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COVER: The shoots and fruits (about natural size) and a single trichome (magnified nearly 160 times) of a Fijian endemic, *Calophyllum leucocarpum* A. C. Smith, form the basis of this year's stylized cover design. A row of trichomes is used in the device on the back cover, while a cluster of leaves appears on the offprints. As in recent years, the designs, based on holotype material in the herbarium of the Arnold Arboretum, were drawn by Karen Stoutsenberger.

Calophyllum L. (Guttiferae) is a wide-ranging genus of tropical forest trees in both the New and Old Worlds, and some species are of considerable economic importance as sources of valuable timber. Its use on the cover of this volume of the *Journal of the Arnold Arboretum* is appropriate since the April and July numbers are devoted to P. F. Stevens's revision of the Old World representatives of this genus.—S. A. S.

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NUMBER 1

FRUITS AND SEEDS OF THE BRANDON LIGNITE,
V. RUTACEAE

BRUCE H. TIFFNEY

THE BRANDON LIGNITE (lat. 43°50' N., long. 73°03' W.) is a small deposit of Early Oligocene brown coal located in the town of Forestdale, Vermont, 27 km. north of Rutland, Vermont, and 230 km. northwest of Boston, Massachusetts. This locality is of particular value both because of the care with which it has been studied, and because it is the only known plant-megafossil-bearing terrestrial deposit of Tertiary age north of New Jersey in eastern North America. Fossil fruits and seeds were first described from the locality by Hitchcock (1853) and by Lesquereux (1861; and in Hitchcock *et al.*, 1861) and were subsequently redescribed by Perkins (1904a, 1904b, 1905, 1906a, 1906b). Barghoorn and his students initiated a modern evaluation of the deposit in the late 1940's, leading to a series of papers on the wood, pollen, and some of the fruits (Spackman, 1949; Barghoorn & Spackman, 1949; Barghoorn, 1950; Traverse & Barghoorn, 1953; Traverse, 1955; Eyde & Barghoorn, 1963; Eyde, Bartlett, & Barghoorn, 1969). The author is presently investigating the remaining fruits and seeds of the deposit (Tiffney & Barghoorn, 1976, 1979; Tiffney, 1977, 1979).

GEOLOGY

The lignite and its associated clays, sands, and gravels unconformably overlie the contact of the Lower Cambrian Cheshire Quartzite and Dunham Dolomite, and are in turn unconformably overlain by Quaternary drift (Burt, 1928, 1930; Cady, 1945; Spackman, 1949). Most of the fossiliferous sediment is subsurface, but an area of roughly 82 square meters was exposed at the northern end of the deposit in 1974. The fossiliferous sediment is divisible into two separate units: a fine- to coarse-grained lignite, rich in fruits, seeds, and wood; and a fine-grained, purple-brown silt containing widely scattered fruits, seeds, wood, flowers, broken leaves, and particulate organic matter.

These two fossiliferous units are associated with a complex of sediments that appear to be a remnant of an extensive river system that flowed through west-central Vermont in mid Tertiary time. The silt, which is rich in anemophilous pollen, is interpreted to represent an open body of still water, perhaps an oxbow lake, within this river system. By contrast, the lignite is seen to represent a sluggish to stagnant fluvial environment, closely overhung by vegetated banks and subject to a considerable influx of organic material. The stratigraphic relationship of the silt and lignite has been rendered indefinite by the deformation associated with the passage of the Quaternary ice sheet. However, the present-day proximity of the two sediments, together with the extreme similarity of their contained flora, suggests that the two were deposited within a short period of time. Thus, while the two sediments represent slightly different ecological circumstances, they are here treated as coeval, and their flora considered as a single unit.

MATERIALS AND METHODS

The Brandon fruits and seeds are preserved as compactions—original organic matter retaining three dimensions and full morphological and anatomical detail. Larger specimens were recovered by manually breaking the matrix and then picking the fossils off of the freshly exposed face. The resulting matrix fragments were subsequently disaggregated in a solution of either sodium carbonate or hydrogen peroxide and were passed through sieves to recover smaller organic fragments. This material was viewed under a dissecting microscope, and the smaller specimens of interest were removed with a small brush. Adherent mineral matter was removed from the specimens with a toothbrush, and they were treated with 52 percent hydrofluoric acid to remove embedded mineral matter. All specimens were stored in a 1:1 solution of glycerine and 50 percent ethyl alcohol. Photomicrographs were made by means of a Wild M-20 compound microscope with camera attachment; whole specimens were photographed in air by using a Leicaflex camera with extension tubes and a Zeiss Planar or Tessar lens. Scanning electron micrographs were made with a model 1000a AMR microscope.

Comparative modern material was obtained from herbarium specimens held by the Arnold Arboretum (A) and Gray Herbarium (GH) of Harvard University. Although many of these sheets had recently been annotated by specialists working in the Rutaceae, several others had only original label data, occasionally over 100 years old. This situation raises the problem of the serious, and often underestimated, potential for utilizing misidentified modern comparative material in the identification of angiosperm fossils. Although the paleobotanist can avoid specimens of particularly dubious provenance, he cannot hope to fulfill his paleontological goals if all modern identifications must also be checked. For this reason, the herbarium sheets examined have been annotated, indicating that they were used in a study of the Brandon flora. Thus, if any of the modern comparative specimens used are subsequently assigned to a different taxon by a neobotanist, it becomes that individual's responsibility to notify the paleobotanical community of the changes, particularly if the specimen is of significance. In addition, fruits and seeds of all

the modern comparative specimens, together with all appropriate label data, have been placed in the fruit and seed collection of the Harvard University Herbaria. All modern material was cleaned and prepared by boiling in 10 percent potassium hydroxide for five to fifteen minutes, then washed, scrubbed with a stiff toothbrush, and dried, thus partially simulating the fossil condition.

FOSSIL RUTACEAE

Fossil seeds of the Rutaceae are known from Lower Eocene through Holocene sediments and comprise over sixty species in eleven genera, including one extinct genus, *Caxtonia* (Chandler, 1961b). The other genera reported are *Acrorychia*, *Euodia*, *Fagara*, *Orixa*, *Phellodendron*, *Ruta*, *Ptelea*, *Spathelia*, *Toddalia*, and *Zanthoxylum*. The form genus *Rutaspermum* primarily includes seeds assignable to *Zanthoxylum*, although some members are rutaceous seeds of uncertain generic affinity. The use of this form genus is discussed further in the description of the *Zanthoxylum* seeds from Brandon.

No extensive summary of the living or fossil seeds of the group is available, although Kirchheimer (1957) discussed the then-known remains of *Phellodendron*, and Gallet (1913) has summarized the development and anatomical structure of the seeds of several genera within the family. Because of this dearth of information, the process of identifying the Brandon fossils commenced with a survey of the modern fruits and seeds of the family. Approximately 151 species in 55 genera were examined, with emphasis on genera and species presently found in the New World and in the tropical and temperate areas of eastern Asia, although representatives from other areas were included. The number of species examined per genus will be presented in the systematic descriptions.

The family Rutaceae is characterized by one, two, or up to a large number of anatropous seeds per carpel, the seeds often being marked by a distinctively elongate hilar scar along their ventral margin. At maturity the carpels can be variously united into berries (*Citrus*) or drupes (*Phellodendron*), or can develop into samaras (*Ptelea*, *Skimmia*). They may also form papery to woody capsules (*Euodia*, *Zanthoxylum*). To summarize the seed structure of the family as a whole is not necessary or possible in the present context. In view of the range of variation in fruit and seed morphology of the group, and of the diversity of forms present in the Brandon Lignite flora, this paper will diverge from the pattern set in the earlier portions of the Brandon Lignite investigation (Tiffney, 1977, 1979; Tiffney & Barghoorn, 1976, 1979) and consider the morphology and fossil history of the seeds of each genus independently. In all cases the important morphological characters of the seeds of each genus are summarized in a table and in an illustration accompanying the description of that genus.

SYSTEMATIC DESCRIPTIONS

Rutaceae A. L. de Jussieu, Gen. Pl. 296. 1789.

Lesquereux (1861; and in Hitchcock *et al.*, 1861) described *Drupa rhabdosperma* (later illustrated in Perkins, 1904b, 1905, 1906b) without assigning

it to a family. This seed is here recognized as belonging to the genus *Zanthoxylum*.

Traverse (1955) reported one species of pollen from the Brandon Lignite, which was provisionally assigned to the tribe Toddalieceae, fruiting remains of which are represented at Brandon by seeds of the genus *Phellodendron*.

Euodia J. R. & G. Forster, Char. Gen. Pl. 13. 1776.

The genus *Euodia* consists of some forty-five (Li, 1963; Willis, 1973) to over one hundred (Mai, 1970a) species of trees and shrubs of temperate to tropical forests in the Old World. These range from northern China south to Australia and east to eastern Africa. The majority of these species are evergreen, although many from northern and central China are deciduous (Wang, 1961). Chinese species of *Euodia* are particularly concentrated in the mixed mesophytic forests of the Yangtze Valley (Wang, 1961).

The fruit is a sometimes rather thinly woody, loculicidal capsule, usually four to five lobed (occasionally unlobed), each lobe separating into two valves to reveal one or two seeds loosely enclosed in a bipartite, parchmentlike endocarp. This endocarp may provide a mechanical means of seed dispersal (see section on ecology). In many specimens, the shiny to iridescent seeds are attached to the open carpel or dangle from it on a short funicle.

The present investigation is based on a survey of the seeds of 26 species of *Euodia*, 13 from China, India, and Japan, and 13 from Malaysia, Indonesia, and the Philippines. The recognition of this geographic separation is suggested by a dichotomy in the morphology of the seeds from the two areas. The seeds of the southern species are rugose and conspicuously irregular in shape, while those of the Indian, Japanese, and northern and central Chinese species are smooth to faintly reticulate and vary from nearly spherical to ellipsoid. These characters are all obtained following the removal of the smooth, shiny outer coat that is common to all seeds of the genus. Since the seeds of *Euodia* from the Brandon locality are comparable to those of the Chinese and Japanese species of the genus, the following discussion of the modern seeds will be limited to this northerly group of species.

The seeds of the northern species of *Euodia* (see FIGURE 2 for a generalized example) are small (2.2–5.3 mm. long by 2.0–3.9 mm. in diameter) and vary from nearly spheroidal to ellipsoid. In those species bearing two seeds per carpel the seeds are superimposed, the points of mutual contact appearing as flattened faces on the mature seeds (see PLATE 1, F). The shiny to iridescent, black or dark brown seed surface is broken only by a light tan ventral hilar scar. This shiny outer surface is formed by a thin, crustaceous layer that is easily removed to reveal the inner layer of the outer integument, thus simulating the fossil condition. The surface of this second, hard layer may be smooth (*Euodia daniellii* Hemsley ex Forbes & Hemsley, *E. hupehensis* Dode) or may be marked by gentle longitudinal ridges that are systematically broken by fainter transverse ridges to form a weak but distinct reticulum (*E. bodinieri* Dode, *E. colorata* Dunn, *E. glauca* Miq., *E. hirsutifolia* Hayata, *E. meliifolia* Bentham, *E. officinalis* Dode, and the fossil reported here; see PLATE 1, A, D). The distinct hilar scar traverses the ventral face of

the seed from the apex to the base; occasionally it develops a wide, distinctive lip or margin on either side of the hilum. The basal end of the hilum leads to a short raphe canal, which bends around to the large basal chalaza. The apical micropyle is small and inconspicuous. The apex in some species bears a more or less developed knob, which, according to Mai (1970a), results from the adherence of an abortive seed to the apex of the remaining seed. If this is correct, then it is always the upper of the two seeds that aborts in a biovular carpel.

The anatomy of the seeds of *Euodia* was briefly summarized by Gallet (1913). The outer integument consists of a thin external unit and a sclerified internal unit. The outer two or three layers of cells are spongy and have a thicker external face that forms the shiny layer. It is this unit that is removed to reveal the inner layer of spirally thickened, radially elongate sclereids that form the sclerotesta. The inner integument is also bipartite, with an outermost single layer of small, longitudinally elongate cells having punctate or spirally thickened walls and an underlying layer, one or two cells thick, of large thin-walled cells.

Fossil seeds of the genus have been reported on two previous occasions. Miki and Kokawa (1962) cited seeds of *Euodia glauca* from Recent deposits of Kyushu, Japan, and Mai (1970a, 1970b) has suggested that a previously unidentified seed of the Oligocene and Miocene of Europe is allied to the genus. This latter report is based on over one hundred specimens of consistent morphology from localities in Germany and western Siberia. Nötzold (1963) identified this seed as *Aldrovanda praevesticulosa* Kirchheimer, which Mai (1970a) correctly argues on morphological grounds it cannot be. Nikitin (1965; and in Dorofeev, 1963) cited it as *Carpolithus nitidus* Nikitin and tentatively allied it with the Rutaceae.

As described by Mai (1970a, 1970b), the seed in question is 1.5–1.8 mm. long and about 1.2–1.3 mm. in diameter, pear shaped in ventral (hilar) view and elliptic in lateral view. Its shiny external surface is marked by a broad, light-colored hilum that passes from a terminal perforation identified as the micropyle, to a point approximately halfway down the ventral face of the seed. From the terminus of the hilum, an angular raphe passes over the remainder of the ventral side to the subbasal chalaza (see FIGURE 1, A, a schematic drawing). Nikitin (1965) has interpreted the seed differently, placing the micropyle at the end of the hilum near the center of the ventral face of the seed, and the chalaza at the terminus now occupied by the perforation (see FIGURE 1, B).

The described and illustrated characters, particularly in view of the slight amount of variation in the abundant material (Mai, 1970a, 1970b), make it difficult to accept this as a seed of the genus *Euodia*. The pearlike shape of the fossil, with its narrowed "micropylar" end (*sensu* Mai), is distinct from the elliptic to ovoid shape of most modern *Euodia* seeds, and the absence of flattened surfaces on any of the fossils suggests that they were consistently borne singly in the carpel. The short hilum that extends about halfway down the ventral face of the fossil contrasts with those of the extant seeds, which run the entire length of the ventral face. The fossils are

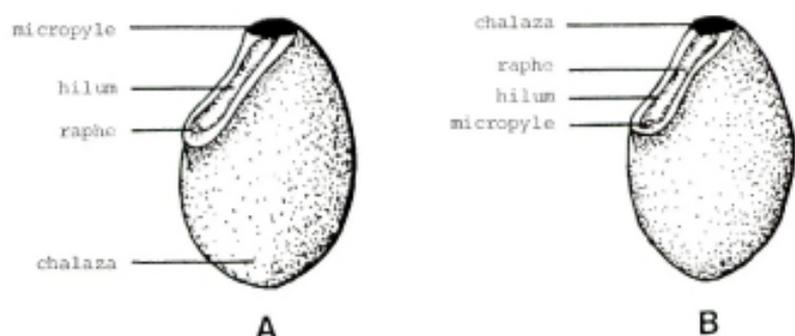


FIGURE 1. Two interpretations of *Carpolithus nitidus*: A, by Mai (1970a, 1970b); B, by Nikitin (1965).

characterized by a shiny exterior surface similar to that of *Euodia*; however, in *Euodia* this coat is easily abraded away to reveal the dull sclerotesta. The fact that the shiny surface of the fossil is consistently whole and is formed by a layer of radially elongate sclereids (Nötzold, 1963; Mai, 1970a) suggests that its structure is quite distinct from that of the membranaceous outer layer of *Euodia*. No modern species of *Euodia* exhibit the large "micropylar" perforation of the fossil, although its consistent presence and location suggest that it is a true morphological character of the seed and not a chance degradational feature. Since these fossils are thus not really comparable with the seeds of *Euodia*, perhaps it is best to return them to the form genus *Carpolithus* in the hope that their correct affinities might be elucidated in the future.

This reevaluation of *Carpolithus (Euodia) nitidus* does not signal the demise of the genus from the European Tertiary, however, since seeds originally identified as *Phellodendron costatum* Chandler from the Eocene of England show a close resemblance to the seeds of modern species of *Euodia*. The seeds of *P. costatum* (Chandler, 1925-26, p. 28, pl. 4, figs. 6a-c; 1961a, p. 125; 1961b, p. 75, pl. 7, figs. 10, 11; 1962, p. 73, pl. 10, fig. 1; 1963b, p. 92, pl. 14, figs. 24-28) are 3.0-3.5 mm. long, 2.0-2.25 mm. in diameter, and ellipsoid, often with a protruding knob on the micropylar terminus. The hilum and its broad margins extend the length of the ventral face of the seed (see particularly Chandler, 1963b, pl. 14, fig. 28), with the short raphe canal commencing at the basal end of the hilum and leading to the large basal chalaza. The micropyle is situated on the knob at the apical terminus of the hilum. The sclerotesta is marked by a series of strong longitudinal ribs connected by weaker transverse ridges, the whole forming a reticulum. The sclerotesta is approximately 300 μ m. thick and is formed of radial rows of equiaxial cells 20-25 μ m. in diameter (Chandler, 1961a). While modern seeds of both *Phellodendron* and *Euodia* have an elongate hilum and a reticulate sclerotestal surface, those of *Phellodendron* are longer, have a narrower hilum without margins, and are flattened laterally from the mutual pressure of

the five seeds in the drupe. Since the other reported fossil species of *Phellodendron* conform to these characters (Kirchheimer, 1957), it is best to consider *P. costatum* not as an aberrant *Phellodendron*, but as a distinct species of *Euodia*. Chandler (1925-26) assumed that the morphology of *P. costatum* was linked to that of the modern species through the Pliocene *P. elegans* C. & E. M. Reid, but Kirchheimer (1957) and Tralau (1963) both expressed doubt as to the assignment of this seed to *Phellodendron*, and Kirchheimer (1957) suggested its possible affinity with the Toddalieae. However, the rounded shape suggesting derivation from a one-seeded carpel, the elongate hilum with wide margins, the apical knob, and the small size suggest placement of this seed in the genus *Euodia*. A formal reassignment of this taxon will be proposed and discussed in detail in a pending publication.

Euodia lignita Tiffney, sp. nov.

PLATE 1, A-G.

MATERIALS. Six seeds have been recovered from the lignite at Brandon. The type specimen (PLATE 1, A, D) is assigned number 51378 of the Paleobotanical Collections of the Botanical Museum, Harvard University. The paratypes are assigned number 51379 in the same collection.

DESCRIPTION. The seeds average 4.5 mm. long (range 3.4-4.9 mm.) and 2.8 mm. in diameter (range 2.7-2.9 mm.). With one exception, each is the product of a carpel containing one seed and is ellipsoid. The exception (PLATE 1, F) is more rounded and has one face flattened from the pressure of a second seed in the mature carpel. One of the seeds bears a very distinct apical knob (PLATE 1, G), and two others display it to a lesser degree. All are marked by a hilar scar that extends from the apex to the base of the seed and is bordered by a wide margin (see FIGURE 2 and PLATE 1, A, E). At the base of the hilum a short raphe leads to the large, pitlike basal chalaza. The micropyle is at the apex of the seed, just beyond the terminus of the hilum. The dull black external surface of the sclerotesta is marked by many faint longitudinal ridges that are crossed at intervals by weak, short transverse ridges, the whole yielding a very faint reticulum of spaces ranging from 175 to 250 μ m. on a side. At higher resolution the surface is marked by a faint pattern of pits 20-30 μ m. in diameter in the outermost layer of sclerotestal cells. Two seeds exhibit only the latter pattern and show distinct signs of abrasion. None shows any evidence of the external layer of the outer integument that forms the shiny surface of the modern seeds. The inner layer of the outer integument (sclerotesta) is 150-250 μ m. thick and is formed of many layers of isodiametric sclereids. The inner integument is thin and hyaline, with an outermost layer of small, longitudinally elongate cells with spiral thickenings, underlain by two (three?) layers of larger isodiametric cells (PLATE 1, B, C).

AFFINITIES. No single modern species is completely similar to the fossil, and only one that has been examined, *Euodia colorata*, is as large. Although *E. colorata* has a reticulate sclerotestal pattern, it lacks hilar margins, any suggestion of an apical knob, and any evidence that more than one seed was ever borne in a carpel. Both *E. glauca* and *E. hirsutifolia*, although

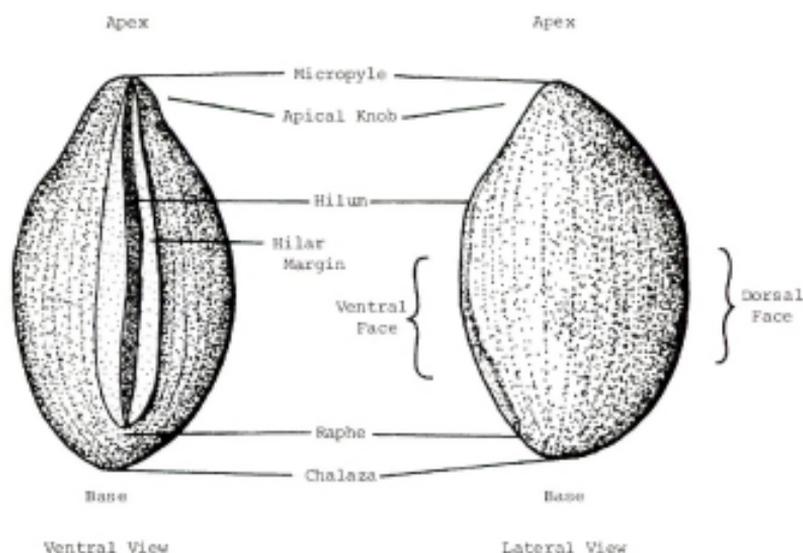


FIGURE 2. Descriptive characters of *Euodia* seeds.

small, have wide hilar margins and a reticulate sclerotestal pattern. *Euodia glauca* has occasional biseminal carpels yielding seeds with flattened sides, and *E. hirsutifolia* has an apical knob and surficial pitting not unlike that of the fossil. Thus, although the fossil is similar to certain modern species, it is not completely comparable to any one, and it is best to regard it as belonging to an extinct species. Two of the three modern species discussed (*E. colorata* and *E. hirsutifolia*) are members of the evergreen oak communities of China, while the third (*E. glauca*) is a member of the mixed mesophytic forests of central China (Wang, 1961).

"*Phellodendron*" *costatum* is smaller and has both a more pronounced sclerotestal reticulation and (in many cases) a more prominent apical knob than *E. lignita*. Thus, while the two fossil species are similar in their wide hilar margins and their sclerotestal pitting, they definitely represent two distinct entities.

The specific epithet *lignita* commemorates the source of this fossil.

ECOLOGY. Although the members of the northerly *Euodia* group (as distinguished by their seeds) range from deciduous species of northern China (*E. daniellii*) to evergreen taxa of the southern Chinese rainforests (*E. melifolia*) (Marl), the strongest concentration of extant species is in the upper Yangtze River valley, where ten occur in the intermixed deciduous and evergreen mesophytic forests of the hills and valleys (Wang, 1961). Both *E. colorata* and *E. hirsutifolia* are probably evergreen since they occur in the evergreen oak forests of Yunnan and the mountains of Taiwan, respectively. *Euodia*

TABLE 1. Descriptive characters of *Euodia* seeds.

Size	Hilum
Length	Percent length of ventral face
Diameter	Hilar margin
Shape	Present/absent
Spherical	Micropylar knob
Ellipsoid	Present/absent
Number of seeds/carpel	Seed surface
One	Smooth
Two	Predominantly low reticulation
	Predominantly low parallel ridges

glauca is a canopy tree of the mixed mesophytic forests, found from 800 to 1400 meters elevation along the Yangtze River. Of interest is its association with species of *Alangium*, *Ilex*, *Illicium*, *Magnolia*, *Nyssa*, and *Quercus* (Lee, 1935; Wang, 1961), all of which are genera found at Brandon. The habitats of the modern species suggest that *E. lignita* was perhaps a denizen of a mixed mesophytic or evergreen broad-leaved sclerophyllous type of forest. Although possibly deciduous, it could equally well have been evergreen, particularly in light of the presence at Brandon of a species of *Magnolia* comparable to the extant evergreen *M. grandiflora* L.

The small number of *Euodia* seeds in the deposit and their abraded condition (two more noticeably so than the others) suggest transport from a distant source. Ridley (1930) has suggested that the dispersal of *Euodia* seeds is similar to that of *Dictamnus*, where the seeds are mechanically tossed from the carpel by tensions created within the drying endocarp. The writer has not seen any evidence of mechanical dispersal in *Euodia*; indeed, the glistening, black seeds hanging free of the carpel on a short funicle seem perfectly adapted for avian dispersal. It is uncertain whether the abrasion of the fossils could have been produced by passage through a bird's digestive tract, or whether it represents aquatic transport from a distant source. In view of the diversity of *Euodia* species in the hills of western China, it is tempting to conceive of *E. lignita* as having grown on the slopes of the Oligocene Green Mountains of Vermont, and then having been transported down to the Brandon deposit. The limited ecological data on the genus (Lee, 1935; Wang, 1961) suggest that it prefers drier, forested slopes, rather than moist riverbottom land, and thus favor a somewhat distant source for the seeds. It is unlikely that the genus was a dominant element in the forests surrounding Brandon in the Oligocene.

Phellodendron Ruprecht, Bull. Acad. Imp. St.-Petersb. 15: 353. 1857.

This genus comprises between nine and thirteen species (Kirchheimer, 1957; Tralau, 1963; Willis, 1973) of small and large dioecious trees. In the absence of a monographic study, the disposition of species is uncertain, and revision may result in a reduction of the total number (Tralau, 1963). Owhi (1965)

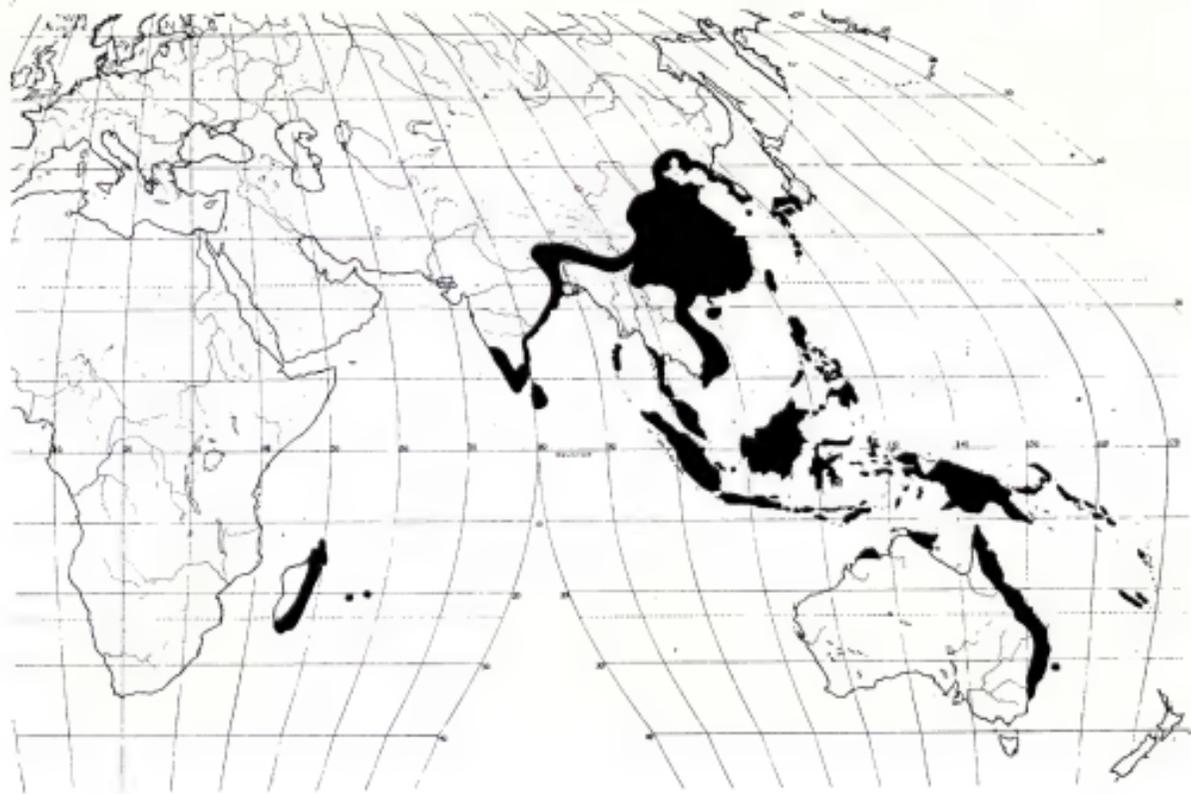
recognizes three of the species considered here (*Phellodendron japonicum* Maxim., *P. lavalleyi* Dode, and *P. sachalinense* Sarg.) as varieties of *P. amurense* Rupr. *Phellodendron* is restricted to the temperate and subtropical regions of eastern Asia. The species with the northernmost distribution is *P. amurense*, a tree of the coniferous and northern hardwood forests of Siberia, northeastern China, Korea, Japan, and Sakhalin. The southern distribution of the genus centers about the mixed mesophytic forests of the Yangtze Valley, where up to five deciduous species occur as low trees in the understory (Wang, 1961).

The fruit of *Phellodendron* is a resinous, black, five-loculed drupe (Lee, 1935), although it may rarely develop four to six locules (Kirchheimer, 1957). Each locule is lined with a two-valved, thin, membranaceous endocarp that splits on a median plane to release the enclosed seed. The mature carpel usually bears only one seed, but two-seeded carpels are known, with the resulting seeds being small and highly deformed (Kirchheimer, 1957).

Dorofeev (1970) noted the absence of herbarium specimens for comparative work, a seemingly not uncommon problem with the genus. The present study is based on seeds from six species (*Phellodendron amurense*, *P. chinense* Schneider, *P. japonicum*, *P. lavalleyi*, *P. molle* Nakai, *P. sachalinense*), the total number available in the herbaria (Δ and GH) at Harvard University.

Seed morphology is rather consistent throughout the species of the genus. Excluding abnormal ones, the seeds range from approximately 4 to 6 mm. in length, 2.5 to 3.5 mm. in height (from the ventral to the dorsal margin), and 1.8 to 2.3 mm. in width (perpendicular to the dorsal-ventral plane). The overall shape is that of a laterally compressed hemisphere, the convex dorsal face bending at either end to meet the essentially linear, sharp, raphe-bearing ventral face formed by the junction of the two shallowly arched lateral faces (see FIGURE 3 and PLATE 2, A-E). The flattened lateral faces are shaped by the mutual pressure of the five seeds within the drupe. Occasionally the dorsal face is marked by large, uneven depressions of unknown origin. These may be seen in the present fossil, *Phellodendron sachalinense*, and in some specimens of *P. amurense*.

The linear hilum extends from one half to the whole length of the ventral face, depending on the species. The raphal canal begins at the basal end of the hilum and leads to the basal chalaza of the seed. The micropyle is situated at the apical end of the hilum, occasionally on a small protrusion or micropylar beak (FIGURE 4). The two lateral faces are marked by a reticulate pattern of varying intensity and organization. In some species (e.g., *Phellodendron lavalleyi*) this consists of a faint pattern of small depressions, while in others more distinct longitudinal ridges parallel the dorsal margin of the seed and are crossed by transverse ridges to form a reticulum. This latter pattern may be strong (*P. japonicum*) or weak (*P. amurense*, *P. chinense*, *P. molle*, and *P. sachalinense*), depending on the species. Germination results in the seed splitting into two equal halves, commencing on the ventral face and passing around to the opposite dorsal face. The outer integument is formed of two layers, an exterior layer of large, open cells, often abraded away in the fossils, underlain by a sclerotesta of many layers of isodiametric



MAP 1. Present distribution of *Euodia* (after Engler (1896), Chiarugi (1933), Lee (1935), and herbarium specimens at A and GH).

