia*, the only one remaining in *Rhizophora* being *R. mangle.* This is, consequently, the type species.

Under *R. mangle* there are several references, partly relating to Caribbean plants, partly to those from Malabar (*Pee-Kandel* RHEEDE). This mixture led also to the definition of *Rhizophora* as having 12 stamens (in *R. mangle* there are 8) obviously derived from the characters of *R. apiculata* (RHEEDE's plate).

KEAY in his careful study of the W. African species (Kew Bull. 1953, 124) records 2 specimens from the Linnean Herbarium, probably entered posterior to 1755: one is possibly *R. mangle*, the other *R. mucronata.* KEAY found good reason to typify *R. mangle* with the specimen in the SLOANE herbarium (BM) which is the basis of a reference mentioned by LINNAEUS.

KEY TO THE SPECIES

1. Inflorescences 2-flowered, shorter than the petiole, in the axils of leaf scars of last year's or season's growth. Bracteoles at the base of the flower completely connate, cup-shaped. Petals glabrous . . . . **1. R. apiculata**
1. Inflorescences 2–16-flowered, longer than the petiole, in the axils of the leaves on the twigs of current year's or season's growth. Bracteoles only connate at their base. Petals hairy.
   2. Style obscure or very short up to $1^1/_2$ mm . . . . **2. R. mucronata**
   2. Style filiform 4–6 mm . . . . **3. R. stylosa**

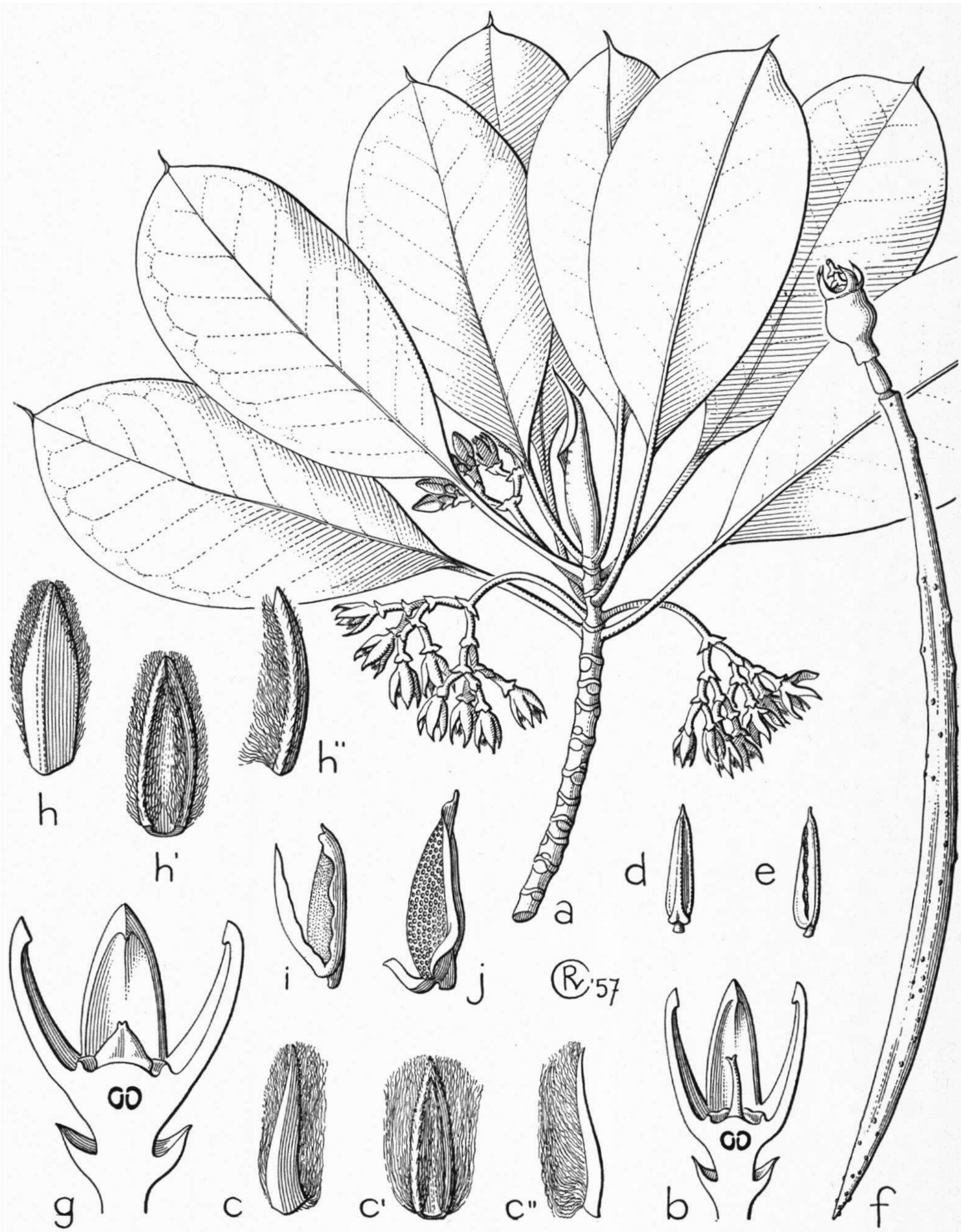

Fig. 8. *Rhizophora stylosa* GRIFF. *a.* Habit, × 2/3, *b.* lengthwise section of flower (petals and stamens removed), × 2, *c–c''.* petal from outside, inside, and laterally, × 3, *d.* stamen, × 3, *e.* opened stamen, × 3, *f.* fruit, × 1/2.—*Rh. mucronata* LAMK. *g.* Lengthwise section of flower (petals and stamens removed), × 2, *h–h''.* petals from outside, inside, and laterally, × 3, *i.* stamen, × 4, *j.* old stamen, × 4 (*a, c–e* JENSEN 239, *b* VAN STEENIS 971, *f* VAN STEENIS 17997, *g–j* CUADRA A 854).

1. Rhizophora apiculata BLUME, En. Pl. Jav. 1 (1827) 91; HOCHREUTINER, Candollea 2 (1925) 446; KANEHIRA, En. Micr. (1935) 377; SALVOZA, Nat. Appl. Sc. Bull. Un. Philip. 5 (1936) 229, t. 9; BACKER, Bekn. Fl. Jav. (em. ed.) 4b (1944) fam. 102, p. 5.—*Pee-Kandel* RHEEDE, Hort. Mal. 6 (1686) 61, t. 34.—*Mangium candelarium* RUMPH. Herb. Amb. 3 (1743) 108, t. 71 & 72.—*R. mangle* (*non* LINNÉ) [LINNÉ, Sp. Pl. (1753) 443, *pro syn.* RHEEDE] BLANCO, Fl. Filip. (1837) 397, ed. 2 (1845) 278, ed. 3, 2 (1878) 151, t. 135.—*R. candelaria* DC. Prod. 3 (1828) 32; W. & A. Prod. (1834) 310; DECAISNE, Herb. Timor. (1835) 124; GRIFF. Trans. Med. Phys. Soc. Calc. 8 (1836) 7, f. 1 & 3; Ann. Sc. Nat. Bot. 10 (1838) 121; TRIM. Fl. Ceyl. 2 (1894) 151; MERR. Philip. J. Sc. 9 (1914) Bot. 118; Int. Rumph. (1917) 387; BROWN & FISCHER, Bull. Bur. For. Philip. 17 (1918) 56, f. 27, reimpr. in BROWN, Min. Prod. Philip. For. 1 (1920) 68, t. 1 & 27; MERR. Sp. Blanc. (1918) 283; En. Philip. 3 (1923) 145; CRAIB, En. Siam. 1 (1931) 592.—*R. conjugata* (*non* LINNÉ) ARN. Ann. Mag. Nat. Hist. 1. (1838) 363; WIGHT, Ill. Ind. Bot. 1 (1840) 209; BL. Mus. Bot. 1 (1849) 134; MIQ. Fl. Ind. Bat. 1, 1 (1855) 584; Sum. (1861) 324; THWAITES, En. Pl. Zeyl. (1859) 120; KURZ, For. Fl. Burma 1 (1877) 447; HENSLOW in Hook. *f.* Fl. Br. Ind. 2 (1878) 436; F.-VILL. Nov. App. (1880) 79; HEMSL. Bot. Chall. 1, 3 (1884) 237; SCHIMP. Bot. Mitt. Trop. 3 (1891) 92, t. 5, f. 3; K. & V. Bijdr. 4 (1896) 282; KING, J. As. Soc. Beng. 66, ii (1897) 213; SCHIMPER in E. & P. Pfl. Fam. 3, 7 (1898) 52, t. 24A; MERR. Philip. J. Sc. 1 (1906) Suppl. 102; Fl. Manila (1912) 347; BACK. Schoolfl. (1911) 480; KOORD. Exk. Fl. Jav. 2 (1912) 668; Atlas 1 (1913) t. 101; GUILL. Fl. Gén. I.-C. 2 (1920) 724; RIDL. Fl. Mal. Pen. 1 (1922) 693; HEYNE, Nutt. Pl. (1927) 1168; WATSON, Mal. For. Rec. (1928) 27, 107, 185, t. 10, 11, 51; VAN DER MEER MOHR, Rec. Trav. Bot. Néerl. 26 (1929) 15–18, f. 1–2; GUILL. J. Arn. Arb. 12 (1931) 252; COSTERUS & SMITH, Bull. Jard. Bot. Btzg 42 (1932) 10; BROWNE, For. Trees Sar. Brun. (1955) 298.—**Fig. 1, 7, 11, 12.**

Tree up to over 30 m tall and 50 cm diam.; bole 10–12 m. Branching primarily sympodial. *Leaves* elliptic-oblong to sublanceolate, 7–18 by 3–8 cm, acute to apiculate, base cuneate; midrib ± tinged reddish beneath; petiole 1½–3 cm, tinged reddish. Stipules 4–8 cm long. *Inflorescences* 2-flowered, peduncle thick, ½–1½ cm. *Flowers* sessile, developing from the cupular involucre after the falling of the sustaining leaf, yellow; mature buds elliptic; 14 mm long; bracteoles at the base of the flower cup-shaped, fleshy, crenulate. *Calyx* lobes brown-yellow to reddish, ovate, concave, acute, 10–14 by 6–8 mm. *Petals* 8–11 by 1½–2 mm, lanceolate, glabrous, membranous, covering the epipetalous stamen only on the back. *Stamens* mostly 12, 4 epipetalous, and 4 pairs episepalous (sometimes 1 or 2 pairs with only 1 stamen), 6–7½ mm long, sessile, acute. Superior part of the ovary 1½–2½ mm high, enclosed by the disk, bluntly conical; style ½–1 mm, 2-lobed. *Fruit* obpyriform, rather rough, 2–2½ cm long, brown, the protruding part of the cotyledons red, 12–20 mm long. *Hypocotyl* cylindric-club-shaped, ± blunt, green with purple, up to 38 cm by 12 mm before falling.

Distr. Tropical SE. Asia (also Ceylon) throughout *Malaysia* to Micronesia (Marianes, Ponape, Guam, Yap) and New Britain.

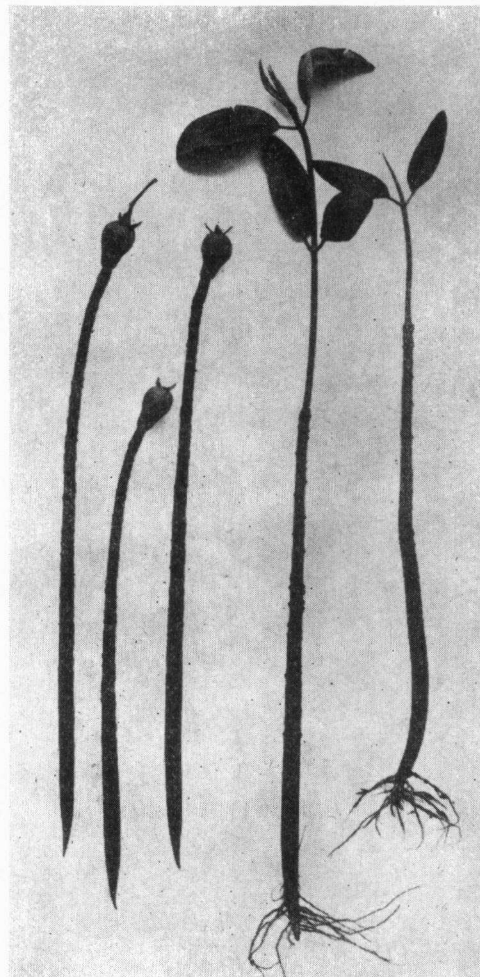

Fig. 9. Detached fruits with hypocotyls and seedlings of *Rhizophora mucronata* LAMK, E. Java, March 1914 (P. ARENS).

Ecol. Gregarious on deep soft mud of estuaries flooded by normal high tides and forming often 90% of the crop, avoiding bottoms which are harder and mixed with sand. Bark grey, with vertical fissures rather than horizontal, sometimes producing aerial roots from the branches. Crabs are sometimes, according to WATSON, a menace to the upgrowth of the seedlings by devouring or removing the bark of the seedlings until they are completely girdled or even bitten right through. In the Malay Peninsula judged to be a slow grower attaining 30 cm diam. in 35 years.

Uses. This most important species has red-brown, heavy, and hard heart-wood. The trees are standing in places very densely and make a pure forest up creeks and in estuaries behind the protecting belt of *Avicennia*. The timber of both *R. apiculata* and *R. mucronata* is used indiscriminately. A great advantage of *Rhizophora* in the eyes of fire-wood dealers is that it can easily be split. Besides it has a high caloric value.

Branched stilt-roots are used for anchors weightened by a stone.

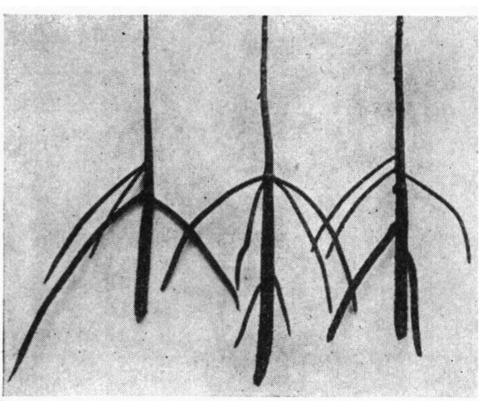

Fig. 10. Root system of young saplings of *Rhizophora mucronata* LAMK, E. Java, March 1917 (P. ARENS).

Vern. *Bakau minjak*, *b. tandok*, *b. akik*, *b' puteh*, *akik*, *akit*, Mal. Pen. & Sumatra, *bangka minjak*, Atjeh, *donggo akit*, N. Simalur, *bako*, *djankar*, J, *bakau minyak*, Born., *bangkita*, Sandakan, *kantar*, *hamu*, *lolaro*, Minah. (Alf.); Philippines: *bakáuan*, *bakáu*, Tag. & other lang., *bakáuan-babáe*, *b. lalaki*, *uakatan*, Tag., *bakád*, Sbl., *bakháu*, S. L. Bis., P. Bis., *bakkáuan*, Bik., *balbaro*, Pamp., *bangkau*, *lupá pulá*, Sulu, *kalamagus*, Bag.; *abat*, Ceram, *ailave*, *kailau*, Aru, *kaihu*, *parai*, Babo, *tonggong*, Blanche Bay, *kora*, Buin, *itasasa*, Fly R., *koriki*, Kiwai, *aua*, *akaka*, Akuna.

Notes. Many authors have for this species adopted the specific name *R. conjugata* L. (Sp. Pl. 1, 443) which was based on *Rhizophora, etc.* LINNÉ, Fl. Zeyl. (1748) 81, *no* 181. The type of the latter is an unpublished plate by HERMANN (t. 279) which is preserved in the Br. Mus.

Part of the plate is a flowering branch with two opposite flowers; each of them is in the leaf axil of the terminal node, which had led LINNAEUS to describe them as 'flowers in twins' (*calyces gemini*). It is unmistakably a *Bruguiera*, but it can hardly be identified with certainty whether it is *B. gymnorrhiza* or *B. sexangula*. TRIMEN (J. Linn. Soc. Bot. 29, 1888, 142) had identified the plate as *B. gymnorrhiza*. However, the tips of petals are obtuse and glabrous and quite similar to those of *B. sexangula*.

At the lower part of the flowering branch, an infructescence is drawn consisting of two 'cylindric, subulate, very long and nodding fruits' (*fructus cylindrici, subulati, longissimi, nutantes*). These two 'fruits' as described by LINNAEUS are actually hypocotyls of *Rhizophora*. One of the 'fruits' is detached from the pedicel and had been placed upside down. To which species they belong is uncertain.

In the Linnean Herbarium there is further a specimen which according to SAVAGE (Cat. 1945, 84) bears LINNAEUS's handwriting. It is sterile and provided with the doubtful locality 'Chin'; it has not yet been identified. It is neither a *Rhizophora* nor a *Bruguiera*. It does not agree with LINNAEUS's description of *R. conjugata* and it may have been added to his Herbarium after 1753. It can not serve for more precise typification.

Merely on the basis of literature and without having studied the drawing and specimen at London MERRILL has proposed to use *R. conjugata* L. as the basionym for what is called here *B. gymnorrhiza* (L.) LAMK (*cf.* Philip. J. Sc. 9, 1914, Bot. 118), with which BACKER (*l.c.* 7) and I disagree.

As *R. conjugata* L. is based on a drawing composed of flowers and fruits of two species of entirely different genera, the specific interpretation of which must remain distinctly uncertain by the inadequacy of the drawing, which has led in the past already to confusion and error, I reject it in agreement with Art. 65 and 66 of the 1956 Code.

VAN DER MEER MOHR (1929, *l.c.*) found near Medan three fruits each with two hypocotyls.

2. Rhizophora mucronata LAMK, Encycl. 6 (1804) 189; Tab. Encycl. Méth. Bot. 2 (1819) 517, t. 396, f. 2; DC. Prod. 3 (1828) 32; DECAISNE, Ann. Sc. Nat. n.s. 4 (1835) 75; ARN. Ann. Mag. Nat. Hist. 1 (1838) 362; WIGHT, Ic. 1 (1840) t. 238; BL. Mus. Bot. 1 (1849) 132; MIQ. Fl. Ind. Bat. 1, 1 (1855) 583; THWAITES, En. Pl. Zeyl. (1859) 120; BENTH. Fl. Austr. 2 (1864) 493; KURZ, For. Fl. Burma 1 (1877) 447; HENSLOW in Hook. *f.* Fl. Br. Ind. 2 (1878) 435; F.-VILL. Nov. App. (1880) 79; HEMSL. Bot. Chall. 1, 3 (1884) 149, 291; SEEM. Fl. Vit. (1890) 19; SCHIMP. Bot. Mitt. Trop. Jena 3 (1891) 92, t. 5, f. 7–8; TRIM. Fl. Ceyl. 2 (1894) 151; K. & V. Bijdr. 4 (1896) 278; KING, J. As. Soc. Beng. 66, ii (1897) 312; SCHIMP. in E. & P. Pfl. Fam. 3, 7 (1898) 52, f. 26, N–Q; BACK. Schoolfl. (1911) 481; MERR. Fl. Man. (1912) 347; KOORD. Exk. Fl. Jav. 2 (1912) 668; Atlas 1 (1913) t. 102; EWART & DAVIES, Fl. North. Terr. (1917) 199; MERR. Sp. Blanc. (1918) 283; BROWN & FISCHER, Bull. Bur. For. Philip. 17 (1918) 56, f. 28 & 29, reimpr. in BROWN, Min. Prod. Philip. For. 1 (1920) 68, t. 28 & 29; GUILL. Fl. Gén. I.-C. 2 (1920) 723, f. 75, 1–4; MERR. En. Born. (1921) 421; En. Philip. 3 (1923) 145; HEYNE, Nutt. Pl. (1927) 1169; WATSON, Mal. For. Rec. 6 (1928) 27, 106, 185, t. 8, 9 & 51; CRAIB, En. Siam. 1 (1931) 592; KANEHIRA, En. Micr. (1935) 377; Formos. Trees

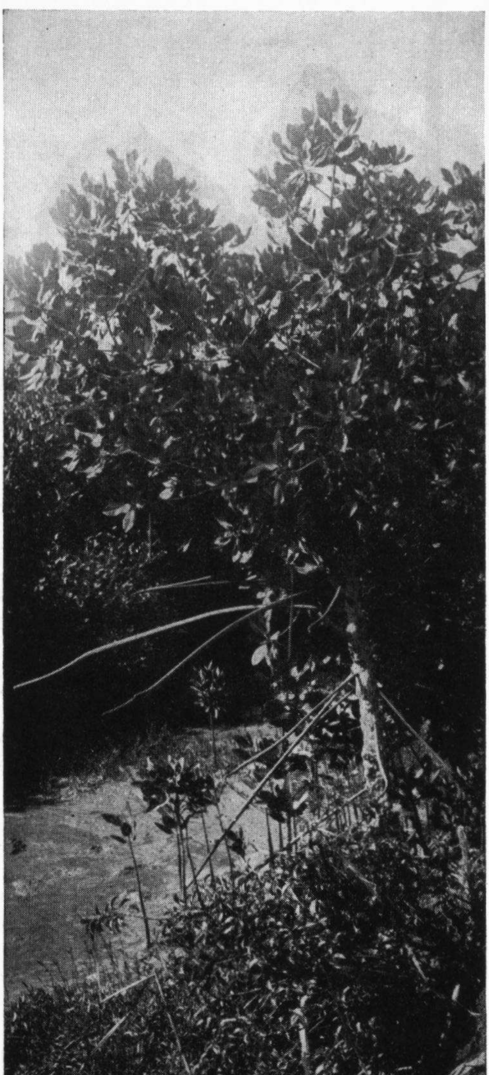

Fig. 11. Young but already fruiting tree of *Rhizophora apiculata* BL., showing the young, unbranched, straight aerial roots sticking out in the air, one of them already attacked by the beetle. Good regeneration by seedlings. E. Java, 1916 (JESWIET).

rev. ed. (1936) 496, f. 456; SALVOZA, Nat. Appl. Sc. Bull. Un. Philip. 5 (1936) 213, t. 4; HOLTHUIS & LAM, Blumea 5 (1942) 217; BACK. Bekn. Fl. Jav. (em. ed.) 4b (1944) fam. 102, p. 6; QUIS. Med. Pl. Philip. (1951) 653; WALKER, Import. Trees Ryukyu (1952) 235, f. 146; BLAKE, Austr. J. Bot. 2 (1954) 133; BROWNE, Forest Trees Sar. Brun. (1955) 298; LEWIS, Fl. Trop. E. Africa, Rhiz. (1956) 2, f. 1. — *R. mangle* (*non* LINNÉ) ROXB. Hort. Beng. (1814) 36; Fl. Ind. 2 (1832) 459; BL. En. Pl. Java 1 (1827) 91.—*R. macrorrhiza* GRIFF. Trans. Med. Phys. Soc. Calc. 8 (1836) 8, f. 2 & 4–7; Ann. Sc. Nat. Bot. II, 10 (1838) 122; Not. Pl. As. 4 (1854) 664.—*R. longissima* BLANCO, Fl. Filip. (1837) 398; ed. 2 (1845) 278; ed. 3, 2 (1878) 151.—*R. latifolia* MIQ. Sum. (1861) 324.—*R. mucronata var. typica* SCHIMP. Bot. Mitt. Trop. 3 (1891) 92; K. & V. Bijdr. 4 (1896) 279, 282; HOCHREUTINER, Candollea 2 (1925) 446.—**Fig. 1, 6d–h, 8g–j, 9–10.**

Tree up to 27 m tall, rarely over 30 m by 70 cm diam. Branching not distinctly sympodial. *Leaves* broad-elliptic to oblong, (8½–)11–18(–23) cm by 5–10½(–13) cm, apex ± blunt to ± acute, base cuneate; midrib green beneath; petiole 2½–5½ cm, green. Stipules 5½–8½ cm long. *Inflorescences* 2–3 times forked, each arm with an apical involucre, 2–5(–12)-flowered; peduncles 2½–5 cm; pedicels 4–8 mm. Free parts of the bracteoles at the base of the flower distinctly 2-lobed, lobes deltoid, acute or obtuse. Buds emerging from the bracteolar involucre long before the falling of the sustaining leaf. Mature buds widest near the base. *Calyx* 13–19 mm long, deeply lobed, lobes ovate, in anthesis pale yellow, *c.* 13–15 by 5–7 mm. *Petals* 9 mm long, densely hairy along the margins, partly clasping the epipetalous stamen with these margins, sparsely hairy on the back, hairs up to 3 mm. *Stamens* 8, sessile, 4 epipetalous, 4 episepalous, anthers 6–8 mm long. Free part of the ovary high-conical, in anthesis already emerging far beyond the disk, 2½–3 mm high; style ½–1½ mm, 2-lobed. Mature *fruit* elongate ovoid, with hardly contracted apex and often rugose base, dull brown-green, 5–7 by 2½–3½ cm; cotyledons 2–4 cm protruding; mature cotyledons green; *hypocotyl* cylindric, strongly rugose, 36–64 by 1¾ cm.

Distr. On the coasts of Old World tropics: East Africa, Madagascar, Seychelles, Mauritius, SE. Asia, Riukiu, throughout *Malaysia* to N. Australia, Melanesia (Fiji, New Caledonia, New Hebrides), and *Micronesia* (Guam, Palau, Ponape, Ogiwal), introduced in Hawaii (SALVOZA, *l.c.*).

Ecol. In similar localities as *R. apiculata* but more tolerant for sandy and firmer bottoms. Generally gregarious near and on the banks of tidal creeks and in estuaries, seldom more than a few chains from tidal water; optimal development with rather deep inundation classes and soils rich in humus and somewhat firmer than those of *R. apiculata*. Bark dark, almost black, with horizontal fissures (WATSON). Occasionally planted along coastal fish-ponds for protecting the banks.

Crabs are great enemies to seedlings and damage plantations when they are made. It has been found in the Philippine Islands that seedlings dried for several days in the shade, before planting are more or less spared by them; BURKILL queries whether the arrest of growth due to this unnatural drying can have led to an accumulation of protecting tannin in the tissues.

Uses. The timber is used for fuel and charcoal. The heart-wood is dark orange-red. The bark is rich in tannin, used for tanning and dyeing, and occasionally medicinally in cases of haematuria. In Malaya the poles are in considerable demand

Fig. 12. Well developed *Rhizophora apiculata* BL., with its cone of branched stilt-roots. Rantau Pandjang, E. Sumatra (H. H. TH. SCHREUDER).

for piling and for frames of houses in and about the swamps; for fish-traps, being preferred over other available trees in certain localities; and particularly for firewood. The bark is rich in tannin, associated with which is a substance darkening gradually. It served as a deep brown or black dye (samak bakau) and its chief function was to toughen fishing-lines and ropes, for which *Ceriops* bark is preferable. See for the cutch industry BURKILL, p. 1898–1902.

Fig. 13. *Rhizophora stylosa* GRIFF. at low tide between granite boulders on the quartz sand beach of the islet P. Tandjung Suka, Anambas Isl., April 1928.

Vern. *Bakau bĕlukap, b. gĕlukap, b. jangkar, b. hitam, b. kurap, b. mèrah, bĕlukap*, Mal. Pen., *bangka itam, b. u*, Atjeh, *dongoh korap*, N. Simalur, *bakau itam, b. korap, b. mèrah*, M, *bako, djankar*, J, *lĕnggayong*, S.; Celebes: *bĕlukap*, Bugin., *lolaro*, Manado; Philippines: *bakáuan-babáe*, Tag. (common name), *bakáu* (many lang.), *bakháu*, C. Bis., *bangkáu*, Tag.; *nanàsi ésatá*, Karakelong; New Guinea: *koriki*, Daru, *pabo*, Babo, *togo* (for fruit), *tortor*, Kanosia, *totoa*, Motu, *kamo*, Binandele, *kui*, Hagen.

Note. RAJAGOPALAN & NATARAJAN found (J. Bomb. Nat. Hist. Soc. 50, 1952, 684–685) ten fruits with 2 and one with 3 hypocotyls.

3. Rhizophora stylosa GRIFF. Not. Pl. As. 4 (1854) 665; Ic. 4 (1854) t. 640; BACK. Schoolfl. (1911) 482; RIDL. Fl. Mal. Pen. 1 (1922) 693; BACK. Bekn. Fl. Jav. (em. ed.) 4b (1944) fam. 102, p. 6. —*R. mucronata var. stylosa* SCHIMP. Bot. Mitt. Trop. 3 (1891) 92; K. & V. Bijdr. 4 (1896) 279, 282; GUILL. J. Arn. Arb. 12 (1931) 252; SALVOZA, Nat. Appl. Sc. Bull. Un. Philip. 5 (1936) 218, t. 5.—**Fig. 5, 8a–f, 13.**

Small tree up to 10 m tall; branching not primarily sympodial. *Leaves* broadly elliptic, 6½–12½ by 3½–6½ cm, apex blunt, base cuneate, midrib green; petiole 2½–3½ cm, green. Stipules 4–6 cm long. *Inflorescences* 3–4 times forked, each arm with an apical bracteolar involucre, (4–)5–8(–16)-flowered; peduncle 2½–5 cm; pedicels ½–1 cm. Buds emerging from the involucre long before the falling of the sustaining leaf. Mature buds widest near the base. *Calyx* in anthesis pale yellow, lobes 9–12 by 3–5 mm. *Petals c.* 8 mm long, densely villose along the margins rarely also on the back, partly enclosing the epipetalous stamen with these margins, hairs 3–6 mm. *Stamens* 8, 4 epipetalous, 4 episepalous, anthers 5–6 mm long, apiculate, filament distinct, short. Superior part of the ovary *depressed-conical, in anthesis enclosed by the disk, hardly 1½ mm high; style* filiform *4–6 mm*, shortly and obscurely 2-toothed. Mature *fruit* obpyriform, with *strongly contracted* apex, *not rugose*, brown, 2½–4 by 1¾–2½ cm; cotyledons emerging for 1½–2½ cm from the calyx,

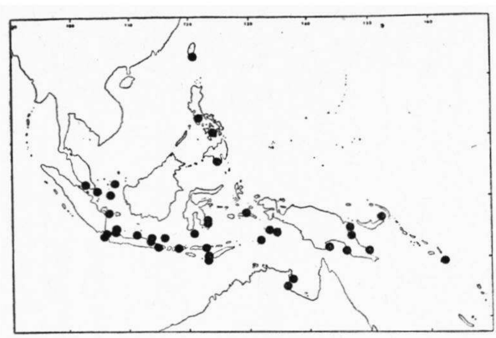

Fig. 14. Localities of *Rhizophora stylosa* GRIFF.

green; *hypocotyl* cylindric, up to 54 cm by 12–16 mm before falling.

Distr. Formosa, throughout *Malaysia:* Philippines, Java, Malay Peninsula, Celebes, Moluccas, New Guinea, to Melanesia (Solomon Isl., Fiji), New Britain, and N. Australia. Fig. 14.

Ecol. Exclusively along sandy shores and coral terraces, facing the open sea, obviously better resisting the surf than the other species.

Excluded

Rhizophora aegiceras GMELIN, Syst. 1 (1791) 747, based on RUMPH. Herb. Amb. 3, t. 82 = *Aegiceras corniculatum* (L.) BLANCO, *cf.* MERR. Int. Rumph. (1917) 413 (*Myrsinac.*).

Rhizophora caseolaris LINNÉ in Stickman, Herb. Amb. (1754) 13, based on RUMPH. Herb. Amb. 3, t. 74 and 73 = *Sonneratia caseolaris* (L.) ENGL. and *S. alba* J. SM., *cf.* BACK. & STEEN. Fl. Mal. I, 4 (1951) 283, 285 (*Sonneratiac.*).

Rhizophora conjugata L. Sp. Pl. 1 (1753) 443 = mixture of different plants and is here rejected, *cf.* p. 453.

Rhizophora corniculata LINNÉ in Stickman, Herb. Amb. (1754) 13; Amoen. Acad. 4 (1759) 123, based on RUMPH. Herb. Amb. 3, t. 77 = *Aegiceras corniculatum* (L.) BLANCO, *cf.* MERR. Sp. Blanc. (1918) 299 (*Myrsinac.*).

Rhizophora obtusa DENNST. Schlüss. Hort. Mal. (1818) 15, 24, 32, based on RHEEDE, Hort. Mal. 6, t. 36 = *Aegiceras* (*Myrsinac.*).

2. BRUGUIERA'

LAMARCK, Tabl. Enc. Méth. (1793 ? or 1797) t. 397; Encycl. Méth. Bot. 4 (1797 or 1798 ?) 696; ARN. Ann. Mag. Nat. Hist. 1 (1838) 365; BLUME, Mus. Bot. 1 (1849) 135; MIQ. Fl. Ned. Ind. 1, 1 (1855) 585–590, *incl. sect. Mangium et Kanilia*; WYATT-SMITH, Mal. For. 16 (1953) 156–181; DING HOU, Nova Guinea n.s. 8 (1957) 164; *non* THOUARS, Gen. Nov. Madag. (1806), *quae est Lumnitzera* (*Combret.*).—*Paletuviera* THOUARS *ex* DC. Prod. 3 (1828) 32.— *Kanilia* BL. Mus. Bot. 1 (1849) 140.—**Fig. 6a-b, 15-23.**

Buttressed trees up to 40 m, with kneed pneumatophores, sometimes with aerial roots when young. *Leaves* decussate, entire, usually coriaceous, glabrous, black-dotted beneath, petioled. Stipules lanceolate, 2–4 cm long, glabrous. *Flowers* bisexual, ebracteolate, articulated at the base with the pedicel, solitary or in 2–5-flowered, peduncled cymes. *Calyx* coriaceous, accrescent, 8–14(–15)-lobed, lobes subulate-lanceolate, acute. *Petals* each embracing a pair of stamens, 2-lobed rarely emarginate, caducous. Disk distinctly cup-shaped and adnate to the calyx tube. *Stamens* twice the number of petals, paired, epipetalous, filaments filiform, unequal in length; anthers linear. *Ovary* inferior, adnate to the lower part of the calyx tube, 2–4-celled, each cell with 2 ovules; style filiform, stigma obscurely 2–4-lobed. *Fruit* included in or adnate to the calyx tube, usually 1-celled, 1(–2)-seeded; cotyledons connate at the base; hypocotyl terete or obscurely ribbed, blunt, perforating the apex of the fruit and falling with it.

Distr. Species 6, widely distributed from tropical East Africa (*B. gymnorrhiza*) to Asia, throughout *Malaysia* to Australia, and Polynesia (*B. gymnorrhiza* to Samoa, and the Marshall Isl.).

Ecol. In tropical mangrove forests, ascending tidal parts of rivers. *Bruguieras* grow in less frequently inundated situations than the *Rhizophoras*, and rely to a greater extent (*B. cylindrica* probably almost entirely) on distribution by surface water following heavy rains. *B. parviflora* is less discriminating than any other mangrove species and forms pure crops under a great variety of conditions.

The calyx falls with the fruit but becomes soon detached, except in *B. parviflora.*

Uses. The wood is seldom used for timber, but is profusely used for fuel and charcoal; the bark is less suitable for tanning than that of *Rhizophora.*

Fig. 15. Fullv developed *Bruguiera* forest at Nusa Kambangan, S. Central Java, with Prof. SKOTTSBERG standing amidst the luxuriant regeneration, 1929 (JESWIET).

Fig. 16. Stem-base with knee-roots of *Bruguiera cf. gymnorrhiza* (L.) LAMK. Nusa Kambangan (JESWIET).

Taxon. BLUME, *l.c.* 140, segregated the many-flowered species from those with solitary flowers and established the former group as a new genus *Kanilia*. MIQUEL, *l.c.* 588, reduced *Kanilia* to a section of *Bruguiera*, dividing the genus into two sections *Mangium*. MIQ. and *Kanilia* (BL.) MIQ. which he distinguished chiefly by the shape of the calyx tube, the anthers, and number of floral parts. Through the recently described *B. hainesii* and *B. exaristata* the distinction between these sections is obscured and they should in my opinion be omitted.

Note. In his Schlüss. Hort. Mal. (1818) DENNSTEDT gave three indexes, the first containing RHEEDE's vernacular names with their Latin equivalents, the second giving the Latin plant names with references to RHEEDE's work, the third tabulating RHEEDE's plates, volume by volume and plate by plate, with their Latin equivalents. In the third index a genus name has not been repeated for successive species and has from the second species onwards been indicated by a dash indicating the repetition. This has led to an error under *Bruguiera* on p. 32 of the 'Schlüssel' where tab. 31–32 = *Bruguiera gymnorrhiza* is followed by tab. 33–36 with four *Rhizophoras* but where the generic name *Rhizophora* has been omitted and erroneously been replaced by a dash, which formally consequently refers to *Bruguiera*. From this omission it can not be concluded that DENNSTEDT's intention was to reduce the genus *Rhizophora* to *Bruguiera* as the lists further agree *inter se*. In case DENNSTEDT made a new combination in his 'Schlüssel' he added consistently '*mihi*'; this was not done here except for his new species *Rhizophora obtusa*. Therefore, it cannot be inferred that he actually made four new combinations under *Bruguiera*.

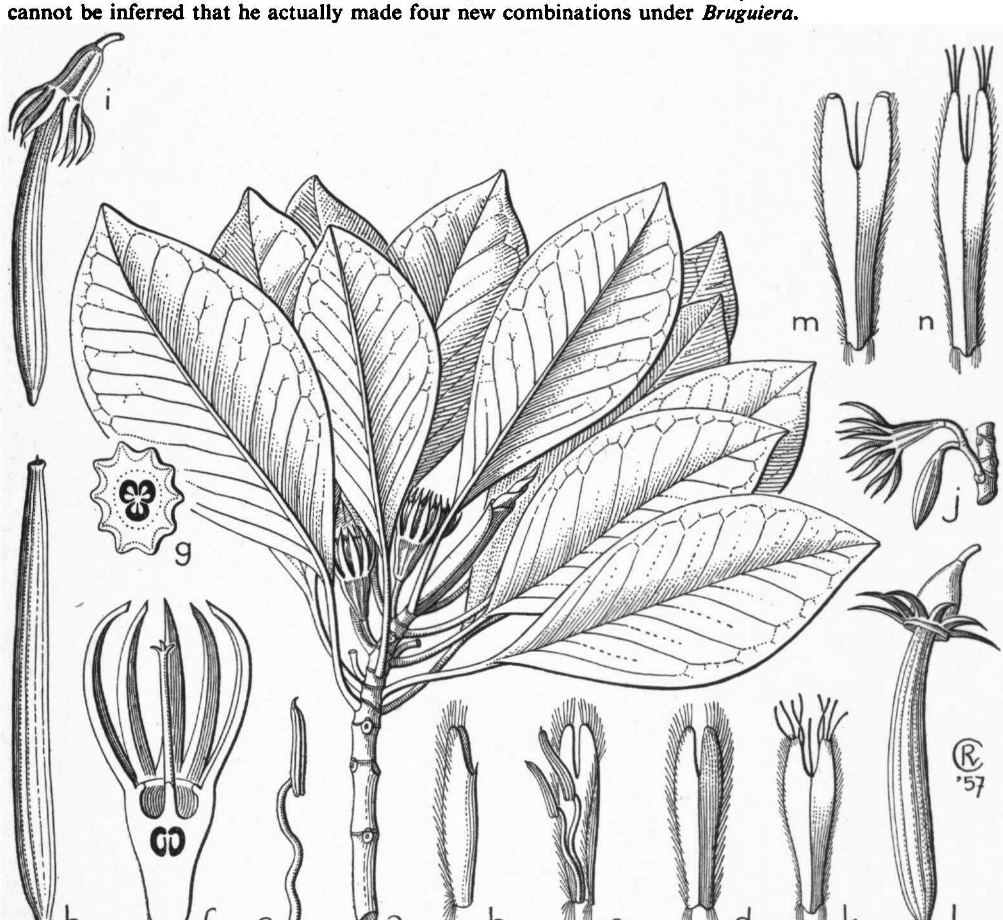

Fig. 17. *Bruguiera exaristata* DING HOU. *a*. Habit, × ²/₃, *b–d*. petals, lateral, ventral (with 2 stamens), and dorsal, × 3, *e*. stamen, × 3, *f*. lengthwise section of flower (petals and stamens removed), × 2, *g*. cross-section of ovary, × 2, *h–i*. hypocotyls, × ²/₃.—*Br. hainesii* ROGERS. *j*. Flower beyond anthesis, × 3, *k*. petals from outside, × 3, *l*. hypocotyl with calyx, × ²/₃.—*Br. sexangula* (LOUR.) POIR. *m*. Petal, from outside, × 3.—*Br. gymnorrhiza* (L.) LAMK. *n*. Petal, from outside, × 3 (*a*, *e–i* BRASS 808, *b–d* VAN ROYEN 4826, *j*, *l* SYMINGTON CF 51661, *k* F.M.S. 3, *m* KOORDERS 6293, *n* HOOGLAND 4182).

KEY TO THE SPECIES

1. Flowers solitary. Bristle in the sinus between the petal lobes not exceeding the lobe tips or minute to absent.
2. Tips of the petal lobes acute, each with 3 or 4 bristles 2–3 mm long, distinctly exceeding the lobe tips . . . . 1. **B. gymnorrhiza**
2. Tips of the petal lobes obtuse, without or each with 1 or 2, rarely 3 short bristles usually less than $1^1/_4$ mm, not or hardly exceeding the apex.
3. Leaves usually elliptic-oblong, flat, 8–13 by 3–6 cm, base acute to obtuse. Petals 13–15 mm long, the lobe tips with 1–3 bristles usually less than $1^1/_4$ mm; a distinct bristle in the sinus between the lobes. . . . . 2. **B. sexangula**
3. Leaves usually obovate (rarely elliptic), with revolute margins, 5–$9^1/_2$ by 3–$4^1/_2$ cm, base acuminate. Petals 9–11 mm long, exaristate, without (or very rarely with an obscure) bristle in the sinus of the lobes . . . . 3. **B. exaristata**
1. Peduncles 2–5-flowered (in some specimens of *B. hainesii* a few solitary flowers have been observed along with 2–3-flowered peduncles). Bristle in the sinus of the petal lobes far exceeding the lobe tips.
4. Calyx lobes $^1/_4$–$^1/_5$ the length of the calyx, erect or slightly spreading in fruit. Petals $1^1/_2$–2 mm long . . . . 4. **B. parviflora**
4. Calyx lobes half length of the calyx, reflexed in fruit. Petals 4–9 mm long.
5. Mature flowers 10–12 mm long. Petals 3–4 mm long. Calyx tube 2 mm diam., lobes 8, completely reflexed in fruit. . . . . 5. **B. cylindrica**
5. Mature flowers 18–22 mm long. Petals 7–9 mm long. Calyx tube 5 mm diam., lobes 10, patent at right angles in fruit . . . . 6. **B. hainesii**

1. **Bruguiera gymnorrhiza** (L.) LAMK, Encycl. Méth. Bot. 4 (1797 or 1798?) 696; Tabl. Encycl. Méth. 2 (1819) 517, t. 397 (as *gymnorhiza*); BL. En. Pl. Jav. 1 (1827) 92; Mus. Bot. 1 (1849) 136, *incl. var. palun;* MIQ. Fl. Ind. Bat. 1, 1 (1856) 586; THWAITES, En. Pl. Zeyl. (1859) 120; KURZ, For. Fl. Burma 1 (1877) 450; HENSLOW in Hook. *f.* Fl. Br. Ind. 2 (1878) 437; SCHIMP. Bot. Mitt. Trop. 3 (1891) 95, t. 5, f. 1; TRIM. Fl. Ceyl. 2 (1894) 153; K. & V. Bijdr. 4 (1896) 292; KING, J. As. Soc. Beng. 66, ii (1898) 314; BACK. Schoolfl. (1911) 484; KOORD. Exk. Fl. Java 2 (1912) 668; Atlas 1 (1913) t. 103; GUILL. in Fl. Gén. I.-C. 2 (1920) 728, f. 75, 16–17; EWART & DAVIES, Fl. North. Terr. Austr. (1917) 200; COSTERUS & SMITH, Ann. Jard. Bot. Btzg 33 (1923) 81; HOCHREUTINER, Candollea 2 (1925) 448; WATSON, Mal. For. Rec. (1928) 42, 108, t. 12; BACK. Bekn. Fl. Jav. (em. ed.) 4b (1944) fam. 102, p. 7; WYATT-SMITH, Mal. For. 16 (1953) 157, f. 1; BROWNE, For. Trees Sar. & Brun. (1955) 301; DING HOU, Nova Guinea, n.s. 8 (1957) 164.—*Kandel* RHEEDE, Hort. Mal. 6 (1686) 57, t. 31, not t. 32.—*Mangium celsum* RUMPH. Herb. Amb. 3 (1743) 120, t. 68. —*Mangium minus* RUMPH. Herb. Amb. 3 (1743) 106, t. 69, *excl. fl. et fig.* A–B.—*Rhizophora gymnorhiza* LINNÉ, Sp. Pl. (1753) 443; WILLD. Sp. Pl. 2, 2 (1800) 843.—*Rhizophora palun* DC. Prod. 3 (1828) 33.—*B. rheedii* BL. En. Pl. Jav. 1 (1827) 92; ARN. Ann. Mag. Nat. Hist. 1 (1838) 367; BL. Mus. Bot. 1 (1849) 138; WIGHT, Ill. Ind. Bot. (1860) 210; Ic. 1 (1839) t. 239A, 1–8.—*Rhizophora tinctoria* BLANCO, Fl. Filip. (1837) 394. —*Rhizophora rheedii* STEUD. Nomencl. 2 (1841) 449.—*B. capensis* BL. Mus. Bot. 1 (1849) 137.—*B. wightii* BL. *op. cit.* 138.—*B. rumphii* BL. *op.cit.* 138.—*B. zippelii* BL. *op. cit.* 139, *incl. var. oblongifolia* BL.—*B. cylindrica* (*non* BL.) HANCE, J. Bot. 18 (1879) 10; ENGLER, Bot. Jahrb. 6 (1885) 63; FORBES & HEMSL. J. Linn. Soc. Bot. 23 (1887) 293.—*B. conjugata* (*non Rhizophora conjugata* L.) MERR. Philip. J. Sc. 9 (1914) Bot. 118; Int. Rumph. (1917) 388; Sp. Blanc. (1918) 284; GAMBLE, Fl. Madras pt 3 (1919) 458; BROWN, Min. Prod. Philip. For. 1 (1920) 52, t. 18; MERR. En. Born. (1921) 421; En. Philip. 3 (1923) 146; COSTERUS & SMITH, Ann. Jard. Bot. Btzg 42 (1932) 10; CHRISTOPH. Bull. Bish. Mus. 128 (1933) 155; CRAIB, Fl. Siam. En. 1 (1931) 595; KANEHIRA, En. Micr. (1935) 376; MERR. Comm. Lour. (1935) 282; BURK. Dict. 1 (1935) 373; KANEHIRA, Form. Trees, rev. ed. (1936) 491, f. 453; HOLTHUIS & LAM, Blumea 5 (1942) 217; WALKER, Import. Trees Ryukyu Isl. (1952) 232, f. 144.—**Fig. 16, 17n.**

Buttressed tree up to 36 m by 40–65 cm. Branching mostly sympodial. Bark grey to almost black, roughly fissured, usually with large corky lenticels on buttresses and base of stems. *Leaves* elliptic-oblong, coriaceous, $8^1/_2$–22 by ($4^1/_2$–)5–7(–9) cm, acute, base cuneate, rarely obtuse; nerves 9–10 pairs, visible beneath, obscure above; petiole 2–$4^1/_2$ cm, pruinose, often reddish. Stipules *c.* 4 cm long, often reddish. *Flowers* in anthesis 3–$3^1/_2$ cm long, generally nodding; pedicel 1–$2^1/_2$ cm, pruinose, bright red on the outside curve. *Calyx* red to pink-red, lobes (10–)12–14(–16), usually $^2/_3$ the length of the calyx, obliquely ascending in fruit, tube usually ribbed at the upper part. *Petals* 13–15 mm long, lobe $^1/_3$–$^1/_2$ the length of the petal, acute, each with 3 or 4 bristles 2–3 mm exceeding the tip, outer margins fringed with white silky hairs especially at the base, rarely the upper part glabrous. *Stamens* 8–11 mm long, anthers linear, 4–5 mm. Style *c.* 15 mm, angular towards the base; stigmatic arms 3–4, filiform, $^1/_2$–$1^1/_4$ mm. *Fruit* not ribbed, 2–$2^1/_2$ cm long. Seeds 1(–2). *Hypocotyl* cigar-shaped, slightly angular, with a blunt narrowed apex, 15–25 by $1^1/_2$–2 cm.

Distr. Tropical South and East Africa, Madagascar, Seychelles, Ceylon, SE. Asia, Riukiu; throughout *Malaysia*, to Australia, Micronesia (Palau, Yap, Marshall Isl., &c.), and Polynesia (Samoa, Fiji).

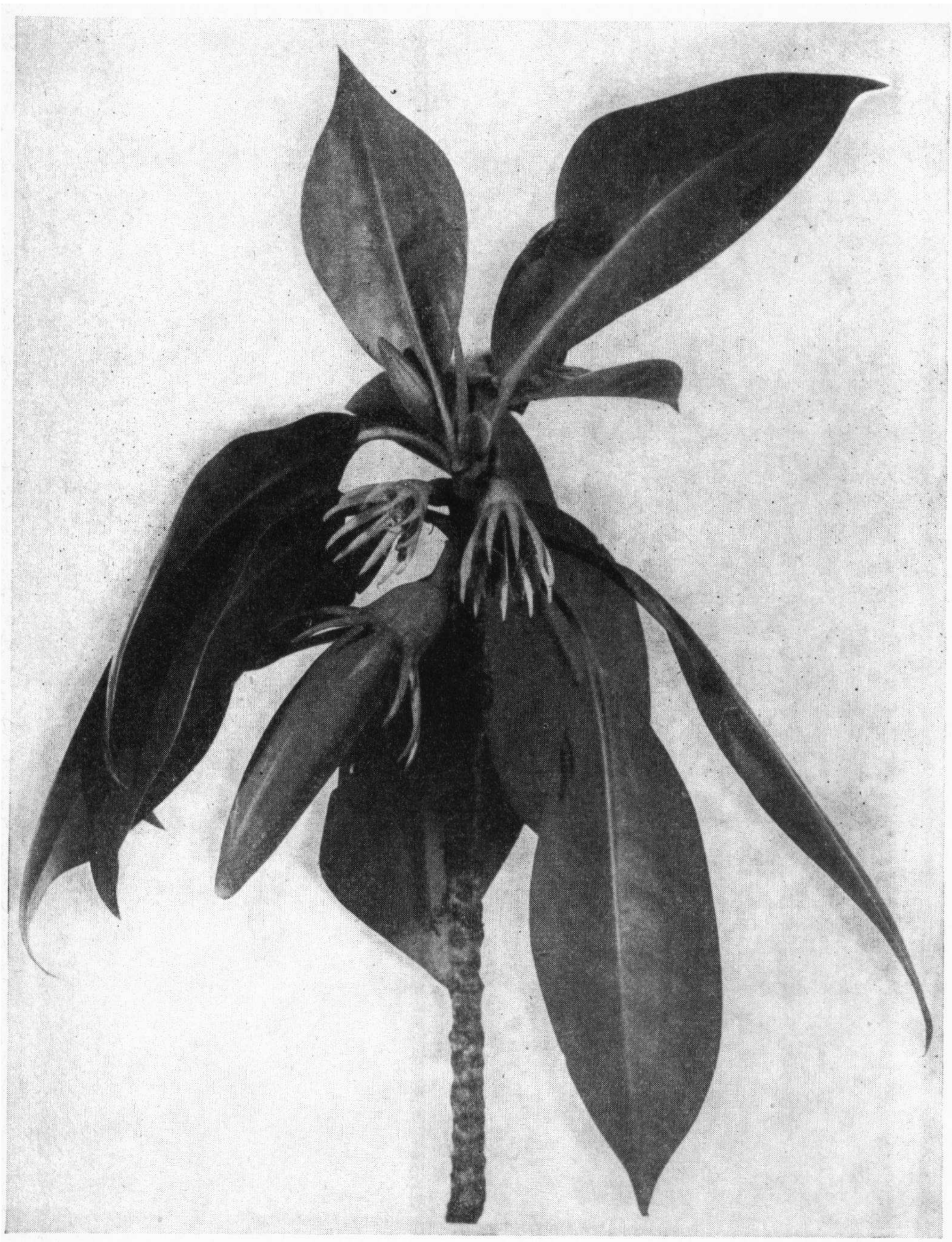

Fig. 18. *Bruguiera sexangula* (LOUR.) POIR. (KEBUN RAJA INDONESIA).

Ecol. One of the largest trees of the mangrove, as a rule on somewhat dry, well aerated soil towards the landward side, often dominating as a tall forest with occasional stems up to 36 m by 65 cm. In the interior of islands it is sometimes pure but more often associated with *R. apiculata*. On the seaface it is only found following erosion.

B. gymnorrhiza marks the final stage in the development of the littoral forests and the beginning of the transition to ordinary inland types. It is the largest and probably the longest lived of the mangroves. It can stand any amount of shade and is frequently able to establish itself in pure bakau stands when the shade is too dense for *Rhizophora* seedlings to develop. WATSON considers it a 'cuckoo species', leaving the nursing of its progeny to be carried out by others. After felling its regeneration is often very scant or absent and there is danger of overgrowth by *Acrostichum*, but once seedlings have established themselves the fern acts rather as a nurse, forcing the seedlings up.

Uses. The red, hard timber is used for fire-wood and for charcoal, less so for piles, house-posts and rafters. RUMPHIUS says that the leaves and peeled hypocotyls are eaten in the Moluccas after having been soaked in water and boiled, which he deems a poor food.

In Djakarta the starchy central part of the hypocotyls is treated with sugar and the sweet-meat sold as 'manisan kandéka'. The fruits are sometimes used as an adstringent in the betel-quid, when not anything better is available.

Vern. *Bakau bĕsar*, *bĕtut*, *tumbus*, *tumu*, *t. mèrah*, *tumus*, Mal. Pen., *pĕrtut*, Atjeh, *taheup*, N. Simalur, *tĕnggĕl*, Simalur (Tapah), *putut*, *tumu*, Sum. E. C., *tomo*, Palemb., *kutit*, *putut*, Sarawak, *kandéka*, M (Djak.), *tandjang*, J, *lindur*, Md, *sala-sala*, Bugin.; Philippines: *potótan*, Tag. & various lang., *bakáuan*, *busling*, *petútan*, Tag., *busain*, Tag., Bik., *potútan*, Tag., S. L. Bis., *putútan*, Tag., Ibn., C. Bis., *bakáu*, Bis., *patótan*, *pulútan*, Ibn., *siap*, *uñgon*, Ilk.; *dau*, M (Molucc.), *tongké*, M (Ambon); Papua: *arara*, Motu, *bagoia*, Binandele, *mapeke*, Kiwai.

Note. For a discussion of the rejection of the combination '*B. conjugata* (L.) MERR.' see under *Rhizophora apiculata* BL.

DOCTERS VAN LEEUWEN found in specimens cultivated in Kebun Raya Indonesia a fruit with 2 hypocotyls (COSTERUS & SMITH, *l.c.* 1923).