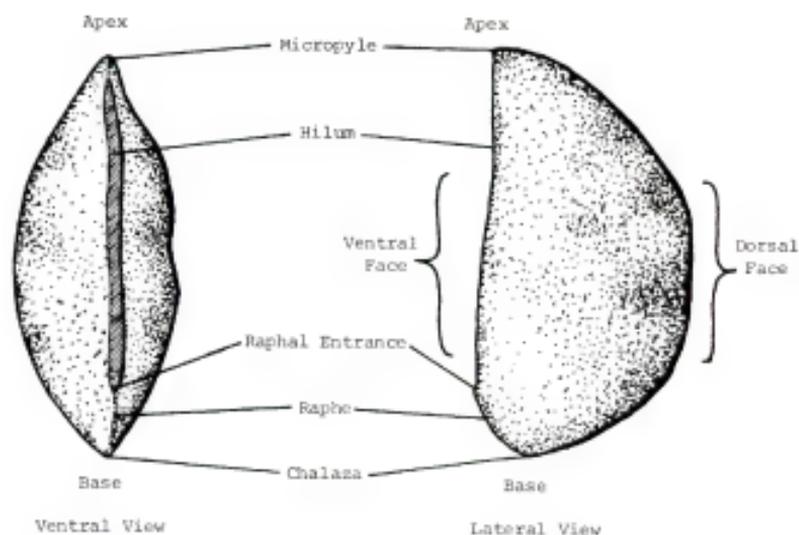


FIGURE 3. Descriptive characters of *Phellodendron* seeds.

sclereids. The exterior of these two layers frequently appears to be striate, a pattern impressed upon it by the inner wall of the fibrous endocarp, likewise striate. The inner integument is formed of three cell layers, the central of which consists of flattened, tangentially elongate cells and is bounded by

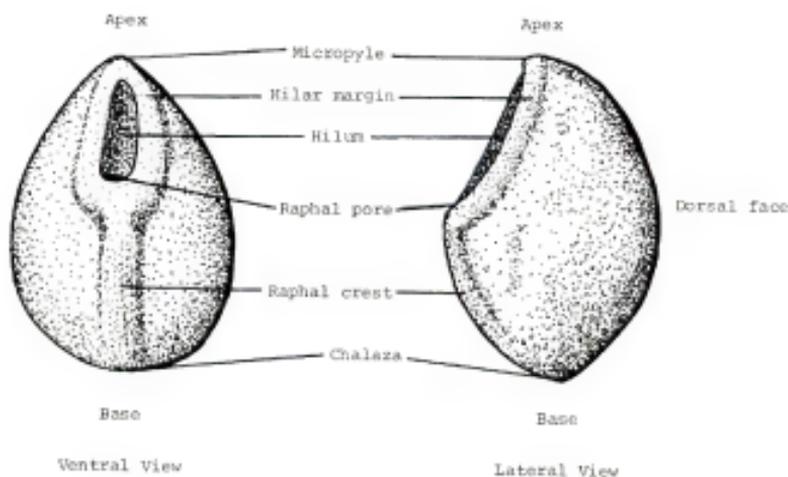


FIGURE 4. Descriptive characters of *Zanthoxylum* seeds.

a layer of large, isodiametric, thin-walled cells on either side. The cell walls of these two enclosing layers have cellulose spiral thickenings (Gallet, 1913). The foregoing suite of characters is presented in TABLE 2.

Unfortunately, even with the aforementioned characters, it is often difficult or impossible to distinguish between the seeds of the modern species, an observation already made by Tralau (1963) and Dorofeev (1970). This might support the view (Tralau, 1963; Owhi, 1965) that a revision of the genus would reduce the number of species. The seeds of *Phellodendron japonicum* seem to have a stronger sclerotestal pattern than do those of other species, and the seeds of *P. chinense* are marked by a distinctively angled face (as seen in lateral view), but the stability of these characters in a large sample is not established. Certainly the variation in the length of the hilum in three samples of *P. amurense* is sufficiently great as to exclude it as a specific character. Reid (1923) presented a table of characters of modern and fossil *Phellodendron* seeds, but many seeds of the same species examined in the present study do not conform to her descriptions. This suggests that the seed characters cited are not particularly constant. Although some fossil seeds have been determined to an extant species of the genus, the practice is not defensible.

In approximately 20 reports, the fossil seeds of the genus have been placed in three extinct and two extant species. This total excludes "*Phellodendron*" *costatum* and *P. europaeum* Menzel (1913), a five-locular drupe that Kirchheimer (1957) concluded could not be proven to belong to the genus. The remaining species can be divided into those displaying strong sclerotestal sculpturing and those showing the weaker sculpturing equivalent to that of today's species.

The former group includes three species that range from the mid-Oligocene to the Pliocene of Europe. *Phellodendron lusaticum* Kirchheimer, of the German Oligocene, is represented by a small, thick-walled, strongly sculptured seed first reported by Kirchheimer (1940). More recent fossils from the Miocene of Germany are of fragments (Mai, 1964), and in one case (Nötzold, 1963) may be incorrectly assigned in view of their divergent morphology. *Phellodendron elegans* C. Reid (Reid & Reid, 1915), of the Miocene and Pliocene

TABLE 2. Descriptive characters of *Phellodendron* seeds.

Size	Seed surface
Length	Smooth
Width	Rough
Thickness	Pattern type, if distinctive
	Pattern scale
Hilum	
Length	Micropylar beak
Percent length of ventral face	Present/absent
Dorsal face	Ventral face
Smooth or marked by small depressions	Notable breaks in straight line of face

deposits of Europe and western Russia, is a larger seed with sculpturing intermediate between that of *P. lusaticum* and that of the extant species. *Phellodendron ornatum* E. M. Reid, of the Pliocene of France (Reid, 1923), is intermediate in size (4.5 mm. long) but very strongly sculptured. The remaining group includes seeds assigned to *P. amurense* (Miki, 1937, 1938; Szafer, 1946, 1954; Kolakovskii, 1958; Miki & Kokawa, 1962; Kokawa, 1966), *P. japonicum* (Szafer, 1946, 1954), and *Phellodendron* sp. (Dorofeev, 1963, 1970), which collectively range from the Miocene through the Recent. Although these assignments are not defensible in view of the variability of the modern seeds, they do correctly imply a greater resemblance to seeds of the present than to the more deeply sculptured and patterned ones of the past.

The chronological transition from the older forms with stronger and more orderly sclerotestal patterns, through the increasing dominance of forms having less pronounced patterns, to the present seeds with faint and only marginally ordered patterns, suggests a directional trend. This could conceivably be paralleled by a trend from the thick sclerotestal walls of *Phellodendron lusaticum* (400 μ m., Kirchheimer, 1940) to the thinner walls (average 200 μ m.) of the present-day species, a tendency not dissimilar to that previously noted for the Vitaceae (Tiffney & Barghoorn, 1976) and the Magnoliaceae (Tiffney, 1977). However, the true significance of these trends in seeds of *Phellodendron* can only be established in light of an understanding of the whole organism.

Phellodendron novae-angliae Tiffney, sp. nov.

PLATES 1, H; 2, A-E.

MATERIAL. Two seeds have been recovered from the lignite at Brandon. Each is broken but is held together by its internal contents. The type specimen (PLATE 2, A, C, E) is assigned number 51380 of the Paleobotanical Collections, Botanical Museum, Harvard University; the paratype is assigned number 51381 in the same collection.

DESCRIPTION. One seed is 5.3 mm. long, 2.9 mm. high (from the dorsal to the ventral margin), and 2.1 mm. wide (perpendicular to the dorsal-ventral plane); the other is 4.8 mm. long, 2.7 mm. high, and 2.0 mm. wide. Their shape is similar to that of the modern seeds: the two gently convex lateral faces join on one margin to form the elliptically curved dorsal surface, which bends upward at either end to join the straight, linelike ventral surface formed by the juncture of the opposite margins of the lateral faces. The narrow hilum extends from the apical end, three quarters of the way toward the base of the seed, where it terminates at the entrance to the raphe, which continues over the remaining portion of the ventral face and leads to the basal chalaza. The micropyle is situated on a beak that protrudes above the ventral margin at the extreme terminus of the hilum (PLATE 2, A). A small depression occurs in the ventral margin just below this apical beak. The dorsal and dorsal-lateral surfaces of both seeds appear broadly scalloped (PLATE 2, E) and bear approximately three large indentations of indefinite origin on each side. The external layer of sclerotestal wall cells provides a faint pitting to the vaguely vitreous surface of the fossil seed. On the

lateral faces this pitting is dominated by a larger pattern of randomly organized weak ridges and depressions (PLATE 2, A).

The outermost layer of the outer integument is missing. The internal portion of the outer integument ranges from 110 to 140 μm . in thickness and is composed of eight to ten layers of isodiametric sclereids. The inner integument is rather badly distorted and its cellular arrangement obscured, but its outermost layer consists of irregular cells, 60–75 μm . long by 20–35 μm . wide. These have spiral thickenings that are 1–2 μm . wide spaced at intervals of 6–8 μm . The remaining portion of the inner integument includes a thick mass of small (25–45 μm . diameter) isodiametric cells with collapsed contents, which could be interpreted as albuminous cells.

AFFINITIES. The laterally compressed shape and long, linear hilum, in conjunction with the spirally thickened cells of the inner integument, mark this as a species of *Phellodendron*. The somewhat similar seeds of *Euodia* and, to a lesser degree, *Zanthoxylum*, can be excluded from comparison on the basis of their round shape, which stems from an absence of interlocular pressure. Similarities can be found with seeds of many of the modern species of *Phellodendron*. The seeds of an unvouchered specimen of *P. amurense* in the seed collection at Harvard (A and GH) are particularly similar to those of *P. novae-angliae*. No evolutionary link is to be inferred from this similarity, however, since other collections of *P. amurense* seeds differ distinctly from the fossil, as well as from each other. Thus, the identification can be pursued no further than to the generic level. *Phellodendron novae-angliae* shares the distinction with *P. lusaticum* of being the earliest reported seed of the genus, but is not similar to this, or any other, fossil seed. *Phellodendron novae-angliae* is primarily distinguished by its distinctively subdued sclerotestal pattern, the chronological appearance of which casts doubt on the possible evolutionary trend toward the reduction of the strength of sclerotestal sculpturing suggested earlier. Similarly, its sclerotestal thickness is far less than that expected in view of the aforementioned trend from thicker Paleogene forms toward thinner Neogene ones.

The specific epithet *novae-angliae* commemorates the geographic source of this paleofloristically important fossil seed.

ECOLOGY. The modern genus *Phellodendron* is restricted to temperate east Asia and is of deciduous habit. Although *P. amurense* is a northerly species of the *Picea-Abies* and northern hardwood forests, the majority of species are low trees of the mixed mesophytic forests of the Yangtze River valley (Wang, 1961) growing in conjunction with other species found at Brandon, including *Euodia* (MAR 2). Since no one modern species is particularly similar to the fossil, the assumption that *P. novae-angliae* is a temperate form rests primarily upon the concentration of modern species in temperate forests, and on its association with other temperate forms, such as *Magnolia*, *Illicium*, and *Euodia*, found at Brandon. Perhaps the greatest significance of *Phellodendron* as an element of the Brandon flora is as a paleobotanical reinforcement of the classic eastern North America–eastern Asia distribution pattern of species, since the genus is restricted today to eastern Asia.



MAP 2. Present distribution of *Phellodendron* (after Engler (1896), Wang (1961), Tralau (1963), and herbarium specimens at A and GH).

No mention is made in the literature of how the seeds of *Phellodendron* are dispersed, although it is to be hoped that Starshova's continuing study (1972, 1973) of the genus will ultimately answer the question. One might logically assume that a fleshy drupe would be dispersed by an animal, most likely a bird; however, the drupes of *Phellodendron* are particularly resinous, even after fifty years on a herbarium sheet. Since strong resins are normally considered repellent to animals, the seeds may be dispersed in another manner. Because only two seeds of *Phellodendron* were found in the deposit, their source may have been relatively distant.

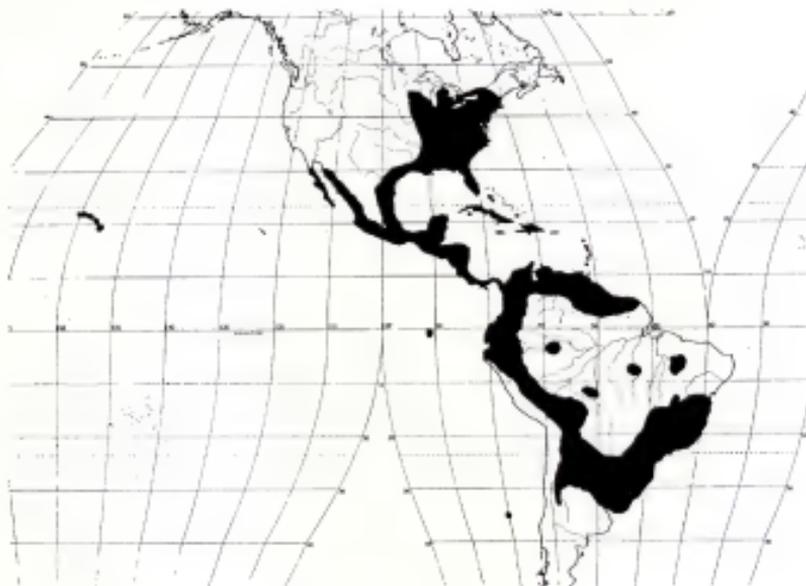
Zanthoxylum L. Sp. Pl. 1: 270. 1753; Gen. Pl. ed. 5. 130. 1754.

Zanthoxylum is a large, pantropical genus with outlying species in the Temperate Zone of eastern Asia and North America (Brizicky, 1962a; MAPS

3, 4). *Zanthoxylum*, in the broad sense (including *Fagara*; Brizicky, 1962b), consists of approximately 215 species. The genus is varied in habit and encompasses deciduous and evergreen trees and shrubs of both wet and dry habitats. The seeds of 79 species, including 26 species of eastern Asia and 53 of the New World, and representing the available fruiting material in the herbaria of Harvard University (Δ and GH), were examined in the present study.

The bivalved carpels occur in clusters, each carpel dehiscent along its dorsal margin to expose shiny seeds, which dangle from the carpel by a short funicle. The membranaceous to woody follicular valves are pitted with oil cells and lined by a free or adherent, cartilaginous, bipartite endocarp. Although two ovules are present in each locule, one normally aborts. Thus only one seed is usually found in the mature carpel.

Modern seeds of *Zanthoxylum* range from 2.5 to 6.2 mm. (average 4.1 mm.) in their maximum dimension and have a variety of shapes, reflecting the nature of the hilar scar and raphe. The majority of the seeds are spherical or roundly ellipsoid, but a few are elongate-ellipsoid and some are laterally compressed hemispheres, with one straight (ventral) and one arched (dorsal) margin. This variation in shape often makes it difficult to define an obvious dorsal and ventral face as was done for the seeds of *Euodia* and *Phellodendron*. In many of the spherical *Zanthoxylum* seeds, the funicle attaches only at

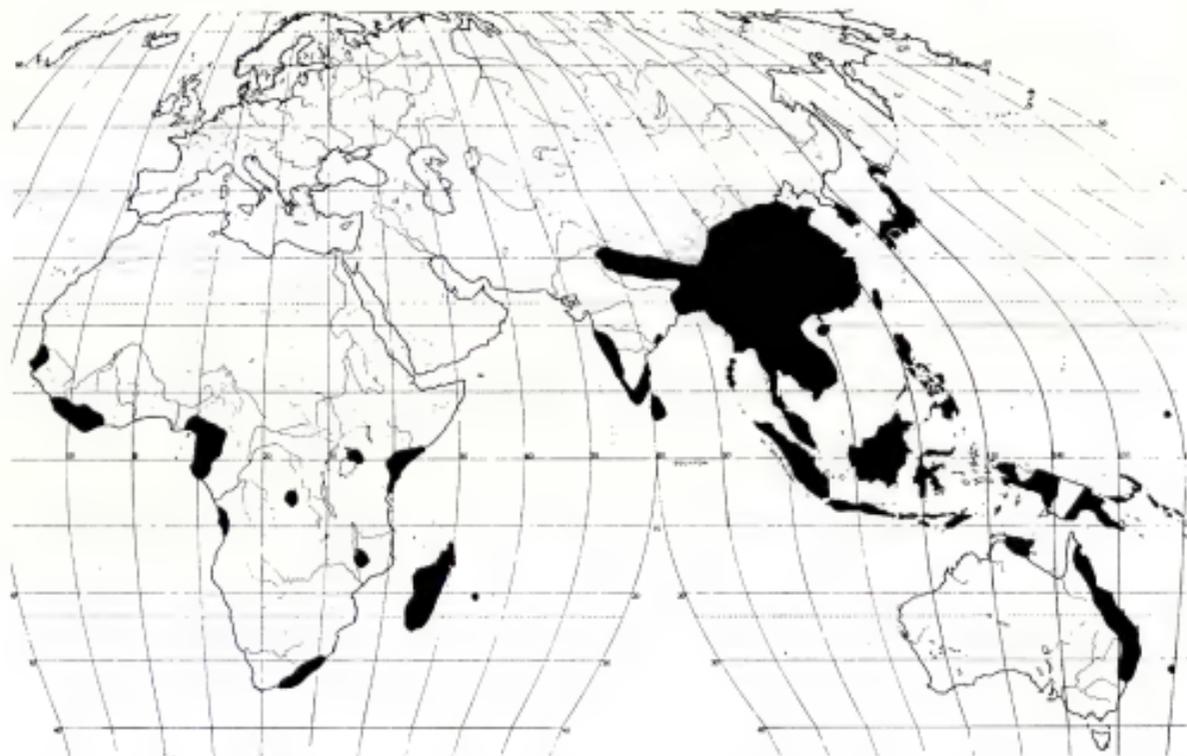


MAP 3. Present New World distribution of *Zanthoxylum* (after Engler (1896) and herbarium specimens at Δ and GH).

one point; thus, the ventral face is more properly termed a ventral hemisphere. In the more elongate forms, the long axis of the ellipsoid is parallel to that of the follicle, with the micropyle at the apex and the chalaza at the base of the ellipsoid, thus isolating the ventral face as the one located between these two points and facing into the locule. If an elongate hilum passes along the entire length of this face, the extent of the ventral margin is made clear; if the hilum is shorter and occupies only a portion of the inwardly directed face (FIGURE 4), the ventral margin becomes less obvious—in isolated seeds it is best defined by the position of the chalaza and micropyle. This interpretation differs from that of Chandler (1925–26, 1960, 1961a, 1961b, 1962, 1963a, 1963b, 1964), who uses the point of funicle attachment (the hilum) to define the extent of the ventral face. In a few seeds (*Z. limonella* (Dennst.) Alston of the extant flora, and the fossil species *Z. bognoyense* Chandler (Chandler, 1961a)) the very long raphe and the hilum oriented perpendicular to the long axis of the seed combine to make Chandler's interpretation more serviceable, but these cases are rare.

The hilum can vary from a circular to an elongate-linear scar, but it is most commonly an elongate triangle with the point directed toward the apex of the seed, and with the flat end, bearing the raphe entrance, toward the base. In those cases where the hilum occupies a portion of the ventral face, it often follows the slope of the ellipsoid, thus falling at an angle relative to a line passing from the apex to the base of the seed. Although the presence or absence (in which case the hilum parallels the long axis of the seed) of this angle seems to be a specific character, the magnitude of the angle does not, since it varies widely on seeds of a single species. The area around the hilum is occasionally differentiated from the rest of the sclerotesta by its inflation (see *Zanthoxylum rhabdospermum* below, and PLATE 3, C) or by the absence of sculpture. The raphe commences at the base of the hilum and passes as a canal around to the hollowed-out basal chalaza. The path of the raphe is often traced externally by a ridge or raphe crest that may occasionally be quite prominent (*Z. rhabdospermum*, PLATE 3, A) and that is frequently more faintly sculptured than is the rest of the seed surface. The micropyle is at the opposite end of the seed, at or just beyond the apical terminus of the hilum (see FIGURE 4).

The seed surface may be completely smooth (*Zanthoxylum americanum* Miller, *Z. dissitum* Hemsley ex Forbes & Hemsley, *Z. scandens* Blume) or may bear a gross pattern of varying intensity and organization. Many species have a rugose surface of small bumps that in some cases (*Z. procerum* Donn. Sm., *Z. piperitum* DC., *Z. pimpinelloides* DC.) are organized into rows paralleling the dorsal margin. In a few species (e.g., *Z. microcarpum* Griseb.) the bumps coalesce into flanges and ridges that approach spines, while in others (*Z. micranthum* Hemsley, *Z. schinifolium* Sieb. & Zucc.) the ridges all join together and form a strong and distinctive reticulum. Occasionally there is a smaller version of this reticulum, which parallels the dorsal margin of the seeds in a series of lunate rows (*Z. myriacanthum* Wall., *Z. panamense* P. Wilson). In many species this large-magnitude sculpture is underlain by a finer pattern of very small pits that vary from 10 μ m.



MAP 4. Present Old World distribution of *Zanthoxylum* (after Engler (1896), Hartley (1966), and herbarium specimens at A and GH).

to approximately 70 μm . in diameter, depending on the species, and occur over the entire seed. They do not seem to be derived from the cells of the sclerotesta and may, as implied by Corner (1976), represent imprints of cells of the external layer of the outer integument upon the surface of the internal layer of the outer integument.

The anatomy of these seeds is similar to that of the other rutaceous genera discussed. The outer integument is subdivided into an easily removed papery exterior layer and an underlying thick sclerotesta having the described sculpture. The exterior layer is thin and invariably shiny, while the inner sclerotesta is dull black and averages 300–400 μm . in thickness, ranging up to 1 mm. in extreme cases (*Zanthoxylum dissitoides* Huang, *Z. nitidum* DC.). Within a single seed the wall is often 100–200 μm . thicker beneath the raphe than on the lateral walls. The multi-layered inner integument is formed of large, spirally thickened, isodiametric cells, which are compressed into a membranaceous layer in the mature seed (Gallet, 1913; see also PLATE 4, A, B).

The majority of the modern seeds seen are rounded or slightly elliptic and have a randomly organized, rough external sculpture. With the exception of certain particularly distinctive seeds (*Zanthoxylum melanostictum* Schlecht. & Cham., for example), it is often difficult to discern clear specific differences between seeds of separate species. In the species examined, smooth-walled forms occurred with equal frequency in both the Old and the New World (four species in each), but seeds with an organized sculptural pattern paralleling the dorsal margin were more common in the New World. Circular hila, representing the attachment of the funicle at a single point, are restricted to New World seeds in the sample examined, while seeds of the Old World species most commonly have hila that extend one-quarter to one-half the length of the ventral face. A summary of these characters is presented in TABLE 3.

Twenty-three species of fossil seeds ostensibly related to *Zanthoxylum* have been reported in the literature. The majority of these are either Eocene (Chandler, 1925–26, 1957, 1960, 1961a, 1961b, 1962, 1963a, 1963b, 1964; Palamarev, 1973; Mai, 1976) or Plio-Pleistocene in age (Miki, 1937, 1938; Miki & Kokawa, 1962; Kokawa, 1966), although a few Miocene species have been reported (Palamarev, 1968; Gregor, 1975, 1978a, 1978b). All of the Plio-Pleistocene reports are from Japan and are of modern species.

Although Berry (1929) did cite an Eocene *Zanthoxylum* seed (as *Fagara*) from western Peru, the majority of the Paleogene reports are from Europe and include seeds of the form genus *Rutaspermum*. This latter genus was erected by Chandler (1957) for rutaceous seeds of uncertain affinity, although many of the seeds included are quite similar to those of *Zanthoxylum*. Chandler (1961a), in transferring *Zanthoxylum ornatum* Chandler to *Rutaspermum*, stated that "it is now clear that no living representative of *Zanthoxylum* has such clearly defined regular superficial ornamentation." However, Palamarev (1973) transferred two species of *Rutaspermum* (*R. bognorense* Chandler and *R. rugosum* Chandler) to *Zanthoxylum*. Since seeds of *Rutaspermum excavatum* Chandler (Chandler, 1962, 1963b), *R. glabrum* Chandler (Chandler,

TABLE 3. Descriptive characters of *Zanthoxylum* seeds.

Size	Raphal crest
Length	Present/absent
Diameter	Prominent/faint
Testal thickness	Smooth/rough
	Percent length of seed
Shape	Surface
Spherical	Smooth
Ellipsoid	Rough
Compressed-hemispheric	Random pattern
Hilum	Spines
Shape	Bumps
Circular	Ridges
Triangular	Reticulation
Slitlike	Organized pattern
Hilar angle in degrees	Pattern strength
Percent length of seed	Pattern scale
Hilar margin	Small pits
Present/absent	Present/absent
Smooth/rough	Diameter
Inflated	

1962), *R. magnificum* Chandler (Chandler, 1962), and *R. striatum* Chandler (Chandler, 1962) are likewise all similar to those of *Zanthoxylum*, they too are perhaps best considered to be representatives of this modern genus. A formal proposal of this transfer must await examination of all the fossils involved. However, it would seem wise to avoid placing a specimen in a form genus when its characters, although not entirely comparable to those of any single modern species, conform closely to those of only one modern genus. *Rutaspermum* sp. (Chandler, 1960, p. 225) is rather similar to the previously reported *R. ornatum* (Chandler) Chandler (Chandler, 1925-26, 1961a), while *R. bognorensis* (Chandler, 1961b; Palamarev, 1973) may be conspecific with *Zanthoxylum compressum* Chandler (Chandler, 1925-26, 1961a) on the basis of morphological similarity. Of the remaining *Rutaspermum* seeds, *R. minimum* Chandler (Chandler, 1961b), *Rutaspermum* sp. (Chandler, 1960, p. 226) and *Rutaspermum* sp. (Chandler, 1964) are distinctly different from *Zanthoxylum* and are appropriately assigned to *Rutaspermum* in its function as a form genus. Mai (1976) proposed the transferral of seeds identified as *R. ornatum* to the extant genus *Acronychia*. The differing seed morphologies of these two forms argue against this proposal.

These Paleogene seeds range from 2.0 mm. (*Rutaspermum excavatum*) to 8.0 mm. (*Rutaspermum* sp., Chandler, 1960, p. 226) in length, the latter fossil exceeding the size of the seeds of all of the modern species of *Zanthoxylum* examined. A few seeds show patches of the external papery layer of the outer integument, but most exhibit only the inner sclerostestal layer. In three cases (assuming *R. bognorensis* and *Z. compressum* Chandler

to be conspecific) this is smooth, while in nine others the sclerotesta is marked by an organized coarse sculpture of ridges paralleling the dorsal margin of the seed. Excluding *R. minimum* (not included here in *Zanthoxylum*), all of the Paleogene seeds have an elongate-triangular hilar scar, which varies from 0° to 30° inclination relative to the micropyle-chalazal axis. The sclerotestal thickness of these fossils ranges from approximately 100 to 200 μm. up to 1000 μm. (*Zanthoxylum* cf. *planispinum* Sieb. & Zucc.; Palamarev, 1968) but may vary within a single seed. The Miocene species described by Gregor (1978a, 1978b) include *Z. ailanthiforme* Gregor, *Z. tiffneyi* Gregor, and *Z. giganteum* Gregor. The last-named is particularly distinctive for its large size (5.0–8.0 mm. long), which approaches that of *Z. hawaiiense* (Hillebr.) Engler and *Z. kauaiense* A. Gray. The seeds all appear to be the products of one-seeded carpels.

These various European *Zanthoxylum* and *Zanthoxylum*-like *Rutaspermum* seeds indicate the distinctive nature of the genus *Zanthoxylum* by Eocene time, while the contemporaneous existence of a Peruvian species suggests its widespread distribution. Although the earliest forms are comparable in size, general morphology, and sclerotestal thickness to today's species, the sclerotestal patterning of the Eocene seeds tends to be stronger and more organized than that of modern ones, an observation also made by Chandler (1961a, 1962, 1963b). The constancy of this distinction between Eocene and modern seed sculpture mirrors a decrease in the randomness of its organization through time. This may represent an evolutionary trend, in view of its predominance, although some modern seeds do have weak but regular sclerotestal patterns and a few Eocene seeds are smooth surfaced.

***Zanthoxylum rhabdospermum* (Lesquereux) Tiffney, comb. nov.**

PLATES 3, A-1; 4, A, B.

Unnamed seed, E. Hitchcock, *Am. Jour. Sci.* II. 15: 100, *fig. 19*. 1853; *Geol. Vermont* 1: 231, *fig. 150*. 1861.

Drupa rhabdosperma Lesquereux, *Am. Jour. Sci.* II. 32: 360. 1861, in Hitchcock *et al.*, *Geol. Vermont* 2: 716. 1861; Perkins, *Rep. Vermont State Geol.* 4: 210, *pl. 81, figs. 168–170*. 1904, *Bull. Geol. Soc. Am.* 16: 514, *pl. 87, fig. 25*. 1905, *Rep. Vermont State Geol.* 5: *pl. 53, fig. 25*. 1906.

MATERIAL. Approximately 370 seeds have been recovered from the lignite at Brandon. The type specimen described by Lesquereux is in the collection of the Division of Paleobotany of the U. S. National Museum and bears the number USNM 222845. Ten selected specimens in the Paleobotanical Collections of the Botanical Museum, Harvard University, have been assigned number 51382 and are stored there with the remainder of the material.

DESCRIPTION. The seeds average 4.9 mm. long (range 4.0 mm.–5.7 mm., standard deviation 0.64 mm.) and 3.3 mm. in diameter (range 2.9 mm.–4.4 mm., standard deviation 0.29 mm.). They range from ovoid to ellipsoid and have a rounded basal terminus and a somewhat pointed apical terminus, the latter formed by the intersection of the curving dorsal face and the flattened ventral hilar

scar. In some cases this point is a ventrally directed beak or hook. Although the laterally compressed shape of one specimen (PLATE 3, E) indicates the presence of two seeds in one carpel, the remaining seeds lack flattened surfaces and are probably from single-seeded carpels. The elongate-triangular to rectangular hilar scar is inclined at an angle of 20–25° relative to the long axis of the seed; in side view it appears as an inclined plane cutting off the apical one third to one half of the ventral face of the seed (PLATE 3, B, H). This hilum averages 2 mm. in length (range 1.5 mm.–2.6 mm.) by 0.7 mm. in width (range 0.6 mm.–0.9 mm.) and is surrounded by a smooth, inflated margin. Occasionally the remains of a vascular strand are seen within this scar, leading to the raphal entrance at the basal end of the hilum. The path of the raphe is marked by a slight ridge or crest with reduced external sculpture, which passes from the base of the hilum over the remainder of the gently curved ventral face to the large basal chalaza (PLATE 3, G). The micropyle is located at the extreme apex of the hilar scar.

The vitreous black surface of the seed is marked by 30 to 32 regular longitudinal ridges that occasionally anastomose and that parallel the curved dorsal margin. These range from 60 to 120 μm . in width and are spaced 180–320 μm . apart. They are absent from the hilar margin and are considerably reduced on the raphal crest. Underlying this pattern is an all-pervasive one of small pits in the seed surface (PLATE 3, D). These pits average 50 μm . in diameter (30 μm . on the hilar margin and portions of the raphal crest). Occasionally they are absent from the crests of some of the longitudinal ridges of the seed coat due to abrasion.

In no case were any remains of the external layer of the outer integument seen. The thickness of the inner sclerotestal portion of the outer integument is 200–300 μm . (to a maximum of 400 μm .) on the lateral and dorsal walls, ranging up to 600 μm . underlying the ventral raphal canal. The inner integument consists of three to five layers of rectangular cells ranging from 40 to 170 μm . in length and from 30 to 45 μm . in width. All the inner integumental cells have spiral thickenings 1–2 μm . wide that are spaced every 3–4 μm . along the cell wall (PLATE 4, A, B).

AFFINITIES. Although the elongate hilar scar, rounded shape, surficial sculpture, and spirally thickened cells of the inner integument clearly identify this as a member of the genus *Zanthoxylum*, no single modern species is comparable. As with the seeds described by Chandler, this is particularly true of the regular sclerotestal structure of the fossil, which is much more pronounced than that of any modern seed of the genus examined in this study. However, other characters of *Z. rhabdospermum* may be found in modern species, and although they do not occur in the same combinations as those of the fossil seed, they confirm the placement of the fossil in the genus *Zanthoxylum*.

Of the modern seeds examined, the most similar were those from Central America and the Caribbean, including *Zanthoxylum acuminatum* Sw., *Z. caribaeum* Lam., *Z. pimpinelloides*, and *Z. pringlei* S. Watson. All are decidedly smaller and more spherical than the fossil, but each has a few characters in common with *Z. rhabdospermum*. *Zanthoxylum acuminatum* has an inflated

hilar margin, *Z. caribaeum* a surficial pitting and sclerotestal sculpture similar to that of the fossil, *Z. pimpinelloides* an inflated hilar margin, and *Z. pringlei* a similar surficial pitting.

Zanthoxylum rhabdospermum is most similar to previously reported fossil species in its strong and regular sculptural pattern, which is held in common with a number of English Eocene forms including *Rutaspermum magnificum*, *R. striatum*, and *R. ornatum*. Of these, *R. striatum* has the pattern most similar to that of the Brandon form, although more weakly displayed. In size, shape, hilar length and angle, fine sclerotestal pitting, and general appearance *R. magnificum* is the most similar to *Z. rhabdospermum*, but it lacks the inflated hilar margin and the parallel sclerotestal ridges of the Brandon species. Although *R. ornatum* is of the correct size and has a similar sclerotestal pattern, the hilum is too long, and while the hilar margin is free of sculpture, it is not inflated. With reference to previously reported fossils, perhaps the most significant factor is that *Z. rhabdospermum* conforms to the previously noted tendency for Paleogene *Zanthoxylum* seeds to have a stronger and more regular sclerotestal pattern than the modern seeds of the genus.

Two other fossil seeds have been ascribed to *Drupa rhabdosperma* since Lesquereux's publication of the species. That figured by Hartz (1909, pp. 18, 19, 275, pl. 2, fig. 5) as *D. rhabdosperma* exhibits a similar pattern of sclerotestal ridges, but the greatly elongate "beak" and the clear hilumlike area on one face are quite unlike the Brandon form. The seed illustrated exhibits little relation to *Zanthoxylum* and may not belong to the Rutaceae. On the other hand, the specimen of *D. rhabdosperma* described by Hofmann from the Eocene of Gaumnitz (1930, pp. 49, 50, pl. 5, figs. 28, 29) is definitely a seed of *Zanthoxylum*. Although these seeds are quite similar to those of *Z. rhabdospermum* from Brandon, particularly with respect to their size and to the strength of seed coat sculpturing, some distinct differences do separate the two. The German form has strong longitudinal ridges joined by short transverse walls; its long, narrow hilum extends for most of the length of the ventral face and is parallel to the long axis of the seed. This is in contrast to the Brandon form, which lacks conspicuous transverse sculptural elements and has a short hilum inclined at an angle of 20-25° relative to the long axis of the seed. For these reasons, Hofmann's material cannot be considered conspecific with that of *Z. rhabdospermum* from Brandon. The characters of Hofmann's specimens are quite similar to those of *Rutaspermum ornatum*, and Mai (1976) has united the two under *Acronychia ornata* (Chandler) Mai in his study of the Eocene Geiseltal flora.

ECOLOGY. The wide ecological range of the species of *Zanthoxylum* (Mars 3, 4), coupled with the lack of a single modern species comparable to the fossil, forestalls any worthwhile ecological conjectures. Even among the four most similar modern species, habitat preferences range from wet (*Z. caribaeum*, Little *et al.*, 1974; *Z. acuminatum*, Fawcett & Rendle, 1920) to quite dry (*Z. pringlei*, Standley, 1923). The presence of a shiny, slightly fleshy, exterior layer around the seeds, and the manner in which they dangle from the carpel

by a short funicle suggests that they are bird dispersed (van der Pijl, 1969). They have been observed to be eaten by a species of thrush in Java (Ridley, 1930) and occasionally by white-winged doves (*Zenaisa asiatica*) and American pipits (*Anthus spinoletta*) in the southern United States (Martin *et al.*, 1961).

Although some *Zanthoxylum* seeds may have arrived at Brandon through bird dispersal, the large number of seeds in the lignite indicates that the plants, either trees or shrubs, grew quite close to the site of deposition and thus presumably preferred wet ground. The slightly abraded nature of a few of the seeds suggests that they were transported to the site of deposition from a distant upstream source, and thus that *Z. rhabdospermum* was a widespread plant—at least along the river margins of the area—in Brandon time.

Also of ecological note is the presence of a circular hole, 1.0–1.2 mm. in diameter, in the sclerotesta of two of the seeds examined (see PLATE 3, I). These closely resemble insect holes observed in some modern species (*Zanthoxylum foetidum* Rose of Mexico, *Z. limoncello* Planchon & Oersted ex Triana & Planchon of Costa Rica, and *Z. microcarpum* of Mexico) and in one other fossil (Chandler, 1925–26). This similarity between modern and fossil holes suggests that perhaps an herbivore-host relationship was established in early Tertiary time and has since persisted. According to Prof. Horace Burke of Texas A & M University (pers. comm.), the holes in the modern seeds of the genus are most likely made by weevils when they mature and emerge from within the seed.

The Rutaceae are well known for their distinctive plant chemistry, an example of which may be evident in these fossils. A single seed of *Zanthoxylum rhabdospermum*, removed from the glycerine-alcohol preservative mixture (to which phenol was finally added), washed, and placed in water, developed a mass of fungal hyphae in four days. This distinction is seemingly specific, since the seeds of other Brandon species were not similarly afflicted; it may provide the basis for future investigation.

***Zanthoxylum echinospermum* Tiffney, sp. nov.**

PLATE 4, E–G.

MATERIAL. One whole seed and several fragments were recovered from the silt at Brandon in 1949; the whole seed was carefully photographed but was subsequently broken. Of necessity, the type now consists of a photograph and a number of fragments, which are collectively assigned number 51384 of the Paleobotanical Collections of the Botanical Museum, Harvard University.

DESCRIPTION. The whole seed is 6.0 mm. long, 3.8 mm. high (from the dorsal to the ventral margin), and 3.4 mm. wide (from lateral face to lateral face). It is essentially ellipsoid (PLATE 4, F, G), with the apical half of the ventral margin appearing flat in lateral view due to the hilum, which, in ventral view, protrudes to form an apical beak. The elongate-triangular hilum, 4.0 mm. long by 0.9 mm. wide, is inclined at an angle of 25° relative to the long axis of the seed and is surrounded by a smooth, inflated margin. The raphe commences at the widened base of the hilum and passes along the

remainder of the ventral margin to the basal chalaza. The external path of the raphe is marked by a low raphal crest, which bears a surficial pattern similar to that of the rest of the seed. The micropyle is located at the apical terminus of the hilum.

The slightly vitreous black surface is traversed by rows of conical to faintly laminar spines that parallel the curved dorsal margin of the seed. These spines project approximately 230 μm . from the surface of the seed and are about 200 μm . in diameter. The laminar forms are usually 200 μm . wide and up to 400 μm . long, with the long axis always parallel to the long axis of the seed. The spines may be from 130 to 250 μm . apart. This pattern of spines is absent from the hilar margin and is slightly suppressed on the top of the raphal crest, but otherwise covers the seed. A pattern of finer pits, 35-50 μm . in diameter, covers the entire surface of the seed including the faces of the spines. This pattern may be derived in a manner similar to that of *Zanthoxylum rhabdospermum*.

Presumably a crustaceous or fleshy external portion of the outer integument was present in life, but no evidence of it is found in the fossil. The patterned sclerotesta, assumedly the inner portion of the outer integument, ranges in thickness from 175 μm . on the lateral walls to 300 μm . beneath the ventral raphe. The inner integument is composed of three or four layers of oblong cells ranging from 60 to 80 μm . in length and from 40 to 60 μm . in width. All of these inner integumental cells have anastomosing spiral thickenings on their walls, the bands being 1-2 μm . wide and occurring at intervals of up to 4 μm . (PLATE 4, E).

AFFINITIES. The rounded shape, indicative of development in a one-seeded carpel, the elongate-triangular hilum, the nature of the sclerotestal pattern, and the presence of spiral thickenings in the walls of the cells of the inner integument all conform with the seeds of *Zanthoxylum*. However, no modern species of *Zanthoxylum* seen has such simultaneously large and regularly placed spines, or combines a strongly patterned sclerotesta with such a large and distinctive hilum. *Zanthoxylum melanostictum* Schlecht. & Cham., of Central America, bears rows of small spines 300 μm . in diameter and 60-80 μm . high; however, the size and shape of the seed and its hilum, the absence of a hilar margin, and the lack of surficial pitting clearly separate it from *Z. echinospermum*. Other modern species (e. g., *Z. coco* Engler, *Z. monophyllum* P. Wilson, and *Z. tomentellum* Hooker f.) have spines, but theirs are really elongate flanges and are not regularly spaced. From the present evidence it may be concluded that *Zanthoxylum echinospermum* represents a highly distinctive and extinct species of the genus; its characters do not match those of any one modern species but do fall well within the range of variation of species of *Zanthoxylum*.

Among the previously reported *Zanthoxylum* fossil seeds, much the same situation obtains. *Rutaspermum excavatum* (Chandler, 1962, 1963b) has an organized surficial pattern of protrusions intermediate between bumps and spines, but its small size, different shape, flat hilum, and lack of a hilar margin disqualify it from comparison with *Z. echinospermum*. *Rutaspermum*

magnificum (Chandler, 1962) is similar in size and shape to *Z. echinospermum*, but lacks the spinose exterior and the inflated hilar margin. Although the overall configuration of *R. striatum* (Chandler, 1962) is also similar, this species may be dismissed for the same reasons; it is also too small. The common denominator between *Z. echinospermum* and the previously reported Paleogene forms is in the strength and regularity of their collective sclerotestal patterns. Although *Z. echinospermum* is represented by only a single specimen, it is rather unlikely that it is a morphological variant of the previously described *Z. rhabdospermum*. In addition to the distinctly different sclerotestal patterns, *Z. echinospermum* has a stronger pattern on the raphe crest and a less vitreous sclerotesta that is decidedly more brittle than that of *Z. rhabdospermum*. Additionally, the large sample of *Z. rhabdospermum* seeds has presented a fairly clear knowledge of the range of variation within that species.

The specific epithet *echinospermum* is in recognition of the echinate nature of the testa of this form.

ECOLOGY. The restriction of this form to the Brandon silt, coupled with its limited representation, suggests that the parent plant was a minor component of the surrounding vegetation. Alternatively, in view of the avian dispersal of at least some modern species (as discussed under *Zanthoxylum rhabdospermum*), these seeds may have been carried from a distant source by birds.

Zanthoxylum cf. tiffneyi GREGOR, Acta Paleobot. 19: 33. 1978. PLATE 2, F-1.

MATERIAL. One whole seed and four fragments have been recovered from the lignite of the deposit. The entire seed is assigned number 51385 in the Paleobotanical Collections of the Botanical Museum, Harvard University. The fragments are collectively assigned number 51386 in the same collection.

DESCRIPTION. The whole seed is 6.25 mm. long, 3.9 mm. high (from the dorsal to the ventral margin), and 3.7 mm. wide (from lateral face to lateral face). It is essentially ellipsoid, the dorsal portion being well rounded, while the ventral part is slightly compressed laterally to form a ridgelike ventral margin. The hilum is 4.4 mm. long; it lacks a true hilar margin but is surrounded by a raised lip. It follows a slightly curved path along most of the ventral face, widening from 0.5 mm. at the apical end to 1.0 mm. at the basal end (PLATE 2, F). The short raphe passes from the hilar terminus around to the large basal chalaza and is marked by a very faint raphe crest. The vitreous black surface of the seed is completely covered with small depressions that range from isodiametric pits 40-50 μ m. in diameter, to elongate pits 40 μ m. wide by 70-90 μ m. long, which parallel the long axis of the seed. This pattern is overlain by a very faint reticulation formed by weak transverse and cross ridges; this occurs over the entire surface of the seed, including the raphe crest.

No evidence of the external portion of the outer integument was seen. The hard inner portion of the outer integument (the sclerotesta) is 130-150 μ m. thick, except beneath the raphe, where it may exceed 280 μ m. The inner integument consists of two or three layers of isodiametric to rectangular cells that average 35 by 80 μ m. in size, all of which have spiral thickenings

on their walls. These thickenings, which range from 1 to 3 μm . in width and are separated by 4–10 μm ; often anastomose and create a particularly spidery pattern (PLATE 2, H).

AFFINITIES. Although this seed is superficially similar to those of *Euodia* (notably with respect to the faintly reticulate sclerotesta and the length of the hilum), its large size, broad but marginless hilum, and, in particular, its inner integument of entirely spirally thickened cells, place it in the genus *Zanthoxylum*. However, no single modern seed has all the characteristics of the fossil. The seeds of many species of *Zanthoxylum* have a long, straplike hilum, but often in conjunction with a rough sclerotestal surface. Only *Z. williamsii* Standley, of Honduras, has a large, smooth seed with an elongate hilum comparable to that of the fossil, but it lacks the appropriate faint surficial pitting and reticulation and is more ovoid than ellipsoid. Among other modern species, a surficial pattern similar to that of the fossil can be found in *Z. jamaicense* P. Wilson (Jamaica) and *Z. obtriangulare* (Urban) Jiménez (Dominican Republic), but neither has the fine pitting of the fossil form. Thus, although parallels can be drawn with a number of modern seeds, the fossil is distinct and has no modern counterparts among the species examined.

The fossil is very similar in several respects to *Zanthoxylum tiffneyi*, described by Gregor (1978a, 1978b) on the basis of three fossils from Middle Miocene (floral zone 6) sediments near Wackersdorf, West Germany. The parallels include large size, thick sclerotestal walls, and, in particular, an elongate hilum and a smooth sclerotestal surface marked by faint pitting. Certain of the reported Paleogene forms (*Rutaspermum bognoense* (Chandler, 1961b); *Z. compressum* Chandler (Chandler, 1925–26, 1961a)—here considered probably conspecific with *R. bognoense*) do resemble the Brandon fossil in overall shape but deviate from it in significant respects (hilum shape, testal surface).

While the Brandon form resembles *Zanthoxylum tiffneyi* more closely than any other known fossil, the limited amount of fossil material presently available, together with the absence of completely distinctive seed characters below the generic level in modern *Zanthoxylum*, renders the present identification somewhat tentative. In addition, certain fragments, which are assumed on the basis of sclerotestal characters to be of the same species, suggest that the morphology of the Brandon form varies beyond that seen in the single whole seed. For these reasons, the identification is cited as "conforming to" *Z. tiffneyi* pending the collection of further material.

ECOLOGY. The limited material is not sufficient to permit any ecological inferences. The rarity of this form may reflect its importation from a distant source, either by birds, or—less likely in view of its unabraded condition—by flowing water.

DISCUSSION

Wolfe (1975) has proposed that a rather homogeneous flora existed in the Northern Hemisphere in early Tertiary time. This view is based on

considerable evidence, which includes the similarity of the Paleogene fruit and seed floras of Clarno, Oregon (Scott, 1954; Manchester, 1976), and the London Clay (Reid & Chandler, 1933; Chandler, 1961b, 1962, 1963b, 1964) of southern England. The presence of *Euodia* and *Phellodendron* in the Paleogene of eastern North America tends to support this hypothesis; both genera are known from the European Tertiary and are presently restricted to eastern Asia. On the other hand, *Zanthoxylum* does not fit this pattern quite as clearly. While it follows a boreotropical distribution in the Tertiary of Europe and eastern North America, the modern distribution of the genus is much larger and includes the Southern Hemisphere (MAPS 3, 4). It is possible that the genus could have attained its present range by post-early Tertiary dispersal, particularly if it was primarily bird dispersed. However, the presence of an apparently correctly identified seed of *Zanthoxylum* (*Fagara*) from the Eocene of Peru (Berry, 1929) indicates that, at least in the New World, the genus had spread beyond the Northern Hemisphere boundary of the boreotropical forest by Eocene time.

Raven and Axelrod (1974) consider the Rutaceae to have a pre-Tertiary, presumably Late Cretaceous, origin and to have been widely dispersed throughout both hemispheres by the early Tertiary. Since floral exchange between North and South America is assumed to have been minimal prior to the Early Miocene (Raven & Axelrod, 1974), the Paleogene *Zanthoxylum* species of Europe and North America were probably more closely related to each other than either was to the group of South American species represented by *Z. piurianum* Berry (Berry, 1929). This possibility is supported by the strong differences in morphology between *Z. piurianum* and the other known Paleogene rutaceous seeds, particularly with respect to the strong rectilinear pattern of the square pits on the testa of the Peruvian specimen.

The postulated early Tertiary division of the range of *Zanthoxylum* would explain the dominance of strong, regular sclerotestal patterns among the Paleogene species of the Northern Hemisphere, since they would all presumably belong to one lineage or a group of related lineages. This postulate does not explain why, of the modern forms examined, all of those most similar to the Paleogene *Z. rhabdospermum* are restricted to the New World. Based on the strong similarity of the European Tertiary flora to the extant flora of southeastern Asia, together with the close affinities of the North American and European Paleogene seeds of *Zanthoxylum*, it is logical to expect to find the modern relatives of the Brandon form in southeastern Asia. A complete resolution of the relationships and distributions of the various lineages of *Zanthoxylum* can result only from the collection of fossil material of the Rutaceae from the Southern Hemisphere.

The taxonomic similarity of the Early Eocene London Clay flora and the Mid Eocene Clarno flora occasionally extends to the specific level. However, those known elements of the presumably Oligocene Brandon flora that are also common to contemporaneous European floras are similar only at the generic level (e.g., *Phellodendron*, *Euodia*, *Illicium*, *Turpinia*). This also holds in the cases of *Magnolia waltonii* Tiffney (Tiffney, 1977) and *Zanthoxylum cf. tiffneyi* (described here), which, although similar to previously described

European species, are not sufficiently so to warrant being considered conspecific. This taxonomic distinctiveness of the Brandon flora relative to contemporary European floras may be explained in one of two ways. The Brandon flora may represent the initial stages in the evolutionary divergence between the Old and New World elements of the boreotropical flora. Such a divergence would presumably be a direct result of the disappearance of the Early Eocene land bridge postulated to have linked eastern North America and Europe (Lehmann, 1973; McKenna, 1975), thus cutting off biotic exchange between the two areas. On the other hand, it is also possible that the boreotropical flora was not a completely homogeneous unit, but contained distinct geographic and ecological subunits. Indeed, the proposed geographic extent of the boreotropical flora (Wolfe, 1975) is such that one would expect some degree of local differentiation. In this light, the London Clay and Clarno floras might represent an ecologically specialized facies within the larger flora that occurred together with other facies restricted to different habitats. The western European floras of the late Paleogene could then be descendents of one such facies, while the Brandon flora could be derived from a different one.

Of these two possibilities, the former is presently felt to be the more acceptable. The concept of the boreotropical forest provides an adequate explanation of the patterns seen in both the past and present flora and vegetation of the Northern Hemisphere. Additionally, it does so within a framework that acknowledges the individualistic nature of the geographic migration of plant species through time.

The presence in the Brandon flora of several genera restricted in modern time to eastern Asia demonstrates that the classic floristic affinities between eastern Asia and eastern North America, which are established on modern distributions, become stronger with increasing age through the Tertiary. The question remains, however, whether both areas commenced in the early Tertiary with an entirely similar flora. Certainly the extant flora of eastern Asia is considerably more diverse than that of eastern North America, even if one includes related Central American floras in the latter category. Wolfe (1977) has suggested four historical factors that could account for this modern disparity in diversity, one of which is "isolation." Such isolation could be enforced from the west by the development of continental climates following the retreat of the Late Cretaceous Mid-Continental Seaway, together with the development of topographic barriers. To the east, isolation might have been a direct result of the opening of the North Atlantic Ocean. Some intracontinental communication between eastern and western North America was undoubtedly possible; there are many instances in which the closest living relatives of western North American fossil species are in the eastern part of the continent. However, the possibility exists that a significant portion of the boreotropical forest of eastern North America was derived from European floras during the early Tertiary via the North Atlantic land bridge. The tenuous temporal and geographic nature of this link might have led to the establishment of a less diverse sample of the boreotropical flora in Paleogene eastern North America. Since the Brandon flora is presumed to

predate the Paleogene climatic deterioration (Wolfe, 1978), it might provide the best sample of this eastern North American boreotropical forest to date, but one that had undergone some 20 million years of evolution since its last exchange with the boreotropical forest at large.

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EXPLANATION OF PLATES

PLATE I

FIGURES A-G. Seeds of *Euodia lignita*. A, #51378, SEM of ventral face, apex directed forward, $\times 12$. B-G, #51379: B, SEM of cross section of sclerotestal wall (outer integument of small rounded cells at bottom of picture is succeeded in a vertical direction by one layer of spirally thickened cells of exterior coat of inner integument, followed by a layer of large, isodiametric parenchymatous cells of interior coat of inner integument), $\times 211$; C, SEM of spirally thickened cells of exterior layer of inner integument, $\times 291$; D, dorsal view, apex directed downward, $\times 8.5$; E, ventral view, apex directed downward, $\times 8.5$; F, ventral view of product of two-seeded carpel (note flattened area to lower left), $\times 8.5$; G, dorsal view (note apical knob on lower end of seed), $\times 8.5$.

FIGURE H. Seed of *Phellodendron novae-angliae* (#51381): spirally thickened cells of outer portion of inner integument, $\times 339$.

PLATE II

FIGURES A-E. Seeds of *Phellodendron*: A, *P. novae-angliae* (#51380), lateral view, ventral margin on right; B, *P. amurense* (C. S. Sargent, August 23, 1903 (A)), lateral view, ventral margin on right; C, *P. novae-angliae* (#51380), ventral view, break in seed disrupting path of hilum; D, *P. amurense* (C. S. Sargent, August 23, 1903 (A)), ventral view; E, *P. novae-angliae* (#51380), dorsal view (note scalloped nature of dorsal face); all $\times 10$.

FIGURES F-I. Seeds of *Zanthoxylum* cf. *tiffneyi*: F, #51385, ventral view, $\times 6.5$; G, #51385, dorsal view, $\times 6.5$; H, #51386, spirally thickened cells of inner integument, $\times 166$; I, #51385, lateral view, ventral margin (hilum) facing upward, $\times 6.5$.

PLATE III

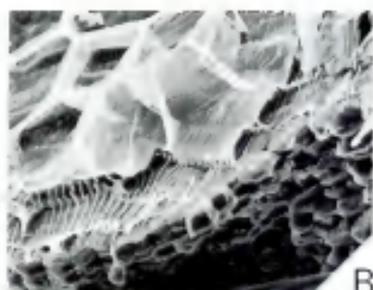
FIGURES A-I. Seeds of *Zanthoxylum rhabdospermum* (#51383): A, SEM of ventral face, apex to left (note central raphe crest), $\times 9.5$; B, SEM of lateral face, apex and hilar area to right, $\times 9.5$; C, SEM of apex, looking basally past hilum and inflated hilar margin, $\times 11$; D, SEM of surficial pits of sclerotesta, $\times 436$; E, ventral view of seed from two-seeded carpel (note flattened face to right), $\times 11$; F, dorsal view, $\times 8.25$; G, interior view of basal chalaza, $\times 8.25$; H, lateral view with apex to left, ventral surface up, $\times 8.25$; I, lateral view with apex to right, ventral surface up (note insect hole in lateral-rear quadrant), $\times 8.25$.

PLATE IV

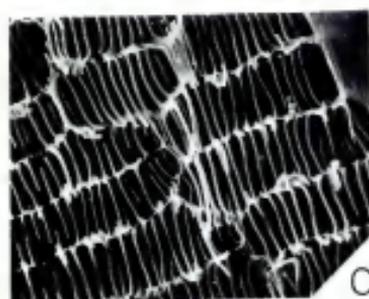
FIGURES A-G. Seeds of *Zanthoxylum*: A, B, *Z. rhabdospermum* (#51383), spirally thickened cells of inner integument: A, $\times 166$; B, $\times 339$. C, D, *Z. caribaeum* (O'Neill 8784 (A)): C, lateral view, apex to right, ventral face up, $\times 7$; D, ventral view, apex uppermost, $\times 7$. E-G, *Z. echinospermum* (#51384): E, remnant spiral thickenings of cells of inner integument, $\times 339$; F, ventral view, apex to left (note small spines), $\times 7$; G, lateral view, apex to left, ventral face up, hilum on upper left margin, $\times 7$.



A



B



C



D



E



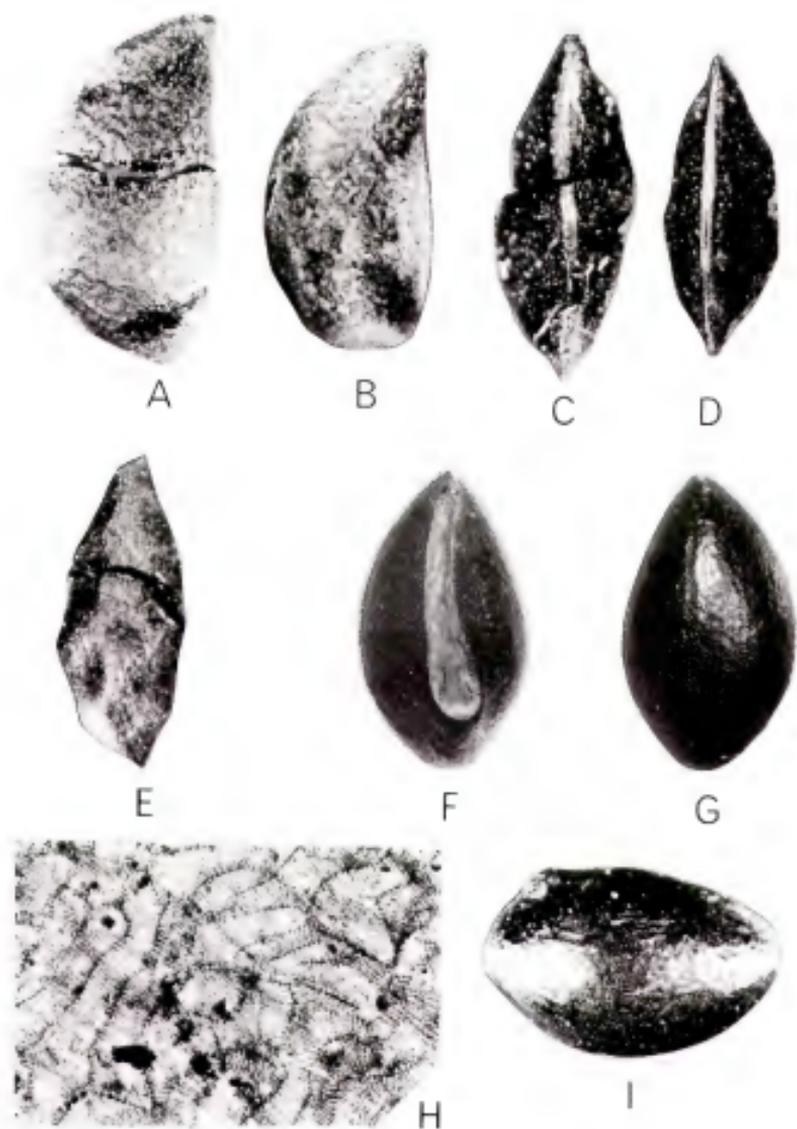
F



G



H



TIFFNEY, BRANDON LIGNITE, V



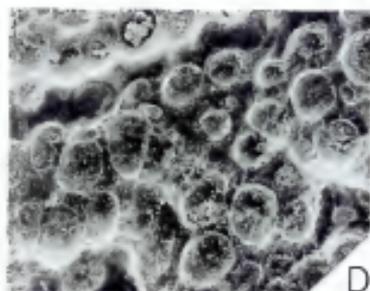
A



B



C



D



E



F



G



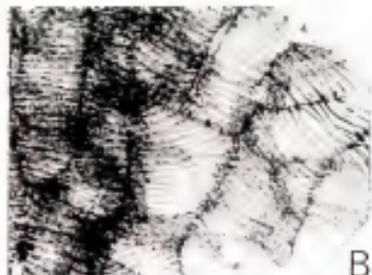
H



I



A



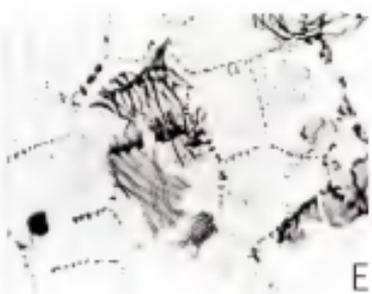
B



C



D



E



F



G

THE METASEQUOIA FLORA AND ITS
PHYTOGEOGRAPHIC SIGNIFICANCE

SHIU YING HU

MY FIRST ASSOCIATION with *Metasequoia glyptostroboides* Hu & Cheng was at the Arnold Arboretum of Harvard University during the winter of 1948-1949. At that time help was needed to place fresh, recently imported metasequoia seed into small envelopes for distribution to botanical institutions, forest experiment stations, and interested individuals around the world. These seeds, mailed from Nanking, China, on November 29, 1948, and totaling 500 grams, were the second shipment received at the Arnold Arboretum. A letter from Professor W. C. Cheng concerning the shipment was later placed with the unmounted specimens of *M. glyptostroboides* that had been collected during the summer of 1948.

In addition to the seed, five shipments of herbarium specimens collected in southwestern Hupeh Province between 1946 and 1948 were received at the Arnold Arboretum by the late Professor Elmer D. Merrill. In 1973 this herbarium material was turned over to me for identification, and this article is concerned with the information resulting from that undertaking. A systematic enumeration of all identifiable species represented in the five collections (an assemblage of species here termed the "metasequoia flora") is presented below. While the type locality of *Metasequoia glyptostroboides* is in eastern Szechwan, the specimens on which this work is based are from the general area (here referred to as the "metasequoia area") in Hupeh Province where *M. glyptostroboides* was later discovered growing in a natural population (see below). Also included are brief summaries of the expeditions that obtained the five collections, as well as a short account of earlier botanical collections from Central China, a description of the salient features of the metasequoia flora, an analysis of the gymnosperms that occur with metasequoia, and my interpretation of the metasequoia flora.

In 1950 K. L. Chu and W. S. Cooper published the results of an ecological reconnaissance of the metasequoia community. A posthumously published paper by E. H. Fulling (1976), along with additions published in 1977, summarizes the history of the discovery of *Metasequoia glyptostroboides* and presents an annotated bibliography of published references to metasequoia. Only information not available in these three readily available articles is included here.

In the enumeration of species, the system followed in the arrangement of the families conforms with that used in *Iconographia Cormophytorum Sinicorum* (Anonymous, 1972-1976). For economy of space, and unless

nomenclatural change is involved, only the name, important synonyms, and voucher specimens are cited. Assistance of specialists is recognized in parentheses after either the group or the species.