2. Bruguiera sexangula (LOUR.) POIR. in Lamk, Encycl. Suppl. 4 (1816) 262; ARN. Ann. Mag. Nat. Hist. 1 (1838) 369; MERR. Int. Rumph. (1917) 389; Sp. Blanc. (1918) 284; BROWN, Min. Prod. Philip. For. 1 (1920) 52, 54, t. 19–20; MERR. En. Born. (1921) 422; En. Philip. 3 (1923) 147; Pl. Elm. Born. (1929) 214; CRAIB, Fl. Siam. En. 1 (1931) 597; DEGENER, Fl. Haw. book 2 (1934) fam. 269, tab.; MERR. Comm. Lour. (1935) 282; BURK. Dict. 1 (1935) 375; BACK. Bekn. Fl. Jav. (em. ed.) 4b (1944) fam. 102, p. 7; DING HOU, Nova Guinea, n.s. 8 (1957) 168.—*Mangium digitatum* RUMPH. Herb. Amb. 3 (1741) 107, t. 70.—*Rhizophora sexangula* LOUR. Fl. Coch. (1790) 297.—*B. sexangularis* SPRENG. Syst. Veg. 2 (1825) 602.—*B. cylindrica* (*non Rhizophora cylindrica* L.) BL. En. Pl. Jav. (1827) 93, *quoad specim.*; ARN. Ann. Mag. Nat. Hist. 1 (1838) 366; BL. Mus. Bot. 1 (1849) 137; MIQ. Fl. Ind. Bat. 1, 1 (1856) 586.—*Rhizophora polyandra* BLANCO, Fl. Filip. (1837) 396, ed. 2 (1845) 277, ed. 3, 2 (1878) 150, t. 415*bis*.—*Rhizophora plicata* BLANCO, *op. cit.* 398, 279, 152.—*B. eriopetala* W. & A. *ex* ARN. Ann. Mag. Nat. Hist. 1 (1838) 368; WIGHT, Ic. 1 (1839) t. 239B, 1–3; Ill. Ind. Bot. 1 (1840) 210; SCHIMP. Bot. Mitt. Trop. 3 (1891) 95, t. 5, f. 2; K. & V. Bijdr. 4 (1896) 295; KING, J. As. Soc. Beng. 66, ii (1898) 316; BACK. Schoolfl. (1911) 485; MERR. Fl. Man. (1912) 347; KOORD. Exk. Fl. Jav. 2 (1912) 669; Atlas 1 (1913) t. 104; GUILL. in Fl. Gén. I.—C. 2 (1920) 729, f. 75, 23; HOCHREUTINER, Candollea 2 (1925) 449; WATSON, Mal. For. Rec. (1928) 109, t. 11a, 14; WYATT-SMITH, Mal. For. 16 (1953) 157, f. 2. —*B. australis* A. CUNN. *ex* ARN. Ann. Mag. Nat. Hist. 1 (1838) 368.—*Rhizophora australis* STEUD. Nomencl. ed. 2, 2 (1841) 449.—*Rhizophora eriopetala* STEUD. *l.c.*—*B. parietosa* GRIFF. Notul. 4 (1854) 670; Ic. Pl. As. (1854) t. 641.—*B. 10-angulata* GRIFF. Notul. 4 (1854) 669.—*B. oxyphylla* MIQ. Sum. (1861) 324.—*B. malabarica* (*non* ARN.) F.—VILL. Nov. App. (1880) 79.—**Fig. 6b, 17m, 18, 23.**

Tree up to 33 m by 65(–80) cm, buttresses up to 1 m high; kneed roots 45 cm. Bark smooth, grey to pale-brown, with a few large corky lenticels especially on the buttresses, sometimes with stilt-roots. Branching mostly sympodial. *Leaves* elliptic to elliptic-oblong, rarely oblanceolate, 8–13(–16) by 3–6 cm, acute at both ends, flat; nerves 7–11 pairs visible to obscure on both surfaces; petiole $1^1/_2$–5 cm, not pruinose. Stipules green or yellowish, $3^1/_2$–4 cm long. *Flowers* generally nodding, at anthesis $2^3/_4$–4 cm long. Pedicels 6–12 mm, green, yellow, or brownish, not pruinose. *Calyx* 10–12-lobed, yellow, yellow-brown or reddish, never bright red, tube 1–$1^1/_2$ cm long, outside distinctly ridged to the base. *Petals* $1^1/_2$ cm long, densely fringed with hairs along the outer margins from the base to the apex; lobes half the length of the petal, apex reflexed and obtuse, each near the top with a few (1–3) bristles up to $1^1/_4$ mm long and not or hardly exceeding the apex; a distinct bristle in the sinus between the lobes. *Stamens* 7–14 mm, anthers linear, 3–5 mm. Style filiform, $1^1/_2$–$2^1/_4$ cm long, arms 3–4, at most $^1/_2$ mm. *Hypocotyl* thick, rather angular, with narrowed blunt ends, 6–8 by $1^1/_2$ cm, straight.

Distr. Ceylon, SE. Asia, throughout *Malaysia*, to New Britain and E. New Guinea, introduced in Hawaii.

Ecol. As of *B. gymnorrhiza*, mainly in the back mangrove in places which are infrequently submerged, but generally preferring wetter soils in association with *B. cylindrica* and *B. parviflora*. According to BURKILL it has been suggested that it is a hybrid between *B. cylindrica* and *B. gymnorrhiza;* there is nothing to sustain this idea and its large area of distribution and fertility indicate its good specific status. According to WATSON the rarest *Bruguiera* in Malaya; it is the only one which occasionally stands on stilt-roots.

Uses. As *B. gymnorrhiza.* The tree yields fire-wood and poles and is suitable for making charcoal. Fruit is said to be used in an application for shingles, and root or leaves are used for burns. In Celebes the fruits are eaten after having been soaked and boiled.

Vern. *Tumu barau*, (*tumu*) *mata buaya*, Mal. Pen., *busing, busung, mata buwaja, tumu*, Sum. E. C., *kurung, tumu, utut*, Sarawak, *bakau tampusing*, Bandjerm., *tandjang*, J, *lindur*, Md, *ting*, Manado (Mol.), *makurung*, Minah. (Alf.), *tongké pĕrampuan*, Ambon, *guwoi*, Weda; Philippines: *potótan*, Tag. & various lang., *bakáuan- babáe, b. laláki, balinsasayan, balinsarayan, busáin, kalabayuan, potótan-babáe, potútan, putútan, tagasa*, Tag., *busáing*, Sulu, *gutulan, lagasa(k), sagasa(k)*, Ibn.; *ai bon*, Nuf, *wapa*, Marind.

Note. For a discussion of the evaluation of *Rhizophora conjugata* L. I refer to *Rhizophora apiculata* BL.

In Hawaii introduced Aug. 1922 by the Hawaiian Sugar Planters' Association and ten years later growing naturalized in the salt marshes near Heeia, Oahu (DEGENER, *l.c.*).

3. Bruguiera exaristata DING HOU, Nova Guinea, n.s. 8 (1957) 166, f. 1–2.—**Fig. 17a-i.**

Small tree up to 10 m by 25 cm. Bark dark-grey and cracked. *Leaves* obovate, rarely elliptic, 5–9½ by 3–4½ cm, acute, base acuminate, margin sometimes revolute; nerves 7 pairs, distinct; petiole 1½–2½ cm. Stipules *c.* 2 cm long. Peduncle 7–12 mm. *Flowers* at anthesis 2–2½ cm long. *Calyx* 8(–10)-lobed, 10–15 mm long, tube distinctly ridged externally down to the base. *Petals* 9–11 mm long, densely fringed with white appressed hairs at the base and along the outer margins, lobes ⅓ the length of the petal, obtuse, without bristles at the apex and in the sinus, very rarely with a minute, obscure one in the sinus. *Filaments* 10 mm, anthers 5 mm long, apiculate. Style *c.* 14 mm long, stigmas obscurely 3-lobed. *Hypocotyl* cylindric, obtuse at both ends, obscurely ridged, 4½–6 cm by 6–8 mm.

Distr. Northern Australia (Northern Territory, Queensland) and *Malaysia:* South New Guinea (Kapa Kapa, Merauke) and Lesser Sunda Islands (Timor). Fig. 19.

Ecol. In mangroves or growing at the rear of other mangroves and along creeks (Mossman River, Queensland).

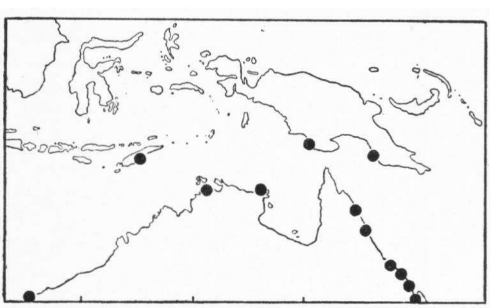

Fig. 19. Localities of *Bruguiera exaristata* DING HOU.

4. Bruguiera parviflora (ROXB.) W. & A. *ex* GRIFF. Trans. Med. Phys. Soc. Calc. 8 (1836) 10; Ann. Sc. Nat. Bot. Paris II, 10 (1838) 123; ARN. Ann. Mag. Nat. Hist. 1 (1838) 369; MIQ. Fl. Ind. Bat. 1, 1 (1855) 588; KURZ, For. Fl. Burma 1 (1877) 449; HENSLOW in Hook. Fl. Br. Ind. 2 (1878) 438; F.—VILL. Nov. App. (1880) 79; VIDAL, Rev. Pl. Vasc. Filip. (1886) 126; SCHIMP. Bot. Mitt. Trop. 3 (1891) 96, t. 5, f. 4; K. & V. Bijdr. 4 (1896) 297; KING, J. As. Soc. Beng. 66, ii (1898) 315; BACK. Schoolfl. (1911) 485; KOORD. Exk. Fl. Jav. 2 (1912) 668; Atlas 1 (1913) t. 105, F–G; MERR. En. Born. (1921) 421; En. Philip. 3 (1923) 147; Pl. Elm. Born. (1929) 214; HOCHREUTINER, Candollea 2 (1925) 450; WATSON, Mal. For. Rec. (1928) 111, t. 17, 18; CRAIB, Fl. Siam. En. 1 (1931) 596; DEGENER, Fl. Haw. book 2 (1934) fam. 269; BROWN, Min. Prod. Philip. For. 1 (1935) 58, t. 23–24; BURK. Dict. 1 (1935) 374; BACK. Bekn. Fl. Jav. (em. ed.) 4b (1944) fam. 102, p. 8; WYATT-SMITH, Mal. For. 16 (1953) 157, f. 5; BLAKE, Austr. J. Bot. 2 (1954) 134; BROWNE, For. Trees Sar. & Brun. (1955) 301; DING HOU, Nova Guinea, n.s. 8 (1957) 168.—*Rhizophora parviflora* ROXB. Fl. Ind. ed. Carey 2 (1832) 461.—? *Rhizophora cylindrica* (*non* L.) ROXB. Hort. Beng. (1814) 36, *nomen.*—*Kanilia parviflora* BL. Mus. Bot. 1 (1849) 140, f. 30.—*B. ritchiei* MERR. Publ. Govt. Lab. Philip. 6 (1904) 11.—**Fig. 6a, 20–21.**

Tree up to 24 m by 15–30(–55) cm. Bark smooth, grey, with a few small, obscure lenticels. *Leaves* elliptic, 7½–13 by 2½–4 cm, apex acute, base cuneate; nerves about 10 pairs, faintly visible on both surfaces; petiole 1½–2 cm. Stipules *c.* 4½ cm long. Cymes 3–7-flowered. Peduncle *c.* 2 cm, 2–5-flowered. *Flowers* yellowish green. Pedicels 6–13 mm. *Calyx* tube ridged, 7–9 mm long, lobes 8, about ¼–⅕ as long as the tube. *Petals* 1½–2 mm long, the lobes ⅓ the length of the petal, each with 3 bristles *c.* ½ mm, white hairy at the lower margin. *Stamens* 1½ mm, anthers slightly oblong, ⅓ mm long. Style *c.* 1¼–1½ mm long, obscurely lobed, stigmas 2–3. Fruit-calyx-tube 1¾–2¼ cm long, lobes erect, not accrescent. *Hypocotyl* cylindric, smooth, 7½–13 by ½ cm; plumule piercing the base of the fruit which remains on the seedling as a cuff.

Distr. SE. Asia, throughout *Malaysia* to Melanesia (New Hebrides, Solomon Isl.) and Australia (N. Queensland and Northern Territory), introduced in Hawaii (DEGENER, *l.c.*).

Ecol. Mostly on the inner side of the mangrove, not infrequently found associated with *B. cylindrica*, but more often with *Rhizophoras* where it is at its best. Occasionally it forms pure, solid stands. It distinctly increases as a result of exploitation of immature areas. It often establishes itself on soils formerly occupied by *Rhizophora* and is frequently common on river-banks where excessive pole

Fig. 20–21. Pure forest of *Bruguiera parviflora* W. & A. as seen from the outside near Palu Piai (E. Sumatra), *c.* 10 years old (H. H. TH. SCHREUDER) and inside, with mud mark of high tide in Malaya (J. WYATT-SMITH).

cutting has been indulged in by fishermen. And then it may become a nurse for the *Rhizophoras*. If it grows mixed with *B. gymnorrhiza* it is evidently under conditions which suit it as then it attains its largest size. It is much more tolerant of submer-

but employed for (inferior) fire-wood and for mining and on the Selangor coast for fishing-stakes and traps, but in Perak fishermen say that, like *B. cylindrica*, it has a peculiar odour which frightens fish away. Sometimes poles are used for rafters.

Fig. 22. ***Bruguiera*** forest with knee-roots in sandy mangrove at low tide, near Kiojoh, south coast of Enggano Isl. (LÜTJEHARMS).

gence than *B. cylindrica*. Though quick to establish itself, WATSON finds it a slow grower and among the *Bruguieras* it has the shortest life, particularly when it grows in pure stands as it frequently does in the wetter parts. WATSON calls it an 'opportunist species' occurring under a variety of conditions. For that reason the forester encourages it if he cuts as frequently as every twenty years.

Uses. By its small dimensions not of much use, Bark is deficient in tannin. Malays sometimes use the germinating embryo as a vegetable.

Vern. *Lĕnggadai*, *lĕnggadis*, *mĕngkadai*, Mal. Pen., *langgadé*, Atjeh, *lĕnggadai*, Banka, Borneo, *mĕngĕlangan*, Palemb., *tandjang*, J, *tĕngit*, M (Palo); Philippines: *hañgarai*, *lañgarai*, Tag. & other lang., *bakáuan-laláki*, *mañgalai*, *potótan*, Tag., *hañgalai*, Tag., Mbo., *hiñgalai*, *hiñgarai*, Tag., P. Bis., *arum*, Bag., *biosan*, *bubutigan*, S. L. Bis., *hanagaiai*, *hañgai*, C. Bis.

5. Bruguiera cylindrica (L.) BL. En. Pl. Jav. 1 (1827) 93, *quoad basionym;* W. & A. Prod. (1834) 311; MIQ. Fl. Ind. Bat. 1, 1 (1855) 586; NAVES in Blanco, Fl. Filip. ed. 3 (1877–83) t. 136; MERR. Fl. Man. (1912) 348; Int. Rumph. (1917) 388; En. Philip. 3 (1923) 147; BROWN, Min. Prod. Philip. For. 1 (1920) 54, t. 21–22; CRAIB, Fl. Siam. En. 1 (1931) 595; BURK. Dict. 1 (1935) 374; HOLTHUIS & LAM, Blumea 5 (1942) 217; DING HOU, Nova Guinea, n.s. 8 (1957) 168.—*Karil-Candel* RHEEDE, Hort. Mal. 6 (1686) 59, t. 33.—*Mangium minus* RUMPH. Herb. Amb. 3 (1743) 106, t. 69, *quoad fl. et fig.* A–B.—*Mangium caryophylloides* RUMPH. *ibid.* 119, t. 78.—*Rhizophora cylindrica* LINNÉ, Sp. Pl. (1753) 443.—*Rhizophora caryophylloides* BURM. *f.* Fl. Ind. (1768) 109, *excl. var.* β; JACK, Mal. Misc. 1 (1820) 34; reimpr. Calc. J. Nat. Hist. 4 (1843) 334.—*Rhizophora ceratophylloides* GMEL. Syst. Veg. (1796) 749; RAEUSCH. Nom. ed. 3 (1797) 136 (*sphalm. caryophylloides*).—*B. caryophylloides* BL. En. Pl. Jav. 1 (1827) 93; ARN. Ann. Mag. Nat. Hist. 1 (1838) 368; MIQ. Fl. Ind. Bat. 1, 1 (1855) 589; KURZ, For. Fl. Burma 1 (1877) 450; TRIM. Fl. Ceyl. 2 (1894) 154; SCHIMP. Bot. Mitt. Trop. 3 (1891) 96, t. 5, f. 5; K. & V. Bijdr. 4 (1896) 299; KING, J. As. Soc. Beng. 66, ii (1898) 315; BACK. Schoolfl. (1911) 485; GUILL. in Fl. Gén. I.-C. 2 (1920) 730; WATSON, Mal. For. Rec. (1928) 110, t. 15, 16; BACK. Bekn. Fl. Jav. (em. ed.) 4b (1944) fam. 102, p. 7; WYATT-SMITH, Mal. For. 16 (1953) 157, f. 4.—*B. malabarica* ARN. Ann. Mag. Nat. Hist. 1 (1838) 369.—*Kanilia caryophylloides* BL. Mus. Bot. 1 (1849) 141.

Tree up to 23 m by 20–30 cm, buttresses small, up to 1 m. Bark grey, with a few small, corky lenticels. *Leaves* thin, elliptic, 7–17 by 2–8 cm, acute, base cuneate; nerves *c.* 7 pairs, distinct, rarely obscure on both surfaces; petiole 1–4$^{1}/_{2}$ cm. Stipules 2$^{1}/_{2}$–3$^{1}/_{2}$ cm long. Cymes 3-flowered. Peduncle 6–8 mm. *Flowers* greenish, at anthesis 10–12 mm long. Pedicels 1–4 mm. *Calyx* tube smooth, 4–6 by 2 mm, lobes 8, about as long as the tube. *Petals* 3–4 mm long, the lobes *c.* $^{1}/_{6}$ as long as the petal, with 2 or 3 bristles at the apex, outer margins usually fringed with white hairs in the lower part. *Stamens* 1$^{1}/_{2}$–2$^{1}/_{2}$ mm long, anthers oblong, $^{1}/_{2}$ mm long, slightly apiculate. Calyx tube in fruit 10–12 mm long, the lobes reflexed, not accrescent. *Hypocotyl* cylindric, often curved, 8–15 cm by 5 mm.

Distr. SE. Asia, throughout *Malaysia* to N. Queensland.

Ecol. Generally not higher than 20 m, essentially gregarious on stiff clay behind *Avicennia* on the seaface; it gives way to other species on better drained soils, existing gregariously by virtue of its ability to grow in newly formed soils unsuitable to other mangroves.

The almost entire absence of aeration in the dense clay habitually occupied by *B. cylindrica* makes the tree more than usually dependent on its pneumatophores for an adequate supply of oxygen, and particularly susceptible to prolonged submersion. Suffocation on a much more extensive scale has occurred in the centre of Trong Island, in the Matang For. Res., Perak, where its progressive dying off over an area that had grown to over 40 ha has recently been checked by the cutting of an extraction canal, which has allowed the accumulated surface water to drain away towards the landward side.

Fig. 23. Spontaneous seedlings of *Bruguiera sexangula* (LOUR.) POIR. between pneumatophores of *Sonneratia caseolaris* (L.) ENGL. in the freshwater swamp of the Botanic Gardens, Bogor (II.Q.F.), Oct. 1956 (JACOBS).

There is good reason to believe that *B. cylindrica* is a legitimate precursor of the *Rhizophoras* in most situations where accretion is proceeding on the sea-face. It is a prolific seed-bearer and healthy forests can be relied upon to regenerate themselves even after clear felling (WATSON).

According to SETTEN the pure stands in Malaya are found normally above reach of the ordinary tides and are inundated only with spring tides. The stocking of the young stands is extremely dense and these pole woods may contain from 55.000–70.000 stems per ha. SETTEN says that *bĕrus* holds the doubtful honour of achieving pride of place as the slowest growing of any commercial tree species in Malaya. From seed it takes *c.* 11–12 years to attain 6 m height, *c.* 16–17 years to attain 9 m by 5 cm diam. and *c.* 60 years to attain 30 cm diam. Its rotation should be longer than 30 years now accepted for average rotation in Malaya of mangrove forest. Heavy early thinnings are necessary to increase the rate of growth.

Uses. Timber mainly used for fire-wood; it is reddish, heavy, and close-grained. The bark is thin and of too poor quality for tanning purpose. According to HEYNE the young radicles are in some areas occasionally eaten with sugar and coconut. Fisherman say that the wood has a peculiar odour which frightens away fish; and many do not like to use it for making fish-traps.

Vern. *Bakau bĕlukap, b. bĕrus, b. putih, bĕrus, b. kĕtjil, bosang,* Mal. Pen., *burus,* M, *tandjang, t. sukun,* J, *lindur,* Md; Philippines: *bakáuan, biuas, busáin, putútan, tañgálan, tañgal-babáe,* Tag., *biuis,* Pang, *bius,* Mag., Sul., *kalapinai,* Ilk., *lañgarai,* Mag., *magtoñgog, magtuñgud,* S. L. Bis.

6. Bruguiera hainesii C. G. ROGERS, Kew Bull. (1919) 225; CRAIB, Fl. Siam. En. 1 (1931) 596; WYATT-SMITH, Mal. For. 16 (1953) 157, f. 3; DING HOU, Nova Guinea, n.s. 8 (1957) 168.—*Rhizophora caryophylloides* (*non* BURM. *f.*) GRIFF. Ic. 4 (1854) t. 642.—**Fig. 17j–l.**

Tree up to 33 m by 70 cm. Bark brown to grey, with large corky yellow-brown lenticels from base to top. *Leaves* elliptic-oblong, 9–16 by 4–7 cm, acute, base cuneate; petiole 2¹/₂–4 cm. Stipules 3¹/₂ cm long. Cymes 2–3-flowered. Peduncle short, 7–13 mm. Pedicels 6–8 mm. *Flowers* in anthesis 1³/₄–2¹/₄ cm long. *Calyx* pale green, 10-lobed, tube 5 mm diam., slightly ridged outside in the upper part, lobes as long as the tube. *Petals* 7–9 mm long, villose at the lower margins, slightly pilose at the upper part of the lobes, lobes ¹/₃ as long as the petal, with 2–4 bristles at the apex. Calyx lobes patent at right angles in fruit. *Hypocotyl* cigar-shaped or slightly clavate, slightly curved, up to 9 cm by 11 mm.

Distr. ?India (*fide* GRIFFITH *l.c.*), S. Burma (Mergui), Siam (Chantaburi, Surat), and *Malaysia:* Malay Peninsula (Klang Isl., Selangor), and Papua (Port Moresby).

Ecol. On dry side or inland of mangrove, only inundated for a few hours at fairly high spring tides.

Vern. *Bĕrus mata buaya,* M.

Excluded

Bruguiera nubicola PRITZ. Icon. Ind. 2 (1866) 51, *nomen, sphalm.* = *Bougueria nubicola* DECNE (*Plantaginac.*).

3. CERIOPS

ARN. Ann. Mag. Nat. Hist. 1 (1838) 363.—**Fig. 24-25.**

Small to medium-sized trees. Stems with appressed stilt-roots up to 1 m tall. *Leaves* decussate, clustered at the end of the twigs, entire, coriaceous, glabrous, not black-dotted beneath; nerves obscure on both surfaces. Stipules lanceolate. *Inflorescences* solitary, subsessile to shortly peduncled, (2–)4-∞-flowered, condensed cymes. Bracteoles 2 at the base of the flower, partly connate, cupular, the free part ovate. *Calyx* deeply 5–6-lobed, ovate and acuminate. *Petals* white, 5 or 6, each embracing 2 stamens, inserted at the margin of the disk, sometimes cohering at the base by the uncinate-hairy margins, apex emarginate or truncate, fringe-like divided or with 3 clavate appendages (occasionally only 2). Disk cupular, shallowly lobed, lobes episepalous. *Stamens* twice the number of calyx lobes, inserted in the sinuations of the disk. *Ovary* semi-inferior, 3-celled, each cell with 2 ovules; style terete, simple; stigma simple or obscurely 2–3-lobed. *Fruits* ovoid, for the greater part superior. *Hypocotyls* clavate, tapering to the apex, ridged and sulcate.

Distr. Species 2, distributed in the tropics of the Old World, from eastern Africa throughout *Malaysia* to Micronesia, Melanesia, and N. Australia.

Ecol. Typical constituents of the inner mangrove.

KEY TO THE SPECIES

1. Petals with 3 clavate appendages at the apex. Anthers obtuse at the apex, *c.* ¹/₄–¹/₆ the length of the filament. Calyx lobes on the fruits reflexed or widely patent. Hypocotyl 15–25(–35) cm . **1. C. tagal**
1. Petals fringe-like divided at the apex. Anthers apiculate, longer than the filament or rarely as long as it. Calyx lobes in fruit erect or ascending. Hypocotyl 9–15 cm long . . . . . . **2. C. decandra**

1. Ceriops tagal (PERR.) C. B. ROB. Philip. J. Sc. 3 (1908) Bot. 306; MERR. Int. Rumph. (1917) 386; Sp. Blanc. (1918) 283; BROWN, Min. Prod. Philip. For. 1 (1920) 60; MERR. En. Born. (1921) 420; En. Philip. 3 (1923) 144; Pl. Elm. Born. (1929) 214; CRAIB, Fl. Siam. En. 1 (1931) 593; KUDO, Bot. Mag. Tokyo 46 (1932) 150, *incl. f. sasakii* (HAY.) KUDO; BURK. Dict. 1 (1935) 515; SALVOZA, Nat. Appl. Sc. Bull. Un. Philip. 5 (1936) 234; BACK. Bekn. Fl. Jav. (em. ed.) 4b (1944) fam. 102, p. 4; QUIS. Med. Pl. Philip. (1951) 652; BLAKE, Austr. J. Bot. 2 (1954) 133; BROWNE, For. Trees Sar. & Brun. (1955) 302; LEWIS, Fl. Trop. E. Afr. (Rhizophorac.) (1956) 5, f. 2.—*Mangium caryophylloides II parvifolium et III latifolium* RUMPH. Herb. Amb. 3 (1647) 119.—*Rhizophora tagal* PERR. Mém. Soc. Linn. Paris 3 (1824) 138.—*Rhizophora timoriensis* DC. Prod. 3 (1828) 32.—*C. candolliana* ARN. Ann. Mag. Nat. Hist. 1 (1838) 364, *nom. illeg.;* WIGHT, Ill. Ind. Bot. 1 (1840) 209; WALP. Rep. Bot. Syst. 2 (1843) 70; BL. Mus. Bot. 1 (1849) 142, *incl. var. spathulata* BL.; MIQ. Fl. Ind. Bat. 1, 1 (1855) 590; THWAITES, En. Pl. Zeyl. (1859) 120; OLIVER, Fl. Trop. Afr. 2 (1871) 409; KURZ, For.

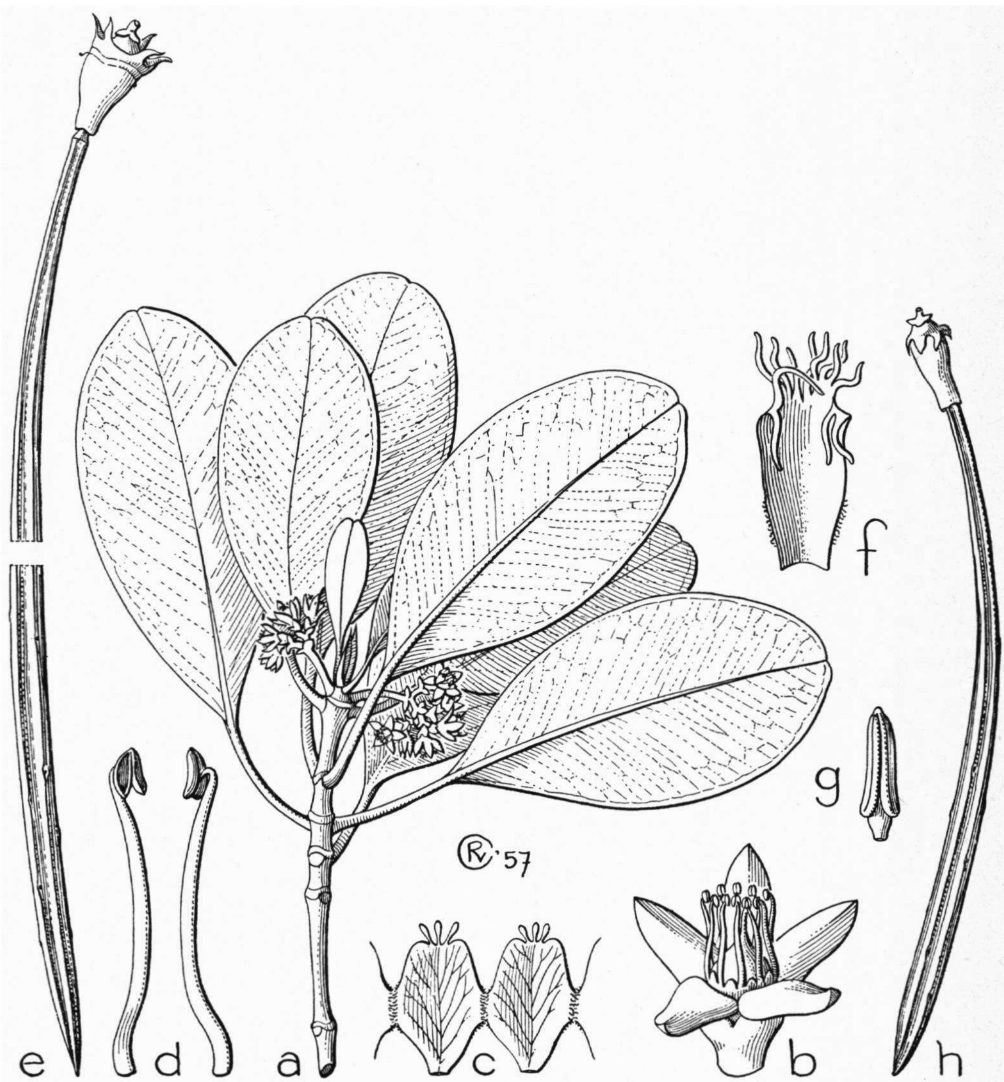

Fig. 24. *Ceriops tagal* (PERR.) C. B. ROBINSON. *a.* Habit, × 2/3, *b.* flower, corolla removed, × 3, *c.* petals, inside, × 5, *d.* stamens, × 13, *e.* hypocotyl, × 2/3.—*C. decandra* (ROXB.) DING HOU. *f.* Petal, inside, × 13, *g.* stamen, × 13, *h.* hypocotyl, × 2/3 (*a–d* HOOGLAND 4315, *e* SAUNDERS 95, *f–g* VERSTEEG 1892, *h* KOORDERS 29925).