Earlier authors have employed different spellings for the same collectors or localities. For those who lack a knowledge of the geography of the region and the Chinese language, these differences are often confusing. In this article, the following guidelines have been used in deciding between alternative spellings of Chinese personal and place names. For collectors the spellings on the herbarium labels have been used. However, with regard to the name of the man who discovered *metasequoia*, earlier authors have used either T. Wang or C. Wang. Since his publication with P. Y. Fu on *Salix* (1974) appeared under his name as Zhan Wang, the initial of his given name adopted here is Z.

Concerning localities, for names of well-known places such as Chungking, Hupeh, and Szechwan, the widely recognized spellings of the Chinese Post Office and foreign presses have been adopted, and the *Rand McNally World Atlas* (Anonymous, 1949) has been used as a reference. Names of minor localities have been transliterated using the system of romanization outlined in the Harvard University Press edition of Mathew's (1931) *A Chinese-English Dictionary*. Cross-references to different spellings of various names that have already appeared in publications are given below,¹ where recognized spellings are given in boldface type. The names listed under "other localities" are alphabetically arranged.

BOTANICAL INVESTIGATIONS IN CENTRAL CHINA AND THE METASEQUOIA AREA

The botanical expeditions that have contributed to our knowledge of the *metasequoia* flora are numerous. Some were mounted specifically for the investigation of the area in which *Metasequoia glyptostroboides* was discovered as an extant plant, while others were conducted for the general botanical exploration of the flora of Central China. *Metasequoia glyptostroboides* is now known to occur naturally in western Hupeh and adjacent Szechwan provinces southward to the hills of western Hunan (cf. Cheng, Fu, *et al.*,

¹Type locality of *Metasequoia glyptostroboides*: Mo-tao-chi, Mo-tao-hsi (Hu & Cheng), Mou-tao-chi (Merrill, Hu).

Collector of syntypes: C. Y. Hsüeh, C. J. Hsueh (Hu & Cheng, Merrill, Florin), C. Y. Hsieh (Hu).

Metasequoia grove: Shui-sa-pa, Shui-hsa-pa (Chaney, Chu & Cooper, Florin).

Other localities: Chien-shih, Kien-shi (Hu & Cheng, *map*); Chung Hsien, Chunghsien (Merrill, *map*); Chungking, Chunking (Hu); En-shih, An-shi (Chu & Cooper, *map*), An-shih (Hu & Cheng, *map*); Feng-chieh, Fungkien (Merrill, *map*); Hsiao-ho, Hsiao-ho (Merrill, *map*), Shia-ho (Chu & Cooper, *map*); Hung-pan-ying, Houg-pin-ying (Merrill), Huang-pan-yin (Chu & Cooper); K'ai Hsien, Kaisien (Merrill, *map*); Li-chuan, Li-chuanhsien (Hu & Cheng, Merrill), Li-chwan (Hu & Cheng, *map*); Wan Hsien, Wanhhsien (Hu & Cheng), Wan-hsien (Merrill); Wang-chia-ying, Wang-jia-ying (*Hwa 182*, field note), Wang-kia-ying (Hu & Cheng, Merrill); Yangtze River, Yang Tze Kiang (Hu & Cheng, *map*); Yun-yang, Yuyang (Merrill, *map*).

1978, p. 310). It is of interest to note that several well-known collectors came within kilometers of the metasequoia area (MAP 1), but none penetrated it until 1943, the year when Z. Wang (FIGURE 1) first collected *Metasequoia*.

EARLIER COLLECTIONS FROM CENTRAL CHINA. Many historical collecting localities are within a 250 kilometer radius of the metasequoia area (MAP 1), and our present knowledge of the flora of Central China is largely the result of the expeditions and collecting activities of both western and Chinese botanists within this larger area. Europeans and Americans who had collected in Central China before the discovery of *Metasequoia glyptostroboides* include Thomas Watters, Augustine Henry, E. H. Wilson, P. Farges, A. von Rosthorn, A. C. Steward, the French missionaries E. Bodinier, J. Cavalerie, and J. Esquirol, and the Italian missionary C. Silvestri.

The many species new to science that were included in the collections made by these botanists were, likewise, described by both American and European taxonomists. Notable among this group were H. F. Hance, W.



FIGURE 1. Z. Wang, discoverer of *Metasequoia glyptostroboides*, left, with his teacher, Professor T. N. Liou, seated, and S. Y. Hu, right, July, 1975. (Photograph, from a color transparency, courtesy of Mr. K. B. Lau, Geography Department, Chinese University of Hong Kong.)

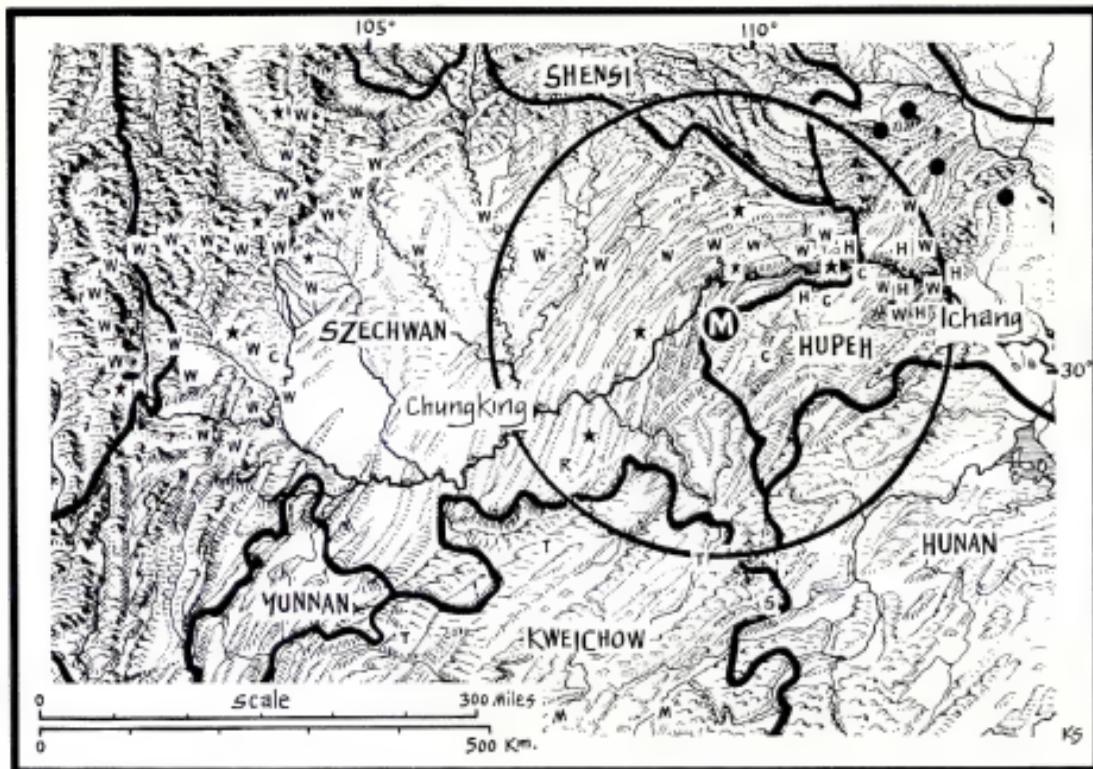
B. Hemsley, D. Oliver, A. Rehder, E. Koehne, C. Schneider, A. Franchet, H. Leveillé, and R. Pampanini.

Active floristic investigations carried out by Chinese botanists in Central China did not begin until western-trained students of botany returned to China and became eminent in that country's educational institutions. Several of the Chinese botanists who received their training at the Arnold Arboretum, and whose activities have advanced our knowledge of the metasequoia flora either directly or indirectly, are mentioned here. The first was Professor S. S. Chien, who, immediately after his return to China, taught in the National Southeastern University of Nanking (later renamed National Central University and now merged with Nanking University). In the late 1920's he was responsible for developing the botanical collections of the newly established Biological Laboratories of the Science Society of China. One of his goals was to establish a reference herbarium; toward this end, he sent one of his students, Y. L. Keng, to collect in Kiangsu and Chekiang in 1927. In the spring of 1928, he sent W. P. Fang to Szechwan to collect at Chin-fu-shan and many other localities (MAP 1). Fang was born and raised in Chung Hsien, 60 kilometers from Mo-tao-chi, and only 75 kilometers west of the metasequoia area. Although he stopped and collected in Chung Hsien, he did not reach the metasequoia area. Duplicates of Fang's collections are deposited in the herbarium of the Arnold Arboretum.

H. H. Chung was another Arnold Arboretum-trained botanist, who, in the early 1930's, became Professor of Botany in the National Wu-Han University. In 1934 he sent Ho-chang Chow (= H. C. Cheo, who had accompanied A. N. Steward on expeditions to Kweichow and Kwangsi in 1931 and 1933, respectively) to botanize southwestern Hupeh Province. Chow (MAP 1) began to collect in Pa-tung in early May, and, to judge from data on his specimens, he went on to collect in Chien-shih in August. By September he had reached En-shih, a locality only 60 kilometers east of the metasequoia area. A set of Chow's collections is also in the Arnold Arboretum herbarium.

Professor H. H. Hu, the botanist who identified Z. Wang's collection as belonging to the genus *Metasequoia* Miki and who became senior author of the name *Metasequoia glyptostroboides*, was a pioneer Chinese student at the Arnold Arboretum and the first Chinese botanist to receive a doctorate from Harvard University. His loyalty to the Arnold Arboretum and his continuous collaboration with E. D. Merrill contributed to the discovery and subsequent wide distribution of metasequoia.

The changes brought about by the Sino-Japanese War (1937-1945) had a definite effect leading to the discovery of *Metasequoia glyptostroboides*. The geographic isolation and the lawlessness associated with the border area where *M. glyptostroboides* is confined had reduced the population and helped to delay botanical exploration of the region. However, to improve wartime communications between the provincial capital of Hupeh at En-shih and the national capital at Chungking, a motor road was constructed in early 1939. Consequently, the formerly isolated hillside villages of Mo-tao-chi and Wang-chia-ying became rest stations, and the once inaccessible type locality of *M. glyptostroboides* and the surrounding region became more easily accessible.



MAP 1. Physiographic land-form map of Central China and adjacent regions. M indicates metasequoia area; circle shows region within 250 kilometer radius of metasequoia area. Letters and symbols designate historical collecting localities of notable botanists: H. C. Chow (C); P. Farges (F); A. Henry (H); French missionaries, including E. Bodinier, J. Cavaleric, and J. Esquirol (M); A. von Rosthorn (R); A. C. Steward and associates (S); Y. Tsiang (T); E. H. Wilson (W); W. P. Fang (black stars); and C. Silvestri (solid black dots).

COLLECTIONS FROM THE METASEQUOIA AREA. The region from which the five collections discussed in this paper were gathered includes an area of approximately 800 square kilometers (cf. maps in Hu & Cheng, 1948; Chu & Cooper, 1950; and Merrill, 1948). Three-fourths of the specimens, however, are known to have been collected in the immediate vicinity of the metasequoia grove at Shui-sa-pa ("Water Fir Grove"); it is at this site that C. T. Hwa discovered a natural stand of mature, reproducing trees of *Metasequoia glyptostroboides* in the fall of 1947 (see below). According to Chu and Cooper, the metasequoia grove at Shui-sa-pa is located on a "strip [of land] along the main river 25 km. long and less than 1.5 km. wide. The altitude here ranges from 1,000 to 1,100 m." With the exception of Hwa's 1947 trip, so far as I am aware, all other expeditions to the area went straight to Shui-sa-pa.

The first shipment of specimens received at the Arnold Arboretum from the metasequoia area contained only two numbers; C. Y. Hsüeh 5, February 20, 1946, which consists of leafless branchlets with microsporangiata and mature megasporangiata cones of *Metasequoia glyptostroboides*; and Hsüeh 51, May 18, 1946, consisting of leafy shoots and immature strobili. These collections later became the syntypes of the species name. Z. Wang's collection of *M. glyptostroboides*, made in 1943, is deposited in the Herbarium, Bureau of Forestry Research, Ministry of Agriculture and Forestry, Government of China, and is not known in herbaria outside China.

The second shipment contained 179 specimens collected by C. T. Hwa during September, October, and November of 1947. Hwa's trip was financed by the Arnold Arboretum especially for the collection of metasequoia seed (Merrill, 1948). However, due to scant seed production, only a small amount was obtained. This was sent to the Arnold Arboretum, arriving there on January 5, 1948. The outstanding contribution of this expedition was neither the amount of seed nor the number of herbarium specimens collected, but the discovery of the location of an actively reproducing population of metasequoia at Shui-sa-pa in Hupeh Province.

During this trip Hwa gathered information from the local people about the occurrence of metasequoia, and he visited all known localities. In Wang-chia-ying, a large village in the Li-chuan District, he saw the largest known metasequoia tree, which measured about 50 meters in height, 3.3 meters in diameter across the basal buttresses, and 2.2 meters in diameter at breast height. Hwa's experiences and field observations laid the foundation for later explorers, and he served as guide for two of the three expeditions made during the spring and summer of 1948.

The third collection of specimens from the metasequoia area was made by Hwa in late February and early March, 1948, when he acted as guide for the expedition of Professor R. W. Chaney, paleobotanist and paleoecologist from the University of California, Berkeley, and Dr. M. Silverman, science writer for the *San Francisco Chronicle*. Although the party was in the metasequoia area for only five days, Hwa collected about 250 specimens. These were received at the Arnold Arboretum without labels, but each had a small tag bearing a number and Hwa's name in Chinese characters.

The fourth collection was made during the summer of 1948, when a team

of Chinese specialists was organized by Professor W. C. Cheng for the intensive investigation of the flora and ecology of Shui-sa-pa. This expedition was financed by the American Philosophical Society under the joint sponsorship of Merrill and Chaney. Dr. Cheng was the leader of the group, Professor K. L. Chu was the ecologist, and Hwa once more served as guide. The specimens resulting from this expedition bear tags stamped "Hupei-Szechwan, 1948, W. C. Cheng-C. T. Hwa," and the numerical sequence ranges from 550 to 1183. Three sets in ten bundles representing the results of the fourth expedition were dispatched, together with Hwa's earlier 1948 collections, to the Arnold Arboretum from Nanking by surface mail on December 29, 1948. The three sets do not have equal numbers of specimens. The Arnold Arboretum set contains 840 specimens that can be identified to species, although some of them include neither flowers nor fruits; in addition, there are 35 sterile specimens, which cannot be placed in genus or family. It would appear that some numbers were assigned in the laboratory after the specimens were sorted. All ferns have relatively high numbers, and specimens of closely related species are essentially in numerical sequence. After identification, duplicate sets were mailed to the Royal Botanic Gardens, Kew, and to the Herbarium of the University of California, Berkeley, in accordance with the arrangements made by Merrill and Cheng.

The fifth collection was made by Dr. J. L. Gressitt, of the Lingnan Natural History Museum and the California Academy of Sciences, who went with his assistant, Mr. Y. W. Djou, to conduct an entomological survey of the metasequoia area in late July, 1948. Gressitt left Shui-sa-pa in late August, while Djou remained there for an additional month. Since their specimens were collected to document the host plants of various insects, many have neither flowers nor fruits. A portion of the collection bears Gressitt's numbers 2401 to 2575, while the remainder have Djou's numbers 101 to 139.

In general, the quality of the specimens resulting from the five collecting trips described above is very poor. Most of the Hwa, Djou, and Gressitt numbers are sterile. Some of the Cheng-Hwa collections are sterile, while others are very inadequate, consisting in some instances of a single small herbaceous plant. Normally such specimens are not retained in research herbaria, but since our objective with these collections has been to document the flora of the metasequoia area as completely as possible, all specimens that could be determined to species have been retained and are included in the enumeration below. The majority of specimens have been named by comparison with types, isotypes, or photographs or fragments of type material in the herbaria of the Arnold Arboretum and Gray Herbarium, and a total of 550 species in 301 genera representing 127 families have been recognized in the five combined collections from the metasequoia area.

Despite the documentation of the metasequoia flora thus made possible, a complete flora of the area has not been forthcoming. Chaney (1948) reported that small fan palms (*Trachycarpus fortunei* (Hooker f.) H. Wendl.) grow at various places in Shui-sa-pa, while Chu (in Chu & Cooper, 1950, p. 273) observed that in a quadrat placed on muddy seepage ground, the surface was covered by a soft carpet of *Diarrhena* sp. (Gramineae). Neither taxon,

however, is represented in the Arnold Arboretum material. In general, foresters, dendrologists, and entomologists pay little attention to the grasses and palms, which may explain the lack of material representing their families.

ECOLOGICAL NOTES ON THE METASEQUOIA AREA

Shui-sa-pa, as mentioned above, is at an elevation of 1050 meters in a flat-floored valley or basin in a mountainous plateau or tableland region located about 60 km. southeast of the Yangtze River in the Li-chuan District, southwestern Hupeh Province (lat. $30^{\circ}10'$ N., long. $108^{\circ}35'$ E.). The Chi-yao Mountains (Permian limestone) attain an altitude of 1500 meters and bound the basin at an oblique angle on the northwest; mountains of another range, the Fu-pao-shan (Jurassic sandstone) reach about 1400 meters and bound the basin on the east.

The main stream of the basin occupies a bed of sandstone for most of its course and flows in a southerly direction for about 25 km. from its headwaters, then "roughly eastward in an S-curve for about 20 km. to the point where it disappears underground at the foot of limestone cliffs 200 m. high" (Chu & Cooper, 1950, p. 264) that form the southern boundary of the basin. Surrounded by mountains or high bluffs, the basin is effectively isolated.

The basin floor in the vicinity of Shui-sa-pa is between 300 and 600 meters wide, has mostly sandstone-derived soils, and is extensively used for the cultivation of rice, while the slopes of the surrounding mountains are "cut by ravines covered by semi-natural vegetation" (Chu & Cooper, 1950, p. 264).

The available climatic data for the metasequoia area have been discussed by Chu & Cooper (1950), who suggest that the region is similar with respect to temperature and total precipitation to the Coastal Plain of Georgia in the southeastern United States. However, in contrast to those of the latter area, the winters in the metasequoia area are relatively dry, while the summers are wet since most of the precipitation falls during the months of June, July, and August.

CHARACTERISTICS OF THE METASEQUOIA FLORA

As I worked with the specimens from the metasequoia area, the characteristics of the flora became increasingly clear. The most striking aspects that became evident relate to the diversity of forms seen in the large number of families and genera, the nature of the few prominent families and large genera in the area, the preponderance of woody species, the proportions of deciduous and evergreen species, the large number of endemic Chinese taxa represented, and the absence of weedy and high mountain species.

DIVERSITY. The diversity of the taxa is the most striking feature of the metasequoia flora. In an area of approximately 800 square kilometers, documentation exists for the presence of at least 550 species of vascular

plants in 301 genera of 127 families, although the Gramineae and Palmae, as mentioned above, are inadequately represented in the collections studied. Thirty-one species are in 24 genera of 15 families of Pteridophyta; 18 species in 15 genera of six families in three classes of Gymnospermae; 357 species in 167 genera of 94 families of Dicotyledoneae; and 111 species in 66 genera of 12 families of Monocotyledoneae.

Three-fourths of the specimens are known to have been collected from the immediate vicinity of the metasequoia grove, which is a very small area situated at Shui-sa-pa. It should be mentioned that during Hwa's 1947 trip, he collected before reaching Shui-sa-pa. Some of the species that are represented by his numbers below 180 and that are not duplicated by his higher numbers are species that do not occur in the immediate vicinity of Shui-sa-pa. In the enumeration of species, there are at least 15 that do not grow in the metasequoia community, including *Larix potaninii*, *Juniperus squamata*, *Eucommia ulmoides*, *Liriodendron chinense*, *Lindera viridis*, *Pittosporum glabratum*, *Euodia melifolia*, *Zanthoxylum simulans*, *Rhus potaninii*, *Acer longipes*, *A. mono*, *Cercis chinensis*, *Ilex ficoidea*, *Elaeagnus henryi*, and *Alangium handelii*. Some of these species may have been gathered from cultivated plants, since *Eucommia* has medicinal properties, *Zanthoxylum* is used as a spice, *Cercis* is an ornamental, and all are frequently cultivated.

The diversity of the flora is more pronounced when one considers the large number of families and genera that are represented by a small number of taxa. Seventy-three of the 127 families (almost 58%) in the area are represented by a single genus. In addition, there are 15 more families (almost 12%) represented by only two genera, and 12 others (ca. 10%) represented by three. Of the 301 genera, 202 (69%) are represented by a single species, 41 (14%) by two species, and 24 (ca. 8%) by three. The overwhelming number of families and genera represented by one or a few genera and species is indicative of the morphological distinctiveness of the components of the flora and probably reflects their history and that of the metasequoia area.

WELL-REPRESENTED FAMILIES AND GENERA. There are a few well-represented families and genera in the metasequoia area. The largest family is the Rosaceae, with 50 species in 16 genera. Additional large families include the Fagaceae (5/29),² Lauraceae (7/28), Ericaceae (5/19), and Theaceae (4/10); the genera/species ratios of these families vary from 2.5 to 5.8.

Other families, including the Leguminosae (14/17), Liliaceae (8/10), Araliaceae (7/10), Compositae (8/9), Cyperaceae (7/8), Pinaceae (6/7), Euphorbiaceae (6/6), Polypodiaceae (5/7) and Labiatae (5/6), have relatively large numbers of genera, yet the numbers of species are comparatively small. These families have low genera/species ratios ranging between 1 and 1.4.

All the well-represented families with high genera/species ratios contain small genera. Examples include the Fagaceae (*Castanea* (2)),³ *Fagus* (2));

²The numbers in parentheses represent the number of genera and species, respectively, in the families concerned.

³The number in parentheses represents the number of species of the genus in the metasequoia flora.

Lauraceae (*Actinodaphne* (1), *Neolitsea* (2), *Sassafras* (1)); Rosaceae (*Agri-
monia* (1), *Chaenomeles* (1), *Kerria* (1), *Stephanandra* (1), *Stravaesia* (1));
Theaceae (*Eurya* (1), *Ternstroemia* (1)); and Ericaceae (*Lyonia* (1), *Pieris*
(1)).

The genus with the greatest diversity in the metasequoia area is *Quercus*, which is represented by 13 species. Other well-represented genera include *Lindera* (12), *Prunus* (12), *Acer* (11), *Ilex* (11), *Viburnum* (11), *Rhododendron* (9), *Litsea* (7), *Salix* (6), *Rubus* (6), *Vaccinium* (6), and *Symplocos* (6). Some of these genera are represented by species belonging to several subgeneric taxa; for example, in *Ilex* the eleven species belong to six different subgenera.

WOODY VS. HERBACEOUS SPECIES. The metasequoia flora has a preponderance of trees, shrubs, woody lianas, and perennial herbs. Woody species make up 76.4% of the 550 species, and 76.6% of the herbaceous species are perennials. It is possible, however, that herbs were under-collected (see above). It is noteworthy that the flora includes three parasites, one woody (*Taxillus sutchuensis*, Loranthaceae) and two herbaceous (*Cuscuta chinensis*, Convolvulaceae, and *Protolirion sinii*, Liliaceae).

DECIDUOUS VS. EVERGREEN SPECIES. Approximately 56 percent of the species associated with metasequoia are deciduous, while the remaining 44 percent are evergreen. The distribution of evergreen and deciduous species in the families is variable. In such families as the Juglandaceae and Betulaceae, all species are deciduous; in others a few species are deciduous, while the majority is evergreen. For example, in the Aquifoliaceae three species belonging to three different subgenera of *Ilex* are deciduous, yet eight others belonging to five subgenera are evergreen. The condition in the Pinaceae and Lauraceae is similar. In still other families (for example, the Taxaceae and Theaceae), all species are evergreen.

ENDEMIC GENERA AND SPECIES. The metasequoia flora is characterized by the presence of a high proportion of unusual plants found only in China. Some of the species, like *Metasequoia glyptostroboides*, belong to monotypic genera restricted to Central China; *Eucommia ulmoides* and *Tetracentron sinense* are additional examples. Other species, including *Decaisnea fargesii*, *Dichroea febrifuga*, *Stranvaesia davidiana*, *Tapiscia sinensis*, *Idesia polycarpa*, *Poliothyrsis sinensis*, *Nothopanax davidii*, and *Serissa foetida*, are endemic to China and belong to oligotypic genera. The degree of endemism and the ranges of the endemic genera are well illustrated by one-third of the gymnosperms that occur naturally with metasequoia (see below).

PAUCITY OF WEEDY AND HIGH ALTITUDE SPECIES. Having lived eight years in the Chengtu Plain and having traveled and botanized in the high mountains known as the rain-screen of the Sino-Tibetan border, I find the absence or paucity of various species a very striking character of the metasequoia flora. (1) *Alnus crematogyne* Burkill (Betulaceae) and *Camptotheca acuminata* Decaisne (Nyssaceae) are elsewhere common and conspicuous along streams and by the banks of rice fields. (2) There are few species of the families Chenopodia-

ceae, Amaranthaceae, Aizoaceae, and Caryophyllaceae, which include many weedy species. (3) The numerous species of *Abies* Miller and *Picea* A. Dietrich, which form extensive forests in the mountainous regions of China, were not represented in the five collections under study from the metasequoia area. Perhaps the metasequoia area is not high and cool enough to support species of these two genera.

GYMNOSPERMS OF THE METASEQUOIA AREA

Seventeen species belonging to fourteen genera and six families of Gymnospermae occur naturally with *Metasequoia glyptostroboides*. Data on the distributional patterns and paleobotanical records of each genus might advance our understanding of the history, evolution, and phytogeographic significance of the metasequoia flora. With this end in view, information concerning these genera has been brought together below, and the data published by Florin (1963) have been heavily drawn upon.

The classes and orders to which the gymnospermous families belong, the genera in each family, the number of species in each genus in the metasequoia flora, and the present geographic range of the genera are given in TABLE 1. All of these genera are known from the fossil record.

ANTIQUITY. The genus *Metasequoia* Miki was first described from Lower Pliocene fossil material from Japan (Miki, 1941). When *M. glyptostroboides* was discovered as an extant plant, the botanists who described it and those who were associated with its introduction and distribution often referred to it as a "living fossil." The metasequoia area supports more than a dozen genera of gymnosperms (TABLE 1), and many of the species belong to monotypic or oligotypic genera now growing at low and middle latitudes in China. As evidenced by the fossil record, however, these genera once had much greater ranges in the Northern Hemisphere, and some of them have a longer geologic history than *Metasequoia*. For example, fossil remains of *Pseudolarix*, *Cupressus*, and *Torreya* have been recorded from Mesozoic deposits and are among the oldest known genera of conifers and taxads. As is well known, the ginkgos are among the oldest known gymnosperms, dating from the early Mesozoic (Andrews, 1961).

MORPHOLOGICAL DISTINCTIVENESS. Including *Metasequoia glyptostroboides* and *Ginkgo biloba*, the eighteen species of gymnosperms in the metasequoia area are distributed in fifteen genera, six families, and three classes. With the exception of *Pinus* and *Juniperus*, these genera are represented by single species in the metasequoia flora. In both *Pinus* and *Juniperus* the species belong to distinct subgeneric groups: the two species of *Pinus* to subg. *PINUS* (*Diploxylon*) and subg. *STROBUS* (*Haploxylon*), and the three species of *Juniperus* to sects. *JUNIPERUS* (*Oxycedrus*) and *SABINA*, the latter a taxon often recognized as a distinct genus.

Obviously, the gymnosperms of the metasequoia area represent many isolated evolutionary lines. Each species has a distinctive genotypic as well

TABLE 1. Genera of gymnosperms in the metasequoia area.

CLASSES AND ORDERS	FAMILIES	GENERA	SPECIES IN METASEQUOIA AREA	PRESENT RANGES OUTSIDE OF CHINA		
				Japan	North America	Europe
CONIFEROPSIDA						
Coniferae	Pinaceae	<i>Keteleeria</i>	1			
		<i>Larix</i>	1	+	+	+
		<i>Pinus</i>	2	+	+	+
		<i>Pseudolarix</i>	1			
		<i>Pseudotsuga</i>	1	+	+	
		<i>Tsuga</i>	1	+	+	
	Taxodiaceae	<i>Cunninghamia</i>	1			
		<i>Metasequoia</i>	1			
		<i>Taiwania</i>	1			
	Cupressaceae	<i>Cupressus</i>	1		+	+
		<i>Juniperus</i>	3	+	+	+
	Cephalotaxaceae	<i>Cephalotaxus</i>	1	+		
TAXOPSIDA						
Taxales	Taxaceae	<i>Taxus</i>	1	+	+	+
		<i>Torreya</i>	1	+	+	

as phenotypic expression, and there is little chance for development of newer types through hybridization. Under favorable growth conditions they can survive, and they have persisted from the Mesozoic or the Cenozoic Era to the present day.

DISTRIBUTIONAL PATTERNS. The present geographic ranges of the gymnosperm genera that occur with metasequoia exhibit six distinctive distributional patterns. These are: (1) genera widespread in the Northern Hemisphere, including one genus (*Juniperus*) with a southward disjunction in the lake-mountain area of eastern equatorial Africa, and another (*Taxus*) with a range extending from southeastern continental Asia to the Philippines and the Celebes; (2) genera with eastern Asian and eastern North American disjunct distribution; (3) one genus (*Pseudotsuga*) with eastern Asian and western North American disjunct distribution; (4) one genus (*Cupressus*) with Sino-Himalayan-Mediterranean and western North and Central American distribution; (5) one genus (*Cephalotaxus*) with Sino-Japanese distribution; and (6) five genera, including *Metasequoia*, endemic to China at low and middle latitudes. These patterns clearly suggest that the gymnosperms of the metasequoia area have had different evolutionary histories and divergent adaptive radiations.

GENERA OF WIDESPREAD DISTRIBUTION. Four genera (*Pinus* and *Larix*, of the Pinaceae; *Juniperus*, of the Cupressaceae; and *Taxus*, of the Taxaceae) represented in the metasequoia flora are widespread in the Northern Hemisphere. The number of extant species in each of these genera is disputable; *Pinus* and *Juniperus* both contain many species that are distinguished by technical characters. However, the ranges of the sections or subgenera into which these genera have been divided are phytogeographically significant.

Pinus. The large genus *Pinus* has been subdivided into subg. PINUS and subg. STROBUS. Florin (1963, pp. 253-256, figs. 57, 58) presented an illustrated account of the distribution of the extant and fossil species. Both subgenera, as noted above, are represented in the metasequoia flora, with *P. massoniana* representing subg. PINUS and *P. armandii* typifying subg. STROBUS.

Larix. Like *Metasequoia*, *Ginkgo*, and *Pseudolarix*, the genus *Larix* is composed of deciduous species. It has a disjunct distribution in the Northern Hemisphere (cf. Florin, 1963, fig. 55) and has four centers of diversity: the northern Rocky Mountains of western North America; eastern Siberia-North China, Korea, and Japan; the interior of western and southwestern China and the adjacent eastern Himalayan area in northern Burma and northern India; and eastern Europe. In China, areas of diversity appear to be the Meridional Ranges on the Sino-Tibetan border, where four species are sympatric. Undoubtedly due to high altitude and sufficient precipitation, the species of this area extend the generic range ten to twenty degrees southward. However, *Larix* does not occur in southeastern China, as is stated by Florin (1963, p. 248).

Juniperus. The genus *Juniperus* is large both in number of species and in the extent of its geographic range. Both sections of the genus accepted by Florin (1963, pp. 227-232, figs. 43, 44) are represented in the metasequoia flora, with *J. formosana* in sect. JUNIPERUS and *J. chinensis* and *J. squamata* in sect. SABINA.

Species of *Juniperus* are adapted to habitats in exposed areas with poor and often dry soils, and they often grow on barren rocky cliffs and windy ridges where seasonal and daily climatic fluctuations are extreme. The ranges of the extant species indicate that the genus contains both widespread and restricted species. *Juniperus communis* L. is widespread; its numerous varieties have a circumboreal distribution. Apparently, there are several centers where species are concentrated, i. e., southwestern North America, the Mediterranean area, Central Asia, and the Sino-Himalayan-Japanese region.

Juniperus occurs in the Northern Hemisphere at middle and high latitudes, and at high altitudes in low latitudes. The generic range is extended southward by species of sect. SABINA in both Central America and eastern Africa. There is no evidence that the genus is native to subtropical southeastern China and adjacent Indochina. *Juniperus formosana*, however, occurs in the high mountains of Taiwan, as well as on the mainland in Hupeh, Szechwan, Yunnan, and Kweichow provinces.

Taxus. The genus *Taxus* exhibits a widespread but discontinuous distribution (cf. Florin, 1963, fig. 61). In contrast to *Juniperus*, *Taxus* has fewer species, and the specimens examined give no evidence of overlapping ranges except in the Sino-Himalayan region. When the specimens from this area are studied critically, the situation may be clarified.

One of the interesting features of the distribution of *Taxus* is that the species in Europe and North America grow at higher latitudes than do the Asian taxa. It is noteworthy that *T. wallichiana* Zucc. extends from the Meridional Ranges of southwestern China, westward to northern Burma, Nepal, and northern India, and southeastward to Annam in Indochina, Luzon in the Philippines, and then southward to the Celebes.

EASTERN ASIAN-EASTERN AND WESTERN NORTH AMERICAN DISJUNCTIONS. Two genera represented in the metasequoia flora exhibit eastern Asian-eastern and western North American disjunct distributions, and in both instances closely related species pairs occur on the two continents.

Tsuga. The genus *Tsuga* is of moderate size with about twelve species. Florin has carefully illustrated and explained the distribution of the fossil and extant species, but it should be noted that in each area of the disjunct generic range (cf. Florin, 1963, fig. 53) there are two or more species, all with overlapping ranges. The Sino-Himalayan region appears to be the present center of diversity for the genus.

The eastern Asian-eastern and western North American disjunction pattern in *Tsuga* is expressed by paired species in sects. TSUGA and HESPEROEUCE. The closely related species in sect. TSUGA are *T. chinensis*, of Central and western China, and *T. caroliniana* Engelm., of Virginia, North and South

Carolina, Tennessee, and Georgia; in sect. *HESPEROPEUCE*, *T. longibracteata* Cheng, from the mountainous areas of Kweichow and northern Kwangtung provinces, and *T. mertensiana* (Bong.) Sarg., widespread in western North America.

Torreya. A small genus of four to six species, *Torreya* occupies a limited geographic range (cf. Florin, 1963, fig. 63). It should be noted that the specimens I have examined have been identified as belonging to six species, three from mainland China, one from Japan, and two from the United States. The species look very similar and have been distinguished from one another by the color and pubescence of the twigs, the length of the leaves, the size and shape of the seeds, and the depth of the surface folding of the ruminant "endosperm."

In *Torreya* the disjunct distribution in eastern and western North America and in eastern Asia is expressed by pairs of species, a fact that was recognized by Rehder and Wilson as early as 1914. They commented (Pl. Wils. 2: 7, 1914) that "it is worthy of note that the eastern American *T. taxifolia* . . . agrees with *T. grandis* [of China] . . . and that the western American *T. californica* . . . agrees with *T. nucifera* [of Japan]." At that time *T. jackii* Chun of Chekiang in eastern China was not known—there is an even more prominent affinity between it and *T. californica* Torrey. It is worthy of note that with the exception of *T. grandis* and *T. jackii*, comparatively distantly related species that both occur in Chekiang, the ranges of *Torreya* species do not overlap. Each species is restricted to an area that is small, particularly so in North America.

EASTERN ASIAN—WESTERN NORTH AMERICAN DISJUNCTIONS. Extant species of *Pseudotsuga* are distributed disjunctly in eastern Asia (five species) and western North America (two species) (cf. Florin, 1963, fig. 52). *Pseudotsuga menziesii* (Mirbel) Franco is widespread in western North America, occurring in the Rocky Mountains and the Coastal Ranges, extending from Alberta and British Columbia in Canada southward through Montana, Idaho, and Washington, to Texas, Arizona, and California in the United States, and into Coahuila, Nuevo León, and Sonora in Mexico. The second North American species, *P. macrocarpa* (Torrey) Mayr, is confined to southwestern California.

In eastern Asia *Pseudotsuga* occupies a broken and scattered range, with *P. japonica* (Shiras.) Beiss. confined to the islands of Honshu and Shikoku of Japan; *P. wilsoniana* Hayata restricted to the mountains of Taiwan; *P. gausenii* Flous endemic to Chekiang and southern Anhwei; *P. sinensis* confined to the metasequoia area and eastern Yunnan; and *P. forestii* Craib occurring only in the high mountainous area of northwestern Yunnan and adjacent Sikiang. The genus may once have been more widely distributed in China, the present distribution having been brought about through the destruction of the natural forest by the conversion of woodlands and open hills into terraced fields. All the described Chinese species appear to be very similar, and future study may indicate that they represent geographic variants of a single widespread species. It should also be mentioned that paleobotanical material of *Pseudotsuga* has been found within or close to the ranges of

the extant species, a situation unlike that found in the other small gymnosperm genera occurring naturally with metasequoia.

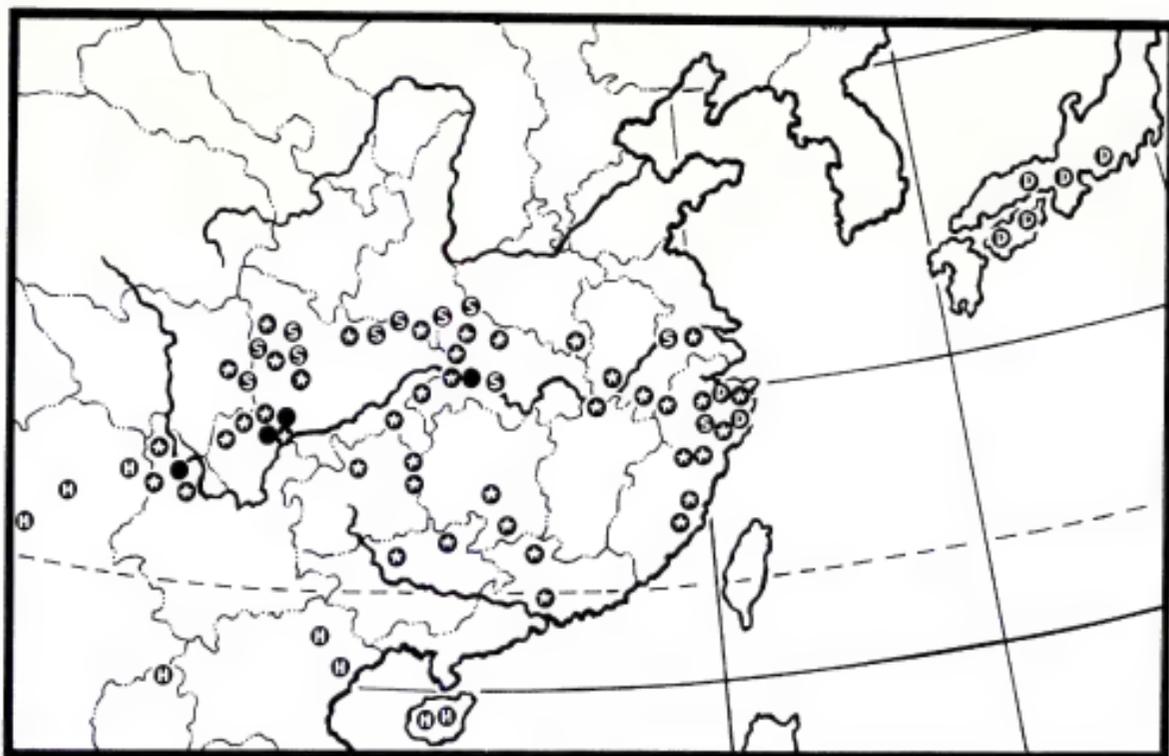
The floristic relationships between eastern Asia and western North America, as exemplified by *Pseudotsuga*, have received less attention from phytogeographers than those between eastern Asia and eastern North America. Nevertheless, this pattern of disjunction is common among the angiosperms. Several genera, predominantly herbaceous perennials and shrubs, are good examples of taxa confined to these regions: *Lysichiton* Schott (Ataceae); *Lloydia* Salisb. (Liliaceae); *Lithocarpus* Blume (Fagaceae); *Eurotia* Adanson (Chenopodiaceae); *Mahonia* Nuttall and *Achlys* A. P. DC. (Berberidaceae); *Parrya* R. Br. and *Smelowskia* C. A. Meyer (Cruciferae); *Chamaerhodos* Bunge (Rosaceae); *Chamaesaracha* A. Gray (Solanaceae); and *Boschniakia* C. A. Meyer (Orobanchaceae).

SINO-HIMALAYAN, MEDITERRANEAN, AND WESTERN NORTH AND CENTRAL AMERICAN DISJUNCTION. The present range of the genus *Cupressus* illustrates a Sino-Himalayan, Mediterranean, and western North and Central American disjunct distributional pattern (cf. Florin, 1963, fig. 38). Species of the genus are adapted to arid habitats, and the main area of differentiation appears to occur in California, followed in importance by the Sino-Tibetan border area. Eleven species, most of them localized endemics, occur in California, while there are four sympatric species in the Sino-Tibetan border area.

Species of *Cupressus* generally grow on rocky outcrops, coastal cliffs, or ridges, in canyons, and on sunny slopes of dry hills in chaparral; in each of its centers of distribution there is at least one widespread species. Thus, *C. arizonica* Greene is widespread in the southwestern United States and northern Mexico; *C. lusitanica* Miller grows widely in Mexico, and in Guatemala and El Salvador in Central America; and *C. torulosa* D. Don occupies a wide range in the Sino-Himalayan region. In the Mediterranean area *C. sempervirens* L. extends from Asia Minor and Iran westward to Morocco and occurs disjunctly in Algeria. Elsewhere in eastern and southeastern Asia *Cupressus* is absent from the floras of Japan, Taiwan, Indochina, and Kwangtung and Kwangsi.

SINO-HIMALAYAN-JAPANESE DISTRIBUTION. The present distribution of *Cephalotaxus* is confined to the Sino-Himalayan-Japanese region (MAP 2; see also Florin, 1963, fig. 60).⁴ Taxonomists differ in their interpretation of the number of species comprising the genus. Rehder (1940, 1949) recognized three (*C. harringtonia*, *C. fortunei*, and *C. oliveri*) and has been generally followed by recent authors including Ohwi in his *Flora of Japan* (1965). I have also followed Rehder in this study. All three species occur in China: two are widely distributed, with *C. harringtonia* (Forbes) K. Koch and its three varieties (vars. *harringtonia*, *drupacea* (Seib. & Zucc.) Koidzumii, and *sinensis* (Rehder & Wilson) Rehder) occupying the periphery of the generic range (MAP 9, H, D, S, respectively), and *C. fortunei* occurring in the metasequoia area

⁴Distribution maps have been plotted on the basis of specimens deposited in the herbaria of the Arnold Arboretum and Gray Herbarium.



MAP 2. Sino-Himalayan-Japanese distribution of *Cephalotaxus*: *C. harringtonia* var. *harringtonia* (H); *C. harringtonia* var. *drupacea* (D); *C. harringtonia* var. *sinensis* (S); *C. oliveri* (solid black dots); *C. fortunei* (stars).

as well as in the warmer provinces of China; the third, *C. oliveri* Masters, has a broken and scattered range and is restricted to western China. The Sino-Himalayan-Japanese distributional pattern represented by *Cephalotaxus* is very common in angiosperms—*Platycarya* Sieb. & Zucc., *Houttuynia* Thunb., *Corylopsis* Sieb. & Zucc., *Euscaphis* Sieb. & Zucc., *Stachyurus* Sieb. & Zucc., *Helwingia* Willd., *Abelia* R. Br., and *Ligularia* Cass. are a few of the many genera from a wide range of families that share similar geographic ranges.

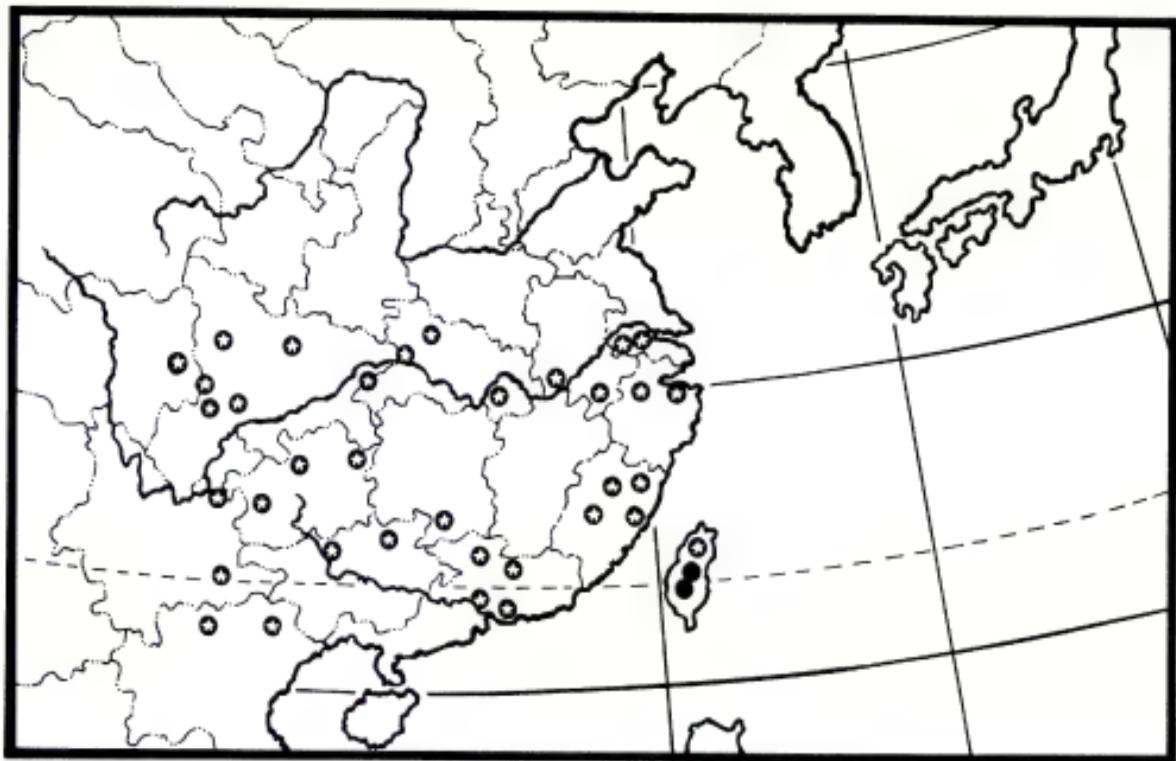
ENDEMIC DISTRIBUTION. Six genera (40%)—and one-third of the species—of the gymnosperms occurring in the metasequoia flora are endemic to China. These genera are *Ginkgo* (Ginkgoaceae), *Keteleeria* and *Pseudolarix* (Pinaceae), and *Cunninghamia*, *Metasequoia*, and *Taiwania* (Taxodiaceae). It is noteworthy that the metasequoia area (lat. 30°30' N.) marks the northern limit of the range of all of them. The seeds of *Ginkgo biloba* have been used by the Chinese people as both food and medicine for centuries, and it would appear that all known trees owe their existence to man's effort, either through protection or by planting. As a result, its distribution is highly artificial and is not considered here. The remaining five genera exhibit four distributional patterns: widespread as in *Cunninghamia* and *Keteleeria*, bicentric as in *Taiwania*, strongly restricted (in the Lower Yangtze region) as in *Pseudolarix*, and extremely restricted as in *Metasequoia* itself.

Cunninghamia. Although the ranges of *Cunninghamia* and *Keteleeria* overlap in many places (MAPS 3, 4), the nature of the distribution of the two genera is different. Less morphological variation is evident in *Cunninghamia* (MAP 3; see also Florin, 1963, fig. 34), and only two species have been recognized. *Cunninghamia konishii* Hayata, distinguished by its short leaves and small cones, is confined to the mountains of Taiwan. *Cunninghamia lanceolata* is widely distributed; however, since it is a fast grower, is easily propagated, and is often cultivated for its wood, its widespread distribution is partially the result of man's activities.

According to Florin (1963, p. 215), *Cunninghamia* has been recorded from Oligocene and Miocene deposits from Central Europe, and from an Oligocene deposit from Oregon.

Keteleeria. The occurrence of *Keteleeria* in China (MAP 4; see also Florin, 1963, fig. 51) is spontaneous; it is more abundant away from human habitation, however, and is found only in mountainous areas. Rare in eastern China, it is frequent in the high mountains of the Sino-Tibetan border, especially at altitudes of 2300–3300 meters.

Keteleeria appears to be phenotypically plastic, depending upon the age of the plants and the environmental conditions under which they are growing. Due to this variability, the genus has received varying taxonomic interpretations. In 1926 E. H. Wilson recognized one species with a bicentric distribution in Taiwan and western China, while Flous (1936) recognized nine species. The characters Flous used to distinguish these species are phenotypically variable and include leaf length and apex shape. In 1978 Cheng and Fu



MAP 3. Distribution of *Cunninghamia lanceolata* (stars) and *C. konishii* (black dots).

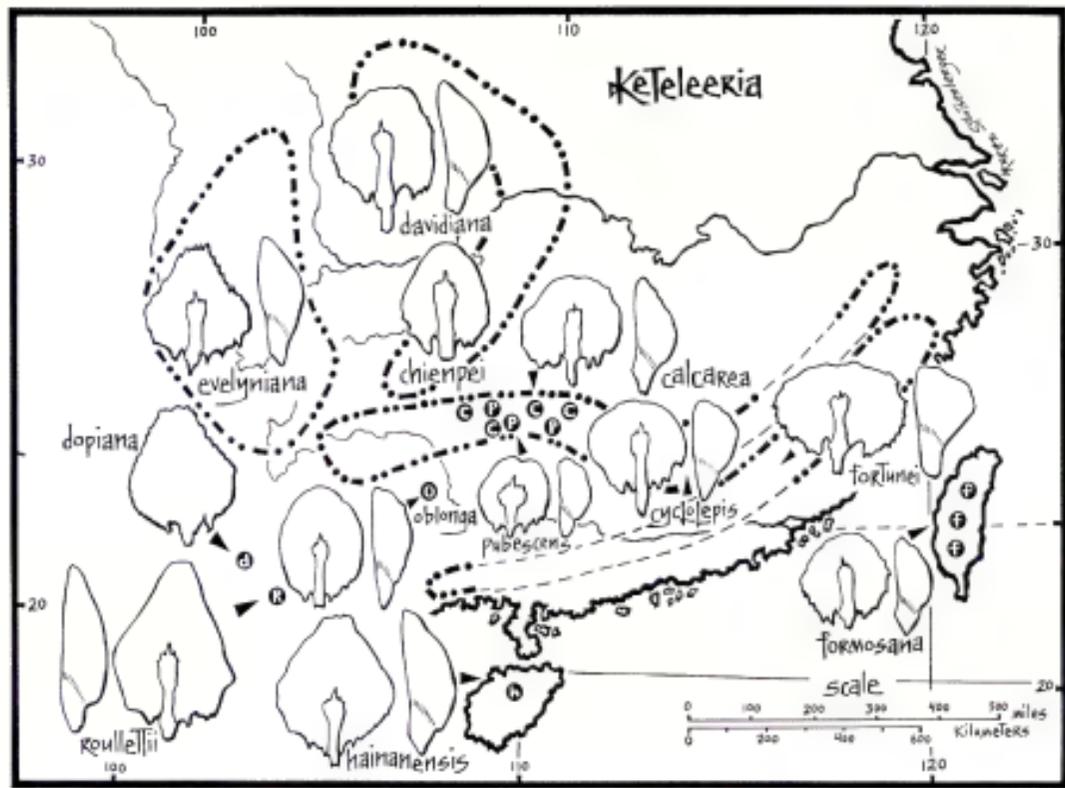
recognized eleven species, nine of them from China (including one from Hainan). Again, the characters employed are phenotypically variable: length of leaves, hairs or papillae on young branchlets, shape of cone scales, and characters of the stomatic bands along the leaf midrib.

Wilson studied the plants in the field in the mountains of both Taiwan and western China. He observed (1926, p. 53) that the leaves of the same species vary from "2 to 5 cm. and may be rounded, emarginate, obtuse or acute at apex. On young trees and adventitious branches of old trees, the leaves are usually sharply acute or spinescent. . . . In length the cones vary from 5 to 20 cm. . . . The bracts vary in shape somewhat according to age and size. . . ." Orr (1933a), after analyzing the western Chinese collections of Forrest, Maire, and others, decided that all of the specimens belong to one species, *Keteleeria davidiana*.

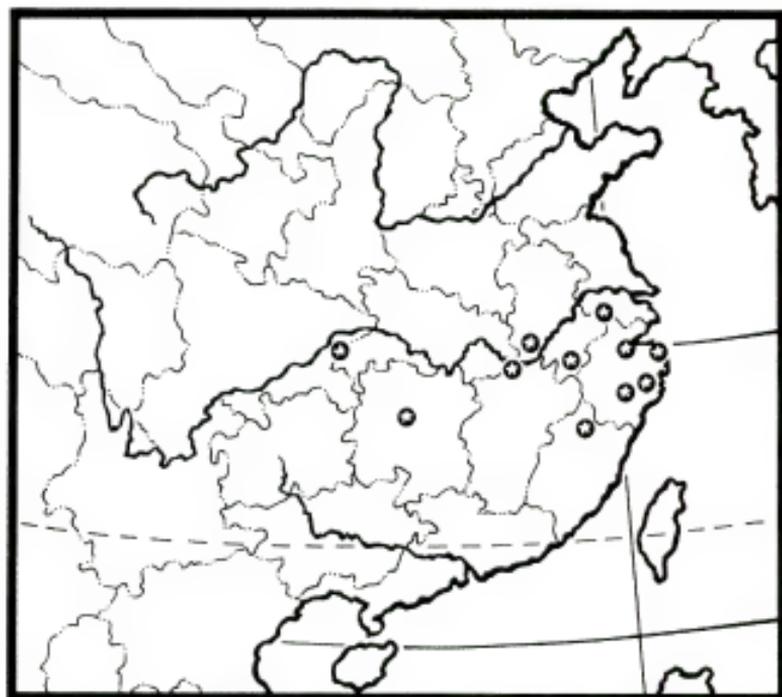
The taxonomic status of species recognized in the genus awaits biosystematic investigation. Data for assessing the taxonomic value of morphological characters heretofore used for distinguishing species are needed. The problems involved in understanding the *Keteleeria* complex exemplify the difficulties inherent in the study of the metasequoia flora. To illustrate these problems, the published data of Flous (1936) and Cheng and Fu (1978) have been correlated with herbarium material deposited at the Arnold Arboretum and the Gray Herbarium and plotted on MAP 4. Interpretation of these data indicates that *Keteleeria* is a genus of warm-temperate Central China and subtropical South China and adjacent northern Indochina, and that variation exists in the morphology of the cone scales and seeds. In the west and southwest cones with large, ovate-rhomboid middle scales are produced, and the seeds have wings broadest below the middle. Eastern and southeastern populations produce cones with suborbicular scales, and seeds with wings broadest above the center. In the middle of the range a diversity of intermediate forms occurs; the Taiwanese element is more closely related to these forms than to those of Yunnan or Fukien. It would also appear that the Nan-lin Range, especially the area along the border of Kwangsi and Kweichow, constitutes a center of diversification; in this region the ranges of several of the recognized elements (*calcareae*, *cyclolepis*, and *pubescens*) overlap.

According to Florin (1963, p. 242), *Keteleeria* had a wider range in the past than it does now. It is represented in fossil remains from Europe in deposits ranging from the Oligocene to the Pliocene; it is also known from the Oligocene and Miocene from the Pacific Northwest and from Pliocene deposits in Japan.

Pseudolarix. The genus *Pseudolarix* is monotypic, and its range is restricted to eastern and Central China. Specimens of *Pseudolarix* from the metasequoia area extend its range 400 kilometers westward from its previously known occurrence (MAP 5; see also Florin, 1963, fig. 56). *Pseudolarix amabilis* was first discovered at Ning-po on the coast of Chekiang Province. In 1910 Wilson found it at an altitude of 1300 meters on Lu-shan, Kiangsi Province; based on this collection, Rehder and Wilson wrote that "this remarkable tree reaches the western limits of its distribution on the Lushan Range . . . where it



MAP 4. Distribution of *Keteleeria* complex in China and adjacent Indochina, showing morphological variation in cone scale outline and seed wings. All cone scales from middle of mature cones.



MAP 5. Distribution of *Pseudolarix amabilis*.

is rare, and no large trees remain" (Pl. Wils. 2: 22. 1914). In 1918 Handel-Mazzetti collected some specimens in Hsin-hua, Hunan Province, and these collections extended the range of the species 400 kilometers into the interior of China. Later, the gap between the Chekiang and Kiangsi localities was filled in by Steward's 1924 collection from Chu-hua-shan in Anhwei and by R. C. Ching's specimens, collected in 1925, from Huang-shan in the same province. Cheng and Fu (1978) reported its occurrence in southern Kiangsu in the north and in northern Fukien in the south.

According to Florin (1963, p. 250), *Pseudolarix* had a wide range in the Northern Hemisphere in geologic time, existing in western North America in the Oligocene, and in Europe and Japan as late as the Pliocene.

Taiwania. *Taiwania* is treated by most taxonomists as a monotypic genus comprising the polymorphic species *T. cryptomerioides*. However, Cheng and Fu (1978) recognized the mainland material from Yunnan, Kweichow, and the metasequoia area as *T. floustantia* Gaussen. *Taiwania cryptomerioides* was described in 1906, and for ten years it was regarded as endemic to Taiwan. In 1915 Handel-Mazzetti collected the species in northwestern Yunnan, and based on this material Wilson (1926, p. 59) commented that

"the occurrence of *Taiwania* . . . and of *Pseudotsuga wilsoniana* . . . in western China and on the mountains of Formosa and at no other place in between these widely separated regions is a remarkable fact in plant distribution." Later, Orr (1933) reported a collection (*J. H. Lace* 52) made in 1912 from Upper Burma. In 1978 Cheng and Fu recorded it from southeastern Kweichow. The specimens from southeastern Kweichow and the metasequoia area have partially filled the distributional gap between Yunnan and Taiwan.

Specimens in the herbarium of the Arnold Arboretum indicate that the species is rather frequent in the sparsely populated mountainous areas of northeastern Yunnan and the adjacent border areas with Szechwan, Sikiang, and Upper Burma (MAP 6; see also Florin, 1963, fig. 35). In these areas, it occurs at altitudes of 2100-3700 meters in mixed evergreen forests.

EVOLUTIONARY AND PHYTOGEOGRAPHIC IMPLICATIONS

The characteristics of the metasequoia flora and the distributional patterns exhibited by the gymnosperms growing in association with *Metasequoia glyptostroboides* have significant implications concerning phyto geography and the evolutionary history of the vegetation. The antiquity of the metasequoia



MAP 6. Discontinuous, bicentric distribution of *Taiwania*.

flora, its status as a relict flora, its origins and probable migration, and its floristic affinities are discussed below.

ANTIQUITY. The vegetation of the metasequoia area is a living sample of a comparatively well-preserved ancient flora. As mentioned above, all the genera of gymnosperms that occur naturally in the area have fossil records in the Tertiary epochs, and some extend back into the Mesozoic era. Paleobotanical discoveries indicate, moreover, that many of the lineages of the angiosperms represented in the metasequoia flora can also be traced back to the Tertiary. Wolfe's work (1969, 1978) on the Neogene floristic and vegetational history of the Pacific Northwest and Miki's findings (1954) concerning the Pliocene flora of Japan corroborate this contention. Wolfe (1969) listed 108 genera as present in the fossil remains of northwestern North America from the early and middle Miocene epoch. Sixty-two of these genera (57.5%) are also represented in the extant metasequoia flora. In addition, 21 other genera (18.5%) occur elsewhere in China (TABLE 2). Some of these genera, such as *Abies* and *Picea*, are important elements of boreal or montane taiga, while others, such as *Glyptostrobus* Endl., *Gordonia* Ellis, and *Exbucklandia* R. W. Br., are elements of subtropical lowland vegetation or montane forests.

In 1954 Miki reported on the occurrence of fossil remains of *Taiwania*, as well as of 26 other species, in the Pliocene clay and lignite beds of Japan. Eighty percent of the genera occurring in these beds are represented in the metasequoia flora, including *Cunninghamia*, *Keteleeria*, *Metasequoia*, *Pseudolarix*, *Taiwania*, *Tsuga*, *Buxus*, *Fagus*, *Hydrangea*, *Ilex*, *Juglans*, *Liquidambar*, *Quercus*, *Pterocarya*, *Schisandra*, *Spondias* (= *Choerospondias*), *Styrax*, and *Symplocos*.

Based on these fossil occurrences, the question that immediately comes to mind is why so many genera and species have disappeared from western North America and Japan but have survived in China (and in the metasequoia area in particular). The answers lie largely in the relative amount of change in topography and climate that have occurred in these regions subsequent to the establishment of modern floras in the early Tertiary or late Mesozoic. The floras of the metasequoia area and the region to the south in China have been spared from the direct effects of the repeated Pleistocene continental glaciation, from the aridity created by the mountain building and continental uplift during the Miocene and Pliocene (which gradually turned forested regions into steppes and deserts as in areas of the same latitude in Tibet), and from the effects of local mountain glaciation and vulcanism (as in Japan).

Although shifts of the climatic belts during the glacial and interglacial ages of the Pleistocene were worldwide and contemporaneous, local conditions in Central China reduced the intensity of the effects of lower temperatures and perhaps also the increased precipitation; hence, no glaciers were formed. As shown in MAP 7, eastern Asia was not covered by continental ice sheets. High mountains to the west and northwest of the metasequoia area and, according to Lee (1939, pp. 376-399), a few lower mountains in the Lower Yangtze Valley to the east (eg., Lu Shan in Kiangsi, Huang Shan in Anhwei, and Tien-mu Shan in Chekiang) were marked by local glaciers. Geographically,

TABLE 2. Genera of Miocene flora of western North America now growing in the metasequoia area or elsewhere in China.