Fl. Burma 1 (1877) 448; HENSLOW in Hook. *f.* Fl. Br. Ind. 2 (1878) 438; F.-VILL. Nov. App. (1880) 79; VIDAL, Sinopsis Atl. (1883) 25, t. 47, f. C; SCHIMP. Bot. Mitt. Trop. 3 (1891) 94, t. 5, f. 6; TRIM. Fl. Ceylon 2 (1894) 152; K. & V. Bijdr. 4 (1896) 284; SCHIMP. in E. & P. Pfl. Fam. 3, 7 (1898) 52, f. 26, J–M; BACK. Schoolfl. (1911) 482; KOORD. Exk. Fl. Java 2 (1912) 668; Atlas 1 (1913) t. 107; HAYATA, Ic. Pl. Form. 3 (1913) 115, t. 20, *incl. var. sasakii* HAY.; GUILL. Not. Syst. 3 (1914) 56; EWART & DAVIES, Fl. North. Terr. Austr. (1917) 199; OSTENFELD, Dansk Bot. Arkiv 2, 8 (1918) 26; GUILL. Fl. Gén. I.-C. 2 (1920) 725, f. 75, 5–8; WATSON, Mal. For. Rec. 6 (1928) 46, 112, t. 19 & 20.—? *C. pauciflora* BTH. in Hook. Lond. J. Bot. 2 (1843) 218.—*C. forsteniana* BL. Mus. Bot. 1 (1849) 143.—*C. boviniana* TUL. Ann. Sc. Nat. IV, 6 (1856) 112.—*C. lucida* MIQ. Sum. (1861) 325, *incl. var. latifolia & subspathulata.* —*Rhizophora candel* (*non* L.) BLANCO, Fl. Filip. (1837) 396, ed. 2 (1845) 277, ed. 3, 2 (1878) 150, t. 415.—*C. timoriensis* DOMIN, Bibl. Bot. 89 (1928) 444; GARDNER, En. Pl. Austr. Occ. (1931) 86.—*C. somalensis* CHIOVENDA, Fl. Somala 2 (1932) 205, f. 125–126.—**Fig. 24a–e, 25.**

Shrub or tree up to 15(–25) m by 20 cm, often degenerating into a bushy shrub under unfavourable conditions. Stem base often with small stilt-roots. Bark light grey, fairly smooth with fine lenticular fissures. *Leaves* obovate to obovate-oblong, rarely elliptic-oblong, 5–11½ by 2–7½ cm, obtuse or sometimes slightly emarginate, base cuneate, margins often wavy; petioles 1½–3½ cm. Stipules 1¼–2½ cm long. *Inflorescences* often on the terminal nodes of the new shoot, usually resinous, (2–)4–10-flowered. *Calyx lobes* erect in flower, widely patent, reflexed in fruit, ovate, acuminate, 4–5 mm long; tube *c.* 2 mm high. *Petals* oblong, white, turning brown, coherent at the base with uncinate hairs, limb *c.* 3½ mm long, with 3 clavate, apical appendages *c.* ½ mm long. *Stamens* 3–5 mm, alternately longer and shorter, anthers slightly ovoid, sagittate, much shorter than the filaments. Superior part of the *ovary* 1½ mm high, style 2 mm, entire. *Fruit* ovoid, 1½–2½ cm long, calyx lobes soon reflexed; *hypocotyl* club-shaped, sharply angular, 15–25(–35) cm long. Seeds 1(–2).

Distr. Eastern Africa, Madagascar, Seychelles, Ceylon, India, Burma (Andamans), Siam (Koh-chang, Koh-kong, Koh-chick), Indo-China (Cambodia, Cochinchina), Formosa, throughout *Malaysia* to Micronesia (Carolines: Palau, Yap), Australia (Northern Territory: Darwin, South Bay, Melville Bay; Queensland: Stradbroke Isl.), and Melanesia (? New Ireland, Solomons, and New Caledonia).

Ecol. On well drained soils, within the reach of occasional tides in the inner mangrove. Fishermen exploit it so much in Malaya that well grown trees are rare, according to BURKILL. On the whole it is much more common than *C. decandra.* It is very interesting that one can break a seedling into halves and regeneration of a new plant occurs from either half, according to CUBITT.

It sometimes occurs as undergrowth in *Rhizophora* or *Bruguiera* mangrove forest, but in other places occurs in thin-stemmed, very dense, gregarious monospecific stands on well-drained soils, *cf.* HEYNE, p. 1167.

In Siam recorded with aerial roots from the branches and according to BECKING also in Indonesia sometimes with aerial roots.

Uses. In Malaya the bent branches are often used as knees for boats and the trunks for house-building. WATSON regards it as the most durable of all the mangroves. It also makes an excellent fire-wood. In Indonesia it is used for pit-props (coal mines of P. Laut) and various other purposes. The heart-wood is yellow to orange without any sharp distinction against the sap-wood.

The Malays use the bark for tanning fishing lines, nets, and sails. It is used as dye in the batik industry for colouring red, or black in combination with indigo, as is done in Pattani and Kelantan, for cotton and matting, *cf.* BURKILL, p. 517.

The tannin is not suitable for medicinal use, though occasionally used; a fragment of the bark or the old calyx is placed in the betel-quid as an astringent.

Vern. *Tĕngar, tĕngah, tangar,* M, *tingi(h),* J; Philippines; *tañgál,* Tag. & various lang., *ligasĕn, tagasa, tañgál-laláki, tanghál, tigasan,* Tag., *magtoñgod, tuñgod, tuñgóg,* P. Bis., *pakat,* Tagb., *roñgon, ruñgon,* Sbl., *tañgág, toñgóg,* S. L. Bis., *toñgong,* Sub., *tonggi,* Kuy, *tuñgúd,* Sulu; *palun, parun,* Ambon (Alf.), *bido-bido,* Galela.

Notes. PERROTTET's original description is very poor and applies to both species of *Ceriops* and I have not seen a type specimen. MERRILL (1923) said that *C. tagal* is abundant in Zamboanga Prov. (Mindanao), the type locality of PERROTTET where *C. decandra* seems to be absent. The febrifugal medicinal use of *C. tagal,* stressed by PERROTTET, is another argument to accept PERROTTET's name as such use is not made of the bark of *C. decandra.*

Ceriops pauciflora BTH. has tentatively been reduced to *C. tagal,* with which it agrees in all characters save the 2-flowered cymes and slightly larger flowers (calyx *c.* 6 mm). It is only known from the type locality: New Ireland, BARCLAY (K).

Ceriops somalensis CHIOV. was said to differ from *C. tagal* in having short filaments and triangular-tipped petals. Obviously these observations are deficient and made on too young material. The fragments of SENNI 134 received through the courtesy of the Firenze Herbarium have very long filaments below the young fruit. I suppose the petals have been drawn upside down and the absence of the 3 apical appendages is due to inaccurate observation; I had no buds available.

KANEHIRA (En. Micr. 1935, 377) recorded this species under the wrong name *C. roxburghiana* from Micronesia; his description and figure in his Fl. Micr. (1933) 255, 447, fig. 119 leave no doubt about the identity.

I have observed one fruit with 2 hypocotyls. Occasionally there are only 2 appendages to a petal (*cf.* KOORD. Atlas 1, 1913, t. 107, fig. E).

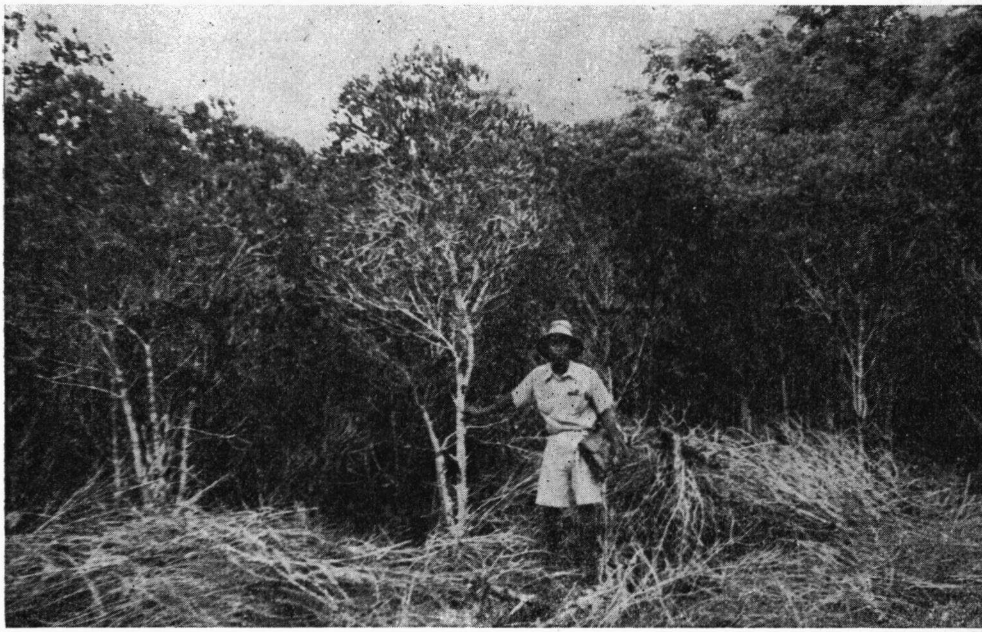

Fig. 25. Pure stand of *Ceriops tagal* covering several hundreds of ha in S. Banjuwangi, Pampang Bay (SE. Java), sharply demarcated against the interior mixed non-mangrove forest. Stand very dense, without undergrowth, cut in front, Sept. 1950 (SOETADI).

2. Ceriops decandra (GRIFF.) DING HOU, *nov. comb.*—*Bruguiera decandra* GRIFF. Trans. Med. Phys. Soc. Calc. 8 (1836) 10; Ann. Sc. Nat. Bot. II, 10 (1838) 124.—*C. roxburghiana* ARN. Ann. Mag. Nat. Hist. 1 (1838) 364; WIGHT, Ill. Ind. Bot. 1 (1840) 209; WALP. Rep. Bot. Syst. 2 (1843) 70; MIQ. Fl. Ind. Bat. 1, 1 (1855) 591; KURZ, For. Fl. Burma 1 (1877) 448; HENSLOW in Hook. *f.* Fl. Br. Ind. 2 (1878) 436; VIDAL, Rev. Pl. Vasc. Filip. (1886) 126; TRIM. Fl. Ceyl. 2 (1894) 153; SCHIMP. Bot. Mitt. Trop. 3 (1891) 94; K. & V. Bijdr. 4 (1896) 287; KING, J. As. Soc. Beng. 66, ii (1897) 317; SCHIMP. in E. & P. Pfl. Fam. 3, 7 (1898) 52; BACK. Schoolfl. (1911) 483; KOORD. Exk. Fl. Java 2 (1912) 668; Atlas 1 (1913) t. 106; MERR. Philip. J. Sc. 1 (1906) Suppl. 102; GUILL. Fl. Gén. I.-C. 2 (1920) 726, f. 75, 9-12; MERR. En. Born. (1921) 420; En. Philip. 3 (1923) 144; BROWN, Min. Prod. Philip. For. 1 (1920) 62, t. 25 & 26; CRAIB, Fl. Siam. En. 1 (1931) 593; BURK. Dict. 1 (1935) 515; HOCHREUTINER, Candollea 6 (1936) 486; HOLTHUIS & LAM, Blumea 5 (1942) 217; BACK. Bekn. Fl. Jav. (em. ed.) 4b (1944) fam. 102, p. 4; WYATT-SMITH, Mal. For. 16 (1953) 222; BROWNE, For. Trees Sar. & Brun. (1955) 303.—*C. zippeliana* BL. Mus. Bot. 1 (1849) 143.—*Rhizophora glomerulata* ZIPP. *ex* BL. *l.c.*, *pro syn.*—*Rhizophora decandra* ROXB. [Hort. Beng. (1814) 36, *nomen*] *ex* GRIFF. Notul. 4 (1854) 663; *cf.* also W. & A. Prod. (1834) 311; drawing in Kew Libr. ROXB. coll. 1140, *cf.* SEALY, Kew Bull. 1956, p. 376 (1957).—**Fig. 24f–h.**

Small tree up to 15 m tall, 15–20 cm diam. *Leaves* obovate or obovate- to elliptic-oblong, $4^1/_2$–10 by $2^1/_2$–6 cm, apex obtuse, rounded or ± emarginate, base cuneate; petiole 1–$2^1/_2$ cm. Stipules $1^1/_2$–$2^1/_2$ cm. *Inflorescences* usually in the axils of several nodes at the upper part of a branch, 3-5-flowered, head-like condensed. *Calyx lobes* erect both in flower and in fruit, ovate, acute, 3–4 mm, tube *c.* 2 mm high. *Petals* white, turning brownish, with broad base, folded longitudinally, hardly or not cohering, *c.* $2^1/_2$ mm long, fringe-like divided at the apex. *Stamens* 1 mm long, ± equal, anthers ovoid, seemingly much longer than the filaments as the erect anthers are dorsifixed. *Fruit* ovoid-conical, *c.* 1–$1^3/_4$ cm long, calyx lobes obliquely erect or ascending; cotyledons red, finally protruding from the fruit for *c.* 2–4 mm; *hypocotyl* club-shaped, sharply angular and sulcate, 9–15 cm.

Distr. India, Burma, Siam, Indo-China (Cochinchina), and *Malaysia:* Malay Peninsula (E. coast), Banka, Java, Borneo, Philippines, Celebes, Moluccas (Ceram), and New Guinea, not yet found in Sumatra and the Lesser Sunda Islands.

Ecol. Edges of mangrove swamps, but relatively rare, and much less common than *C. tagal.*

Uses. For fire-wood.

Vern. *Tĕngal, tĕngar*, M, *tingi*, *J*, *bakau lali*, Sarawak, *landing-landing*, Sarawak (Lawas); Philippines: *tañgál*, Tag., Bik., *matañgál*, *tagasa*, Tag., *bulabadiang*, *tuñgúg*, P. Bis., *tuñgúng*, C. Bis., *palun*, *parun*, Ambon, *bido-bido*, Halmaheira.

Note. According to WYATT-SMITH *l.c.* the fruits of the *Ceriops* species can be distinguished in the field by the following characters: *C. tagal*: hypocotyl hardly ridged and warty over its whole length; calyx smooth; lobes reflexed in fruit. *C. decandra:* hypocotyl distinctly ridged, only warty at the apex; calyx distinctly warty; calyx lobes erect in fruit.

4. KANDELIA

W. & A. Prod. (1834) 310.—**Fig. 26.**

Small tree. *Leaves* decussate, entire. Stipules linear. *Inflorescences* peduncled solitary, cymose, 4–9-flowered. *Calyx* deeply 5(–6)-lobed. *Petals* 5(–6), bilobed, with a long seta in the sinus, each lobe multifid. *Stamens* free, unequal in length,

Fig. 26. *Kandelia candel* (L.) DRUCE. *a.* Habit, × ²/₃, *b.* longitudinal section of a flower (petals and stamens removed), × 3, *c.* petal, × 5, *d.* stamen, × 3, *e.* hypocotyl, × ¹/₃ (*a*, *b*, *d* SALIM A 1727, *c* CUADRA A 1415, *e* BROOKE 8826).

exserted. *Ovary* inferior, 1-celled, with 6 apical ovules. Style simple. *Fruit* ovoid, 1-seeded. *Hypocotyl* cylindric to spindle-shaped or clavate, pointed.

Distr. Monotypic, locally distributed in SE. to E. Asia (Kwantung, Hainan, Formosa, Riukiu, Kyushu) and *W. Malaysia* (Sumatra, Malay Peninsula, and Borneo). Fig. 27.

Ecol. On banks of tidal rivers in the mangrove forest.

1. Kandelia candel (L.) DRUCE, Rep. Bot. Exch. Club Br. Isl. 1913, 3 (1914) 420; MERR. En. Born. (1921) 421; KANEHIRA, Form. Trees rev. ed. (1936) 493, t. 45 (upper one), f. 455; SLOOT. Blumea Suppl. 1 (1937) 169–170, map 3; WALKER, Import. Trees Ryukyu (1952) 233, f. 145.—*Tsjeru-Candel* RHEEDE, Hort. Malab. 6 (1686) 63, t. 35.—*Rhizophora candel* LINNÉ, Sp. Pl. (1753) 443; DC. Prod. 3 (1828) 32.—*K. rheedei* W. & A. Prod. (1834) 311, *nom. illeg.*; ARN. Ann. Mag. Nat. Hist. 1 (1838) 365; WIGHT, Ill. 1 (1840) 209, t. 89; HOOK. Icon. Pl. (1841) t. 362; BL. Mus. Bot. 1 (1849) 135; MIQ. Fl. Ind. Bat. 1, 1 (1855) 585; BENTH. Fl. Hongk. (1861) 110; KURZ, For. Fl. Burma 1 (1877) 449; HENSLOW in Hook. *f.* Fl. Br. Ind. 2 (1878) 437; FORBES & HEMSL. J. Linn. Soc. Bot. 23 (1887) 293; K. & V. Bijdr. 4 (1896) 290; BACK. Schoolfl. (1911) 483; GUILL. Fl. Gén. I.-C. 2 (1920) 727, f. 75, 13 & 14; RIDL. Fl. Mal. Pen. 1 (1922) 694; WATSON, Mal. For. Rec. (1928) 49, 113, t. 21; CRAIB, Fl. Siam. En. 1 (1931) 594.—Fig. 26.

Shrub or small tree up to *c.* 7 m tall. Stem base thickened, generally without proper buttresses. No pneumatophores. Bark smooth, lenticellate, greyish to reddish brown, inner bark thin, pink. *Leaves* elliptic-oblong to narrowly so, or obovate-oblong, 6–13 by 2½–6 cm, obtuse, base cuneate, margin usually reflexed; nerves 6–7 pairs, obscure beneath, distinct or slightly elevated above; petiole 1–1½ cm. Stipules 2 cm long. *Inflorescences* dichotomously branched, 4(–6–9)-flowered, peduncle 1½–5 cm; pedicels 2–3 mm. *Flowers* white, at anthesis 1½–2 cm long. Bracteoles 2–4, connate, cup-shaped and adnate to the base of the calyx. *Calyx tube* exceeding the ovary, lobes linear, acute, reflexed after anthesis. *Petals c.* 14 mm long. *Stamens* 8–13 mm, filiform. Disk cup-shaped. *Ovary* 1-celled, with 6 ovules; ovules attached mostly at the apical part of the central axis, pendulous; style filiform, with 3 stigmas. *Fruit* green, ovoid, 1½–2½ cm long. *Hypocotyl* clavate, 15–40 cm long, terete, clavate.

Distr. India, Burma, Siam, Indo-China (Tonkin, Annam, and Cochinchina), China (Kwantung, Hongkong, and Formosa), Riukius, S. Japan (Kyushu: Saksuma), and *Malaysia:* NE. Sumatra, Malay Peninsula, and West N. Borneo, very local and rare. Fig. 27.

MIQUEL recorded *Kandelia* from New Guinea, but this specimen has appeared to be *Ceriops decandra.* KURZ recorded it from Banka (Nat. Tijd. Ned. Ind. 27, 1864, 150, 165) but though it might occur there I have seen no specimen and KURZ's identification may have been an error.

It has also been recorded from the Philippines, by F.-VILLAR, Nov. App. (1880) 79 and VIDAL, Sinopsis Atlas (1883) 25, t. 47, f. D, and VIDAL's material was, according to him, based on material from Bulacan Prov., Luzon, but neither MERRILL nor I have seen any material collected in the Philippine Islands. As it is known from N. Borneo and Formosa it is likely to occur there.

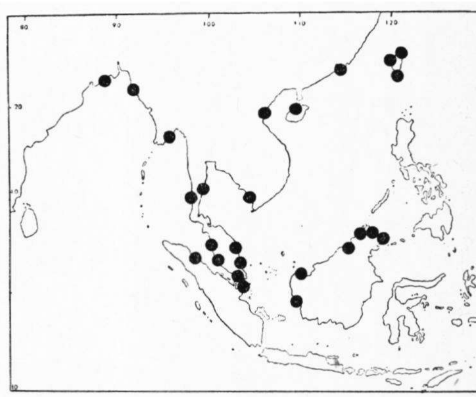

Fig. 27. Localities of *Kandelia candel* (L.) DRUCE; the localities in the Riukiu Islands and Kyushu (S. Japan) have not been drawn in this map.

Ecol. A small tree with conically thickened stem base but without buttresses or pneumatophores, sporadic on banks of tidal rivers among other mangroves but almost everywhere scarce and obviously occupying a narrow niche in the mangrove forest, rarely common in association with *Sonneratia alba* (Batu Lima R., Brunei). In 1939 STEUP found *Kandelia* as pioneer on mud-shoals in the mouth of Indragiri R. (Amphitrite Bay, Mandah courses) fronting *Rhizophora.*

Uses. Timber too small and tree too scarce to have real value, only occasionally used according to BURKILL.

Vern. *Bĕrus-bĕrus* (false *Bruguiera*), *bĕras-bĕras, pulut-pulut, mĕmpulut, pisang-pisang laut* (bastard sea banana), *mĕm-pisang,* Mal. Pen., *bĕus,* Bajau (Borneo), *lingajong, l. laut, pulut-pulut,* Brunei.

Note. This plant is easily distinguished by the indefinite number of stamens, multifid petals, and long, narrow calyx lobes which are completely reflexed in fruit. Two or more radicles (5 have been recorded) are not infrequently formed on one fruit (WATSON).

5. ANISOPHYLLEA

R.BR. *ex* SABINE, Trans. Hort. Soc. 5 (1824) 446; KING, J. As. Soc. Beng. 66, ii (1897) 322.—*Anisophyllum* G. DON *ex* HOOK. Niger Fl. (1849) 342, 575, *non* HAW. 1812; BAILL. Adansonia 3 (1862) 22.—*Tetracrypta* GARDN. & CHAMP. in Hook. J. Bot. Kew Misc. 1 (1849) 314; BTH. J. Proc. Linn. Soc. 3 (1859) 72, as *Tetracarpaea, sphalm.*—**Fig. 28.**

Trees and shrubs. Leaf-axils with 4–6 superposed serial buds. *Leaves* alternate (distichous), often inequilateral, entire, isomorphous, or dimorphous (in *A. disticha* and some specimens of *A. scortechinii*), generally *curvinerved* with 3–5 longitudinal nerves (including the midrib) running from base to apex, more rarely pinnate-nerved but in that case always provided with an intramarginal vein. Stipules 0. *Inflorescences* axillary or supra-axillary, solitary or serial (supernumerary), simple or branched, spike-like, racemose, or paniculate, ebracteate or with minute bracts, brownish pubescent. Monoecious, *flowers* unisexual, polygamous or bisexual, in *A. disticha* the inflorescences either ♀ or ♂; male flowers more or less globose, female flowers cylindric and more or less quadrangular. *Calyx* lobes (3–)4(–5), lobes deltoid, acute, tube adnate to the ovary. *Petals* entire, lobed, or lacerate. *Stamens* twice as many as petals, usually unequal in length, episepalous ones longest; filaments short, subulate, in some *spp.* the epipetalous filaments adnate to the basal part of the petal; anthers small, ovoid; abortive in the females. Disk obscure, crenulate or lobed. *Ovary* inferior, 3–5-celled, each cell with 1 ovule, abortive in the ♂ flowers and consisting of 3–4 small conical or subulate appendages homologous with the styles with the ovary suppressed. Styles (3–)4, free, subulate. Ovules pendulous. *Fruits* ellipsoid to pyriform, smooth or ridged, usually 1-seeded, floral parts persistent; pericarp generally consisting of 3 layers, rather hard and fibrous, in *A. disticha* exocarp fleshy, mesocarp and endocarp bony and ridged. *Seeds* with a coriaceous testa, consisting of a solid body of which the main part is formed by a thick, hard albumen; embryo linear or slightly spindle-shaped, longitudinally embedded in the seed, possibly for the greater part consisting of a hypocotyl.

Distr. About 25 *spp.* distributed in tropical Africa, Ceylon, India, SE. Asia, *Malaysia* (Sumatra, Malay Peninsula, and Borneo), with one species in tropical South America (British Guiana, *viz. A. guyanensis* SANDWITH).

It is remarkable that the Malaysian species have such clear cut areas, *A. disticha* occurring throughout the Sunda shelf area (Java excepted), the others being confined to one subarea, *viz* Malaya: *apetala, corneri, curtisii, grandis, griffithii,* and *scortechinii,* Borneo: *beccariana, ferruginea,* Sumatra: *Anisophyllea sp.*

Ecol. Primary rain-forests below 1000 m, one record of 1250 and one of 1870 m.

Uses. The wood is hard and durable. The timber of some species is used for house-beams, *cf.* BURK. Dict. 1 (1935) 161.

The fruit of the W. African species *A. laurina* is edible and is called monkey apple, *cf.* SABINE, *l.c.* In our area only *A. disticha* has a fleshy drupe but is not known to have been eaten by men.

Note. There is some doubt about the exact structure of the seed as far as could be ascertained from the Malaysian herbarium material. The pericarp consists always of three layers, the inner one being the thinnest and of hard, bony texture, the meso- and exocarp being both hard, but more fibrous, the exocarp being in some species fleshy.

The seed coat is coriaceous and envelops a solid body of endosperm and embryo, differentiated by a very thin brown layer. In cross-section both 'endosperm' and 'embryo' appear to consist of rather amorphous parenchymatic tissue. I have concluded that the outer thick layer represents the endosperm which then tightly envelops the embryo. It appeared impossible to separate embryo from endosperm and though the impression is that it almost wholly consists of the hypocotyl, this point should be left to further examination with abundant fresh material. This evaluation is contrary to BAILLON's who stated (Hist. Pl. 3, 304): '*embryonis exalbuminosi carnosi radicula macropoda clavata*'. According to this interpretation the thick outer seed tissue can only represent the united cotyledons (as occur in *Rhizophora*!) tightly enveloping the thick longitudinal radicle. I believe, however, that this interpretation is wrong.

KEY TO THE SPECIES

1. Leaves of one kind.
  2. Nerves thin, pinnate, an intramarginal vein running less than 1 mm from the leaf-edge. Leaves 5–9 cm long. Fruit large. Flowers solitary, sessile. . . . . 1. **A. griffithii**
  2. Besides the intramarginal vein at least 2 large nerves curved and running from the leaf-base to the apex (3–5-plinerved nervation).
    3. *All* leaves ± rhombic, distinctly unequal-sided, the apical half much broader than the basal one. Cross-veins between the curved nerves *distinctly* prominent-scalariform beneath, faintly sunken in on the upper surface. Twig-ends brownish pubescent-tomentose. (Fruit small, thin-shelled, globular to broad-elliptic, *c.* $1^1/_2$–2 cm long) . . . . 9. **A. scortechinii**
    3. Leaves not rhombic and not *all* distinctly unequal-sided. Cross-veins *not distinctly* prominent-scalariform beneath. Twig-ends glabrous or with a very thin, smooth, strictly appressed rusty tomentum.
      4. Twigs and undersurface of the leaves initially covered by a thin, smooth indument of strictly appressed, rusty tomentum, *glabrescent* but vestiges almost always found along the nerves or in the nerve-axils at the base. (Venation tessellate; fruits large with a thick pericarp; endocarp woody). . . . . 4. **A. ferruginea**
      4. Twigs and leaves without such indument. (Leaves tessellate or not; fruits large or average; endocarp woody or not).
        5. Flowers in contracted simple or compound panicles, the flowers on very short thickish side-branches of both the main rachis and its main branches. Fruits very large, with a dense thin rusty tomentum consisting of very short hairs and scales. Main nerves 5(–3), the inner ones separating from the midrib at *c.* 1 cm above the insertion of the lower ones. Dried leaves generally discoloured, the upper surface pale yellowish-greenish, the under surface cinnamon to pale brown. (Petals entire, long-hairy all over) . . . . 5. **A. grandis**
        5. Flowers in racemes, spikes or open panicles, in the latter case the few branches elongated and resembling the main axis.
          6. Leaves nigrescent, small, 5–8 by $1^1/_2$–$2^1/_2$ cm. Petals split into filiform segments nearly to the base . . . . 3. **A. curtisii**
          6. Leaves not nigrescent, larger, at least 3 cm wide. Petals entire, glabrous or sparingly ciliate along the margin.
            7. Curved main nerves about as prominent as the venation, much less prominent than the midrib. (Leaves *c.* 2 times as long as broad, under 10 cm long). . . . . . 2. **A. beccariana**
            7. Curved main nerves about as prominent as the midrib. (Leaves *c.* 2–3 times as long as broad, mostly larger).
              8. Venation prominent on both sides, but the meshes (areolae) rather irregular and not tessellate. Leaves *c.* 12–20 by 4–$9^1/_2$ cm, in the herbarium usually yellowish or pale brown, mostly long-caudate-acuminate. Flowers dark red or purple. Mature fruits spindle-shaped, acuminate at both ends, 5–6 by *2–$2^1/_2$* cm, the pericarp *c. 2* mm thick; endocarp merely a lining, woody mesocarp and exocarp both 1 mm diam. . . . . 6. **A. apetala**
              8. Venation prominent and tessellate on both surfaces. Leaves $7^1/_2$–13 by $2^1/_2$–$5^1/_2$ cm, in the herbarium the upper surface rather dark brown, shorter and less abruptly acuminate on the whole. Flowers (? always) white with 2 yellow lines. Mature fruits (5–$5^1/_2$-)7–9 by *4–5* cm, broad-ellipsoid, slightly acuminately narrowed at both ends, pear-shaped or broad-ellipsoid, the pericarp *c. 5–9* mm diam.; endocarp 1 mm, mesocarp woody 4–6 mm, exocarp corky $1^1/_2$–3 mm . . . . 7. **A. corneri**
              8. Venation prominent and tessellate on both surfaces. Leaves 8–17 by 4–7 cm, in the herbarium yellowish or pale green, acute to shortly acuminate. Flowers (inadequately known) yellow. Immature fruits ellipsoid, $5^1/_2$ by $2^1/_2$ cm, acuminate at both ends, pericarp *c.* 4 mm diam.. 8. **Anisophyllea sp.**
1. Leaves distinctly of 2 kinds, 2 rows of spreading leaves and 2 rows of small to minute, stipule-like, mostly falcate ones, generally appressed to the twig, and more or less alternating with the large leaves. (Leaves distinctly rhombic and *all* unequal-sided; twigs brownish pubescent-tomentose).
  9. Curved nerves 2–4, all rising from the leaf-base. Scalariform cross-veins distinctly prominent on the under surface. Fruits globular to broadly ellipsoid (*c.* 15–20 by 12–17 mm), pericarp smooth outside, exocarp obviously not becoming fleshy . . . . 9. **A. scortechinii**
  9. Curved nerves 3, 2 outer ones rising from the leaf-base, 1 inner one emerging on the apical half of the blade from the midrib above and separate from the 2 outer ones. Scalariform cross-veins faintly prominent on the under surface. Fruits narrow-oblong, the hard mesocarp *c.* 15–18 by 5–8 mm, with (6–)8 prominent lengthwise ridges (section!), exocarp obviously fleshy, red when ripe 10. **A. disticha**

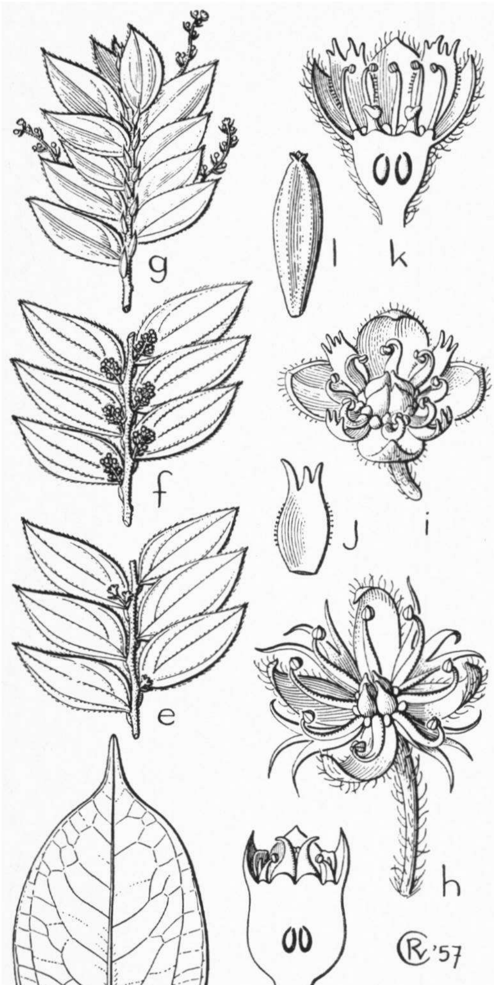

Fig. 28. *Anisophyllea beccariana* BAILL. *a.* Leaf, lower surface, × $^2/_3$, *b.* longitudinal section of ♂ flower, × 9, *c.* longitudinal section of ♀ flower, × 9, *d.* petal of ♀ flower with staminode, × 13. —*A. disticha* (JACK) BAILL. *e–f.* Flowering branches, lower surface, × $^2/_3$, *g.* flowering branch, upper surface, × $^2/_3$, *h–i.* ♂ flowers, × 9, *j.* petal, × 13, *k.* longitudinal section of ♀ flower, × 9, *l.* dried fruit, nat. size (*a, c, d* BECCARI P.B. 1001 (type), *b* DICKSON 5, *e, k* GRASHOFF 1144, *f, i, j* DUMAS 1574, *g* BÜNNEMEIJER 7336, *l* S.F. 306).

1. Anisophyllea griffithii OLIVER, Trans. Linn. Soc. 23 (1862) 460, t. 48; HENSLOW in Hook *f.* Fl. Br. Ind. 2 (1878) 442; KING, J. As. Soc. Beng. 66, ii (1879) 325; RIDL. Fl. Mal. Pen. 1 (1922) 702; BURK. Dict. 1 (1935) 162; CORNER, Ways. Trees (1940) 124, f. 30.

Tree up to 25 m by 60 cm. Bark light brown, smooth, becoming shallowly ridged, cracked and rugged. Young *leaves* bronze and drooping (*sec.* CORNER); mature leaves elliptic to ovate-lanceolate, rarely lanceolate, slightly asymmetric at the base, thinly coriaceous, glabrous, shining above, rather dull below; $5^1/_2$–$10^1/_2$ by 2–5 cm, shortly, bluntly acuminate, base cuneate, margin revolute when dry; midrib much stronger than the 6–8 pairs of pinnate nerves; leaf edge with a distinct intramarginal vein; veinlets slightly elevated beneath, visible but sometimes obscure above; petiole *c.* 3 mm. *Inflorescences* solitary or serial, sometimes 2–3-branched at the very base, spike-like, ± zigzag, up to 7 cm long. *Flowers* bisexual, sessile, green, slightly obovoid, *c.* 4 mm long. *Calyx* lobes 4, deltoid, *c.* 1 mm long, acute. *Petals* oblong, fleshy. *Stamens c.* 1 mm long, filaments fleshy, subulate-oblong, in the epipetalous stamens for *c.* $^1/_3$ adnate to the petals. Styles 4, subulate, *c.* 1 mm. *Fruits* broadly ellipsoid or subglobose, obtuse at each end, glabrous, smooth, $4^1/_2$–5 by $3^1/_2$–4 cm, with a woody pericarp up to $1^1/_2$ cm diam. *Seeds* globose, $1^1/_4$–$1^1/_2$ cm diam.

Distr. *Malaysia:* Malay Peninsula (Johore, Kedah, Malacca, Penang, Selangor, and Singapore).

Ecol. In lowland forests up to 230 m.

Uses. The heavy durable timber is suitable for house-beams.

Vern. *Delek tĕmbaga, kĕmpas dadeh, pĕlĕpap, poko kumpao dadĕh, sĕluang bĕrlĕring*, M.

Note. In the available specimens I found only bisexual flowers.

2. Anisophyllea beccariana BAILLON, Adansonia 11 (1875) 311; MERR. En. Born. (1921) 422.—**Fig. 28a–d.**

Medium-sized tree up to 25 m, with a narrow outline; bark rough. *Leaves* elliptic or ovate, chartaceous to thinly coriaceous, glabrous on both surfaces, $7^1/_2$–$10^1/_2$ by 3–5 cm, bluntly acuminate, base acute rarely obtuse; longitudinal nerves 5, subequal at the base, elevated beneath, depressed or distinct above; veinlets reticulate, slightly elevated beneath, plane above; petiole 4–8 mm. *Inflorescences* in groups, branched near the base, racemose, up to 10 cm long. *Flowers* unisexual, bright yellow, slightly pubescent outside. *Male flowers* $1^1/_2$ mm long, shortly pedicelled. Calyx lobes 4, deltoid, 1 mm long. Petals oblong, $^2/_3$ mm long, slightly emarginate, margins incurved. Stamens 8, 4 epipetalous, sterile, $^1/_2$ mm long, antherless or glandular at the tip; 4 episepalous, fertile, $^2/_3$ mm long; filaments thick, flat, subulate. Disk obscure. Pistil rudiments 4, subulate, $^1/_3$ mm. *Female flowers* cylindric, *c.* $2^1/_2$ mm long, slightly pubescent outside, sessile or subsessile. Calyx lobes and petals similar as in the males. Disk none. Staminodes 8. Styles 4, free, subulate, $^2/_3$ mm, thick, recurved. *Fruit* unknown.

Distr. *Malaysia:* Borneo (Sarawak).

Ecol. In forests from the lowland up to 650 m.

Vern. *Kĕrdam*, Paloh, *pei*, Kayan.

Note. The fruit-like bodies on SAR S 0250 are insect galls of the ovary which are subglobose or ellipsoid, 1½ by 1⅓ cm, with scattered lenticels.

3. Anisophyllea curtisii KING, J. As. Soc. Beng. 66, ii (1897) 326; RIDL. Fl. Mal. Pen. 1 (1922) 702.

Tree 10–13 m; young branches appressed rusty-pubescent. *Leaves* elliptic-oblong, rarely slightly unequal at the base, 6–8 by 2–2½ cm, thinly coriaceous, usually glabrous on both surfaces, sometimes sparsely hairy near the base underneath, shining on both surfaces, acuminate, base cuneate; longitudinal nerves 5, starting from the apex of the petiole (sometimes 1 starting a little higher), slightly elevated beneath, plane but visible above, the marginal ones visible beneath and faint above; petiole 2–5 mm. *Inflorescences* spike-like, simple, *c.* 1 cm long. *Flowers* unisexual, shortly pedicelled, with a minute bract at the base. *Male flowers c.* 3 mm long, brownish pubescent. Calyx 4-lobed, lobes deltoid, acute, 1½ mm long. Petals *c.* 3 mm long, divided almost to the base, 5–7-fid, filiform, twisted. Stamens 1½–2½ mm. Sterile pistil *c.* ½ mm. *Female flowers* (*fide* KING) 6 mm long. Calyx lobes reflexed, tube ribbed. Petals as in the males but larger and with more lobes. Styles as long as the petals. *Fruits* unknown.

Distr. *Malaysia:* Malay Peninsula (Penang CURTIS 746).

Note. Known only from the type collection. HANIFF & NUR 2378 has been referred to this species by BURKILL & HENDERSON (in Gard. Bull. S.S. 3, 1925, 370) and RIDLEY *l.c.* However, that specimen clearly belongs to *Lindera* (*Laurac.*).

4. Anisophyllea ferruginea DING HOU, *nov. sp.*

Arbor, ramulis ferrugineo-tomentosis, gemmis 5 vel 6, in seriem verticalem dispositis. Folia oblongo-elliptica, vel oblongo-ovata, (7½–) 9–18½(–24) ×3½–11 cm, integra, apice breviter acuminata, basi attenuata, cuneata vel rotundata, coriacea, supra glabriuscula, subtus ferrugineo-tomentosa, demum ± glabrescentes, nervis 3–5 prominulis, venulis tessellatis. Flores parvi, unisexuales, sessiles. Fructus immaturus visus, ellipsoideus. Typus Neth. Ind. For. Serv. bb 25118, Bo.

Tree up to 31 m by 40 cm. Young branches always rusty, pubescent-tomentose. *Leaves* oblong-elliptic to oblong-ovate, coriaceous, rusty tomentose beneath rarely above, glabrescent but vestiges of indument always found on the veins or in axils of the veins at the base, (7½–)9–18½(–24) by 3½–11 cm, shortly acuminate, base attenuate to rounded, margin rarely recurved; longitudinal nerves 3–5, prominent and elevated beneath, depressed above, sometimes a faint intramarginal vein along the margin; cross-veinlets slightly elevated, venation distinctly tessellate on both surfaces; petiole 1–1½ cm, furrowed above. *Inflorescences* (inadequately known) short, branched, paniculiform, densely rusty pubescent. *Flowers* unisexual, sessile. *Male flowers c.* 1 mm long. Calyx lobes (3–)4(–5), deltoid, acute, *c.* ⅔ mm long. Petals minute, deltoid, *c.* ⅙ mm long, brownish hairy all over. Disk obscurely crenulate. Stamens *c.* ⅓ mm long, filament as long as the anther. Pistil rudiments *c.* ⅓ mm long, brownish hairy at the base. *Female flowers* slightly cylindric, quadrangular, 1½ mm long, densely brownish hairy outside. Calyx lobes and petals similar as in the males. Staminodes almost sessile, *c.* ⅙ mm long. Apex of the styles slightly curved. *Fruits* (immature) ellipsoid, obtuse at both ends.

Distr. *Malaysia:* W. & SE. Borneo (Boentok, Lower Dajak, Ketapang, Landak, Melawie, Sanggau, Tajau: Neth. Ind. For. Serv. bb 2057, 2365, 6406, 8304, 8169, 14192, 17143, 18005).

Ecol. Lowland forests up to 450 m.

Vern. *Kĕpajang, sangkuak, tĕngoda,* Dajak, *bĕlian landak, bulu, kĕpajang landak,* M.

5. Anisophyllea grandis (BENTH.) BURKILL, Gard. Bull. S.S. 4 (1927) 426; Dict. 1 (1935) 161; CORNER, Ways. Trees (1940) 124, f. 29.—*Strychnos grandis* WALL. Cat. (1831) *no* 4454, *nomen.*—*Cocculus flavicans* WALL. Cat. (1831-32) *no* 4976, *nomen.* —*Anisophyllum grande* BENTH. J. Proc. Linn. Soc. 1 (1856) 79.—*A. gaudichaudiana* BAILL. Adansonia 11 (1875) 311; KING, J. As. Soc. Beng. 66, ii (1897) 324; OLIV. in Hook. Ic. Pl. (1887) t. 1551; RIDL. Fl. Mal. Pen. 1 (1922) 702; BURK. & HENDERS. Gard. Bull. S.S. 3 (1925) 371.—*A. grandifolia* HENSLOW in Hook. *f.* Fl. Br. Ind. 2 (1878) 442.—*A. flavicans* HOOK. *f.* & THOMS. *ex* DURAND & JACKS. Ind. Kew. Suppl. 1 (1906) 468, *nomen.*

Tree up to 25 m, with rather narrow conical crown and drooping branches and leaves. *Leaves* large, broadly ovate-oblong, rarely narrowly oblong-elliptic, coriaceous, glabrous, usually yellowish green above when dry, (15–)24–30 by (4–)6–11 cm, acuminate, base abruptly acute or rounded; longitudinal nerves 5 (middle 3 stronger than the 2 outer ones), elevated beneath, plane or slightly depressed above, besides 2 intramarginal veins; transverse veinlets subparallel; petiole 6–12 mm. *Inflorescences* irregularly and unevenly branched, paniculate, up to 20 cm long, branches flattened when dry. *Flowers* unisexual, brownish pubescent outside, usually crowded on very short lateral branches. *Male flowers* shortly pedicelled. Calyx lobes 4, deltoid, acute. Petals deltoid, *c.* ¼ mm long, long brownish hairy all over. Stamens *c.* ½ mm long. Disk crenulate. Pistil rudiments subulate, sparsely brownish hairy in the lower part. *Female flowers* sessile, cylindric, more or less quadrangular, *c.* 2½ mm long. Calyx lobes and petals similar as in the males. Sterile stamens *c.* ½ mm; filaments sometimes twice as long as the anthers. Styles conical, ½ mm, recurved, densely brownish hairy in the lower part. *Fruits* pyriform, 8–12 by 5–7 cm, saccate at the base, minutely rusty-pubescent; pericarp 8–10 mm diam. *Seeds* very hard, solid and large.

Distr. *Malaysia:* Malay Peninsula (Penang, Perak).

Ecol. In forests from the lowland up to 1250 m.

Vern. *Penang pear*, E, *dalek limau manis.*

6. Anisophyllea apetala SCORT. *ex* KING, J. As. Soc. Beng. 66, ii (1898) 323; RIDL. Fl. Mal. Pen. 1 (1922) 702, *p.p.*; BURK. & HENDERS. Gard. Bull. S.S. 3 (1925) 370; BURK. Dict. 1 (1935) 161.

Tree up to 14 m. *Leaves* broadly ovate-oblong to elliptic-oblong, 10–21 by 4–9 cm, glabrous, chartaceous to thin-coriaceous, shining above, rather dull beneath, caudate-acuminate or rarely acute, base rounded, rarely acute, margin entire; longitudinal nerves 5 (middle 3 conspicuous and elevated beneath, plane or depressed above, lateral 2 faint), besides the intramarginal veins; transverse veinlets reticulate, petiole 6 mm. *Inflorescences* spike-like, serial, usually branched at the base, up to 19 cm long. *Flowers* unisexual, usually in groups on very short lateral stalks, brownish pubescent outside. *Male flowers* 2½ mm long, 1½ mm pedicelled. Calyx lobes 4, deltoid, acute, 2 mm long. Petals deltoid, acute, *c.* 1/6 mm long, entire, sometimes sparsely ciliate on the margins. Stamens ½–1 mm. Pistil rudiments 4, subulate, ⅓ mm long, sparsely hairy at the base. Disk 4-lobed, each lobe crenulate. *Female flowers* sessile. Calyx tube cylindric and more or less quadrangular, *c.* 1½ mm long. Calyx lobes and petals similar as in the males. Staminodes ¼–1/6 mm. Styles 4, exserted, spread and recurved, ⅔ mm, sparsely brownish pubescent at the base. *Fruits* ellipsoid or ovoid, usually tapering at each end, glabrous, with red stripes when fresh, 5–7½ by 2½ cm; pericarp woody. *Seeds* ellipsoid, 3 by 1 cm.

Distr. *Malaysia:* Malay Peninsula (Johore, Perak, Selangor, Trengganu).

Ecol. In forests from the lowland up to 280 m.

Uses. The red-brown, hard, durable wood is used for house-beams.

Vern. *Dalek bukit, dalek limau manis, dalek tĕmbaga, keolundang, mĕdang bĕronok, m. bĕrunit, m. bunut*, M.

Notes. In flower structure this species does not show any appreciable difference with *A. corneri*, but the leaves, their venation, and the fruits are different. I follow CORNER in distinguishing it as a separate species.

KING & GAMBLE obviously had difficulty with this genus as they cite only a small part of the then available material, and two numbers (KING's coll. 6318, 6881) which they cited under *A. apetala* belong to *A. corneri*.

There is one dubious specimen (CORNER 36299) collected in the lowland forest of Johore which CORNER doubts to belong to *A. corneri*; it differs by the apple-green pear-shaped fruit which is not striped when fresh (but appears to be striped in the herbarium, D.H.); the fruit measures 5 by 3½ cm and its pericarp is as thick as that in *A. apetala*.

7. Anisophyllea corneri DING HOU, *nov. sp.—Anisophyllea sp.*, CORNER, Ways. Trees (1940) 125.

Folia elliptica-oblonga, 7½–13½ × 2½–5½ cm, integra, apice acuminata, basi cuneata, nervis 3 subtus prominulis, venulis tessellatis distinctis. Racemi axillares, simplices vel basi ramosi, usque ad 10 cm longi. Flores parvi, unisexuales, femineis sessilies, masculinis pedicellati. Fructus late ellipsoideus, 6–9 × 4–4½ cm, utrinque obtusus. Typus CORNER S. F. 25927, SING, BO, KEP.

Small to medium-sized tree up to 23 m. Old twigs dark brown when dry. *Leaves* elliptic-oblong, chartaceous to thinly coriaceous, glabrous on both surfaces, 7½–13½ by 2½–5½ cm, shortly acuminate, bluntly tipped (tip 4–10 mm long), base cuneate; longitudinal nerves 3, prominent and elevated beneath, slightly elevated above; petiole 1 cm. *Inflorescences* racemose, simple or rarely branched at the base, 1–8 cm long, slightly pubescent. *Flowers* unisexual, sparsely pubescent, glabrescent. *Male flowers c.* 1 mm pedicelled. Calyx lobes 4(–5), deltoid, acute, ⅔ mm long. Petals minute, glabrous, 1/6 mm long; stamens ⅓–½ mm, filaments fleshy, subulate; disk lobes 4, each at the base of a pistil rudiment and slightly embracing it. Pistil rudiments subulate, ⅓ mm, glabrous. *Female flowers* sessile, 1⅓ mm long. Calyx lobes and petals as in the male flowers. Calyx tube cylindric, more or less quadrangular, shortly pubescent outside. Sterile stamens ¼–⅓ mm, filament flat. Disk lobes 4, each at the base of a style and embracing it. Styles 4, brownish scaly at the base, ½ mm. *Fruits* broadly ellipsoid, blunt at both ends, 6–9 by 4–4½ cm, greenish to yellow then brownish with dull red stripes, with purple stripes when dry. *Seeds* ellipsoid, 5 by 2 cm.

Distr. *Malaysia:* Malay Peninsula (*Kedah:* ABDOELLAH C. F. 33044; *Perak:* BURKILL & HANIFF S. F. 12829, CURTIS 1649, HANIFF & NUR S. F. 2391, HASHIM 4, KING's coll. 6318, 6881, SYMINGTON C. F. 25550, WRAY 2625, YEOB 1365; *Trengganu:* CORNER S.F. 25927 & 30178; *Pahang:* M. ZIN C.F. 27740; *Selangor:* V. BAIN C.F. 5203, BURKILL S.F. 13470 & 13482, DESCH C.F. 45075, JA'AMAT C.F. 10256, STRUGNELL C.F. 11233, WATSON 538, C.F. 24306; *Negri Sembilan:* BURKILL S.F. 828, HOLTTUM S.F. 9771; *Malacca:* ALVINS 991, 1078; *Johore:* V. BAIN 5211, 5958, CORNER S.F. 29324 & 36999).

Ecol. In forests from the lowland up to 1000 m.

Vern. *Nipis kulit, pĕparah, sial meaun*, M.

8. Anisophyllea sp.

Tree up to 38 m by 60 cm. *Leaves* ovate to ovate-oblong or elliptic-oblong, chartaceous to thinly coriaceous, glabrous and shining on both surfaces, 8–17 by 4–7 cm, acute to shortly acuminate, blunty tipped (tips up to 1½ cm long), base cuneate to rounded; longitudinal nerves 3(–5), conspicuous and elevated on both surfaces; petiole 3–7 mm. *Inflorescences* branched at the base, paniculiform, up to 7 cm long, branches flattened when dry, brownish pubescent, rather stout as in *A. grandis*. *Flowers* (inadequately known) yellow, crowded on very short lateral branches. *Female flowers* sessile, 1½ mm long. Calyx lobes deltoid, ⅔ mm long; tube cylindric and more or less quadrangular, shortly pubescent outside. Petals not seen. Sterile stamens *c.* 1/6 mm long. Disk obscure. Styles 4, subulate, ⅔ mm long, exserted and slightly recurved, densely brownish hairy at the lower part. *Fruits* (immature) ellipsoid'

$5^1/_2$ by $2^1/_2$ cm, with purple stripes when dry, pericarp 4 mm diam.

Distr. *Malaysia:* Sumatra (*Tapanuli:* Pariaman: TEYSMANN 2339 HB, Sibolga: Neth. Ind. For. Serv. bb 19655; *W. Coast Res.:* Neth. Ind. For. Serv. bb 7395, bb 6135, bb 5222, bb 3114, SWK I–45; *Indragiri:* Neth. Ind. For. Serv. bb 30053 & 30096).

Ecol. In primary forests from the lowland up to 400 m.

Vern. *Kalek sakam, mĕdang lawang, sakam,* Minangk.

Notes. This is in all probability a new species, but unfortunately all but two specimens are sterile, and the fertile ones (SWK I–45, bb 30096) bear only immature fruits and too fragmentary flowers respectively. The sheets are very homogeneous and have all been collected in a rather restricted coherent area in Central Sumatra. It is closest allied to *A. corneri*, but I have refrained from describing it; it is easily distinguished by the colour and size of the leaves.

The oldest collection of it is by TEYSMANN (HB 2339); his sheets were wrongly referred to the *Lauraceae* by MIQUEL who, in his Supplement Sumatra (1860, p. 142, last two lines from bottom), referred it to *Cinnamomum eucalyptoides* NEES; he was possibly misled by the (wrong) Malay vernacular *madang kulit manis.*

9. Anisophyllea scortechinii KING, J. As. Soc. Beng. 66, ii (1897) 325; RIDL. Fl. Mal. Pen. 1 (1922) 701; BURK. Dict. 1 (1935) 161; Corner, Ways. Trees (1940) 125.

Small tree up to 10 m. Young branches sometimes rusty-pubescent. *Leaves* usually of one kind (rarely with a few small, stipule-like ones appressed to the twig), falcately elliptic to slightly rhomboid, thinly coriaceous, rather silvery in living condition, shining on both surfaces, glabrous, sometimes with a few scattered, appressed, brownish hairs on both surfaces and especially on the main nerves and veins, 4–$15^1/_2$ by $1^1/_2$–6 cm, acuminate, base obliquely cuneate; longitudinal nerves usually 5, rarely the middle one forked, middle 3 prominent and elevated beneath, depressed or plane above, marginal 2 slightly elevated below, visible or obscure above; cross-veinlets distinctly prominent-scalariform beneath, faintly depressed on the upper surface. *Inflorescences* racemose or spike-like, 1–7 cm long. *Flowers* polygamous, brownish pubescent outside. *Male flowers* 1 mm pedicelled, minutely bracteate at the base. Calyx lobes 4(–5), ovate, *c.* 1 mm long, acute. Petals 3-fid at the apex, $^3/_4$ mm long; stamens *c.* $^1/_2$ mm. Disk deeply lobed. Pistil rudiments conical. *Bisexual flowers* sessile or subsessile, cylindric, *c.* 2 mm long. Calyx lobes $^1/_2$ the length of the calyx, deltoid, acute. Petals 2–3-fid at the apex. Stamens 8, equal in length. Styles conical, *c.* $^3/_4$ mm, rusty hairy at the base; stigmas subcapitate. *Fruits* ellipsoid, obtuse on both ends, $1^1/_2$–2 by $1^1/_4$–$1^3/_4$ cm; pericarp woody, persistent, $1^1/_2$ mm diam.; calyx lobes reflexed. *Seeds* ellipsoid, $1^1/_2$ by 1 cm.