GENERA OCCURRING IN THE METASEQUOIA AREA			GENERA ELSEWHERE IN CHINA
<i>Cephalotaxus</i>	<i>Schoepfia</i> (?)*	<i>Cedrela (Toona)</i>	<i>Abies</i>
<i>Keteleeria</i>	<i>Cercidiphyllum</i>	<i>Rhus</i>	<i>Picea</i>
<i>Pinus</i>	<i>Clematis</i>	<i>Toxicodendron</i> (?)†	<i>Chamaecyparis</i>
<i>Pseudotsuga</i>	<i>Cocculus</i>	<i>Ilex</i>	<i>Fokienia</i>
<i>Tsuga</i>	<i>Liriodendron</i>	<i>Acer</i>	<i>Thuja</i>
<i>Cunninghamia</i>	<i>Magnolia</i>	<i>Aesculus</i>	<i>Glyptostrobus</i>
<i>Metasequoia</i>	<i>Sassafras</i>	<i>Sageretia</i>	<i>Carya</i>
<i>Populus</i>	<i>Hydrangea</i>	<i>Tilia</i>	<i>Ainus</i>
<i>Salix</i>	<i>Liquidambar</i>	<i>Idesia</i>	<i>Aristolochia</i>
<i>Juglans</i>	<i>Prunus</i>	<i>Cornus</i>	<i>Mahonia</i>
<i>Pterocarya</i>	<i>Pyrus</i>	<i>Nyssa</i>	<i>Itea</i>
<i>Betula</i>	<i>Rosa</i>	<i>Alangium</i>	<i>Exbucklandia</i>
<i>Ostrya</i>	<i>Rubus</i>	<i>Clethra</i>	<i>Platanus</i>
<i>Castanea</i>	<i>Sorbus</i>	<i>Rhododendron</i>	<i>Amelanchier</i>
<i>Castanopsis</i>	<i>Spiraea</i>	<i>Diospyros</i>	<i>Crataegus</i>
<i>Fagus</i>	<i>Albizia</i>	<i>Kalopanax</i>	<i>Sophora</i>
<i>Quercus</i>	<i>Cercis</i>	<i>Fraxinus</i>	<i>Pistacia</i>
<i>Celtis</i>	<i>Cladrastis</i>	<i>Catalpa</i>	<i>Karwinskia</i>
<i>Ulmus</i>	<i>Gymnocladus</i>	<i>Sambucus</i>	<i>Zizyphus</i>
<i>Zelkova</i>	<i>Ailanthus</i>	<i>Viburnum</i>	<i>Vitis</i>
		<i>Clerodendrum</i>	<i>Gordonia</i>
			<i>Leucothoë</i>
			<i>Halesia</i>

*In a letter from Cheng to Merrill dated October 31, 1948, *Schoepfia jasminodora* Sieb. & Zucc. was listed among the immediate associates of metasequoia. However, none of the specimens that I have examined can be identified as that species.

†In this paper *Toxicodendron* is not segregated from *Rhus*.

the metasequoia area is situated in the Middle Yangtze region at middle latitude. During the glacial periods, it received a less pronounced increase in precipitation than did the mountainous areas mentioned above. Geologically, the continuous Tsinling Range of high mountains on the north, northwest, and west formed a natural "Great Wall" that shielded the area from the intense cold of the southward-shifting northern climatic zones. Moreover, the southwest-northeast orientation of the mountains of the metasequoia area permitted meridional circulation of warmer air. As a result of the combination of these factors, the vegetation of the metasequoia area was undoubtedly far less disrupted than the vegetation and floras of areas covered by continental glaciation in Europe and North America, and also less disrupted than the nearby vegetation of the Lower Yangtze Valley. While direct evidence on this point is unavailable, it may be that *Metasequoia glyptostroboides* and its associates survived the Pleistocene *in situ* in the metasequoia area.



MAP 7. Extent of continental and mountain glaciation in Eurasia during the Pleistocene. *Metasequoia* area indicated by M. (Map based mainly on Flint, 1957, and Lee, 1939.)

ORIGIN AND MIGRATION OF THE METASEQUOIA FLORA. After visiting the metasequoia area, Chaney (1948) concluded that the general aspect of the *Metasequoia*-hardwood assemblage is similar to that of the *Taxodium*-hardwood association of moist flood plains of the southeastern United States. For the early and middle Tertiary he reconstructed a profile of mild climate with summer rainfall and moderate temperature not regularly falling below freezing. *Metasequoia* and *Taxodium* were both widely distributed at high latitudes during the early Tertiary and occurred in western North America and northern Asia during the middle Tertiary. Chaney also advanced a theory with regard to the origin and migration of the Arcto-Tertiary metasequoia flora. "We conclude that this forest type had its origin in the north, in Eocene and Cretaceous time . . . and its southward migration during the Tertiary period." Chaney proposed this theory on the strength of the "deciduous habit of the dominant trees, including *Metasequoia* and *Taxodium*." He suggested that the length of the arctic night was the primary factor causing the deciduous habit.

Floristic analysis of the metasequoia flora and recent paleobotanical evidence do not support Chaney's theory. First, the deciduous habit is not predominant in the metasequoia flora since approximately 44 percent of the species are evergreen. Of the 18 species of gymnosperms in the area, only one-sixth are deciduous. These include *Larix potaninii*, *Metasequoia glyptostroboides*, and *Pseudolarix amabilis*, all of which grow in wet habitats and are hydrophilous. It would appear that the alternation of a dry winter season with a wet summer results in a fluctuation in the water supply that affects physiological activities, inducing the deciduous habit of these conifers. In the angiosperms, the texture of the leaves and the effects of dry winter on the plants are

obviously the controlling factors governing the annual shedding of leaves in areas where frost never occurs. In the tropical monsoon forest of Hong Kong, I have observed two definite periods when leaves are shed. Species with thin, chartaceous leaves shed them after the beginning of the dry season and appear deciduous in winter. Species with coriaceous leaves drop them after the dry season as, or soon after, flower and leaf buds unfold in early spring. This latter group of species appears evergreen in winter. A similar phenomenon was observed in Chengtu in the Red Basin of Szechwan, where frost seldom occurs.

Second, Chaney's theory of the origin and direction of migration of the metasequoia flora is oversimplified. His assumption of a holarctic origin and southward migration of the flora was formulated on the basis of an insufficient number of species from the metasequoia area. He listed (1948, p. 510) only eight species of deciduous dicotyledonous angiosperms, four species of gymnosperms, and one palm. At the generic level, his list includes less than twenty-five percent of the genera of gymnosperms, and less than four percent of the angiosperms now documented as growing in the metasequoia area. Yet, based on this scant evidence, Chaney concluded that "this assemblage is essentially the same as that recorded in the fossil record of the Eocene from high latitudes. . . ."

Numerous recent paleobotanical discoveries have negated the concept of an Arcto-Tertiary geoflora with temperate broad-leaved deciduous forests occurring at high latitudes. To the contrary, the high percentages of large leaves with entire margins, palmate venation, and elongated apices occurring in the fossil assemblages in Europe, Japan, and the western United States from middle Eocene and Miocene deposits suggests the existence of tropical rain forest vegetation (Wolfe, 1978).

Although the fossil record of Miocene western North America is very incomplete, it is perhaps noteworthy that 39 genera in 20 families (TABLE 3) are found in the metasequoia area but not in the Miocene of western North America. All 39 genera of the 20 families included in TABLE 3 occur in the southeastern portion of the Asian mainland and in Malaysia and are elements of tropical or subtropical forests. Moreover, all attain the northern limits of their ranges in or beyond the metasequoia area, indicating a southern affinity for the metasequoia flora. Although the genera all contain a large number of species outside the metasequoia area, representatives of these genera grow and multiply naturally in the same area with *Metasequoia glyptostroboides*.

These southern elements have very complicated floristic affinities. Although a few, such as *Michelia*, *Eriobotrya*, *Camellia*, and *Schima*, are confined to the Asiatic mainland with only one or two species in Japan or the Philippines, most have ranges that extend far into the Pacific land areas. Reference to TABLE 3 will show that several genera are world wide in distribution, while others exhibit tropical Asian-Pacific and tropical American affinities; eighteen genera show African relationships. The eastern North American-southeastern Asian distribution pattern is illustrated by *Lindera*; the western North American-eastern Asian distribution by *Photinia* (*Heteromeles* M. Roemer).

TABLE 3. Selected families and genera in the metasequoia flora not represented in the Miocene flora of western North America.

FAMILY	GENUS	PRESENT DISTRIBUTION*													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Moraceae	<i>Ficus</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Ulmaceae	<i>Trema</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Magnoliaceae	<i>Michelia</i>					+	+	+	+	+					
Lauraceae	<i>Cinnamomum</i>					+	+	+	+	+	+				
	<i>Lindera</i>	+				+	+	+	+	+					
	<i>Litsea</i>	+	+			+	+	+	+	+	+	+	+		
Pittosporaceae	<i>Pittosporum</i>					+	+	+	+	+	+	+	+	+	
Rosaceae	<i>Eriobotrya</i>					+	+	+		+					
	<i>Photinia</i>	+				+	+	+		+					
Leguminosae	<i>Dalbergia</i>	+	+	+	+	+	+	+	+	+	+	+		+	
	<i>Indigofera</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	
Euphorbiaceae	<i>Aleurites</i>					+	+	+	+	+	+		+	+	
	<i>Croton</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	<i>Phyllanthus</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	<i>Sapium</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Rutaceae	<i>Euodia</i>					+	+	+	+	+	+	+	+		
	<i>Toddalia</i>					+	+	+		+				+	
	<i>Zanthoxylum</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Celastraceae	<i>Celastrus</i>	+	+	+		+	+	+	+	+	+	+	+	+	+
	<i>Euonymus</i>	+	+	+		+	+	+	+				+		

Sabiaceae	<i>Meliosma</i>					+	+	+	+	+				
Rhamnaceae	<i>Berberia</i>	+				+	+	+	+				+	
	<i>Rhamnus</i>	+	+	+	+	+	+	+	+				+	+
Elaeocarpaceae	<i>Elaeocarpus</i>					+	+	+	+	+	+	+	+	
	<i>Sloanea</i>		+	+	+	+	+	+	+	+	+	+		
Theaceae	<i>Camellia</i>					+	+	+	+					
	<i>Eurya</i>					+	+	+	+	+				
	<i>Schima</i>					+	+	+	+					
	<i>Ternstroemia</i>		+	+	+	+	+	+	+					
Elaeagnaceae	<i>Elaeagnus</i>	+				+	+	+	+			+	+	+
Araliaceae	<i>Schefflera</i>		+	+	+	+	+	+	+					
Myrsinaceae	<i>Ardisia</i>	+	+	+	+	+	+	+	+	+		+		
	<i>Maesa</i>					+	+	+	+	+	+	+	+	
	<i>Myrsine</i>					+	+	+		+		+	+	
Styracaceae	<i>Styrax</i>	+	+	+	+	+	+	+		+			+	+
Symplocaceae	<i>Symplocos</i>	+	+	+	+	+	+	+	+	+	+			
Oleaceae	<i>Jasminum</i>					+	+	+	+	+	+	+		
	<i>Ligustrum</i>					+	+	+	+					+
	<i>Osmanthus</i>	+				+	+	+	+	+	+			

*Regions are represented by numbers, as follows: 1, North America; 2, Central America; 3, West Indies; 4, South America; 5, China and Japan; 6, Indochina and India; 7, Malaysia; 8, Papuaia; 9, Philippines; 10, Polynesia; 11, New Caledonia; 12, Australia; 13, Africa; and 14, Europe. The distributional data for these genera have been tabulated from specimens in the herbaria of the Arnold Arboretum and Gray Herbarium, and the sequence of geographic regions is adapted from the system utilized in filing those collections.

This analysis of the metasequoia flora serves to point out its complexity; it gives neither a clue to its place of origin nor an indication of the direction of past migration routes. The gymnosperms have several distributional patterns: those exhibited by *Larix* and *Tsuga* indicate northern affinities, while those of *Cephalotaxus*, *Keteleeria*, and *Taiwania* attest to southern affinities. The information derived from the various phytogeographic elements points to the dynamic nature of plant evolution and distribution—the various taxa in a small area remind one of the phenomenon of traffic congested in a rotary, where slow-moving vehicles of all makes and ages are gathered together. The flora of any given region is never static; the metasequoia flora provides a sample of an ancient flora growing today in an area where it may have survived *in situ* and offers an example of the ecological conditions under which such a flora may have been able to survive and evolve. That the metasequoia area is ecologically diverse is evidenced by the complexity of its flora.

AN ENUMERATION OF THE SPECIES

PTERIDOPHYTA

(Identified with the assistance of Professor R. M. Tryon)

LYCOPSIDA

Lycopodiaceae

Lycopodium complanatum L. Cheng & Hwa 1081.

Selaginellaceae

Selaginella uncinata (Desv.) Sprengel, Cheng & Hwa 987.

FILICES

Plagiogyriaceae

Plagiogyria stenoptera (Hance) Diels, Cheng & Hwa 1138.

Schizaeaceae

Lygodium japonicum (Thunb.) Sw. Cheng & Hwa 998.

Lindsaeaceae

Sphenomeris chusana (L.) Copel. (*Stenoloma chusana* (L.) Ching), Cheng & Hwa 794.

Pteridaceae

Pteris henryi Christ, Cheng & Hwa 916.

Pteris vittata L. Cheng & Hwa 877.

Sinopteridaceae

Onychium japonicum (Thunb.) Kunze, Cheng & Hwa 647.

Gymnogrammaceae

Coniogramma japonica (Thunb.) Diels, Cheng & Hwa 646.

Adiantaceae

Adiantum pedatum L. Cheng & Hwa 846.

Athyriaceae

Diplazium chinense (Baker) C. Chr. Cheng & Hwa 583.

Diplazium japonicum (Thunb.) Bedd. Cheng & Hwa 580, 585.

Thelypteridaceae

Cyclosorus aridus (D. Don) Ching (*Aspidium aridum* D. Don), Cheng & Hwa 874.

Cyclosorus parasiticus (L.) Farwell, Cheng & Hwa 581.

Thelypteris decursivo-pinnata (van Hall) Ching, Cheng & Hwa 584, 586.

Onocleaceae

Matteuccia orientalis (Hooker) Trev. Cheng & Hwa 645, 876, 881.

Aspidiaceae

Cyrtomium fortunei J. Sm. Cheng & Hwa 693, 915.

Dryopteris fuscipes C. Chr. Cheng & Hwa 694, 695.

Polystichum acutidens Christ, Cheng & Hwa 960.

Polystichum tripterum (Kunze) Presl, Cheng & Hwa 696.

Polystichum tsus-simense (Hooker) J. Sm. Cheng & Hwa 699, 959.

Polypodiaceae

Arthromeris lehmannii (Mett.) Ching (*Polypodium lehmannii* Mett.), Cheng & Hwa 906.

Lepisorus pseudonudus Ching, Cheng & Hwa 924.

Microsorium fortunei (Moore) Ching (*Drymaria fortunei* Moore), Cheng & Hwa 698.

Microsorium hymenodes (Kunze) Ching (*Polypodium hymenodes* Kunze), Cheng & Hwa 932.

Neolepisorus phyllomanes (Christ) Ching (*Polypodium phyllomanes* Christ), Cheng & Hwa 933.

Polypodium nipponicum Mett. Cheng & Hwa 912.

Pyrrosia lingua (Thunb.) Farwell, Cheng & Hwa 697.

Pyrrosia sheareri (Baker) Ching, Cheng & Hwa 750.

SPERMATOPHYTA

GYMNOSPERMAE

Ginkgoaceae

Ginkgo biloba L. Gressitt 2412.

Pinaceae

Keteleeria davidiana (Bertrand) Beiss. Cheng & Hwa 1175; Hwa 1, 450.

Larix potaninii Batalin, Hwa 80.

Pinus armandii Franchet, Cheng & Hwa 1147, 1166; Gressitt 2536; Hwa 14.

Pinus massoniana Lambert, Cheng & Hwa 655, 825, 1098, 1165, 1178; Gressitt 2405 (sterile); Hwa 439.

Pseudolarix amabilis (Nelson) Rehder, Cheng & Hwa 1169; Hwa 466.

Pseudotsuga sinensis Dode, *Cheng & Hwa* 1170; *Hwa* 22, 449.

Tsuga chinensis (Franchet) Pritzell, *Hwa* 176, 543.

Taxodiaceae

Cunninghamia lanceolata (Lamb.) Hooker, *Cheng & Hwa* 1164; *Gressitt* 2403 (sterile).

Metasequoia glyptostroboides Hu & Cheng, *Cheng & Hwa* 558, 571, 617, 808, 816, 851, 1141, 1163, 1168; *Gressitt* 2401, 2564; *Hwa* 209, 219, 220, 296, 342, 351.

Taiwania cryptomerioides Hayata, *Cheng & Hwa* 1099, 1172; *Hwa* 443, 460, 480.

Cupressaceae

Cupressus funebris Endl. *Cheng & Hwa* 828; *Djou* 104; *Gressitt* 2404, 2504, 2506.

Juniperus chinensis L. *Gressitt* 2505; *Hwa* 253.

Juniperus formosana Hayata, *Cheng & Hwa* 1176; *Gressitt* 2535; *Hwa* 39, 150, 547.

Juniperus squamata Buch.-Ham. ex Lamb. *Hwa* 252.

Cephalotaxaceae

Cephalotaxus fortunei Hooker, *Cheng & Hwa* 725, 814A; *Gressitt* 2402 (sterile); *Hwa* 21 (sterile), 214A, 218, 284, 299, 302, 415, 422, 509.

Taxaceae

Taxus chinensis (Pilger) Rehder, *Cheng & Hwa* 1142; *Hwa* 27, 164, 229, 294.

Torreya grandis Fortune, *Gressitt* 2407 (sterile); *Hwa* 201, 210, 211, 241.

ANGIOSPERMAE

Dicotyledoneae

Saururaceae

Houttuynia cordata Thunb. *Cheng & Hwa* 641.

Chloranthaceae

Chloranthus henryi Hemsley, *Cheng & Hwa s.n.*

Salicaceae

Populus adenopoda Maxim. *Hwa* 70 (sterile).

Populus tremula L. var. *davidiana* Schneider, *Cheng & Hwa* 663.

Salix biondiana Seem. *Hwa* 394, 395.

Salix caprea L. *Hwa* 113, 242.

Salix ernestii Schneider, *Gressitt* 2465, 2516, 2546; *Hwa* 438.

Salix heterochroma Seem. *Hwa* 379 (sterile).

Salix longiflora Andersson, *Cheng & Hwa* 805.

Salix rosthornii Seem. *Hwa* 391, 392.

Juglandaceae

Juglans cathayensis Dode, *Gressitt* 2458; *Hwa* 505, 536.

Juglans regia L. *Cheng & Hwa* 834; *Gressitt* 2401, 2528, 2547; *Hwa* 403.

Platycarya strobilacea Sieb. & Zucc. Cheng & Hwa 1117; Gressitt 2509; Hwa 161.

Pterocarya hupehensis Skan, Cheng & Hwa 594; Gressitt 2425.

Pterocarya paliurus Batalin, Cheng & Hwa 863, 880; Hwa 492.

Pterocarya stenoptera C. DC. Cheng & Hwa 865, 961; Gressitt 2530; Hwa 463.

Betulaceae

Betula albo-sinensis Burkill, Cheng & Hwa 1080.

Betula alnoides Buch.-Ham. ex D. Don, Gressitt 2412, 2522, 2566; Hwa 400.

Betula fargesii Franchet, Hwa 299.

Betula luminifera Winkler, Hwa 257.

Betula wilsoniana Schneider, Cheng & Hwa 1078; Hwa 25, 386.

Carpinus fargesii Franchet, Cheng & Hwa 728, 1051, 1102; Gressitt 2468; Hwa 63.

Carpinus sp., Cheng & Hwa 866, 950.

Corylus fargesii (Franchet) Schneider, Cheng & Hwa 745; Hwa 20, 212.

Ostrya multinervis Rehder, Cheng & Hwa 661, 1137; Hwa 128, 267, 324.

Fagaceae

Castanea henryi Rehder & Wilson, Cheng & Hwa 548; Hwa 6, 15.

Castanea mollissima Bl. Cheng & Hwa 556, 726; Hwa 5, 323.

Castanopsis chinensis Hance, Cheng & Hwa 1012.

Castanopsis eyrei (Champ. ex Benth) Tutchet, Cheng & Hwa 1009; Hwa 42, 442, 456.

Castanopsis hystrix A. DC. Cheng & Hwa 1007.

Castanopsis sclerophylla (Lindley) Schottky, Hwa 420.

Castanopsis tibetana Hance, Cheng & Hwa 1043; Hwa 301, 486.

Fagus longipetiolata Seem. Gressitt 667, 2481; Hwa 36, 321.

Fagus lucida Rehder & Wilson, Cheng & Hwa 1058, 1174.

Lithocarpus glabra (Thunb.) Nakai, Cheng & Hwa 776, 1021.

Lithocarpus hancei Rehder, Cheng & Hwa 748, 1073; Hwa 116, 334, 440.

Lithocarpus henryi (Seem.) Rehder & Wilson, Cheng & Hwa 683, 1074, 1095; Hwa 336.

Quercus acutissima Carr. Cheng & Hwa 771; Hwa 79.

Quercus aliena Bl. Cheng & Hwa 1126; Hwa 78, 517.

Quercus cocciferoides Hand.-Mazz. Cheng & Hwa 1054; Hwa 175, 444.

Quercus delavayi Franchet, Cheng & Hwa 856, 944.

Quercus engleriana Seem. Cheng & Hwa 907, 951, 986; Hwa 169.

Quercus fabri Hance, Cheng & Hwa 739; Hwa 8.

Quercus glauca Thunb. Cheng & Hwa 733, 1000, 1128; Hwa 85, 479, 522.

Quercus glauca Thunb. var. *gracilis* Rehder & Wilson, Cheng & Hwa 774; Hwa 145.

Quercus nubium Hand.-Mazz. Cheng & Hwa 612; Hwa 333.

Quercus oxyodon Miq. Cheng & Hwa 854, 893; Gressitt 2447; Hwa 308, 361.

Quercus singuliflora (Lévl.) A. Camus, Cheng & Hwa 600; Hwa 167, 330.

Quercus spathulata Seem. Cheng & Hwa 1119; Hwa 86, 407, 519.

Quercus stewardiana A. Camus, Hwa 451.

Quercus variabilis Bl. Hwa 62.

Quercus sp., Cheng & Hwa 120, 681, 1079; Hwa 287, 493 (flowering material too young to determine).

Ulmaceae

- Celtis labilis* Schneider, *Cheng & Hwa* 962, 1131; *Gressitt* 2529; *Hwa* 108, 289, 431.
Trema laevigata Hand.-Mazz. *Hwa* 429.
Ulmus bergmanniana Schneider, *Hwa* 419, 513.
Ulmus multinervis Cheng, *Cheng & Hwa* 1130 (syntype), 1153; *Hwa* 286, 406 (syntype), 435 (all specimens det. W. C. Cheng).
Ulmus prunifolia Cheng, *Hwa* 258, 549 (syntypes).
Zelkova schneideriana Hand.-Mazz. *Cheng & Hwa* 798, 1136.

Eucommiaceae

- Eucommia ulmoides* Oliver, *Hwa* 77.

Moraceae

- Broussonetia papyrifera* (L.) Vent. *Gressitt* 2543; *Hwa* 413, 474, 475.
Cudrania tricuspidata (Carr.) Bur. *Cheng & Hwa* 830, 943; *Gressitt* 2407, 2453, 2498, 2511; *Hwa* 467.
Ficus heteromorpha Hemsley, *Gressitt* 2561; *Hwa* 54, 138.
Ficus lacor Buch.-Ham. ex D. Don, *Cheng & Hwa* 1180.
Ficus sarmentosa Buch.-Ham. ex D. Don, *Cheng & Hwa* 709.
Ficus stapfii Lévl. *Cheng & Hwa* 1120; *Hwa* 411.
Morus cathayana Hemsley, *Gressitt* 2557; *Hwa* 326, 508, 514.

Urticaceae

- Chamabainia cuspidata* Wight, *Cheng & Hwa* 598, 843.
Elatostema sessile Forster, *Cheng & Hwa* 839.
Pilea notata Wright, *Cheng & Hwa* 872.

Loranthaceae

- Taxillus sutchuenensis* (Lecomte) Danser, *Cheng & Hwa* 939 (det. B. A. Razi).

Polygonaceae

- Antenoron neofiliforme* (Nakai) Hara, *Cheng & Hwa* 692.
Polygonum cuspidatum Sieb. & Zucc. *Cheng & Hwa* 716.
Polygonum multiflorum Thunb. *Cheng & Hwa* 966.
Polygonum perfoliatum L. *Cheng & Hwa* 976.
Polygonum runcinatum Buch.-Ham. ex D. Don, *Cheng & Hwa* 958.

Tetracentraceae

- Tetracentron sinense* Oliver, *Cheng & Hwa* 1067.

Cercidiphyllaceae

- Cercidiphyllum japonicum* Sieb. & Zucc. var. *sinense* Rehder & Wilson, *Cheng & Hwa* 562.

Ranunculaceae

- Anemone hupehensis* Lemoine, *Gressitt* 2551.
Clematis meyeniana Walp. *Hwa* 295.
Clematis montana Buch.-Ham. ex A. P. DC. *Cheng & Hwa* 627.
Clematis spooneri Rehder & Wilson var. *subglabra* S. Y. Hu, var. nov.

A typo differt in foliis praeter nervas glabris, foliis lateralibus subsessilibus; pedunculis pilosis; achenis glabris.

Cheng & Hwa 1075 (holotype, A).

Clematis spooneri Rehder & Wilson is characterized by trifoliolate leaves with firm leaflets, the terminal ones elliptic, 5-7 cm. long, 2.5-4 cm. wide, with 2 or 3 large teeth on each side, the lateral leaflets ovate with oblique bases, 3.5-6.5 cm. long, 1.5-3.5 cm. wide, with 1 or 2 teeth on each side; and by elongated fruiting peduncles $1\frac{1}{2}$ - $2\frac{1}{2}$ times longer than the petioles. The species is closely related to *C. chrysocoma* Franchet, the leaves of which are densely covered by coarse golden hairs. The leaves of *C. spooneri* var. *spooneri* are densely pilose, while those of *C. spooneri* var. *subglabra* are sparsely pilose on the primary nerves but otherwise glabrous.

Coptis chinensis Franchet, *Cheng & Hwa 657*.

Trollius yunnanensis Franchet, *Cheng & Hwa 871*.

Lardizabalaceae

Decaisnea fargesii Franchet, *Cheng & Hwa 654*; *Gressitt 2438*.

Berberidaceae

Berberis fallax Schneider, *Cheng & Hwa 1158*.

Berberis julianae Schneider, *Hwa 157*.

Menispermaceae

Cocculus orbiculatus (L.) A. P. DC. *Cheng & Hwa 995*.

Magnoliaceae

Liriodendron chinense (Hemsley) Sargent, *Hwa 162*.

Magnolia denudata Desrouss. *Cheng & Hwa 1049, 1066*; *Hwa 65, 104, 213*.

Magnolia officinalis Rehder & Wilson, *Cheng & Hwa 1160*; *Hwa 38, 290, 404*.

Magnolia sprengeri Pampan. *Cheng & Hwa 1171*; *Hwa 81, 276, 528*.

Michelia floribunda Finet & Gagnep. var. *hupehensis* Cheng, *Cheng & Hwa 688, 1005* (isotype; det. W. C. Cheng); *Hwa 317, 503*.

Michelia martinii (Lévl.) Dandy, *Hwa 411*.

Michelia wilsonii Finet & Gagnep. *Cheng & Hwa 889, 938*; *Hwa 357, 502*.

Schisandraceae

Kadsura longipedunculata Finet & Gagnep. *Cheng & Hwa 650*.

Schisandra sphenanthera Rehder & Wilson, *Cheng & Hwa 823, 825*; *Gressitt 2444*.

Illiciaceae

Illicium brevistylum A. C. Sm. *Cheng & Hwa 614*.

Illicium lanceolatum A. C. Sm. *Cheng & Hwa 936*; *Hwa 23, 154, 304, 551*.

Calycanthaceae

Chimonanthus praecox (L.) Link, *Cheng & Hwa 921*.

Lauraceae

Actinodaphne cupularis (Hemsley) Gamble, *Hwa 436, 483*.

- Cinnamomum inunctum* Nees var. *albosericeum* Gamble, *Cheng & Hwa* 782; *Hwa* 117.
- Cinnamomum mairei* Lévl. *Cheng & Hwa* 1028; *Hwa* 410, 497.
- Cinnamomum platyphyllum* (Diels) Allen, *Cheng & Hwa* 1010; *Hwa* 484, 506.
- Lindera cercidifolia* Hemsley, *Cheng & Hwa* 1108.
- Lindera communis* Hemsley, *Hwa* 34, 165, 386 (carpellate plant in flower; matches isotype in all important characters except that leaves are glabrous beneath), 515.
- Lindera communis* Hemsley var. *esquirolii* (Lévl.) S. Y. Hu, comb. nov.**
Litsea esquirolii Lévl. in *Repert. Sp. Nov.* 9: 459. 1911.
Benzoin commune (Hemsley) Rehder in *Jour. Arnold Arb.* 1: 144. 1919, *pro parte*.
 Rehder in 1919 considered *Lindera communis* Hemsley and *Litsea esquirolii* Lévl. to be synonymous. The holotype of *L. esquirolii* was collected outside Kwei-yang in Kweichow Province (*Esquirol* 372). It represents a taxon with leaves having a rufous lower surface, a densely gold-pubescent midrib, and primary lateral nerves. I have examined eight sheets of the syntypes of *Lindera communis* (*Henry* 1204, 1207, 1523, 2662, 3413, 3413B, 4551), all from western Hupeh. All these specimens have a glaucous lower leaf surface and are sparingly and very finely pubescent on the midrib and lateral nerves. The taxon with a rufous lower leaf surface and densely pubescent veins and twigs has a more southerly distribution than the typical variety. Additional specimens of var. *esquirolii* examined are *Cheng & Hwa* 743, 858, 1050, and *Hwa* 418, 516.
- Lindera fruticosa* Hemsley, *Cheng & Hwa* 576, 636; *Gressitt* 2572.
- Lindera glauca* Sieb. & Zucc. *Cheng & Hwa* 575; *Gressitt* 2487, 2549; *Hwa* 19, 100.
- Lindera hemsleyana* (Diels) Allen, *Hwa* 307, 408, 414, 507.
- Lindera ichangensis* Gamble, *Djou* 110; *Gressitt* 2571.
- Lindera megaphylla* Hemsley, *Cheng & Hwa* 857; *Hwa* 103.
- Lindera stewardiana* Allen, *Cheng & Hwa* 779.
- Lindera subcaudata* (Merr.) Merr. *Cheng & Hwa* 619, 963; *Hwa* 35, 235.
- Lindera umbellata* Thunb. *Cheng & Hwa* 952 (too immature to be identified with certainty).
- Lindera* sp., *Hwa* 88.
- Litsea chunii* Cheng, *Hwa* 246.
- Litsea cubeba* (Lour.) Pers. *Cheng & Hwa* 797, 885, 1011; *Djou* 125; *Hwa* 215, 233.
- Litsea elongata* (Nees) Hooker f. *Cheng & Hwa* 672, 895, 1047, 1106; *Hwa* 109, 266.
- Litsea glutinosa* (Lour.) C. B. Robinson, *Cheng & Hwa* 815.
- Litsea pungens* Hemsley, *Hwa* 259, 264, 313.
- Litsea verticillata* Hance, *Hwa* 371 (sterile; identification not certain).
- Machilus chinensis* (Champ. ex Benth) Hemsley, *Hwa* 141, 468.
- Machilus ichangensis* Rehder & Wilson, *Cheng & Hwa* 886.
- Machilus lichuanensis* Cheng ex Li, *Cheng & Hwa* 1017 (syntype); *Hwa* 476 (syntype; det. W. C. Cheng).
- Neolitsea sieboldii* (O. Kuntze) Nakai, *Cheng & Hwa* 668.
- Neolitsea viridis* Cheng & S. Y. Hu, sp. nov.**

Arbor sempervirens, ramulis glabris; foliis subcoriaceis, ellipticis, 4.5-7 cm. longis, 1.2-2.5 cm. latis, acuminatis, ad basin acutis, supra prominente

reticulatis, glabris, viridis, subtus foveolatis, sub lente pilosis, penninervis, nervis 9- vel 10-jugatis, subalternatis; petiolis 10-14 mm. longis, glabris rugosisque; inflorescentiis fasciculatis, axillaribus, subsessilibus; floribus masculinis pedicellis dense ferruginoso-hirsutis, 2 mm. longis; perianthis 4-lobatis, tubis utrinque ferruginoso-hirsutis, lobis ovatis, ciliatis, 3 mm. longis, 1.5 mm. latis, extus pubescentibus, intus glabris; staminibus 6, exsertis, filamentis 4 mm. longis, glabris, 2 raro 1 interioribus bi-glandulosis, glandulis breviter stipitatis, antheris magnis; ovariis rudimentalibus, 1-2 mm. longis, glabris; floribus femineis et fructibus ignotis.