Distr. *Malaysia:* Malay Peninsula (Dindings, Johore, Kedah, Pahang, Perak, Singapore, and Wellesley) and Lingga.

Ecol. In forests from the lowland up to 230 m.

Vern. *Kayu ribu-ribu*, M.

Notes. In *A. scortechinii*, though closest allied to *A. disticha*, the reduced, stipule-like leaves are much less in number and less frequent than in the latter species. For this reason it has been entered in the key in two places.

10. Anisophyllea disticha (JACK) BAILLON, Adansonia 11 (1875) 311; HOOK. *f.* Fl. Br. Ind. 2 (1878) 442; KING, J. As. Soc. Beng. 66, ii (1897) 322; SCHIMP. in E. & P. Pfl. Fam. 3, 7 (1898) 56, f. 30; MERR. En. Born. (1921) 422; RIDL. Fl. Mal. Pen. 1 (1922) 701; BURK. & HENDERS. Gard. Bull. S.S. 3 (1925) 370; CORNER, Ways. Trees (1940) 122, fig. 28.—*Haloragis disticha* JACK, Mal. Misc. 2 (1822) 19; reimpr. Calc. J. Nat. Hist. 5 (1843) 336.—*Anisophyllum trapezoidale* BAILL. Adansonia 3 (1862) 24, 36.—*Anisophyllea rhomboidea* BAILL. Adansonia 11 (1875) 310; MERR. En. Born. (1921) 422.—**Fig. 28 e–l.**

A miniature tree up to $7^1/_2$ m by 10 cm. Branches graceful, drooping, generally arranged in distant whorls; upright main stems only provided with the stipule-like dwarf leaves. Twigs brownish pubescent, all lateral branches provided with leaves of several successive flushes. *Leaves* dimorphous, thin, very distichous, closely set with touching margins, the main upright stems and branches only with small leaves. Large leaves oblong-rhomboid, subfalcate, only on the lateral branches, densely brownish pubescent on both surfaces of the young leaves, glabrescent, $1^1/_2$–9 by $^1/_2$–3 cm, acute at both ends; midrib slightly elevated beneath, depressed above; 1 or 2 longitudinal nerves on each side of the midrib, visible beneath, obscure above; transverse veinlets obscure on both surfaces. Small leaves stipule-like, falcate, generally appressed to the upper side of the twig, and more or less alternating with the large leaves on the lateral twigs, stipule-like, *c.* 5 mm long. *Inflorescences* either with ♂ or ♀ flowers, flowers pinkish white. *Male inflorescences* fasciculate or racemose, up to 7 cm long, rarely branched in the axils of the large leaves, turned to the underside of the twigs. *Male flowers c.* 2 mm long, yellowish, shortly pedicelled, minutely bracteate at the base. Calyx deeply (3–)4(–5)-lobed, lobes deltoid, $1^1/_4$ mm long, acute, brownish appressed-hairy outside. Petals obovate, irregularly 3–5-fid, $1^1/_4$ mm long. Stamens small as compared with other *spp.* Disk deeply lobed. Pistil rudiments subulate. *Female inflorescences:* flowers usually solitary, very rarely in a short, up to 2 cm long, spike-like inflorescence. *Female flowers* sessile, *c.* 2 mm long. Calyx lobes and petals similar as in the males. Staminodes alternating with the disk lobes. Style columnar *c.* $^1/_2$ mm, glabrous; stigma capitate. *Drupes* bright red when fresh, oblong, hanging singly or in pairs from the underside of the twigs, sessile, $1^3/_4$–$2^1/_2$ cm long, the stone yellow-white, 1–2 by $^1/_2$–1 cm, acute at both ends, with 6–8 grooves and ridges; hard pericarp 1–$1^1/_2$ mm diam.

Distr. *Malaysia:* Sumatra, Lingga Isl., Malay Peninsula, and Borneo.

Ecol. Common species in low woods and secondary forests, in wet places, on granitic sands, and on ridges, sometimes occurring up to 714 m, one collection said to have been found at 1785 m (Mt Kinabalu), *fl.* April-Aug., *fr.* throughout the year.

Uses. The hard wood of the main stem is used for making walking sticks and shafts of pikes, spears, and lances. An infusion of the leaves is used against diarrhoea and dysentery. NOORUDIN reported that in Borneo the roots of this plant are boiled together with jintan itam (seeds of *Nigella sativa* L.) and bawang merah (*Allium cepa* L.) for drinking to relieve weariness; also the leaves of it are grinded with the same ingredients for external application towards the same purpose.

Vern. *Leechwood*, E, *pokok kanchil*, *kaju pachat*, *kaju ribu-ribu*, *raya bĕrangkat*, *rambai ayam*, *balam ayam*, Mal. Pen., *ibu ibu*, Djambi, *tsul tsul*, Lingga, *kaju kantjul*, *k. ribu*, Palemb., *mĕmpiding*, *sĕmpiding*, *nasi-nasi*, *sapit*, Banka; Borneo: *piambat*, Murut, *ambun*, Kedayan, *kĕribu*, W. Born.

Notes. The size of leaves is very variable, ranging from 9 by 3 to 1½ by ½ cm. All specimens from the Malay Peninsula have small leaves and their size is usually less than 3½ by 1½ cm. As far as could be ascertained on the available material, the male and female flowers are borne on separate inflorescences.

A specimen of *A. disticha* in K marked as 'Luzon, LOBB' has been cited by ROLFE (J. Bot. 23, 1885, 212) as a Philippine plant. MERRILL (Philip. J. Sc. 10, 1915, Bot. 191) has pointed out that no representative of *Anisophyllea* is known from the Philippines and that the LOBB specimen must have been erroneously localized; it may have come from Borneo.

6. COMBRETOCARPUS

HOOK. *f.* in B. & H. Gen. Pl. 1 (1865) 683.—Fig. 29.

Tree. *Leaves* alternate, entire. Stipules 0. *Inflorescences* solitary or rarely fasciculate (branched from the very base), inserted on a tubercular basis. *Calyx* lobes 3(–4). *Petals* 3(–4), linear, entire, rarely laciniate. *Stamens* 6(–8). *Ovary* trigonous, cuneate to the base, lepidote, inferior, 3(–4)-celled, each cell with 2 ovules. Styles 3(–4), subulate, free. *Fruit* trigonous-fusiform, widely 3(–4)-winged, 1-celled, 2 cells aborted, 1-seeded. *Seed* narrow spindle-shaped (compressed in the herb. when not well developed), a solid whole, without a sharp demarcation between endosperm and embryo under the microscope; embryo obviously central and longitudinal, fusiform.

Distr. Monotypic. *Malaysia:* Sumatra, Riouw (Karimon Island), Banka, Billiton, and Borneo.

Ecol. In water-logged soils of peat-swamp and kĕrangas forests at low altitude.

1. Combretocarpus rotundatus (MIQ.) DANSER, Bull. Jard. Bot. Btzg III, 10 (1929) 345; DURANT, Rep. For. Brunei (1933) 3, 6, 29, 41, 44, tab.; AIRY-SHAW in Hook. Ic. Pl. (1937) t. 3335; BROWNE, For. Trees Sar. & Brun. (1955) 303, t. 41.—*Macrosolen rotundatus* MIQ. Sum. (1861) 138 & 346.—*C. motleyi* HOOK. *f.* in B. & H. Gen. Pl. 1 (1865) 683; ENDERT, Tectona 13 (1920) 122; DIELS & HACK. Bot. Jahrb. 60 (1926) 294–316; HEYNE, Nutt. Pl. (1927) 1173; BURK. Dict. 1 (1935) 643; MARCO, Trop. Woods *no* 44 (1935) 20.—Fig. 29.

Tree up to 25 m by 80(–100) cm, easily producing coppice shoots. Bark grey, usually pale, fissured. Buttresses none or small. *Leaves* coriaceous, obovate, elliptic, broad-elliptic, to suborbicular, 8–14½ by 5½–9 cm, apex rounded, base cuneate; nerves 6–10 pairs, slightly elevated beneath, flat above; petiole 7½–15 mm. Young leaves dark red; fallen leaves usually drying grey above and yellowish below. *Inflorescences* 1½–6½ cm peduncled, including the latter up to 9 cm long; pedicels *c.* 6 mm. *Flowers* yellow. *Calyx* lobes ovate, obtuse, 2½–4 by 2 mm, outside lepidote in the apical part, slightly ciliate on the margin. *Petals c.* 2 mm long. *Stamens* inserted between the lobes of the disk, filament filiform, *c.* 2–2½ mm; anther ovoid, versatile. Disk annular, obscurely 6-lobed. *Ovary c.* 2 mm; *fruit* including the wings 1½–2 by 2–3 cm, wings semicircular, membranous, with parallel, transverse veins. *Seed* elongate-fusiform.

Distr. *Malaysia:* Sumatra (Palembang, Tebing-tinggi), Riouw (Karimon Isl.), Banka, Billiton, and Borneo.

Ecol. From near sea-level up to 100 m, on sandy soils, peat swamps, freshwater swamps, and along the coast.

A distinctly gregarious tree of fairly large size confined to coastal swamp forest common from Borneo to Palembang and adjacent islands, in Brunei associated with *Dactylocladus* & *Gonystylus*, in Palembang with *Campnosperma* & *Shorea albida*.

According to BROWNE (*l.c.* p. 7) it may be dominant in the peat-forests 'padang paya' of Sarawak and Brunei in similar places as *Shorea albida var.* or as a co-dominant of *Sh. albida* (alan);

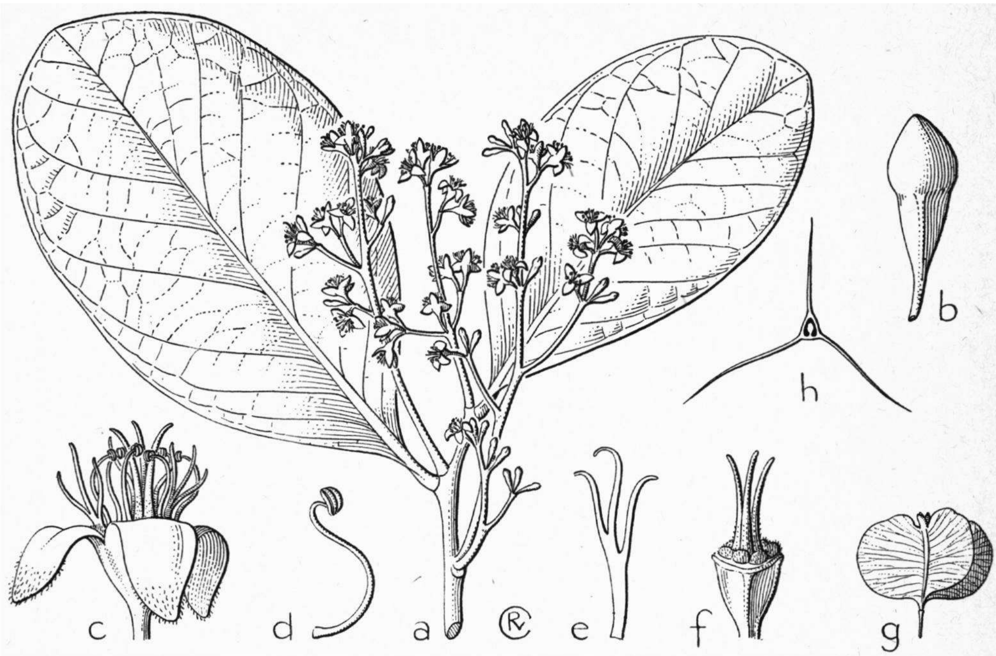

Fig. 29. *Combretocarpus rotundatus* (MIQ.) DANS. *a*. Habit, × $^2/_3$, *b*. bud, × 7, *c*. flower, × 7, *d*. stamen, × 13, *e*. petal, × 13, *f*. gynoecium, × 7, *g*. fruit, × $^2/_3$, *h*. cross-section of a fruit, × $^4/_3$ (*a* partly after ENDERT 302 partly after SHAW, *b–f* ENDERT 302, *g* MONDI 286, *h* after SHAW).

he says it also occurs on dry kĕrangas soils and in the mixed swamp forest type (*l.c.* p. 303). Over considerable areas, particularly in Baram and Brunei, it may average more than 5 large trees per ha. Stems of old trees are in some localities hollow and produce upward curved, short 'hunger roots' in the lower part of the bole from fissures in the bark. Generally it is small-sized but this is often compensated by abundance.

In South Sumatra ENDERT (*l.c.*) found it in peat-forests in the Musi delta associated with *Campnosperma macrophylla* and *Shorea sp.*

Kĕruntum coppices are remarkably vigourous, and posts used for fencing and similar purposes often take roots and sprout (*cf.* BROWNE *l.c.*); the young red leaves of the coppices are conspicuous. Branches of wind-blown trees may easily take root and when the old stem in the course of time disintegrates, there may be eventually 4–6 young trees standing in its place, a most remarkable way of vegetative reproduction (Browne, *l.c.* t. 41; DIELS & HACKENBERG, *l.c.* p. 295).

Uses. The reddish-brown heart-wood is fairly hard and heavy; logs sink in water. It is locally highly favoured for heavy interior construction; strength properties appear to be roughly equivalent to those of teak or mĕrbau, easy to saw and work. It has a reputation for durability under cover. Large supplies are available and it deserves much more attention than it now receives (BROWNE).

Vern. *Kaju tanah*, W. Borneo, *pĕrĕpat paya*, *kĕruntum*, Brunei, *pĕrĕpat-pĕrĕpat*, Bajau, N. Borneo, *marapat*, Dayak (Ngadju), *puru*, Sampit; *pĕrpat darat*, Billiton, *pragat darah*, *tĕruntum batu*, Banka, *pĕrpat*, Palemb.

7. CARALLIA

ROXB. Pl. Corom. 3 (1811) 8, t. 211, *nom. gen. conserv.;* R. BR. in Flinders, Voy. Bot. 2, app. 3 (1814) 549, *nomen*; BL. Mus. Bot. 1 (1849) 131; BENTH. J. Proc. Linn. Soc. Bot. 3 (1859) 67 & 74.—*Kare Kandel* ADANS. Fam. Pl. 2 (1763) 88, 532, *nom. illeg.*—*Diatoma* LOUR. Fl. Coch. (1790) 296, *nom. gen. rejic.*—*Barraldeia* THOUARS, Gen. Nov. Madag. (1806) 24, *nom. gen. rejic.*—*Demidofia* DENNST. Schlüss. Hort. Malab. (1818) 31, *non* GMEL. 1791.—*Baraultia* SPRENG. Syst. 2 (1825) 313, *nom.*

illeg.—*Symmetria* BL. Bijdr. (1826–27) 1130.—*Petalotoma* DC. Prod. 3 (1828) 294.—*Karekandelia* ADANS. *ex* O.K. Rev. Gen. 1 (1891) 234.—*Sagittipetalum* MERR. Philip J. Sc. 3 (1908) Bot. 247.—**Fig. 30–32.**

Shrubs or trees, a single *sp.* occasionally with small stilt-roots at the base of the stem. Twigs solid. *Leaves* decussate, petioled, entire to dentate or serrate, papyraceous to thinly coriaceous, black-dotted beneath; midrib sulcate above, prominent below. Stipules lanceolate. *Inflorescences* sessile or peduncled, cluster-like condensed or lax, di- or trichotomously branched, sometimes reduced to 2, or even a single flower. Bracteoles 2, free and caducous or at least connate at the base and persistent. *Flowers* sessile or pedicelled. *Calyx* lobes 5–8, deltoid, acute to acuminate. *Petals* 5–8, unguiculate, caducous or persistent. *Stamens* twice the number of petals, persistent, free or towards the base connate into a tube (*C. papuana*), unequal in length, the short ones oppositisepalous, the long ones oppositipetalous; filaments subulate, flat or slightly fleshy; anthers ovoid or subglobose. Disk annular, fleshy. *Ovary* inferior, 5–8-celled, each cell 2-ovuled, or 1-celled with a central axis and 10–12 pendulous ovules inserted at its top; style filiform or slightly conical; stigmas discoid or capitate, grooved or obscurely lobed. *Fruits* pulpy, globose, ellipsoid or obovoid, 1-celled, 1(–2–5)-seeded. *Seeds* ellipsoid or reniform, albuminous, areolate; embryo straight or curved.

Distr. About 10 *spp.* in Madagascar, Ceylon, India, SE. Asia, throughout *Malaysia* to northern Australia and Melanesia (Solomon Isl.).

Ecol. On lowland ridges, hills, and in swampy places up into the mountains to *c.* 1800 m.

Morph. Stilt-roots have been observed to occur occasionally in *C. brachiata* (KOORDERS, BACKER, BROWNE); KOORDERS's specimen was collected in the Kampar swamp forest in Central Sumatra. ENDERT observed the same in Borneo.

Nomencl. *Carallia* is a conserved generic name, but the citations in the Rules of Nomenclature (Paris Code 1956) are unsatisfactory.

Carallia was not described by R. BROWN, in Flinders, Voy. Bot. 2, app. 3 (1814) 549, but was merely referred to as a *nomen nudum*. The proper description and plate had been given by ROXBURGH himself three years earlier.

Kare Kandel ADANS. Fam. Pl. 2 (1763) 88, 532, based on RHEEDE's name and description (H.M. 5, t. 13), is an illegitimate name according to art. 68 (4) and need not to be mentioned among the rejected names of which *Diatoma* LOUR. and *Barraldeia* THOUARS should stand.

The leaf margin is in this genus either entire, crenulate, or dentate; juvenile specimens of some species, notably *C. brachiata*, are sometimes densely and sharply dentate; the taxonomic value of the leaf margin is, hence, not particularly significant.

KEY TO THE SPECIES

1. Cyme(s) and flowers sessile. (Leaves thin-coriaceous.) . . . . **1. C. coriifolia**
1. Cyme(s) at least short-peduncled. Flowers sessile or pedicelled. (Leaves papyraceous to thin-coriaceous.)
  2. Bracts and bracteoles semi-amplexicaulous, not connate, caducous in or after anthesis. **2. C. eugenioidea**
  2. Bracts and bracteoles persistent, at least connate at the base.
    3. On top of the common peduncle 2 or 3 simple or forked branches, each branch densely covered by decussate and deltoid or semi-orbicular bracts or bracteoles, the internodes between which are *invisible* from the outside; usually some of the bracteoles with solitary, sessile flowers. Leaves entire.
      4. Leaf-base usually rounded, more or less abruptly set off from the petiole. Petals with a claw *c.* 2½ mm long, lamina elliptic, 1½ by 1 mm, shortly fimbriate (ovate and sessile when young). Filaments fleshy, connate about halfway up into a ventrally grooved tube . . **3. C. papuana**
      4. Leaf-base cuneate-attenuate, gradually narrowed into the petiole. Petals with a claw 1 mm long, lamina transversely oblong, 0.6 by 1 mm, slightly emarginate. Filaments thin, subulate, free. **4. C. hulstijnii**
    3. Inflorescences distinctly cymose, each pair or triplet of bracts with 2 or 3 flowers or axes with *clearly* visible internodes, each ultimate cyme 3-flowered, the central flower bractless, sessile, the

lateral flowers pedicelled, sustained by cup-shaped, connate or partly connate bracteoles. Leaf margins distinctly fimbriate-dentate, serrulate, denticulate, very shallowly dentate-crenate, or entire.

5. Petals sagittate, persistent. Calyx lobes inside with short hairs. Seed obovoid or ellipsoid; embryo straight.
 6. Inflorescences only in the axils of the upper leaf pair on each shoot. Disk divided in the upper half into deltoid lobes. Leaves serrulate to denticulate. . . . . **5. C. borneensis**
 6. Inflorescences in the axils of each or several successive leaf pairs on each shoot, not confined to the terminal pair. Disk crenulate. Leaves fimbriate-dentate . . . . . . **6. C. suffruticosa**
5. Petals suborbicular or obovate-spathulate, caducous in or after anthesis. Calyx lobes inside glabrous. Seed reniform or curved, embryo curved.
 7. Flowers 6–8 mm long, not resinous. Petals obovate-spathulate, 3–3½ by 1½–2 mm. Ovary 1-celled. Fruits obovoid, 6 by 3 mm, ridged . . . . **7. C. calophylloidea**
 7. Flowers *c.* 3 mm long, usually resinous. Petals suborbicular, 1–2 mm diam. Ovary 5–8-celled. Fruits globose, 5–7 mm diam. . . . . **8. C. brachiata**

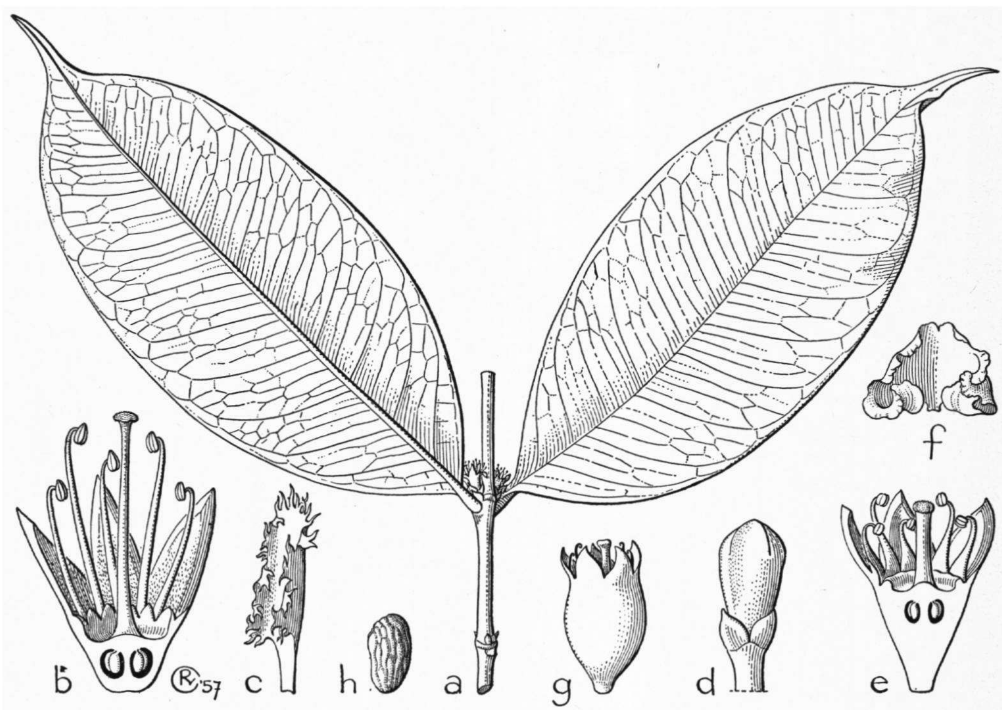

Fig. 30. *Carallia coriifolia* RIDL. *a.* Habit, × ⅔, *b.* longitudinal section of flower (petals removed), × 5, *c.* petal, × 7.—*C. eugenioidea* KING. *d.* Bud, × 4, *e.* longitudinal section of flower (petals removed), × 4, *f.* petal, × 7, *g.* fruit, × 2, *h.* seed, × 2 (*a–c* HAVILAND 1797, *d, f, h* PURSEGLOVE 4244, *e, g* SCORTECHINI *s.n.*).

1. Carallia coriifolia RIDL. Kew Bull. (1938) 283. —Fig. 30a–c.

Small tree. *Leaves* ovate-oblong to elliptic-oblong, entire, 7–17 by 3–6 cm, shining and deep-brown when dry, acute to acuminate (acumen up to 2 cm long), base cuneate or rarely rounded; nerves 7–11 pairs, slightly elevated on both surfaces, sometimes obscure on the upper surface; petiole thick, ½–1 cm. Stipules 1½–2½ cm long. *Inflorescences* and flowers sessile, 1–4-flowered; bracts and bracteoles crowded together, decussate, ovate, amplexicaulous and embracing the lower part of the flower. *Flowers* 7–8 mm long, green, petals, stamens, and style exserted. *Calyx* lobes 5 or 6, lanceolate, 2½–3½ mm long, with a tuft of hairs at the tip, shortly brownish hairy within. *Petals* sagittate, 4½ mm long, fimbriate, conduplicate, base acute and involute, unguiculate. Disk cup-shaped, halfway divided into deltoid lobes. *Stamens* filiform, 8–10 mm; anthers ovoid, slightly apiculate. *Ovary* 1-celled, ovules 10–12, pendulous, attached on the axis; style filiform, 10 mm; stigmas capitate. *Fruits* oblong-ellipsoid, 12 by 7 mm, 1-celled, 1-seeded, the floral parts persistent. *Seeds* obovoid, obtuse at both ends, areolate, 9 by 4½ mm; embryo straight.

Distr. *Malaysia:* W. Borneo (Sarawak, Sintang, Kapuas).

Ecol. Rain-forests at low altitude.

2. Carallia eugenioidea King, J. As. Soc. Beng. 66, ii (1897) 320 (*eugenoidea*); Ridl. Fl. Mal. Pen. 1 (1922) 697.—*C. montana* Ridl. J. Fed. Mal. St. Mus. 6 (1915) 145; Fl. Mal. Pen. 1 (1922) 697.—*C. euryoides* Ridl. Fl. Mal. Pen. 1 (1922) 698.—**Fig. 30d–h.**

Shrub or small tree, up to 8 m. *Leaves* usually at the branch ends, obovate, obovate-oblong, or elliptic-oblong, 4–8 by 1½–4½ cm, shining above, rather dull beneath, thinly coriaceous, acuminate to abruptly acute, rarely rounded, base cuneate, margin entire or rarely crenulate; nerves 7–10 pairs; petiole *c.* 5 mm. Stipules 5–7 mm long. *Inflorescences* cymose, once or twice branched, 2½–5 cm peduncled. *Flowers* green, yellowish-green, or white; pedicels up to 7 mm, sometimes the central flower of the ultimate cyme sessile. *Calyx* lobes 5, deltoid, acuminate, 2–3 mm long. *Petals* suborbicular, 2 mm diam., shortly unguiculate. Disk fleshy, slightly crenulate. *Stamens* 1½–2 mm; filament subulate; anthers slightly apiculate. *Ovary* campanulate, 3–5 mm long, 5-celled, each cell with 2 ovules; style 2½ mm; stigma capitate, slightly 5-grooved. *Fruits* slightly obovoid, 4–5 by 3 mm. *Seed* oblong-ovoid, areolate, corrugate, 3 by 1½ mm; embryo straight.

Distr. *Malaysia:* Malay Peninsula and Central Sumatra (Mt Sago).

Ecol. This species has rather seldom been collected and as far as these specimens go they show a rather remarkable vertical distribution, having been found in the Malay Peninsula at low altitude (*c.* 200–300 m) with rather thin, narrow leaves (once noted on a quartzite ridge) and further at much higher altitude (*c.* 1400–1700 m) with coriaceous, more blunt, and broader leaves. The Sumatra collection was made between 1500 and 1800 m and approaches the type of leaf as found in the Malayan mountains.

Note. The single collection from Sumatra (Jacobs 4685) is a young flowering specimen, which matches the present species very well; the bracts and bracteoles are still on the inflorescences, which may be due to the young stage.

3. Carallia papuana Ding Hou, *nov. sp.*

Affinis C. hulstijnii sed foliis basi rotundatis diversa; petala unguiculata, 2½ mm longa, lamina elliptica, 15 × 1 mm, breviter fimbriata; filamenta crassiuscula, infra ad dimidium in tubum canaliculatum connata. Typus Docters van Leeuwen 9530, L; Sing.

Small tree, 4–6 m. *Leaves* elliptic-oblong to ovate-oblong, chartaceous, 12–20 by 5½–8½ cm, entire, shortly acuminate, base rounded; nerves 7–12 pairs, slightly elevated on both surfaces; petiole 6–10 mm. Stipules 1½–2 cm long. *Inflorescences* cymose, up to *c.* 2 cm long, 7–11 mm peduncled. *Flowers c.* 5 mm long, white. *Calyx* lobes 5, deltoid, acuminate, sparsely short-whitish hairy inside. *Petals c.* 2½ mm long, obovate-spathulate, erose, unguiculate. *Stamens* fleshy, 2–3 mm, anthers small, oblong and obtuse. Disk thin, crenulate. *Ovary* 5-celled, each cell with 2 pendulous ovules; style conical, *c.* 2½ mm; stigma obscure. *Fruit* unknown.

Distr. *Malaysia:* West New Guinea (Mamberamo: Docters van Leeuwen 9530, 11343).

Ecol. On hill ridge at 75 m.

4. Carallia hulstijnii Valeton, Bull. Jard. Bot. Btzg III, 2 (1920) 347.

Leaves narrow elliptic-oblong, 14–19½ by 5–7 cm, entire, bluntly acuminate, base cuneate-attenuate; petiole *c.* 1 cm. Stipules 1¾–2¼ cm long. *Inflorescences* cymose, up to 3 cm long, peduncles ½–1¼ cm. *Flowers* 4 mm long. *Calyx* lobes 5 or 6, deltoid, *c.* 2 mm long, acute. *Petals* transversely oblong, unguiculate, with claw *c.* 1 mm long and wide. *Stamens* 1–1½ mm; anthers ovoid, slightly apiculate. Disk thick, crenulate. *Ovary* 5–6-celled; style filiform, 2 mm, stigma discoid, obscurely lobed. *Fruit* unknown.

Distr. *Malaysia:* (Moluccas: Sula Isl.) once collected.

5. Carallia borneensis Oliver in Hook. Ic. Pl. (1896) t. 2459; Merr. En. Born. (1921) 421.——*Sagittipetalum mindanaense* Merr. Philip. J. Sc. 3 (1908) Bot. 247.—*Sagittipetalum palawanense* Elm. Leafl. Philip. Bot. 5 (1913) 1830.—*C. mindanaensis* Merr. En. Philip. 3 (1923) 146.

Tree up to 24 m by 45 cm. Bark finely fissured, pale brown. *Leaves* broad-elliptic, suborbicular to obovate or elliptic-oblong, acuminate to shortly abruptly acuminate (tip acute or rounded), 5½–10 by 2½–7 cm, shallowly crenulate, base cuneate to broad-cuneate; nerves 6–8 pairs, slightly elevated beneath, obscure or visible above; petiole 7 mm. Stipules linear, 1½ cm long. *Inflorescences* cymose up to 3½ cm long, (di-)trichotomously branched, ¾–2 cm peduncled, sometimes with only 2, or even a single flower, in the ultimate cymes the lateral flowers pedicelled and with 2 to 3 bracteoles united into a basal cup, central flower sessile and without bracteoles. *Flowers* white or pale green, 7–8 mm long. *Calyx* lobes 6, lanceolate, 3–4 mm long, shortly whitish hairy within. *Petals, stamens,* and style exserted. Petals sagittate, 3–5 mm long, unguiculate, fimbriate, conduplicate, base acute and inflexed. Filaments filiform, 3½–5 mm; anthers ovoid, slightly apiculate. Disk cup-shaped, fleshy, halfway divided into deltoid lobes. *Ovary* cylindric or cuneate, 2½–4 mm long, 1-celled, with 12 ovules; ovules pendulous, borne at the top of the central axis; style filiform 4–6 mm, stigmas capitate. *Fruit* oblong-ellipsoid 1¾ by 1 cm, crowned by the persistent floral parts, base abruptly narrowed, 1-celled, 1-seeded. *Seeds* oblong-ellipsoid or obovoid, 9 by 6 mm, black, slightly areolate.

Distr. *Malaysia:* Borneo, Philippines (Palawan, Mindanao), and (once found) in W. New Guinea (Lake Amaru).

Ecol. Primary forests at low altitude.

Vern. *Karibas*, Bandjermasin, *kĕmuning hutan*, Dusun, *koroh*, Papua.

6. **Carallia suffruticosa** RIDL. J. As. Soc. Str. Br. *no* 61 (1912) 6; Fl. Mal. Pen. 1 (1922) 698; BURK. Gard. Bull. S.S. 4 (1927) 77, *p.p.;* BURK. & HANIFF, Gard. Bull. S.S. 6 (1930) 198; BURK. Dict. 1 (1935) 449.—*C. fascicularis* GUILL. Not. Syst. 3 (1914) 24; Fl. Gén. I.-C. 2 (1920) 733, f. 75, 18–22.

Shrub or small tree, 2–3 m. *Leaves* elliptic-oblong to narrow elliptic-oblong, papyraceous, 10–18 by 4–6$^1/_2$ cm, acuminate, base cuneate to subrotundate, margins distinctly fimbriate-dentate; nerves 8–13 pairs, slightly elevated on both surfaces; petiole 1–1$^1/_2$ cm. Stipules 7–10 mm long. *Inflorescences* cymose, 1$^1/_2$ cm long, 5 mm peduncled. *Flowers* white or red. Bracteoles decussate, ovate, keeled, persistent. *Calyx* 5–7-lobed, lobes lanceolate, acuminate, 3–4 mm long, shortly hairy within. *Petals* sagittate, unguiculate, *c.* 4 mm long, slightly emarginate, conduplicate, base acute and inflexed. *Stamens* 3–4 mm; anthers ovoid, obtuse, rarely slightly apiculate. *Ovary* 1-celled, with 10–12 ovules; style 4$^1/_2$ mm; stigma discoid. *Fruits* wine-red, ellipsoid, sometimes slightly curved, 15 by 6 mm, 1-celled, 1-seeded, crowned by the remains of the floral parts. *Seeds* oblong, slightly curved, 11 by 4 mm, brown.

Distr. Indo-China (Cochinchina) and *Malaysia:* Malay Peninsula (Selangor, Perak, Trengganu).

Ecol. In lowland forests.

Uses. The leaves are used by the Malayans both internally and externally. "In the form of an infusion of the leaves, it is taken internally for worms, coughs, and after child-birth as a protective medicine; in the form of a decoction it is employed for bathing in fever; and as a poultice of the pulped leaves it is applied to boils" (*cf.* BURK. Dict. *l.c.*).

Vern. *Sisek puyoh, sisek puyu, mĕransi, rĕdip pĕpuyoh, tulang daing.*

Notes. BURKILL (Gard. Bull. S.S. 4, 1927, 77) said that *C. spinulosa* RIDL. does not adequately differ from the *C. suffruticosa* RIDL. He also referred his own collection (4690) to the latter, which actually is *C. brachiata.* The type specimen of *C. spinulosa* RIDL. is RIDLEY 11858 which clearly belongs to *C. brachiata.* Sterile specimens of *C. brachiata* with denticulate leaves can hardly be distinguished from the present species.

7. **Carallia calophylloidea** DING HOU, *nov. sp.*

Folia lato elliptica vel oblongo-elliptica, 6–12 × 3–6$^1/_2$ cm, integra, apice acuta vel breviter acuminata, basi cuneata vel rotundata, nervis primariis numerosis subparallelis. Cymae usque ad 10 cm longae, pedunculis 3–6 cm longis. Calycis tubus campanulatus. Petala obovato-spathulata, 2$^1/_2$–3$^1/_2$ × 2 mm, unguiculata, irregulariter denticulata. Stamina 3–4 mm longa, antheris apiculatis. Ovarium uniloculare, ovulis ab apice axis pendulis. Fructus obovatus, leviter costatus, 1-spermus. Semina anguste reniformia. Typus HALLIER 2199, Bo.

Leaves broadly elliptic or elliptic-oblong, 6–12 by 3–6$^1/_2$ cm, thin coriaceous, shining above, rather dull beneath, entire, acute to shortly acuminate (tip acute to obtuse), base cuneate to rounded; nerves numerous and parallel, slightly elevated on both surfaces; petiole slender, 12–15 mm. Stipules 7–10 mm long. *Inflorescences* distinctly cymose, up to 10 cm long, 3–6 cm peduncled, (di)trichotomously branched. Bracts and bracteoles 2 or 3, united at the base into a cup, their free parts ovate, acute. Lateral *flowers* of the ultimate cymes pedicelled and bracteolate, the central flowers ebracteolate and sessile. Flowers 6–8 mm long. *Calyx* lobes 5–6(–7), lanceolate, 4 mm long. *Petals* obovate-spathulate, 2$^1/_2$–3$^1/_2$ by 2 mm, unguiculate, erose. Disk fleshy. *Stamens* 3–4 mm long, filaments subulate, flat; anthers distinctly apiculate. *Ovary* 1-celled, with 10–12(–14) ovules, pendulous; style 4 mm long; stigma discoid, grooved and obscurely lobed. *Fruits* obovoid, excluding the persistent floral parts 7 by 3$^1/_2$–4 mm, lengthwise ridged outside, 1-seeded. *Seed* reniform, curved, black, 5 by 3 mm, areolate.

Distr. *Malaysia:* W. Borneo (Sg. Smitau: HALLIER 1264; Sg. Kenibung: HALLIER 1317; Sg. Kenepai, P. Malaju: HALLIER 8646).

8. **Carallia brachiata** (LOUR.) MERR. Philip. J. Sc. 15 (1919) 249; En. Philip. 3 (1923) 146; CRAIB, Fl. Siam. En. 1 (1931) 597; MERR. Comm. Lour. (1935) 281; BURK. Dict. 1 (1935) 448; HOLTHUIS & LAM, Blumea 5 (1942) 114, 119; BLAKE, Austr. J. Bot. 2 (1954) 133.—*Kare-kandel* RHEEDE, Hort. Mal. 5 (1685) 25, t. 13.—*Kare Kandel* ADANS. Fam. Pl. 2 (1763) 88, 532.—*Diatoma brachiata* LOUR. Fl. Coch. (1790) 296, ed. Willd. (1793) 362.—*C. lucida* ROXB. Corom. Pl. 3 (1811) 8, t. 211; Hort. Beng. (1814) 92 (*Corallia*); DC. Prod. 3 (1828) 33; W. & A. Prod. (1834) 312; GRIFF. Trans. Med. Phys. Soc. Calc. 8 (1836) 11; Ann. Sc. Nat. Bot. 10 (1838) 124; WIGHT, Ic. 2 (1843) t. 605; BL. Mus. Bot. 1 (1849) 130; KURZ, For. Fl. Burma 1 (1877) 447; KING, J. As. Soc. Beng. 66, ii (1897) 319; BACK. Schoolfl. (1911) 486; GUILL. Fl. Gén. I.-C. 2 (1920) 732, f. 75, 23–25; MERR. En. Born. (1921) 421; CRAIB, Fl. Siam. En. 1 (1931) 599; CORNER, Ways. Trees (1940) 522, f. 177 & 178. —*Demidofia nodosa* DENNST. Schlüss. Hort. Mal. (1818) 31, *no* 13.—*Baraldeia madagascariensis* DC. Prod. 1 (1824) 732.—*C. lanceaefolia* ROXB. Hort. Beng. (1814) 37, *nomen* (*lanceofolia*); DC. Prod. 3 (1828) 33; WIGHT, Ic. 2 (1843) t. 604; BENTH. J. Proc. Linn. Soc. Bot. 3 (1858) 75; HENSLOW, in Hook. *f.* Fl. Brit. Ind. 2 (1878) 439; GUILL. Fl. Gén. I.-C. 2 (1920) 733.—*Symmetria obovata* BL. Bijdr. (1826-27) 1131.—*C. integerrima* DC. Prod. 3 (1828) 33; BL. Mus. Bot. 1 (1849) 129; MIQ. Fl. Ind. Bat. 1, 1 (1855) 594; THWAITES, En. Pl. Ceyl. (1859) 120; BENTH. J. Proc. Linn. Soc. Bot. 3 (1858) 74; Fl. Hongk. (1861) 111; BAILL. Adansonia 3 (1862-63) 37; HENSLOW, in Hook. *f.* Fl. Br. Ind. 2 (1878) 439; F.-VILL. Nov. App. (1880) 80; VIDAL, Sin. Atlas (1883) 25, t. 47, f. E; Rev. Pl. Vasc. Filip. (1886) 126; FORBES & HEMSL. J. Linn. Soc. Bot. 23 (1887) 294; TRIM. Fl. Ceyl. 2 (1894) 155; K. & V. Bijdr. 4 (1896) 301; SCHIMP. in E. & P. Pfl. Fam. 3, 7 (1898) 53, f. 27, A–D;

MERR. Philip. J. Sc. 1 (1906) Suppl. 102; KOORD. Exk. Fl. Java 2 (1912) 669; Atlas 1 (1913) t. 109; EWART & DAVIES, Fl. North. Terr. Austr. (1917) 199; MERR. Sp. Blanc. (1918) 284; RIDL. Fl. Mal. Pen. 1 (1922) 696.—*Petalotoma brachiata* DC. Prod. 3 (1828) 295.—*C. sinensis* ARN. Nov. Act. Ac. Caes. Leop.-Car. 18 (1836) 335; Ann. Mag. Nat. Hist. 1 (1838) 371.—*C. ceylanica* ARN. Nov. Act. Ac. Caes. Leop.-Car. 18 (1836) 334; Ann. Mag. Nat. Hist. 1 (1838) 371.—*C. corymbosa* WIGHT *ex* ARN. Ann. Mag. Nat. Hist. 1 (1838) 371, *nom. illeg.*—*C. barraldeia* W. & A. *op. cit.* p. 370, *nom. illeg.*—*C. integrifolia* GRAHAM, Cat. Pl. Bombay (1839) 68.—*Bruguiera nemorosa* BLANCO, Fl. Filip. ed. 2 (1845) 275, ed. 3, 2 (1878) 147.—*C. celebica* BL. Mus. Bot. 1 (1849) 131; MERR. En. Born. (1921) 421.—*C. symmetrica* BL. *l.c.* 130, *nom. illeg.*—*C. confinis* BL. Mus. Bot. 1 (1849) 129, *incl. var. pauciflora;* MIQ. Fl. Ind. Bat. 1, 1 (1855) 595, *incl. var. latifolia*; Sum. (1861) 326, *incl. var. oxyodon;* MERR. En. Born. (1921) 421.—*C. cuspidata* BL. Mus. Bot. 1 (1849) 129; MERR. En. Born. (1921) 421.—*C. multiflora* BL. *l.c.* 131.—*C. timorensis* BL. *l.c.* 128.—*C. cerisopsifolia* MIQ. Analecta pt 3 (1852) 8.—*C. multiflora* MIQ. Fl. Ind. Bat. 1, 1 (1855) 594, *non* BL. 1849. —*C. madagascariensis* TUL. Ann. Sc. Nat. IV, 6 (1856) 117.—*C. floribunda* MIQ. Fl. Ind. Bat. 1, 1 (1858) 1088.—*C. calycina* BTH. J. Linn. Soc. 3 (1859) 75.—*Stalagmites lamponga* MIQ. Sum. (1861) 496.—*Garcinia cymulosa* MIQ. Ann. Mus. Bot. Lugd.-Bat. 1 (1864) 208.—*Karekandelia brachiata, calycina, celebica, confinis, cuspidata, lanceaefolia et multiflora* O.K. Rev. Gen. 1 (1891) 235.—*C. arguta* K. & V. Bijdr. 4 (1896) 301.—*C. scortechinii* KING, J. As. Soc. Beng. 66, ii (1897) 319; RIDL. Fl. Mal. Pen. 1 (1922) 697.—*C. spinulosa* RIDL. J. Str. Br. R. As. Soc. *no* 82 (1920) 184; Fl. Mal. Pen. 1 (1922) 698.—*C. cuprea* RIDL. Kew Bull. (1938) 282.—*C. viridiflora* RIDL. Kew Bull. (1938) 282.—Fig. 31–32.

Tree up to 50 m by 70 cm. Bark deeply fissured, corky, gray to dark warm-brown, ridges invariably riddled by small black ants, occasionally buttressed and with adventitious roots to 1 m tall. *Leaves* elliptic-oblong, broadly-elliptic, obovate to obovate-oblong, rarely suborbicular or oblanceolate, 5–15 by 2–10 cm, papyraceous to thin-coriaceous; in the herbarium shining above, rather dull beneath, yellowish green to dark brown, entire, serrate, or denticulate, acute to shortly acuminate (acumen up to 1 cm long), base cuneate; nerves 8–12 pairs; petiole 1 cm. Stipules 1–2½ cm long. *Inflorescences* solitary, di- or trichotomously branched, 1–6 cm long, usually shining by secreted resin; peduncles short, up to 2½ cm. *Flowers* white or greenish, 3 mm long, shortly pedicelled or sessile. Bracteoles 2 or 3, entirely connate or rarely partially united into a cup at the base of the flower. *Calyx* deeply (4–)6–7(–8)-lobed, lobes deltoid. *Petals* suborbicular, obscurely bilobed, crenate, unguiculate, including the claw *c.* 1½ mm long. *Stamens c.* 2 mm long, anthers ovoid, small, filament usually glabrous rarely scaly. Disk annular, obscurely crenulate. *Ovary* semi-inferior, the free part ovoid, 5–8-celled, each cell with 2 ovules; style filiform 1½–2½ mm, stigma discoid, obscurely grooved or lobed. *Fruits* globose *c.* 7 mm diam., translucent pink to red when ripe. *Seeds* reniform.

Distr. Widely distributed from Madagascar to Ceylon, India, Siam, Burma, China (Kwangtung, Hainan), Hongkong, and Indo-China (Tonkin), throughout *Malaysia*, to New Britain, the Solomon Isl., and northern Australia.

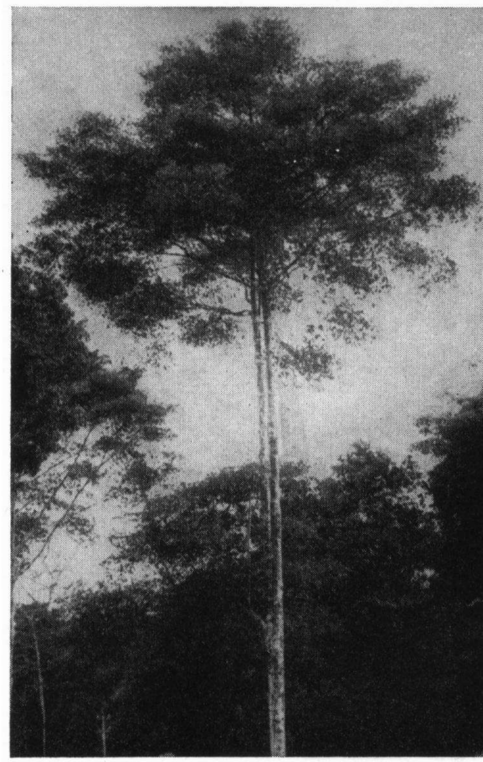

Fig. 31. *Carallia brachiata* (LOUR.) MERR. Planted specimen, For. Res. Institute, Kepong, Malaya, Jan. 1952 (HENDERSON).

Ecol. In rain-forest, more rarely in savannahs and edges of freshwater swamp forests, from the lowland up to 1800 m. In swampy forest it may occasionally produce adventitious aerial roots. According to CORNER remarkably like a *Eugenia.* Sometimes flowering in juvenile state.

Uses. Timber very handsome, moderately heavy, according to BURKILL used for building purposes in the Malay Peninsula; it makes very satisfactory picture-frames, and is most suitable for ornamental work, such as veneered panels for railway carriages, being not liable to insect attack. Also in the Philippines it is esteemed for durable cabinet work, for furniture, musical instruments, posts, and structural timber. Unfortunately it is, though of a common tree, nowhere available in quantity.

Various minor medicinal uses are known, BURKILL, *l.c.* 448.

Vern. Sumatra: *Bĕlidah, maransi, ringgit darah, sĕpat*, M, *ambaradé, tinggiran bata*, Batak, *kukur*, Gajo, *maransi, tinggiran rimbo*, Minangk., *sĕmĕragi*, Kubu Distr., *hĕrkat, kandis pulan, manggris, tĕnggeris*, Banka, *gandang, ganding, mĕrpoi, mĕrpuing, tĕngkawa, bongbong, junggut kĕli, kĕsingi, mĕransi, mĕ(r)singa, mundar, siseh puyoh*, Mal. Pen.; *ki kukuran, ki tamijang*, S, *bibis, gigil, kĕdalèn, kĕlumpit, kukuran, krintjing, liris, ki kukuran, kukurang, sumjak, pututan, sĕpat, tandjang girang, t. gunung*, J, *kotjèngal*, Md, *djanggut kĕli*, M; Borneo: *bĕlĕngkĕching, dabong, massulie, mundar, patjar*, M, *bara, bĕranggae, tulangular*, Dajak, *ganggang putih, tulang ular*, Bandjar., *kitirkitir*, Kwijau, *mundar burung*, Loa Djanan, *sawar bubu*, Bettoton, *tampilas*, Dusun, *aru*, Central E. Born.; Philippines: *anosep, kamaäan, karaékan, kulingmanók*, Tag., *bakáuan-gúbat, mañgua*, Mang., *katolit*, Ilk., *magtuñgod, malibasag*, Mbo., *tandul*, Sulu; Celebes: *Marabia* = *barabia*, Bug., *moro-*

Fig. 32. *Carallia brachiata* (LOUR.) MERR. in the Bornean rapah-swamp forest develops occasionally abundant aerial roots at the stem-base. Kutei, E. Borneo, 1925 (ENDERT).

huho-motea, Tobelo, *kĕndis rĕndai*, *bawachi*, Minah. (Alf.); Moluccas: *utala*, Ceram, *aitabuin*, Aru; New Guinea: *angaur*, Bbembi, *hanaw*, Pemboa, *ngarsar*, Marind, *joseh*, Koropa, *kaisi*, Okena, *kanana*, Rawa, *konak*, Mamberamo Mts, *kwarean*, Wanigela, *tawa-ulo*, Dawa Dawa, *tongatong*, Madang, *uvila*, Upper Waria, *waku*, Onjob.

8. GYNOTROCHES

BLUME, Bijdr. (1825) 218; HASSK. Cat. Hort. Bog. (1844) 213, as *Gynaecotrochus*, *corr. etym.;* BL. Mus. Bot. 1 (1849) 126.—*Dryptopetalum* ARN. Ann. Mag. Nat. Hist. 1 (1838) 372.—**Fig. 33.**

Shrub or tree. Young branchlets hollow. *Leaves* decussate, entire. Stipules lanceolate. *Flowers* tiny, solitary on short stalks, fascicled in short, condensed and tubercular clusters, bracteolate. Pedicels articulated. *Calyx* deeply 4–5-lobed. *Petals* 4–5, obovate rarely elliptic, unguiculate, divided into filamentous appendages at the upper third or half. *Stamens* 8–10, free. *Ovary* superior, slightly ridged, at the base connate with the calyx, 4–6-celled, each cell with 3–8 ovules; style simple. *Fruit* a berry, few- to many-seeded, globose, sometimes oblong, much wrinkled when dry. *Seeds* with fleshy endosperm; embryo linear, axile.

Distr. Monotypic, from Burma (Uppèr Tenasserim) and Siam throughout *Malaysia* (not yet recorded from the Lesser Sunda Islands) to Micronesia (Carolines: Tjaparna, Ponape), and Melanesia (Solomons and New Britain).

Ecol. Primary and secondary forests, up to 2250 m.

1. Gynotroches axillaris BL. Bijdr. (1825) 219; Mus. Bot. 1 (1849) 127, t. 31, *incl. var. parvifolia;* BENTH. J. Proc. Linn. Soc. 3 (1859) 76; MIQ. Fl. Ind. Bat. 1, 1 (1855) 592; KURZ, For. Fl. Burma 1 (1877) 451; HENSLOW, in Hook. *f.* Fl. Br. Ind. 2 (1878) 440; KING, J. As. Soc. Beng. 66, ii (1897) 321; SCHIMP. in E. & P. Pfl. Fam. 3, 7 (1898) 51, f. 26, A–E; K. & V. Bijdr. 4 (1896) 308, *incl. var. obtusa l.c.* 310; BACK. Schoolfl. (1911) 486; KOORD. Exk. Fl. Java 2 (1912) 667; Atlas 1 (1913) t. 108; MERR. En. Born. (1921) 420; En. Philip. 3 (1923) 144; CRAIB, Fl. Siam. En. 1 (1931) 599; KANEHIRA, En. Micr. (1935) 377; BURK. Dict. 1 (1935) 1121; BACK. Bekn. Fl. Java (em. ed.) 4b (1944) fam. 102, p. 2; CORNER, Ways. Trees (1940) 522, f. 179; BROWNE, For. Trees Sar. & Brun. (1955) 305.—*Microtropis? coriacea* WALL. Cat. *no* 4338 (1831), *nomen.*—*Dryptopetalum coriaceum* ARN. Ann. Mag. Nat. Hist. 1 (1838) 373.—*G. dryptopetalum* BL. *incl. var. lanceolata* BL. Mus. Bot. 1 (1849) 127.—*G. micrantha* BL. *incl. var. tuberculata* BL. *op. cit.* 127.—*G. reticulata* A. GRAY, in Wilkes, Bot. U.S. Expl. Exped. 1 (1854) 607.—*G. parvifolia* MERR. Publ. Gov. Lab. Philip. *no* 35 (1905) 46; En. Philip. 3 (1923) 144, not based on *G. axillaris* BL. *var. parvifolia.*—*G. puberula* MERR. Philip. J. Sc. 10 (1915) Bot. 333; En. Philip. 3 (1923) 144.—*G. lanceolata* MERR. Philip. J. Sc. 11 (1916) Bot. 21; En. Philip. 3 (1923) 144.—**Fig. 33.**

Tree up to 15–30(–45) m by 30–50 cm, but very often rather small, and occasionally shrubby; 1–2 m high specimens have been found with flowers and fruit. Bark transversely fissured, grey to blackish; young branches hollow, brown coloured, sometimes pubescent; nodes ± swollen. *Leaves* variable in shape (ovate, ovate-oblong, elliptic-oblong, obovate oblong, or lanceolate), 4½–20 by 1½–9 cm, bluntly or shortly acuminate to acute, acute rarely obtuse at the base, usually glabrous, rarely pubescent beneath or only on the nerves and veinlets, sometimes lepidote on both surfaces, shining and dark brown when dry; nerves 5–9 pairs, ascending along the margins, veinlets prominent beneath, flat to slightly prominent above; petiole ½–1 cm. Stipules 1½ cm long, sometimes pubescent. Bracteoles sometimes pubescent and condensed into short, tubercular glomerules. *Flowers* greenish-white, few to 16, subsessile to 5 mm pedicelled, bisexual, but obviously occasionally male by abortion. *Calyx* lobes 4–5, ovate, 1½–2½ by 1½–3 mm, with a tuft of hairs at the apex. *Petals* 2–2½ by ¾ mm. Disk cup-shaped or nearly flat, crenulate to 8–10-lobed. *Stamens* 8–10, attached on the margin of the disk or just beneath it; filaments incurved, 1–1½ mm; anthers subglobose to ovoid, obtuse or slightly apiculate. *Ovary* ovoid, sometimes abortive; style columnar, short, up to 2 mm; stigma discoid and 4–8-lobed or slender with spreading lobes. *Berries* red, then shiny black, pulpy, usually globose and *c.* 3 mm diam., rarely oblong and 5–7 by 3–5 mm, calyx lobes erect or completely reflexed. *Seeds* ellipsoid, 1½ by ½ mm, areolate.

Distr. From S. Burma (Upper Tenasserim) and S. Siam (Nakawn Sritamarat) throughout *Malaysia* to Australia, Melanesia (Solomon Isl.: Ysabel & Bougainville Isl.; New Britain), and Micronesia (Carolines: Tjaparna, Ponape), not yet recorded from Central to E. Java and the Lesser Sunda Islands.