HUPEH: Li-chuan District, Tuan-pao-hsiang, C. T. Hwa 125 (holotype, ♀).

This collection was distributed as a new species of *Litsea*. After having checked all the collections of the genera *Litsea* and *Neolitsea* in the herbarium of the Arnold Arboretum and having dissected the flowers, I decided to place it in *Neolitsea*. The species is closely related to *N. wushanica* (Chun) Merr., which differs in having glaucous lower leaf-surfaces, and "pedicellis sericeo-hirsutis." From *N. pinninervis* Yang & Huang, it differs in having glabrous filaments and rudimentary ovaries.

Sassafras tzumu (Hemsley) Hemsley, *Cheng & Hwa* 764; *Djou* 105; *Gressitt* 2440; *Hwa* 208.

Papaveraceae

Macleaya cordata (Willd.) R. Br. *Cheng & Hwa* 1021.

Saxifragaceae

Astilbe chinensis Franchet & Sav. *Gressitt* 2478.

Dichroa febrifuga Lour. var. *glabra* S. Y. Hu, var. nov.

A typo differt in ramis glabris; foliis minoribus, 5-11 cm. longis, 2-4 cm. latis, utrinque glabris; inflorescentiis, hypanthiis, calycibus, petalis et antheris omnino glabris.

Cheng & Hwa 587 (holotype, ♀).

Other specimens examined. HUPEH: En-shih, *H. C. Chow* 1881; Pa-tung, *H. C. Chow* 697 (a better specimen than the holotype; in flower), 1025. SZECHWAN: Chung Hsien, *W. P. Fang* 492; Nan-chuan, *W. P. Fang* 1246, 5720.

Dichroa febrifuga Lour. was described on the basis of Loureiro's collection from the vicinity of Canton, now deposited in the British Museum. Many specimens from this area, as well as from many other provinces in the warmer region of China, were examined. A wide range of variation exists in the size of the plants, the shape, texture, and dentation of the leaves, and the number of flowers per cluster. It appears that the nature of trichomes on the leaves and inflorescences is constant. A distinctive species with strigose-villose indumentum, *D. longipila* Merr., was described from the mountains on the border of Kwangtung and Kwangsi. Here a glabrous variety of *D. febrifuga* is reported from the mountains on the border of Hupeh and Szechwan provinces.

Hydrangea chinensis Maxim. *Cheng & Hwa* 884.

Hydrangea paniculata Sieb. *Cheng & Hwa* 1065.

Hydrangea strigosa Rehder, *Cheng & Hwa* 812; *Gressitt* 2437, 2464.

Hydrangea umbellata Rehder, *Cheng & Hwa* 1082.

Parnassia wrightiana Wall. var. *flavida* Franchet, *Cheng & Hwa* 778.

Philadelphus sericanthus Koehne, *Cheng & Hwa* 602.

Pittosporaceae

- Pittosporum adaphniphyloides* Hu & Cheng, *Hwa* 268.
Pittosporum glabratum Lindley var. *glabratum*, *Hwa* 133.
Pittosporum glabratum Lindley var. *nerifolium* Rehder & Wilson, *Hwa* 340.
Pittosporum truncatum Pritzell, *Hwa* 405.

Hamamelidaceae

- Corylopsis henryi* Hemsley, *Hwa* 245.
Corylopsis platypetala Rehder & Wilson, *Hwa* 281, 283.
Corylopsis sinensis Hemsley, *Cheng & Hwa* 1057; *Hwa* 49.
Liquidambar formosana Hance, *Cheng & Hwa* 708; *Gressitt* 2415.
Loropetalum chinense Oliver, *Cheng & Hwa* 1024.
Sycopsis sinensis Oliver, *Cheng & Hwa* 747, 1179; *Hwa* 260, 271, 300, 542.

Rosaceae

- Agrimonia pilosa* Ledeb. *Cheng & Hwa* 658.
Chaenomeles cathayensis Hemsley, *Hwa* 292, 469.
Cotoneaster gracilis Rehder & Wilson, *Hwa* 387.
Cotoneaster hebeophylla Diels, *Cheng & Hwa* 653, 1048.
Cotoneaster horizontalis Decaisne, *Cheng & Hwa* 781.
Cotoneaster salicifolia Franchet, *Cheng & Hwa* 940; *Hwa* 123.
Eriobotrya cavaleriei (Lévl.) Rehder, *Hwa* 146, 448, 588.
Eriobotrya deflexa Hemsley, *Hwa* 344.
Eriobotrya japonica (Thunb.) Lindley, *Cheng & Hwa* 1159; *Hwa* 526.
Kerria japonica DC. *Cheng & Hwa* 595; *Hwa* 251.
Malus halliana Koehne, *Cheng & Hwa* 1025; *Hwa* 279.
Malus prunifolia (Willd.) Borkhausen, *Hwa* 401.
Photinia amphidox (Schneider) Rehder & Wilson, *Cheng & Hwa* 1151; *Hwa* 122, 269.
Photinia beauverdiana Schneider, *Cheng & Hwa* 999; *Hwa* 94, 110, 114, 306, 482.
Photinia davidsoniae Rehder & Wilson, *Cheng & Hwa* 1118; *Hwa* 106.
Photinia franchetiana Diels, *Cheng & Hwa* 1001; *Hwa* 409, 523.
Photinia parvifolia Schneider, *Cheng & Hwa* 563, 831, 1094; *Hwa* 470.
Photinia sp. *Cheng & Hwa* 608, 799.
Prunus conradinae Koehne, *Djou* 126; *Hwa* 297, 358.
Prunus glyptocarpa Koehne, *Hwa* 60, 247, 263, 331, 349, 552.
Prunus grayana Maxim. *Cheng & Hwa* 703; *Gressitt* 2552; *Hwa* 285, 347, 550.
Prunus microbotrys Koehne, *Cheng & Hwa* 669, 737, 1149; *Hwa* 170, 338.

From Nepal extending eastward via China to Japan, there exists a group of species of evergreen *Prunus* characterized by subcoriaceous leaves that are eglandular beneath and by simple axillary racemose inflorescences. The names proposed for the species are *Prunus wallichii* Steudel (1841) for the Nepalese species, *P. spinulosa* Sieb. & Zucc. (1843) for the Japanese species, and *P. microbotrys* Koehne (1911) for the species from Central China. Kalkman (1965) renamed some of the Chinese specimens *P. wallichii* and others *P. spinulosa* (including *P. microbotrys*). However, it is thought that there are three species in this complex. Typical *P. wallichii* has large, thin leaves 12-13 cm. long and 5-7 cm. wide. The racemes are usually

fasciculate, and the rachis and pedicels are glabrous. The basal portion of the ovary is pilose. Typical *P. spinulosa* from Japan has leaves that are smaller (6-9 cm. long, 1.5-3 cm. wide) and acute at the base. The racemes are always solitary, and the rachis and pedicels are strigose. The ovary is glabrous. Typical *P. microbotrys* from Central China has oblong or ovate-oblong leaves 6-9 cm. long and 2.5-3.5 cm. wide. The racemes are solitary, and the rachis and pedicels are pilose. The ovary is hairy at the base. Specimens from Central and West China are variable, especially in the size, shape, texture, and dentation of the leaves. These involve morphological characters that do not exist in the specimens from Japan, Nepal, and adjacent northern India. The name *P. microbotrys*, originally published for the taxon of Central and West China, should be maintained.

***Prunus microbotrys* Koehne var. *obovata* S. Y. Hu, var. nov.**

Arbor, ramulis glabris; foliis glabris, oblongo-obovatis, 10-11 cm. longis, 4.5-5 cm. latis, basi acutis, apice caudato-acuminatis, acuminibus 1.2-1.4 cm. longis; racemis axillaribus, solitariis, 4-7 cm. longis, rachibus et pedicellis pilosis, calycibus glabris, petalis 2 mm. diametro.

Cheng & Hwa 735 (holotype, ♀).

Prunus mume (Sieb.) Sieb. & Zucc. *Gressitt* 2524 (sterile).

Prunus padus L. *Gressitt* 5248; *Hwa* 390.

Prunus persica (L.) Batsch, *Djou* 135.

Prunus pseudocerasus Lindley, *Gressitt* 2534.

Prunus salicina Lindley, *Djou* 109; *Gressitt* 2439; *Hwa* 256.

Prunus szechuanica Batalin, *Hwa* 248, 343.

Prunus venosa Koehne, *Cheng & Hwa* 816; *Hwa* 7.

Prunus wilsonii (Diels) Koehne, *Gressitt* 2570; *Hwa* 369.

Prunus wilsonii (Diels) Koehne var. *leiobotrys* Koehne, *Cheng & Hwa* 592.

Pyracantha crenato-serrata (Hance) Rehder, *Cheng & Hwa* 977; *Djou* 127; *Gressitt* 2426.

Pyrus calleryana Decaisne, *Djou* 106.

Pyrus pyrifolia (Burman f.) Nakai, *Hwa* 319.

Rosa helenae Rehder & Wilson, *Djou* 116.

Rosa roxburghii Tratt. *Cheng & Hwa* 956.

Rubus adenophorus Rolfe, *Cheng & Hwa* 637, 742.

Rubus ampelinus Focke, *Cheng & Hwa* 702.

Rubus cavaleriei Lévl. *Cheng & Hwa* 826; *Gressitt* 2432, 2519 (very closely allied to *R. setchuensis* Bur. & Franchet, but with leaf apex truncate).

Rubus ichangensis Hemsley & Kuntze, *Cheng & Hwa* 905.

Rubus malifolius Focke, *Gressitt* 2459.

Rubus pectinellus Maxim. *Cheng & Hwa* 591.

Sorbus aronioides Rehder, *Cheng & Hwa* 901, 1101.

Sorbus caloneura (Stapf) Rehder, *Cheng & Hwa* 671; *Hwa* 52, 311.

Sorbus folgneri (Schneider) Rehder, *Cheng & Hwa* 674, 1103; *Hwa* 58, 501, 553.

Sorbus wilsoniana Schneider, *Cheng & Hwa* 899, 1070.

Spiraea chinensis Maxim. *Cheng & Hwa* 945.

Spiraea japonica L. f. var. *fortunei* Rehder, *Gressitt* 2436.

Spiraea prunifolia Sieb. & Zucc. *Hwa* 398.

Stephanandra chinensis Hance, *Cheng & Hwa* 878.

Stranvaesia davidiana Decaisne var. *undulata* (Decaisne) Rehder & Wilson, *Cheng & Hwa* 900, 1034; *Hwa* 159, 325, 380.

Leguminosae

- Albizia kalkora* Prain, *Cheng & Hwa* 1054; *Gressitt* 2472; *Hwa* 37.
Amphicarpaea edgeworthii Bentham, *Cheng & Hwa* 832 (det. C. E. Wood, Jr.), 1144.
Cercis chinensis Bunge, *Hwa* 69 (sterile).
Cladrastis sinensis Hemsley, *Gressitt* 2461; *Hwa* 417.
Dalbergia dyeriana Prain, *Cheng & Hwa* 822.
Dalbergia mimosoides Franchet, *Cheng & Hwa* 804 (det. Y. T. Lee).
Desmodium podocarpum DC. *Cheng & Hwa* 626, 820; *Gressitt* 2497.
Gleditsia macracantha Desf. *Gressitt* 2443; *Hwa* 45, 477.
Gymnocladus chinensis Baillon, *Cheng & Hwa* 1038; *Hwa* 478 (det. Y. T. Lee).
Indigofera amblyantha Craib, *Gressitt* 2514.
Indigofera pseudotinctoria Matsumura, *Cheng & Hwa* 1116 (det. Y. T. Lee).
Lepedeza cuneata G. Don, *Cheng & Hwa* 659, 727; *Djou* 128.
Lepedeza thunbergii (DC.) Nakai, *Cheng & Hwa* 895; *Gressitt* 2532.
Maackia chinensis Takeda, *Cheng & Hwa* 1146.
Ormosia puberula Cheng, *Hwa* 485 (isotype; det. W. C. Cheng).
Pueraria lobata (Willd.) Ohwi, *Cheng & Hwa* 731; *Gressitt* 2562.
Robinia pseudo-acacia L. *Djou* 139 (sterile; introduced).

Oxalidaceae

- Oxalis griffithii* Edgew. & Hooker f. *Cheng & Hwa* 787 (sterile; Dr. A. Lourteig consulted).

Rutaceae

- Boeninghausenia albiflora* (Hooker) Meissner, *Cheng & Hwa* 870.
Euodia fargesii Dode, *Hwa* 504.
Euodia meliaefolia Bentham, *Hwa* 57.
Euodia officinalis Dode, *Cheng & Hwa* 706, 1013; *Gressitt* 2421, 2442, 2475, 2540; *Hwa* 83.
Orixa japonica Thunb. *Hwa* 346.
Phellodendron chinense Schneider, *Gressitt* 2451; *Hwa* 13.
Toddalia asiatica (Lam.) Kurz, *Cheng & Hwa* 927, 942; *Hwa* 423.
Zanthoxylum dissitum Hemsley, *Cheng & Hwa* 601.
Zanthoxylum nitidum (Roxb.) DC. *Hwa* 337.
Zanthoxylum simulans Hance, *Hwa* 152.

Simaroubaceae

- Ailanthus altissima* (Miller) Swingle, *Cheng & Hwa* 720, 818, 1156; *Djou* 133; *Gressitt* 2554.

Meliaceae

- Toona sinensis* (A. Juss.) Roemer, *Cheng & Hwa* 1152; *Hwa* 151.

Polygalaceae

- Polygala wattersii* Hance, *Hwa* 5, 416.

Euphorbiaceae

- Aleurites fordii* Hemsley, *Djou* 136.
Croton tiglium L. *Cheng & Hwa* 1182.

Glochidion pubescens (L.) Hutch. *Cheng & Hwa* 687; *Djou* 115, 124; *Gressitt* 2538.

Phyllanthus flexuosus (Sieb. & Zucc.) Mueller-Arg. *Cheng & Hwa* 648 (det. G. L. Webster).

Ricinus communis L. *Cheng & Hwa* 1183.

Sapium sebiferum (L.) Roxb. *Cheng & Hwa* 1181.

Daphniphyllaceae

Daphniphyllum glaucescens Bl. *Cheng & Hwa* 1030; *Hwa* 454.

Daphniphyllum longistylum Chien, *Cheng & Hwa* 660, 1072; *Hwa* 533, 534.

Coriariaceae

Coriaria sinica Maxim. *Gressitt* 2442, 2563; *Hwa* 238, 249, 250.

Buxaceae

Buxus microphylla Sieb. & Zucc. *Cheng & Hwa* 806.

Anacardiaceae

Choerospondias axillaris (Roxb.) Burt & Hill, *Cheng & Hwa* 920; *Hwa* 447, 481, 498, 525, 555.

Rhus chinensis Miller, *Djou* 123; *Gressitt* 2470, 2533.

Rhus potaninii Maxim. *Hwa* 71.

Rhus trichocarpa Miq. *Cheng & Hwa* 744, 1104.

Rhus verniciflua Stokes, *Cheng & Hwa* 722; *Gressitt* 2473; *Hwa* 10, 149.

Aquifoliaceae

***Ilex dasyphylla* Merr. var. *lichuanensis* S. Y. Hu, var. nov.**

A type differt in ramulis petiolisque sparse pilosis; foliis subglabris, costa supra elevata; fructibus 6 mm. diametro, sepalis persistentibus glabris.

Cheng & Hwa 1055 (holotype, ♀).

In shape, size, and texture, the leaves of this variety are similar to those of *Ilex dasyphylla* Merr. var. *dasyphylla*, a variety of the mountainous area of northern Kwangtung and eastern Kwangsi, characterized by dense, ferruginous, long hairs on the branchlets, leaves, and inflorescences. The fruit of var. *lichuanensis* is small, 4-5 mm. in diameter, and the persistent sepals are hirsute.

Ilex elmerrilliana S. Y. Hu, *Cheng & Hwa* 767; *Hwa* 487.

Ilex ficoidea Hemsley, *Hwa* 134 (sterile).

Ilex intermedia Loes. *Hwa* 132, 518, 521.

Ilex intermedia Loes. var. *fangii* (Rehder) S. Y. Hu, *Cheng & Hwa* 937.

Ilex macrocarpa Oliver, *Hwa* 97, 409, 520.

Ilex macropoda Miq. *Cheng & Hwa* 1111.

Ilex micrococca Maxim. *Cheng & Hwa* 1026.

Ilex pedunculosa Miq. *Cheng & Hwa* 1113.

Ilex pernyi Franchet, *Cheng & Hwa* 829; *Hwa* 4.

Ilex suaveolens (Lévl.) Loes. *Cheng & Hwa* 729, 1035; *Hwa* 41.

Ilex wilsonii Loes. *Cheng & Hwa* 775, 1139; *Hwa* 541.

Celastraceae

Celastrus gemmatus Loes. *Djou* 111.

Celastrus hypoleucus (Oliver) Warb. *Cheng & Hwa* 1062.

- Euonymus acanthocarpa* Franchet, *Cheng & Hwa* 1037.
Euonymus acanthocarpa Franchet var. *sutchuenensis* Franchet ex Loes. *Cheng & Hwa* 1004.
Euonymus alata Regel, *Hwa* 112, 524.
Euonymus japonica Thunb. var. *acuta* Rehder, *Cheng & Hwa* 1121; *Gressitt* 2518; *Hwa* 102.
Euonymus myriantha Hemsley, *Cheng & Hwa* 949.
Euonymus sanguinea Loes. var. *camptoneura* Loes. *Djou* 122; *Gressitt* 2413; *Hwa* 82.

Aceraceae

- Acer amplum* Rehder, *Cheng & Hwa* 740; *Hwa* 8, 360.
Acer cordatum Pax, *Hwa* 428, 446, 540.
Acer davidii Franchet, *Cheng & Hwa* 714, 902, 1069; *Hwa* 288, 345.
Acer erianthum Schwerin, *Cheng & Hwa* 704; *Gressitt* 2565.
Acer faberi Hance, *Cheng & Hwa* 991; *Hwa* 428, 489.
Acer henryi Pax, *Hwa* 335 (a very young shoot), 472.
Acer longipes Franchet ex Rehder, *Hwa* 55.
Acer mono Maxim. *Hwa* 28.
Acer oliverianum Pax, *Cheng & Hwa* 862.
Acer sinense Pax, *Cheng & Hwa* 783; *Hwa* 139, 339.
Acer wilsonii Rehder, *Cheng & Hwa* 569; *Hwa* 348, 465.

Hippocastanaceae

- Aesculus wilsonii* Rehder, *Cheng & Hwa* 1134; *Hwa* 96 (sterile).

Sabiaceae

- Meliosma beaniana* Rehder & Wilson, *Hwa* 59, 67, 131, 545 (59 and 131 both sterile).
Meliosma pendens Rehder & Wilson, *Cheng & Hwa* 577; *Gressitt* 2460.
Meliosma sinensis Nakai, *Cheng & Hwa* 772.

Balsaminaceae

- Impatiens lucorum* Hooker f. *Cheng & Hwa* 642, 796, 838 (very young).

Staphyleaceae

- Euscaphis japonica* (Thunb.) Kanitz, *Cheng & Hwa* 768; *Gressitt* 2476; 2531; *Hwa* 565.
Tapiscia sinensis Oliver, *Cheng & Hwa* 564; *Hwa* 50, 538.

Rhamnaceae

- Berchemia floribunda* (Wall.) Brongn. *Cheng & Hwa* 621; *Djou* 119; *Gressitt* 2406, 2542.
Berchemia polyphylla Wall. ex Lawson, *Cheng & Hwa* 1046.
Hovenia trichocarpa Chun & Tsiang, *Cheng & Hwa* 561, 734, 1039; *Hwa* 168.
Rhamnus esquirolii Lévl. *Cheng & Hwa* 810.
Rhamnus paniculiflorus Schneider, *Cheng & Hwa* 1115.
Rhamnus rugulosus Hemsley, *Cheng & Hwa* 613, 1045.
Rhamnus utilis Decaisne, *Cheng & Hwa* 607, 629, 833, 909, 970, 971; *Djou* 131; *Gressitt* 2448, 2523; *Hwa* 68, 98, 512.
Sageretia henryi J. R. Drumm. *Cheng & Hwa* 864.

Vitaceae

Ampelopsis chaffanjonii (Lévl.) Rehder, *Cheng & Hwa* 766, 827.

Parthenocissus heterophylla (Bl.) Merr. *Cheng & Hwa* 917.

Trastigma serrulatum Planchon, *Cheng & Hwa* 943.

Elaeocarpaceae

Elaeocarpus chinensis (Gardner & Champion) Hooker f. *Cheng & Hwa* 680;
Hwa 434.

Sloanea hemsleyana (Ito) Rehder & Wilson, *Cheng & Hwa* 1097; *Hwa* 293.

Tiliaceae

Tilia tuan Szysz. *Cheng & Hwa* 741, 1059, 1114.

Tilia sp., *Cheng & Hwa* 1095.

Malvaceae

Hibiscus syriacus L. *Cheng & Hwa* 721; *Hwa* 99.

Actinidiaceae

Actinidia arguta Planchon ex Miq. *Cheng & Hwa* 1109.

Actinidia callosa Lindley, *Cheng & Hwa* 606.

Actinidia chinensis Planchon, *Gressitt* 2419, 2495.

Actinidia coriacea (Finet & Gagnep.) Dunn, *Cheng & Hwa* 567.

Theaceae

Camellia caudata Wall. *Cheng & Hwa* 620, 931.

Camellia cuspidata (Kochs) Veitch, *Cheng & Hwa* 609, 686; *Gressitt* 2471;
Hwa 270.

Camellia japonica L. *Hwa* 255.

Camellia oleifera Abel, *Cheng & Hwa* 568, 1044; *Gressitt* 2450.

Camellia sinensis (L.) O. Kuntze, *Cheng & Hwa* 689, 1140; *Gressitt* 2490;
Hwa 320.

Eurya nitida Korthals var. *aurescens* (Rehder & Wilson) Kobuski, *Hwa* 136,
273.

Schima sinensis (Hemsley & Wilson) Airy Shaw, *Cheng & Hwa* 890; *Gressitt*
2480.

Schima superba Gardner & Champion, *Cheng & Hwa* 1023.

Schima parviflora Cheng & H. T. Chang, *Cheng & Hwa* 953 (isotype; det.
W. C. Cheng).

Ternstroemia nitida Merr. *Hwa* 455 (flower buds very young).

Guttiferae

Hypericum ascyron L. *Gressitt* 2431.

Hypericum attenuatum Choisy, *Cheng & Hwa* 819.

Hypericum hookerianum Wight & Arnott, *Cheng & Hwa* 593.

Hypericum patulum Thunb. *Cheng & Hwa* 624.

Hypericum petiolulatum Hooker f. & Thomson, *Cheng & Hwa* 736, 1092.

Violaceae

Viola cf. *confusa* Champion ex Bentham, *Cheng & Hwa* 1087 (sterile).

Viola inconspicua Bl. *Cheng & Hwa* 965, 1091.

Viola triangulifolia W. Beck, *Cheng & Hwa* 1086.

Flacourtiaceae

- Carrierea calycina* Franchet, *Cheng & Hwa* 928.
Idesia polycarpa Maxim. *Cheng & Hwa* 723, 979; *Djou* 118; *Hwa* 539.
Idesia polycarpa Maxim. var. *vestita* Diels, *Cheng & Hwa* 1060.
Poliothyrsis sinensis Oliver, *Cheng & Hwa* 1132; *Hwa* 511.

Stachyuraceae

- Stachyurus himalaicus* Hooker f. & Thomson, *Cheng & Hwa* 604, 988, 994.

Begoniaceae

- Begonia evansiana* Andr. *Cheng & Hwa* 590.
Begonia pedatifida Lévl. *Cheng & Hwa* 840.

Elaeagnaceae

- Elaeagnus bockii* Diels, *Cheng & Hwa* 800; *Gressitt* 2462.
Elaeagnus henryi Warb. *Hwa* 158.
Elaeagnus schnabeliana Hand.-Mazz. *Cheng & Hwa* 608.
Elaeagnus viridis Servetaz, *Cheng & Hwa* 809.

Lythraceae

- Lagerstroemia indica* L. *Cheng & Hwa* 765.

Alangiaceae

- Alangium chinense* (Lour.) Rehder, *Cheng & Hwa* 678; *Gressitt* 2492.
Alangium handelii Schnarf, *Hwa* 105 (closely related to *A. chinense*; recognized by hairy fruits and strigose branchlets and inflorescences).

Nyssaceae

- Nyssa sinensis* Oliver, *Cheng & Hwa* 611; *Hwa* 61, 432, 433.

Melastomataceae

- Sarcopyramis nepalensis* Wall. *Cheng & Hwa* 572, 730 (very small and young; more material needed for positive determination).

Onagraceae

- Circaea erubescens* Franchet & Sav. *Cheng & Hwa* 842.
Epilobium angustifolium L. *Cheng & Hwa* 712.

Araliaceae

- Aralia decaisneana* Hance, *Cheng & Hwa* 888.
Dendropanax chevalieri (Vig.) Merr. *Cheng & Hwa* 684; *Hwa* 156, 174 (both sterile).
Evodiapanax evodiifolius (Franchet) Nakai, *Cheng & Hwa* 900, 903, 980; *Hwa* 464.
Hedera nepalensis K. Koch var. *sinensis* (Tobler) Rehder, *Cheng & Hwa* 780, 1129; *Hwa* 129.
Kalopanax septemlobus (Thunb.) Koidzumi (*Kalopanax pictus* (Thunb.) Nakai), *Cheng & Hwa* 711; *Hwa* 76.
Nothopanax bodinieri (Lévl.) S. Y. Hu, comb. nov.
Aralia bodinieri Lévl. In *Bull. Géogr. Bot.* **24**: 143. 1914.
Nothopanax delavayi sensu Rehder in *Jour. Arnold Arb.* **15**: 115. 1934, *pro parte*.

Rehder in 1934 interpreted *Heptapleurum esquirolii* Lévl. (*Cavalerie* 871, holotype), and *Aralia bodinieri* Lévl. (*Cavalerie* 2696, syntype) as synonyms of *Nothopanax delavayi* (Franchet) Harms. He was correct with the first epithet. Fragments and a photograph of the syntype of *Aralia bodinieri* Lévl. and a specimen with good fruiting material (*Cheng & Hwa* 969) show distinctive characteristics in leaves and inflorescences that do not appear in over 40 sheets of Yunnan specimens of *Nothopanax delavayi* examined. *Aralia bodinieri* (*Cavalerie* 2696) is a species of *Nothopanax* and is transferred above. *Nothopanax bodinieri* has unifoliolate, trifoliolate, and pentafoliolate leaves with the leaflets 2-4 times wider than those of *N. delavayi*. The fruiting peduncles of the umbels are half as long as those of *N. delavayi*. It is a distinctive species of northeastern Kweichow and the adjacent areas of Szechwan and Hupeh, while *N. delavayi* is endemic to western Yunnan.

Nothopanax davidii (Franchet) Harms, *Cheng & Hwa* 783; *Gressitt* 2525; *Hwa* 43.

Nothopanax rosthornii Harms, *Cheng & Hwa* 773; *Gressitt* 2556.

Schefflera delavayi (Franchet) Harms, *Cheng & Hwa* 978.

Schefflera venulosa (Wight & Arnott) Harms, *Hwa* 72.

Cornaceae

Aucuba chinensis Benth. f. *angustifolia* Rehder, *Hwa* 315.

Cornus controversa Hemsley, *Cheng & Hwa* 634; *Hwa* 458.

Cornus kousa Buerger var. *chinensis* Bean, *Cheng & Hwa* 570, 664, 908; *Hwa* 31, 107.

Cornus macrophylla Wall. *Cheng & Hwa* 632, 919, 1014; *Djou* 137; *Gressitt* 2428; *Hwa* 29, 91, 130.

Helwingia japonica (Thunb.) Dietrich, *Cheng & Hwa* 640, 930, 1093; *Gressitt* 2429.

Toricellia intermedia Harms, *Cheng & Hwa* 1145; *Hwa* 12, 421.

Umbelliferae

Daucus carota L. *Djou* 130; *Gressitt* 2520.

Clethraceae

Clethra fargesii Franchet, *Cheng & Hwa* 821, 1068, 1110.

Ericaceae

Enkianthus chinensis Franchet, *Cheng & Hwa* 1100.

Enkianthus serrulatus Schneider, *Cheng & Hwa* 616; *Hwa* 171, 275.

Lyonia ovalifolia (Wall.) Drude, *Cheng & Hwa* 746, 1053; *Hwa* 73.

Pieris formosa D. Don, *Cheng & Hwa* 802, 1041; *Hwa* 44, 243.

Rhododendron argyrophyllum Franchet, *Hwa* 66, 274.

Rhododendron caeruleum Lévl. *Cheng & Hwa* 891.

Rhododendron ciliicalyx Franchet, *Hwa* 277.

Rhododendron farrerae Tate ex Sweet, *Cheng & Hwa* 897, 1027; *Hwa* 377.

Rhododendron fortunei Lindley, *Cheng & Hwa* 896; *Hwa* 353.

Rhododendron lutescens Franchet, *Hwa* 278.

Rhododendron ovatum (Lindley) Planchon, *Cheng & Hwa* 1029; *Hwa* 298, 445.

Rhododendron oxyphyllum Franchet, *Cheng & Hwa* 682; *Hwa* 84.

Rhododendron simsii Planchon, *Cheng & Hwa* 879; *Gressitt* 2417; *Hwa* 453.

- Vaccinium bracteatum* Thunb. *Cheng & Hwa* 990.
Vaccinium carlesii Dunn, *Hwa* 299.
Vaccinium hirtum Thunb. *Cheng & Hwa* 605, 675, 1135.
Vaccinium iteophyllum Hance, *Cheng & Hwa* 610.
Vaccinium japonicum Miq. *Cheng & Hwa* 685.
Vaccinium mandarinorum Diels, *Cheng & Hwa* 673, 898, 1056.

Myrsinaceae

- Ardisia chinensis* Bentham, *Cheng & Hwa* 1154.
Ardisia crenata (Thunb.) DC. *Cheng & Hwa* 1031.
Maesa hupehensis Rehder, *Cheng & Hwa* 922.
Myrsine cf. *semiserrata* Wall. *Cheng & Hwa* 1148 (leaves and inflorescences match well, but uniformly punctate lower leaf surface differs).

Primulaceae

- Lysimachia fortunei* Maxim. *Cheng & Hwa* 1085.

Ebenaceae

- Diospyros lotus* L. *Cheng & Hwa* 710; *Hwa* 30.