Ecol. Marshy places, swamps, particularly along creeks in tall rain-forests, slopes of partially

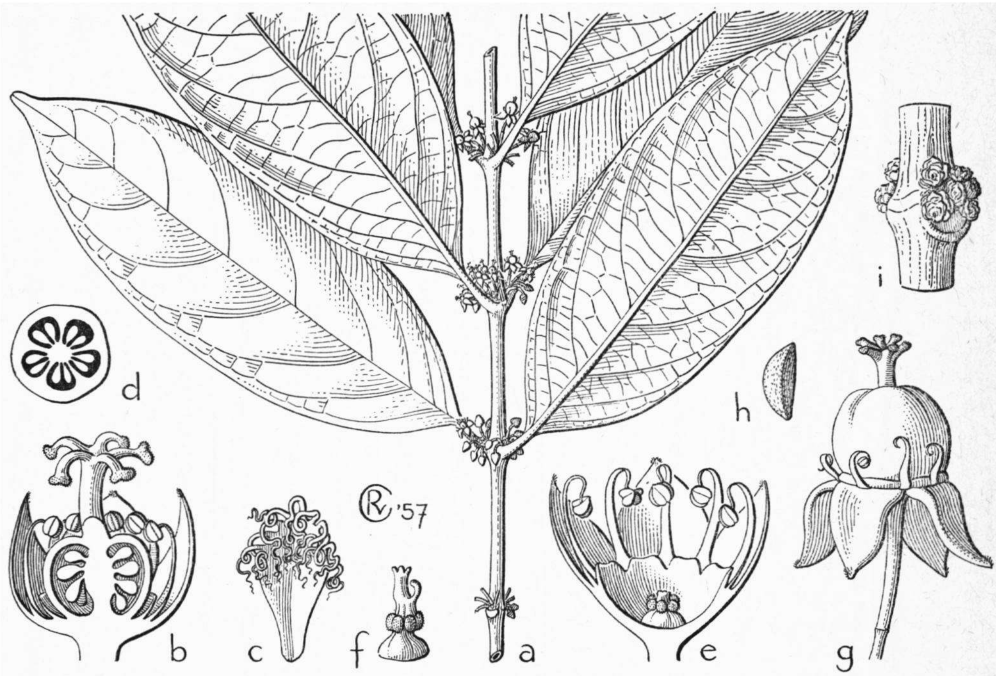

Fig. 33. *Gynotroches axillaris* BL. *a.* Habit, × 2/3, *b.* longitudinal section of ♀ flower (petals removed), × 10, *c.* petal, × 10, *d.* cross-section of ovary, × 10, *e.* longitudinal section of ♂ flower (petals removed), × 10, *f.* pistil rudiment of ♂ flower, × 13, *g.* fruit, × 5, *h.* seed, × 10, *i.* a node showing condensed bracts, × 5/3 (*a, g* VAN STEENIS 5101, *b, d* RICHARDS 1430, *c, e, f* RICHARDS 1565, *h* POLAK 733, *i* KOORDERS 1117).

open virgin forests, and very common in secondary forests, from the lowland up to 2250 m.

It clearly avoids regions subject to a seasonal climate as it is absent from Central Java to Timor; in Java it is confined to the Res. of Bantam, Bogor, and Preanger, one specimen being found in an everwet forest in S. Banjumas.

HOSOKAWA found *G. axillaris* common in the mossy hill forest of the Micronesian islands Ponape and Kusaie together with *Alsophila* where it produces aerial roots from the boughs of the crowns (Mem. Fac. Sc. Kyushu Univ. E 1, 1952, 65–82).

Uses. The brownish-white timber is of little use and not durable, it is occasionally used under roof, further for blades of oars, and sometimes for rafters and house-posts.

Vern. *Bulu-bulu* (in common with several superficially similar trees), *bĕbulu, junggut kĕtjil mata kĕli, mĕmalu kĕtjil, mĕmbulu, mĕrbulu,* Mal. Pen., *kata kĕli,* M (Sum.), *sibeuruwah, surimanuh,* Simalur (Ṭapah dial.), *kaju bulu,* Kubu Distr., *mĕngkĕli, mĕnsollong, tĕlundju, sabar bulu,* Banka, *kukuran,* S, *kupi-kupi,* Brunei, *mĕmbuloh, sabar baku,* Sarawak; Philippines: *kibal, malakulambisan,* Tag., *auai,* Mbo., *bayasbas, doyok-dóyok, talingan,* C. Bis.

Notes. This species is very widely distributed and is markedly variable in leaf-size and shape. Some specimens collected above 1000 m have small and obovate leaves and larger flowers and fruits. The filamentous appendages of the petals are usually in a fringe at the upper third or half, or sometimes there are 9 of them, 3 at the apex, and 3 at the margin of each side (BRASS 2475, LAM 1797). There is a remarkable variability in the structure of the ovary, namely in the placentation: the ovules are fascicled and attached at the top (ACHMAD 163), at the base (LAM 1972), or at the middle (BRASS 2495) of the axis, or even along the axis (RICHARDS 1430). The stigmas vary from discoid and obscurely grooved to deeply divided into linear and spreading lobes.

The remarkable 'looseness' in floral characters of this monotypic genus suggests a promising matrix for future phylogenetical development into several more restricted, rigid types.—VAN STEENIS.

Excluded

Gynotroches membranifolia MIQ. Analecta pt 3 (1852) 7 (T. METZ 713 in Pl. Hohenack.) = *Dryptopetalum membranaceum* MIQ. in Pl. Hohenack. *no* 713 *in sched.* = *Blepharistemma corymbosum* [BENTH. in Wall. Cat. *no* 6320, *nom. nud.*] WALL. *ex* BENTH. J. Proc. Linn. Soc. Bot. 3 (1858) 65, 78 = *Blepharistemma membranifolia* (MIQ.) DING HOU, *nov. comb.*

BENTHAM omitted reference to MIQUEL's publication and only cited the unpublished provisional name MIQUEL had attached to the type *exsiccata* METZ 713. As far as I know no evaluation of MIQUEL's name was ever proposed and it has fallen into oblivion. The tracing of its identity I owe to Dr R. C. BAKHUIZEN VAN DEN BRINK *f.*

9. PELLACALYX

KORTH. Tijd. Nat. Gesch. Phys. 3 (1836) 20.—*Plaesiantha* HOOK. *f.* in B. & H. Gen. Pl. 1 (1865) 681.—*Craterianthus* VAL. *ex* HEYNE, Nutt. Pl. 4 (1917) 196, *nom. semi-nud.*, *cf.* STEEN. Bull. Jard. Bot. Btzg III, 17 (1948) 457.—**Fig. 34–35.**

Trees. Young branches hollow. *Leaves* decussate, entire, obscurely serrulate, or rarely serrate, densely or sparsely pubescent with stellate-hairs rarely mixed with simple ones, or simple hairs only, sometimes glabrescent or subglabrous. Stipules with not overlapping margins, minutely stellate-hairy outside. *Flowers* fascicled or on branched glomerules, 2–8 together, rarely solitary, with minute bracteoles. *Calyx* (incl. ovary) tubular, lobes (3–)4–5(–6), lower part of the tube inside always hairy. *Petals* densely puberulous outside, inserted on the margin of the calyx tube; apex denticulate to fringed in various degree. *Stamens* twice as many as petals, inflexed, inserted on the margin of calyx tube, subulate or deltoid, connate at the base or free, 1- rarely 2-seriate, unequal, 5 long, 5 short (except in *P. pustulatus*); anthers suborbicular. *Ovary* inferior, 9–10(–12)-celled, each cell with 8–25 fasciculate ovules; style columnar, usually pilose; stigma discoid or capitate, obscurely 8–10-lobed. *Fruit* a subglobose, few- to many-seeded berry, 1 to several in each axil. *Seeds* oblong or ellipsoid, black; endosperm fleshy; embryo linear, axile.

Distr. Species 7 or 8, distributed in Burma, Siam, S. China (Yunnan), and *Malaysia:* Sumatra, Malay Peninsula, Borneo, North Celebes, and the Philippines.

In continental Asia *P. yunnannensis* H.H.HU seems rather disjunct from the Siam-Burmese generic frontier; it has been described on a fruiting specimen; no material was available to me.

In Malaysia 4 of the 6 species have rather restricted areas in one island or district, but they seem to me all perfectly good species.

Ecol. In forests from the lowland up to 1300 m.

KEY TO THE SPECIES

1. Flowers 4–merous, very rarely with a few 3- or 5-merous flowers together with the 4-merous ones. Calyx mostly glabrous outside, the tube inside with only very short straight hairs in the lower half. Petals denticulate at the upper end. (Flowers 2–3 mm wide).
 2. Leaves usually obovate rarely obovate-oblong, 7–11(–15) by 3½–5 cm. Nerves 5–7 pairs. Stipules 3–5(–7) mm. Style not ridged . . . . **1. P. lobbii**
 2. Leaves usually elliptic-oblong rarely obovate, 12–18½ by 3–6½ cm. Nerves 9–11 pairs. Stipules 10–12 mm. Style distinctly ridged . . . . **2. P. saccardianus**
1. Flowers 5–merous, very rarely with a few 4- or 6-merous flowers together with the 5-merous ones. Calyx usually densely or sparsely stellate-pubescent, rarely glabrous outside, the tube inside with a zone of woolly or villous hairs (except in *P. symphiodiscus*), its bottom covered with very short straight hairs. Petals always with filamentous or subulate appendages at the upper end. (Flowers 4–6 mm wide.)
 3. Calyx tube very short, not longer than broad, base acute. Calyx lobes about half as long as the tube. Free filaments isomorphic, 1–seriate, equal in size and shape . . . . . **3. P. pustulatus**
 3. Calyx tube always longer than broad, base rounded or slightly truncate. Calyx lobes always shorter than the tube. Free filaments dimorphic, alternately shorter and longer, 1- or 2-seriate.
  4. Stamens 2-seriate. Filaments of the outer whorl united at the base, free part of the filaments alternisepalous and slightly incurved at the apex; stamens of the inner whorl with an extremely short (knob-like) filament, inserted distant from the sinuses. Calyx tube with only short, straight hairs inside in the lower part. Undersurface of the leaves with stellate hairs mixed with simple ones. Fig. 35b–c. . . . . **4. P. symphiodiscus**
  4. Stamens 1-seriate, free filaments alternately shorter and longer. Calyx tube inside with a zone of woolly or villous hairs above the short and straight ones.

5. Leaves thin, underneath distinctly pubescent with simple, long, white hairs. Nerves *c.* 8 pairs. Style usually exserted and glabrous at the upper third . . . . **5. P. parkinsonii**
5. Leaves chartaceous to firmly chartaceous, underneath with densely or sparsely stellate hairs. Nerves 9–14 pairs. Style $^1/_3$–$^1/_2$ the length of the tube, pilose or covered with short hairs throughout.
 6. Leaves usually with a rather dense, rarely sparse indument of rusty, stellate or more or less lepidote hairs, very rarely subglabrous or mixed with some simple hairs. Calyx tube inside with a zone of woolly hairs. Petals 1$^1/_2$–2 mm long, the upper end usually with a few short appendages up to 1$^1/_2$(–2$^1/_2$) mm. Calyx lobes reflexed in anthesis . . . . **6. P. axillaris**
 6. Leaves underside usually subglabrous with scattered, lepidote-like, minute stellate hairs. Calyx tube inside with a zone of villous hairs. Petals 2$^1/_2$–3$^1/_2$ mm long, the upper end always fringed with many rather long appendages 3–5 mm. Calyx lobes erect in anthesis . . **7. P. cristatus**

1. Pellacalyx lobbii (HOOK. *f.*) SCHIMP. in E. & P. Pfl. Fam. 3, 7 (1893) 54.—*Plaesiantha lobbii* HOOK. *f.* in Benth. & Hook. *f.* Gen. Pl. 1 (1865) 145.—**Fig. 34.**

Tree up to 35(–45) m by 40(–65) cm, sometimes with buttresses 1$^1/_2$–5 m high. Bark grey to brown, regularly polygonally fissured. *Leaves* obovate, obovate-oblong, 7–11(–15) by 3$^1/_2$–5 cm, entire to

Fig. 34. Stem-base of *Pellacalyx lobbii* (HOOK. *f.*) SCHIMP. in the forest reserve Bajunglintjir, Aug. 1919 (ENDERT).

remotely serrulate, glabrous, sometimes lepidote above, rarely puberulous on the midrib and nerves on both surfaces, abruptly acute, base cuneate; nerves 5–7 pairs, slightly elevated beneath, plane above; petiole 6 mm. Stipules 3–5(–7) mm long. *Calyx* (incl. ovary) narrow, 6$^1/_2$–8 by 2–3 mm, glabrous or sparingly pubescent with minute, stellate hairs without, green, (3–)4(–5)-lobed, lobes deltoid, 1$^1/_2$–2 mm long, acuminate. *Petals* white, slightly obovate, 1$^1/_2$–2 mm long, slightly dentate in the upper half. *Ovary* 9-celled, style 3 mm long, slightly pilose. *Fruit* green, subglobose, *c.* 8 mm diam., calyx lobes erect, very rarely reflexed. *Seeds* ellipsoid, 1–2 by 1 mm.

Distr. *Malaysia:* Borneo (common), and Sumatra (Palembang, Asahan).

Ecol. A rather small tree of open hill-sides and undulating country at low altitudes. *Fl.* Jan.–April, *fr.* Jan.–Dec.

Uses. Wood fairly heavy, yellowish-brown, occasionally used for rafters and fuel.

Vern. *Bulu-bulu, bĕbulu, mĕmbulu rimba, pianggu jantan, johor, lĕmak kĕtam,* Mal. Pen., *bulu, rĕbung,* Sum., *kaju bulu,* Palemb., *pasĕrujan gunugo, rasu,* Dyak.

Note. *P. lobbii* is closely related to *P. saccardianus*, and most specimens of it were misidentified as belonging to the latter species.They can easily be separated by the leaf shape and the floral structure.

2. Pellacalyx saccardianus SCORT. Nuov. Giorn. Bot. Ital. 17 (1885) 145; HEMSL. in Hook. Ic. Pl. 16 (1886) t. 1546; RIDL. Fl. Mal. Pen. 1 (1922) 699; CORNER, Ways. Trees (1940) 524, f. 181, *p.p.*

Small tree up to 15 m by 25 cm. Young branches puberulous. *Leaves* elliptic-oblong to rarely obovate, 12–18$^1/_2$ by 3–6$^1/_2$ cm, entire, rarely with fascicles of hairs or serrulate, usually glabrous, rarely with minute stellate hairs on the veins, sometimes also on both surfaces of the young blades, shortly acuminate, base rounded to cuneate; nerves and veins elevated beneath, visible or slightly elevated above; petiole 8–10 mm. Stipules 10 mm long. *Calyx* (incl. ovary) glabrous or short-sparingly hairy outside, 5$^1/_2$–9 by 3 mm, (3–)4(–5)-lobed, lobes deltoid, 2 mm long, acuminate, tube cylindric *c.* 3 mm long. *Petals* obovate, 1$^1/_2$–2$^1/_2$ mm long, apex rounded sometimes slightly emarginate and denticulate. *Ovary* 9-celled; style distinctly ridged, 3 mm long, with short, straight hairs; stigma discoid and slightly lobed. *Fruits* subglobose, glabrous, 10 mm diam., greenish-yellow when ripening. *Seeds* 1–1$^1/_2$ mm long, ellipsoid.

Distr. *Malaysia:* Malay Peninsula.

Ecol. Common in damp lowland forests up to 950 m; *fl.* May-Dec., *fr.* June-Nov.

Vern. *Huka hurgu, kayu johor, mĕmbuloh rimbah, piango jantan,* M.

Note. The leaf size and shape in *P. saccardianus* is more variable than in *P. lobbii.* CORNER recorded that the leaves may be occasionally in whorls of three.

3. Pellacalyx pustulatus MERR. Publ. Gov. Lab. Philip. *no* 35 (1905) 47; Philip. J. Sc. 1 (1906) Suppl. 103; En. Philip. 3 (1923) 148.

Tree up to 18 m by 25 cm. Young branches sparingly puberulous. *Leaves* elliptic, ovate or slightly obovate, entire or rarely obscurely glandular-toothed, 11–17 by 4–7 cm, abruptly acute, base cuneate, midrib elevated beneath, depressed above; nerves 6–8 pairs, slightly elevated beneath, distinct above; petiole *c.* 1 cm, glabrous, or slightly pubescent. Stipules 6–8 mm long. *Calyx* (incl. ovary) subcampanulate, acute to the base, sparingly stellate-puberulous or glabrous; lobes 5(–6), deltoid, acute, 2–3 mm long; tube short 2 mm long, densely villous within, its bottom covered with short straight hairs, the long hairs falling off in fruit, the short ones persistent. *Petals* white, obovate rarely suborbicular, 2–3½ mm long, apex obtuse, sometimes with 1–3 subulate appendages, base narrowed. *Stamens* equal. *Ovary* 1½ mm long, 9-celled; style 1½–3 mm, glabrous or with sparse straight hairs at the base; stigma discoid, 8–9-lobed, or 4–5-lobed and then each lobe bifid, lobes slender, reflexed. *Fruits* globose, 12–15 mm diam. *Seeds* elliptic-oblong, obtuse at both ends, 2 by 1 mm, slightly areolate.

Distr. *Malaysia:* Philippines (Leyte, Luzon, Mindanao, and Samar), and N. Celebes (Minahasa).

Ecol. Primary forests from the lowland up to 900 m.

Vern. Philippines: *magatalo*, Mago, *mamatog*, Tag., *pamaluian*, Bag.

4. Pellacalyx symphiodiscus STAPF, Kew Bull. (1898) 224; MERR. En. Born. (1921) 422.—**Fig. 35a–e.**

Shrub or small tree up to 12 m tall. Branches and branchlets covered with rusty-stellate hairs. *Leaves* ovate-oblong to obovate-oblong, 9–19 by 3½–7 cm, shortly acuminate to acute, base rounded or acute, margin with tufted hairs, sometimes glabrous; midrib and nerves elevated beneath, slightly depressed or plane above; petiole 4–10 mm, with minutely stellate hairs. Stipules 13 mm long. *Calyx* (incl. ovary) cylindric or slightly campanulate-tubular, 9–12 by 4–5 mm, densely stellate-hairy outside, lobes 5(–6), deltoid, *c.* 2 mm long, acuminate, lower part of the tube inside with short, straight hairs; pedicels 6–10 mm. *Petals* obovate-oblong, 1½–2½ mm long, the top fringed with filamentous, up to *c.* 2 mm long appendages. *Ovary* half the length of the calyx tube; style columnar, *c.* ¾ the length of the calyx tube, covered with short, straight hairs, stigma capitate,

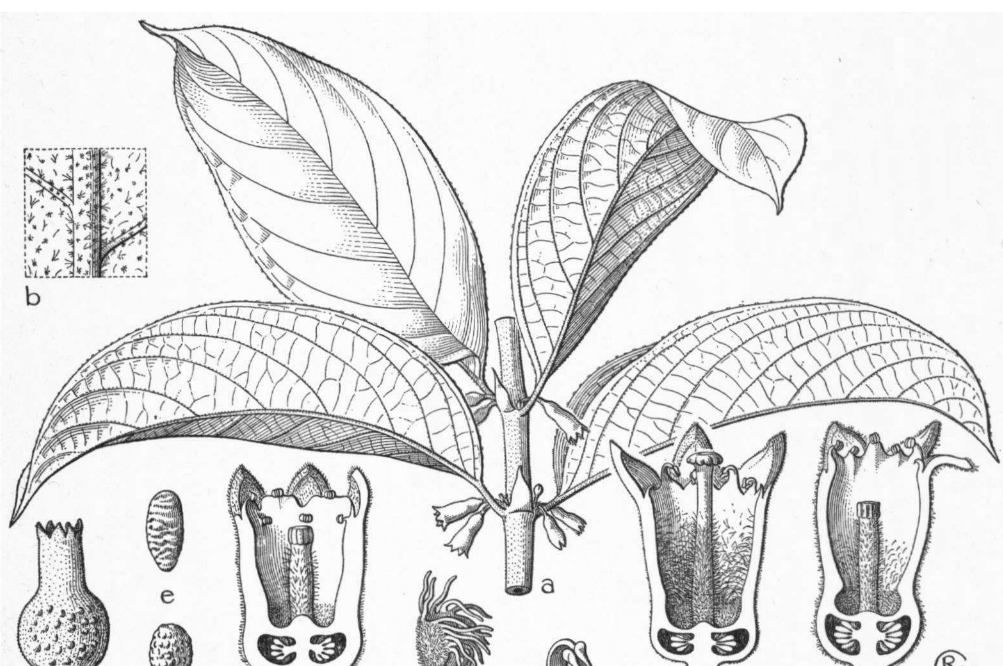

Fig. 35. *Pellacalyx symphiodiscus* STAPF. *a.* Habit, × ⅔, *b.* undersurface of a portion of leaf, × 5, *c.* longitudinal section of flower (petals removed), × 3, *d.* young fruit, × 4/3, *e.* seeds, × 13.—*P. axillaris* KORTH. *f.* Longitudinal section of flower (petals removed), × 3.—*P. parkinsonii* FISCHER. *g.* Longitudinal section of flower (petals removed), × 3, *h.* petal, × 7, *i.* stamen, × 11 (*a, b, d, e* RAMOS 1427, *c* HAVILAND b.q.v.f., *f* HAVILAND & HOSE *s.n.* = 2312, *g–i* KERR 12134).

slightly grooved. *Fruits* subglobose, *c.* 9 mm diam., calyx lobes erect. *Seeds* ellipsoid, 1½ mm long, slightly transversely striate.

Distr. *Malaysia:* Borneo (Sarawak).

Vern. *Mura buloh.*

5. Pellacalyx parkinsonii FISCHER, Kew Bull. (1927) 311, with fig.; CRAIB, Fl. Siam. En. 1 (1931) 599.—**Fig. 35g–i.**

Tree up to *c.* 18 m tall. Branchlets sparsely pubescent with minutely stellate hairs. *Leaves* elliptic or elliptic-oblong, 10–19 by 5–7 cm, entire, thinly white-hairy beneath, with rather scattered, short, simple hairs above, especially on the midrib and nerves, abruptly acute, base rounded or cuneate; midrib elevated beneath, depressed above; nerves slightly elevated beneath, visible above; petiole 7–10 mm, pubescent. Pedicel *c.* 7 mm. *Calyx* (incl. ovary) oblong, 8–12 by 3–5 mm, minutely stellate-hairy outside; lobes 5(–6), ovate, acuminate, 2–3 mm long; tube inside villous in the lower half down to *c.* 1 mm of the basal part which is, as the bottom, covered with very short, straight hairs. *Petals* white, obovate (suborbicular when young), 2–3 mm long, fringed with filamentous, *c.* 1–1½ mm long appendages in the upper half or third. *Ovary c.* ¼–⅙ of the length of the calyx tube, 10-celled; style columnar, 6–8 mm, slightly exserted, covered with short, straight hairs below, glabrous in the upper third; stigma capitate, flat, slightly lobed. *Fruit* unknown.

Distr. Burma (Mergui, Victoria Isl.), Siam (Kamala, Pato), not yet found in *Malaysia.*

Ecol. In forest from the lowland up to 1200 m.

6. Pellacalyx axillaris KORTH. Tijd. Nat. Gesch. Phys. 3 (1836) 20, t. 2; GRIFF. Notul. 4 (1854) 429; Ic. Pl. Asiat. (1854) t. 486, f. 1; MIQ. Fl. Ind. Bat. 1, 1 (1858) 1088; BENTH. J. Proc. Linn. Soc. Bot. 3 (1858) 76; HENSLOW, in Hook. *f.* Fl. Br. Ind. 2 (1878) 440; SCHIMP. in E. & P. Pfl. Fam. 3, 7 (1898) 54, f. 27, O–P; KING, J. As. Soc. Beng. 66, ii (1897) 320; RIDL. Fl. Mal. Pen. 1 (1922) 699; VAL. Bull. Jard. Bot. Btzg III, 2 (1920) 346-347, t. 8–9, *incl. var. serratifolia;* MERR. En. Philip. 3 (1923) 148; CORNER, Ways. Trees (1940) 523, f. 180.—*Craterianthus fimbripetalus* VAL. *ex* HEYNE, Nutt. Pl. 4 (1917) 196, *nom. semi-nud.*, based on HALLIER 121B (Bo), *cf.* STEEN. Bull. Jard. Bot. Btzg III, 17 (1948) 457.—**Fig. 35f.**

Tree up to 24 m by 60 cm, trunk straight, monopodial, rather slender, buttresses up to 1 m. Branches stiffly horizontal, twigs rusty pubescent. *Leaves* drooping, oblong rarely obovate-oblong, 10–20 by 5–6 cm, densely stellately rusty-pubescent beneath, scattered hairy and glabrescent to glabrous above, acute, abruptly acute, or rarely acuminate, base obtuse to rounded, margin entire to serrulate; midrib prominently elevated beneath, slightly elevated above, nerves 9–12 pairs, ascending, elevated beneath, plane or slightly depressed above; petiole 5–8 mm. Stipules 1–1½ cm long, rusty pubescent. Inflorescence densely rusty-pubescent. Pedicels 1–2 cm. *Calyx* (incl. ovary) oblong, *c.* 10 mm long, base acute, densely pubescent without; lobes 5(–6) deltoid, 1½ mm long; tube densely woolly hairy inside at the base. *Petals* yellowish green or white, broad-elliptic, obtuse rarely emarginate, sometimes the apex with filamentous appendages 1½(–2½) mm long, soon caducous. *Ovary c.* 1 by 4 mm, 10-celled; style 3 mm, pilose. *Fruits* ovoid or subglobose, *c.* 10 by 8 mm, (*c.* 18 by 16 mm when fresh *sec.* CORNER), calyx lobes reflexed. *Seeds* oblong, obtuse at both ends, *c.* 1½ by 1 mm, obscurely striate.

Distr. *Malaysia:* Sumatra, Malay Peninsula, Borneo, and the Philippines (Mindanao).

Ecol. Common in damp lowland primary and secondary forests, especially along streams, up to 1300 m. According to CORNER, *l.c.*, it develops in swampy ground loop-like breathing roots like some mangrove trees. *Fl.* April-Dec., *fr.* Jan.-June.

Uses. According to HEYNE the timber is red, hard, and heavy and would be durable under roof.

Vern. *Bulu-bulu* (in common with *Diospyros* and other trees), *abu-abu air, buloh, bĕbuloh, kaju bulu, k. baro, mĕmbuloh, bĕrbulu, mata kĕli, piangu jantan,* Mal. Pen., *bĕbulu, mèrah bulu,* Sum. E.C., *kaju bulu,* Palemb., *kaju mèrah kuku,* Banka, *mĕrbuloh,* Sarawak, *kiramu, mĕndĕrakan,* Borneo.

Note. CORNER recorded the flowers occasionally 6-merous.

7. Pellacalyx cristatus HEMSL. in Hook. Ic. Pl. 16 (1886) t. 1546; RIDL. Kew Bull. (1938) 282.

Small tree up to *c.* 9 m tall. *Leaves* narrowly oblong to ovate-oblong, 10–17 by 3–5 cm, gradually acuminate, base rounded, rarely cuneate, margin serrulate to serrate; midrib elevated beneath, depressed above; nerves elevated beneath, visible above; young leaves with minute, scale-like, short, stellate hairs on both surfaces, glabrescent; petiole 7–10 mm. Stipules 1½ cm long. Pedicels *c.* 7 mm. *Calyx* (incl. ovary) green, 7–12 by 4 mm, with scattered, minute, scaly, stellate hairs outside; lobes 5(–6), deltoid, 2 mm long; tube cylindric, slightly contracted at the middle, with a zone of villous hairs near the base. *Petals* green, elliptic, 2½–3½ mm long, the upper end fringed with filamentous appendages up to 5 mm long. *Ovary c.* 2 mm long, 10-celled; style columnar, slightly ridged, covered with short straight hairs; stigma capitate, slightly grooved. *Fruits* subglobose, *c.* 1 cm in diam., calyx lobes erect. *Seeds* ellipsoid, transversely striate, *c.* 1½ mm long.

Distr. *Malaysia:* Borneo (Dallas, Mt Kinabalu, Sarawak, and Landak).

Ecol. On mountain ridges, 400–900 m.

Excluded

Cremnobates RIDL. Trans. Linn. Soc. Bot. 9 (1916) 41 = *Schizomeria, cf.* SCHLTR, Bot. Jahrb. 55 (1918) 194 (*Cunoniac.*).

Legnotis lanceolata BLANCO, Fl. Filip. (1837) 445 = *Decaspermum fruticosum* FORST., *cf.* MERR. Sp. Blanc. (1918) 287.