Styracaceae

- Alniphyllum megaphyllum* Hemsley, *Cheng & Hwa* 984, 1008; *Hwa* 490.
Pterostyrax hispidus Sieb. & Zucc. *Cheng & Hwa* 1107; *Hwa* 491, 566.
Styrax bodinieri Lévl. *Cheng & Hwa* 559, 662, 975; *Gressitt* 241, 2573; *Hwa* 16, 427 (young inflorescences of some specimens infested by insect galls).
Styrax suberifolius Hooker f. & Arn. *Cheng & Hwa* 677, 918; *Hwa* 121.

Symplocaceae

- Symplocos anomala* Brand, *Cheng & Hwa* 770, 1064; *Hwa* 147.
Symplocos botryantha Franchet, *Cheng & Hwa* 690, 868, 904; *Hwa* 74, 140, 316, 373, 382.
Symplocos caudata Wall. *Cheng & Hwa* 603, 1061; *Hwa* 244, 310, 314.
Symplocos discolor Brand, *Hwa* 280, 544.
Symplocos lancifolia Sieb. & Zucc. *Cheng & Hwa* 691, 984; *Djou* 107; *Hwa* 172, 309.
Symplocos stellaris Brand, *Cheng & Hwa* 1112; *Hwa* 425.

Oleaceae

- Fraxinus chinensis* Roxb. *Cheng & Hwa* 807; *Djou* 101 (sterile); *Hwa* 402.
Fraxinus punctata S. Y. Hu, sp. nov.

Arbor vel frutex, glabra, ramulis robustis, hornotinis 4-5 mm. diametro, lenticellis albidis numerosis notatis; foliis trifoliolatis, petiolis 3.5-5 cm. longis, canaliculatis, basi incrassatis, foliolis petiolulis medianis 2-3 cm. longis, lateralibus 6-8 mm. longis, laminis subcoriaceis, ovatis, medianis 10-13 cm. longis, 6-7 cm. latis, lateralibus 8.5-12 cm. longis, 4-5 cm. latis, basi acutis, apice acuminatis, acumine 1-1.5 cm. longis, subtus glabris et punctatis, margine crenulato-serratis, costa supra impressa, subtus elevata et glabra, nervis lateralibus utrinque 15-17, subtus prominentibus, nervis secundariis bene reticulatis; infructescentiis terminalibus; samaris lineari-spathulatis, 2.5-3 cm. longis, 5 mm. latis, apice retusis; calycibus persis-

tentibus patelliformibus, lobis deltoideis, apice subulato-acuminatis vel acutis.

Cheng & Hwa 946 (holotype, ♀).

The trifoliolate, subcoriaceous leaves and the linear-spathulate samaras of this species suggest a close relationship to *Fraxinus trifoliolata* W. W. Smith of the drainage basin of the Yangtze River in northwestern Yunnan. The lower leaf surface of the Yunnan species is densely white-hirsute, and the persistent calyx of the fruit is subcampanulate with very shallow erose lobes. The ovary of this species is covered by peltate glandular scales that are persistent in fruit and become rather conspicuous on the basal one-third of the samara. In contrast, the lower leaf surface of the species in the metasequoia area is glabrous and punctate, and its persistent calyx is patelliform and has well-defined lobes that are subulate-acuminate or acute at the apex. The glandular scales on the fruit are very sparse and obscure.

Jasminum lanceolarium Roxb. *Cheng & Hwa 989*.

Ligustrum lucidum Aiton, *Cheng & Hwa 1157; Hwa 68*.

Ligustrum quihoui Carr. *Cheng & Hwa 713*.

Ligustrum sinense Lour. *Cheng & Hwa 1077; Hwa 115*.

Osmanthus cooperi Hemsley, *Hwa 430*.

Osmanthus fragrans Lour. *Cheng & Hwa 724; Hwa 272, 303*.

Loganiaceae

Buddleia davidii Franchet, *Cheng & Hwa 811; Gressitt 2501; 2527*.

Gentianaceae

Swertia bimaculata Clarke, *Cheng & Hwa 955*.

Apocynaceae

Trachelospermum jasminoides (Lindley) Lemaire, *Hwa 261*.

Asclepiadaceae

Cynanchum auriculatum Royle, *Cheng & Hwa 638A; Djou 114, 132*.

Convolvulaceae

Cuscuta chinensis Lam. *Cheng & Hwa 860*.

Verbenaceae

Callicarpa bodinieri Lévl. var. *girdalii* (Rehder) Rehder, *Cheng & Hwa 1124; Gressitt 2526*.

Callicarpa rubella Lindley var. *hemsleyana* Diels, *Cheng & Hwa 1042*.

Clerodendron bungei Steudel, *Cheng & Hwa 631, 914; Gressitt 2454, 2553*.

Clerodendron mandarinorum Diels, *Cheng & Hwa 769, 894; Hwa 40*.

Clerodendron trichotomum Thunb. *Cheng & Hwa 913*.

Premna puberula Pampan. *Cheng & Hwa 560; Gressitt 2427, 2483, 2558*.

Labiatae

Mosla chinensis Maxim. *Cheng & Hwa 788, 1096*.

Mosla dianthera (Buch.-Ham.) Maxim. *Cheng & Hwa 789*.

Perilla frutescens (L.) Britton, *Gressitt 2567*.

Pogostemon glaber Benthham, *Cheng & Hwa 835*.

Prunella vulgaris L. Cheng & Hwa 793.

Teucrium bidentatum Hemsley, Cheng & Hwa 1032.

Solanaceae

Solanum lyratum Thunb. Cheng & Hwa 1177.

Scrophulariaceae

Botryopleuron nervosum (Hemsley) Hemsley, Cheng & Hwa 1015.

Paulownia fargesii Franchet, Hwa 95, 462.

Phtheirospermum chinense Bunge ex Fischer & Meyer, Cheng & Hwa 1088.

Bignoniaceae

Catalpa fargesii Bur. Cheng & Hwa 855, 935; Gressitt 2418; Hwa 510.

Gesneriaceae

Didissandra cf. *sesquifolia* C. B. Clarke, Cheng & Hwa 718, 841 (specimens resemble *D. sesquifolia* of northern India in having pubescent leaves and short-pedicellate flowers, but differ in having leaf margins subentire, not subduplo-serrate).

Didymocarpus hwaianus S. Y. Hu, sp. nov.

Herbae succulentae, perennes, glabres; internodiis caulium 4-7 cm. longis, 3 mm. crassis; foliis oppositis, sessilibus, integris, ellipticis, 12-15 cm. longis, 4.5-5 cm. latis, supra glabris vel leviter hirsutis, subtus glabris, basi cuneatis, decurrentibus et connato-perfoliatis, apice acuminatis; inflorescentiis axillaribus, pedunculis 5 mm. longis, ramis subcymosis, axibus secundariis 6-10 mm. longis, pedicellis 3-4 mm. longis; sepalis foliaceis, fere ad basim libris, obovato-oblongis, 8-9 mm. longis, 5-6 mm. latis, glabris, apice rotundatis; corollis et staminibus ignotis; capsulis juvenilibus compresso-cornutis, 2.5 cm. longis, 3 mm. latis; annulis interruptis; stylis 1 cm. longis, stigmatibus inaequaliter bilobatis.

Cheng & Hwa 923 (holotype, λ).

The foliaceous sepals free almost to the base, the short axillary inflorescences and the laterally compressed, curved, cornute young capsules of this species suggest a close relationship with *Didymocarpus bicornutus* (Hayata) S. Y. Hu,³ comb. nov., from Taiwan, which has petiolate leaves. Another closely related species is *D. tibeticus* Franchet, which differs in having villose, lanceolate sepals and petiolate leaves.

Lysionotus pauciflora Maxim. Cheng & Hwa 1003.

Acanthaceae

Hemigraphis cuneata S. Y. Hu, sp. nov.

Herba prostrata, caulibus quadrangulatis, glabrescentibus; foliis parvis, rhomboideis, 1-2.5 cm. longis, 0.7-2 cm. latis, basi cuneatis, apice acutis, margine remote serratis, utrinque glabrescentibus, petiolis 5-15 mm. longis, glabris; floribus solitariis, in axillis foliorum sessilibus, bracteis foliaceis, obovato-cuneatis, 3 mm. longis, 2 mm. latis, apice obtusis; calycibus glabris, fere ad basim partitis, laciniis linearibus, 1.5 cm. longis, 1.5 mm. latis,

³*Didymocarpus bicornutus* (Hayata) S. Y. Hu, comb. nov.

Chirita bicornuta Hayata, Ic. Pl. Formos. 3: 154. 1913.

apice obtusis; capsulis oblongis, ad basim constrictis, 12-13 mm. longis, 2 mm. diametro, glabris; seminibus plano-compressis, suborbicularibus, 1.5-2 mm. diametro, atro-fuscis, papillosis.

Cheng & Hwa 887 (holotype, ♀).

This species is related to *Hemigraphis procumbens* (Lour.) Merr., from which it is readily distinguished by its glabrous leaves, sepals, and capsules. The leaves of *H. procumbens* are hirsute and the sepals hispid-strigose; the capsules are hairy at the apex.

Peristrophe roxburghiana (Schultes) Bremek. *Cheng & Hwa 715*.

Plantaginaceae

Plantago major L. *Cheng & Hwa 717*.

Rubiaceae

Emmenopteryx henryi Oliver, *Cheng & Hwa 1173; Hwa 166*.

Galium bungei Steudel, *Cheng & Hwa 784, 1143*.

Hedyotis lindleyana Hooker var. *glabra* Hara, *Cheng & Hwa 790*.

Lasianthus hartii Franchet, *Cheng & Hwa 622*.

Paederia chinensis Hance, *Cheng & Hwa 926, 973, 996*.

Paederia scandens (Lour.) Merr. *Cheng & Hwa 628, 824*.

Serissa foetida Commerson, *Cheng & Hwa 983*.

Caprifoliaceae

Abelia myrtilloides Rehder, *Cheng & Hwa 861, 1133*.

Abelia uniflora R. Br. *Hwa 452*.

Lonicera henryi Hemsley, *Cheng & Hwa 676, 1036, 1083*.

Lonicera macranthoides Hand.-Mazz. *Cheng & Hwa 882*.

Sambucus racemosa L. *Hwa 11, 372*.

Viburnum ichangense (Hemsley) Rehder, *Cheng & Hwa 814, 1105; Gressitt 2559*.

Viburnum ovatifolium Rehder, *Cheng & Hwa 649, 992; Hwa 46*.

Viburnum propinquum Hemsley, *Cheng & Hwa 867; Hwa 265, 537*.

Viburnum propinquum Hemsley var. *mairi* W. W. Sm. *Cheng & Hwa 860, 1122*.

Viburnum rhytidophyllum Hemsley, *Hwa 359*.

Viburnum rosthornii Graebner var. *xerocarpa* Loes. *Cheng & Hwa 892; Hwa 47, 535*.

Viburnum setigerum Hance, *Cheng & Hwa 803, 993, 1071; Djou 117; Gressitt 2434, 2521*.

Viburnum sympodiale Graebner, *Hwa 341 or 355* (number not clear).

Viburnum ternatum Rehder, *Cheng & Hwa 589, 732, 1019; Gressitt 2474; Hwa 56*.

Viburnum theiferum Rehder, *Hwa 473*.

Viburnum tomentosum Thunb. *Hwa 282, 426*.

Viburnum tsangii Rehder, *Cheng & Hwa 883, 1161*.

Weigela japonica Thunb. var. *sinica* (Rehder) Bailey, *Cheng & Hwa 573; Hwa 471*.

Valerianaceae

Patrinia villosa (Thunb.) Juss. ex DC. *Cheng & Hwa 964*.

Cucurbitaceae

Gymnostemma pentaphyllum Makino, Cheng & Hwa 925, 1014.

Campanulaceae

Campanumoea javanica Bl. Cheng & Hwa 625; Gressitt 2424.

Lobelia davidii Franchet, Cheng & Hwa 643 (very similar to *L. fangiana* (E. Wimmer) S. Y. Hu, comb. nov.,⁵ from which it may be distinguished by the subglabrous ovary and hairy anthers).

Lobelia radicans Thunb. Cheng & Hwa 578.

Pratia nummularia (Lam.) A. Br. & Ascherson (*Lobelia angulata* Forster), Cheng & Hwa 599.

Compositae

Adenocaulon adhaerescens Maxim. Cheng & Hwa 719.

Ainsliaea fulvipes Jeffrey, Cheng & Hwa 786.

Anaphalis margaritacea (L.) Benth. & Hooker f. Cheng & Hwa 762.

Carpesium abrotanoides L. Cheng & Hwa 679.

Eupatorium chinense L. Cheng & Hwa 967.

Eupatorium japonicum Thunb. Cheng & Hwa 837.

Ixeris gracilis (DC.) Stebbins, Cheng & Hwa 1084.

Leontopodium sinense Hemsley, Gressitt 2515.

Ligularia duciformis (C. Winkler) Hand.-Mazz. Cheng & Hwa 850.

Monocotyledoneae

Alismataceae

Sagittaria pygmaea Miq. Cheng & Hwa 761.

Sagittaria sagittifolia L. subsp. *sagittata* (Thunb.) Rataj. Cheng & Hwa 760.

Hydrocharitaceae

Ottelia alismoides (L.) Pers. Cheng & Hwa 847 (material too young to show species characteristics).

Gramineae

Chimonobambus sp., Hwa 495, 496 (sterile; det. T. R. Soderstrom).

Miscanthus sinensis Andersson, Gressitt 2555.

Phyllostachys sp., Gressitt 2410 (sterile; det. T. R. Soderstrom).

Sinarudinaria sp., Gressitt 2494 (det. T. R. Soderstrom); Hwa 494.

⁵*Lobelia fangiana* (E. Wimmer) S. Y. Hu, comb. nov.

Pratia fangiana E. Wimmer, Repert. Sp. Nov. 38: 3. 1935.

Lobelia omiensis E. Wimmer, Ann. Nat. Mus. Wien 56: 366. 1948.

Szechwan: Mt. Omei, W. P. Fang 2853 (holotype, NY; isotype, GH), E. H. Wilson 5034 (isotype of *L. omiensis*, GH), H. C. Chow 7927, 8106 (A), S. C. Sum & K. Chang 1139, 1227 (A), L. Y. Tai 87 (A), F. T. Wang 23376 (A), K. N. Yin 127 (A).

Wimmer's material of *Pratia fangiana* is in fruit, and his specimen of *Lobelia omiensis* is in flower. More recent collections from the same area give a fuller picture of morphological variation of the species, and the gaps caused by age differences in Wimmer's samples are bridged. The species is characterized by hirsute inflorescences, pubescent ovaries, and glabrous anthers. A transfer of the earlier specific epithet from *Pratia* to *Lobelia* is necessitated.

Cyperaceae

- Bulbostylis capillaris* (L.) Clarke, *Cheng & Hwa* 1089.
Carex brunnea Thunb. *Cheng & Hwa* 791 (det. T. Koyama).
Cyperus orthostachys Franchet & Sav. *Cheng & Hwa* 753 (det. T. Koyama).
Eleocharis congesta D. Don subsp. *japonica* (Miq.) Koyama, *Cheng & Hwa* 758 (det. T. Koyama).
Kyllinga brevifolia Rottb. *Cheng & Hwa* 596, 757.
Pycreus flavescens (Poiret) Koyama, *Cheng & Hwa* 754 (det. T. Koyama).
Pycreus sanguinolentus Vahl, *Cheng & Hwa* 755 (det. T. Koyama).
Scirpus wallichii Roxb. *Cheng & Hwa* 756 (det. T. Koyama).

Eriocaulaceae

- Eriocaulon buergerianum* Koern. *Cheng & Hwa* 759.

Commelinaceae

- Commelina communis* L. *Cheng & Hwa* 785, 957.

Pontederiaceae

- Monochoria vaginalis* (Burman f.) Presl, *Cheng & Hwa* 763, 848.

Juncaceae

- Juncus setchuensis* Buchenau, *Cheng & Hwa* 644.

Liliaceae

- Cardiocrinum giganteum* (Wall.) Makino, *Cheng & Hwa* 849.
Disporum cantoniense (Lour.) Merr. *Cheng & Hwa* 941.
Lilium leucanthum Baker var. *chloraster* (Baker) Wilson, *Gressitt* 2513.
Paris chinensis Franchet, *Cheng & Hwa* 1033.
Protolirion sinii Krause, *Cheng & Hwa* 623.
Reineckea carnea Kunth, *Cheng & Hwa* 597.
Smilax lancifolia Roxb. *Cheng & Hwa* 982.
Smilax megalantha A. DC. *Cheng & Hwa* 633; *Hwa* 350.
Smilax myrtilus DC. *Cheng & Hwa* 929.
Smilax riparia DC. *Cheng & Hwa* 972, 974, 1155.

Iridaceae

- Belamcanda chinensis* (L.) DC. *Gressitt* 2416.
Iris japonica Thunb. *Cheng & Hwa* 652.

Dioscoreaceae

- Dioscorea cirrhosa* Lour. *Cheng & Hwa* 1018.
Dioscorea kamaonensis Kunth var. *fargesii* (Franchet) Prain & Burkill, *Cheng & Hwa* 638, 656, 836, 1016 (det. B. G. Schubert).

Orchidaceae

- Cymbidium ensifolium* Sw. *Cheng & Hwa* 1006.
Cypripedium japonicum Thunb. *Cheng & Hwa* 1162.
Pleione henryi Rolfe, *Cheng & Hwa* 911.

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NOTES ON AIROSPERMA (RUBIACEAE), WITH A NEW SPECIES FROM FIJI

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THE GENUS *Airosperma* Lauterbach & K. Schumann has not been widely discussed by taxonomists concerned with Rubiaceae of the western Pacific, although it has recently been studied by botanists revising the Rubiaceae for *Flora Malesiana* (Ridsdale, Bakhuizen van den Brink, & Koek-Noorman, 1972). Although a formal revision of the genus would be premature, notes on the distribution, morphological variation, pollen, and nomenclature of *Airosperma* species are presented here.

Future workers will have to deal with the problematic tribal affinity of *Airosperma*. I previously (Darwin, 1979) referred the genus to the tribe Alberteae, for the most part following earlier opinion. Interested readers should consult that discussion for a historical outline as well as for an enumeration of the morphological characters that define *Airosperma* and suggest a relationship with *Boholia* Merr. from the Philippines.

As interpreted here, *Airosperma* comprises six species, four in New Guinea and two in Fiji. Schumann and Lauterbach (1900) established the genus with two species, *A. psychotrioides* and *A. ramuense*, both from New Guinea. I have already designated *A. psychotrioides* the lectotype species (Darwin, 1979); of the two original species, it is by far the better collected. In addition, it was provided by its authors with the more expanded description and was the only species illustrated. Valetton added a third species in 1912, and S. Moore a fourth in 1927. Smith (1945) later transferred Gillespie's monotypic Fijian genus *Abramsia* to *Airosperma*. A sixth described species of *Airosperma*, also from Fiji, is presented here as new.

It has been pointed out (Darwin, 1979) that nearly all genera of Pacific Rubiaceae center in Malesia, or at least their closest allies can usually be found there. To varying degrees, many of those genera have probably expanded their geographic ranges into the Pacific by migrating southward over an island chain now represented by the Solomon Islands, the New Hebrides, Fiji, and associated smaller islands. Smith (1979, p. 25 *et seq.*) has outlined in a general way the probable geologic events that made such a migration route possible, and pointed out that such a route may have been only intermittently present. If archipelagoes have come and gone along the eastern edge of the Australian continental plate, it would not seem unusual to find two closely related species of *Airosperma* in Fiji, well isolated from the New Guinean members of the genus. It may well be that the southernmost species of *Airosperma* trace their ancestry to one or a few diaspores reaching Fiji by

means of long-distance dispersal, but there is no apparent adaptation for such dispersal, except, possibly, floating fruits. The more likely hypothesis, it seems to me, is that other geographically intermediate populations have become extinct, leaving survivors only at the extreme ends of a once more continuous range.

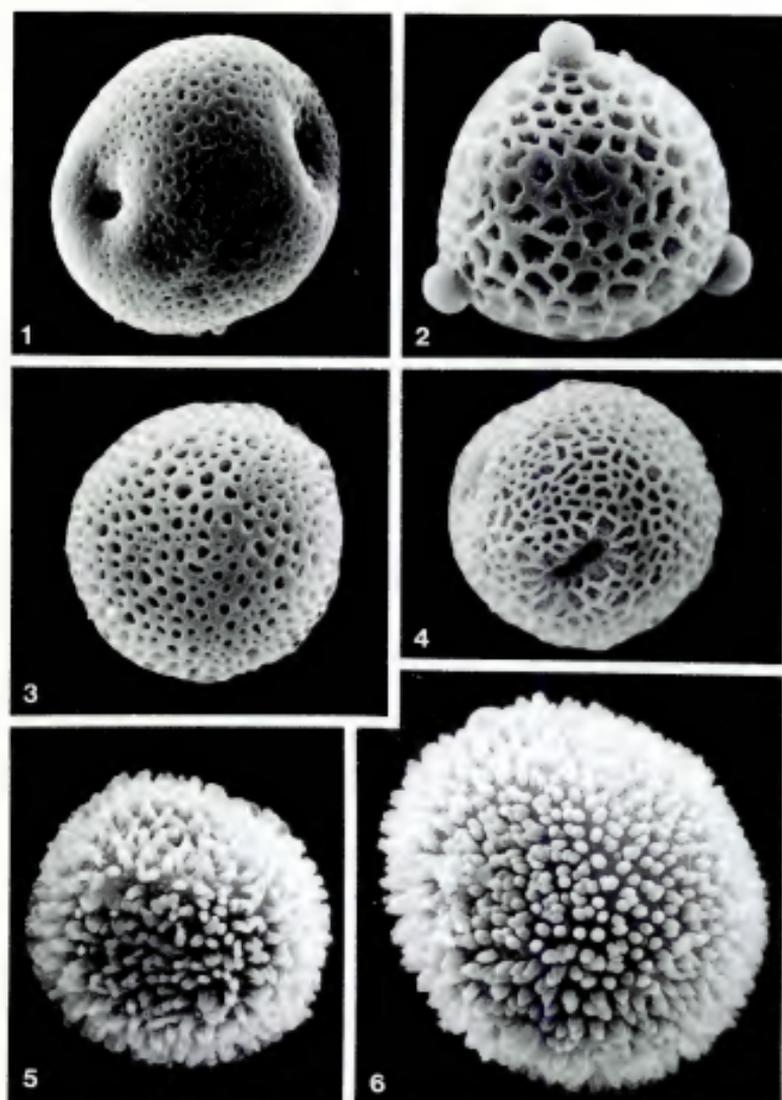
A similar distributional pattern is exhibited by the genus *Mastixiodendron* Melchior, in which three Fijian species are quite isolated from four other species in the Solomon Islands, New Guinea, and the Moluccas; the genus is absent only from the New Hebrides, although it may once have occurred there or on an earlier island group in the same area.

Airosperma Lauterb. & K. Schum. in K. Schum. & Lauterb. Fl. Deutschen Schutzgeb. Südsee, 565. 1900; Krause in Engler & Prantl, Nat. Pflanzenfam. Nachtr. 3: 328. 1908; A. C. Sm. Jour. Arnold Arb. 26: 107. 1945, *ibid.* 36: 288. 1955.

Abramsia Gillespie, Bishop Mus. Bull. 91: 27. 1932.

KEY TO SPECIES OF AIROSPERMA

1. Branchlets usually more than 5 mm. broad toward apex; leaves with at least 15 secondary nerves and petioles more than 3 mm. broad near middle; inflorescences frequently with as many as 200 flowers, the pedicels more than 5 mm. long; New Guinea. 1. *A. grandifolium*.
 1. Branchlets usually less than 4 mm. broad toward apex; leaves with fewer than 15 secondary nerves and petioles less than 3 mm. broad near middle; inflorescences usually with fewer than 200 flowers, the pedicels less than 5 mm. long; New Guinea and Fiji.
 2. Stipules frequently more than 4 mm. long; pedicels not conspicuously elongating in fruit; corolla limb less than 4 mm. broad; anthers apiculate by the produced connectives; mature fruits less than 10 mm. long and 6 mm. broad; New Guinea.
 3. Calyx lobes at least 2.5 mm. long, frequently much longer.
 4. Leaf blades lanceolate to broadly elliptic; inflorescences usually with fewer than 50 flowers. 2. *A. psychotrioides*.
 4. Leaf blades elliptic to broadly obovate; inflorescences usually with more than 50 flowers. 3. *A. fuscum*.
 3. Calyx lobes less than 2 mm. long. 4. *A. ramuense*.
 2. Stipules usually less than 3 mm. long; pedicels conspicuously elongating in fruit; corolla limb usually more than 4 mm. broad; anthers emarginate to obtuse or acute at apex, not apiculate; mature fruits at least 10 mm. long, usually more than 8 mm. broad; Fiji.
 5. Corolla tube less than 3 mm. long, the throat glabrous. 5. *A. trichotomum*.
 5. Corolla tube more than 3 mm. long, the throat densely villose. 6. *A. vanuense*.
1. *Airosperma grandifolium* Valetton, Nova Guinea Bot. 8: 760. 1912 (as *grandifolia*); Bot. Jahrb. 61: 32. 1927 (as *grandifolia*). FIGURE 1.



FIGURES 1-6. Scanning electron micrographs of pollen grains from species of *Airosperma*: 1, *A. grandifolium* (from NGF 48274), $\times 1000$; 2, *A. psychotrioides* (from Brass 23535), $\times 1000$; 3, *A. ramuense* (from NGF 39326), $\times 1000$; 4, *A. aff. ramuense* (from Brass 3884), $\times 640$; 5, *A. trichotomum* (from Degener 14549), $\times 1000$; 6, *A. vanuense* (from Smith 1849), $\times 1200$.

Probably the most distinct species of *Airosperma*, readily distinguished by its large (20–40 cm. long \times 9–18 cm. wide), elliptic to obovate leaf blades, which taper to a short, stout petiole. The inflorescences are much congested, often with as many as 300 relatively long-pedicellate flowers. Like flowers of other *Airosperma* species in New Guinea, those of *A. grandifolium* have the same relative calyx and corolla size, a dense ring of white hairs at the corolla throat, and short-apiculate anthers. As discussed below, the pollen of this and all other *Airosperma* species from New Guinea is 3- to 4-porate and tectate-perforate to semitectate.

Collections of *Airosperma grandifolium* are very few. Valetton (1912, cited above) founded the species on a single collection, *Gjellerup 239*, collected at "Salzquelle am Beguwri" (Beguwi River, Djajapura, West New Guinea (Irian Barat)). Valetton evidently studied the material at Buitenzorg (now Bogor, see Valetton, *op. cit.*, p. 755); I have seen neither the holotype (at so?) nor any isotypes. I have not examined two other collections referred to this species by Valetton (1927, cited above), *Schlechter 20175* and *Ledermann 8351*, both from the Sepik River drainage of Papua New Guinea. More than a dozen other collections have since been annotated as *A. grandifolium*, but most of the specimens previously attributed to this species are better referred to other genera on the basis of the presence of raphid crystals, basally attached ovules, or valvate corolla lobes. Many such excluded collections may be allies of *Psychotria*, some species of which bear a strong superficial resemblance to *A. grandifolium*. Only one specimen seen, *NGF 48274* (cited below), conforms to Valetton's precise description in nearly every detail, except that the stipules of *A. grandifolium* were described as being strongly caducous, whereas in the collection examined they are relatively persistent. *NGF 48274* was collected in the West Sepik District of Papua New Guinea, reasonably close to the locality given by Valetton for the type, and agrees also in its label information—the specimen taken from a herbaceous shrub about 1 meter tall with white flowers.

Valetton reported the type collection as having only flower buds, these much damaged by insects. This is also true of the single collection I have seen. Dr. C. E. Ridsdale (pers. comm.) suggests that recent additional collections of *Airosperma grandifolium* may have been sent to Kew and Leiden, but that they have not as yet been processed or distributed. Collections with mature, undamaged flowers and fruits would be very welcome.

SPECIMEN EXAMINED. Papua New Guinea. WEST SEPIK: sago swamp, N. of Kilifas Village, 305 m. alt., *NGF 48274* (Foreman & Kumul) (LAE).

2. *Airosperma psychotrioides* Lauterb. & K. Schum. in K. Schum. & Lauterb. Fl. Deutschen Schutzgeb. Südsee, 565. t. XXI. 1900; Valetton, Bot. Jahrb. 61: 32. 1927 (as *psychotrioides*); Merr. & Perry, Jour. Arnold Arb. 26: 14. 1945. FIGURE 2.

This species is recognizable by its relatively few-flowered inflorescences (I have counted 15 to 40 flowers in each), and its calyces, which are 2.5–6 mm. long, the subulate to narrowly oblanceolate lobes considerably longer

than the cupular base. This and the two following species are distinct from *Airosperma grandifolium* in their smaller leaves and relatively slender petioles, among other characters.

Lauterbach and Schumann based *Airosperma psychotrioides* on four collections made by Lauterbach, all from Kaiser Wilhelmsland, all presumably deposited in the Berlin Herbarium and now destroyed. I have located duplicates of three of those collections at the Wrocklaw Herbarium (WRSL) and here designate *Lauterbach 510* as lectotype, cited below. The lectotype is noted (on a Berlin Museum label) as having been taken from Sattelberg, Kekagalla, at an altitude of 970 meters on 22/26 June, 1890; a Herb. Lauterbach label on the single isolectotype (also at WRSL) adds that the plant was a shrub with greenish flowers. *Lauterbach 510* represents flowering material only, flowers being much more abundant on the lectotype than on the isolectotype.

Information from herbarium labels of other collections describes this species as a "woody herb" or erect shrub to 2 meters tall growing in rich rain forests from 20 to more than 1800 meters altitude. The bark is variable, smooth or flaking, the wood straw colored and sometimes with white latex; the flowers are usually greenish white when young, at maturity cream-white and often with brownish or pale purple centers. The young fruits are greenish white, eventually becoming bright blue. Flowering and fruiting collections have been gathered throughout the year.

Further investigation into the *Airosperma psychotrioides* "complex" must also take into account floral dimorphism, possibly associated with out-breeding mechanisms. In the herbarium material studied, there are two flower types. In the first, growth of the style keeps pace with the elongation of the corolla tube; in late bud the stigma is at the corolla throat and is to varying degree exerted beyond the limb after separation of the corolla lobes. The mature stigma lobes are about 1 mm. long and widely divergent. In the same flowers, the anthers are much reduced (to 1 mm. long) and apparently sterile. Collections with flowers of this type include *NGF 37976*, *Schodde & Craven 4635* and *4328*, and the type of *A. fuscum* (see below). In the second flower type, the anthers are at least 1.5 mm. long and shed abundant pollen before the corolla bud opens; in such flowers the style was never observed to be more than about 2 mm. long. The flowers of *A. psychotrioides* thus appear to be either functionally staminate or pistillate. As far as I am able to determine, these two floral morphologies are confined to separate plants and suggest dioecism in this species.

SPECIMENS EXAMINED. **Papua New Guinea.** MADANG: Amaiaba River, *NGF 45871* (*Foreman et al.*) (LAE), *NGF 45890* (*Foreman et al.*) (CANB, LAE); Ramu River, tributary 9, *Lauterbach 3112* (WRSL); upper course of Gogol River, *Lauterbach 1124* (WRSL). MOROBE: vicinity of Kaiapit Mission, *Clemens 10756 bis* (A); Umi River, Markham Valley, *Brass 32539* (A, CANB, K); Boana, *Clemens 41578* (A); Atzera Range, *NGF 11923* (*Henty*) (A); Busom River, *NGF 37976* (*Katik*) (A, LAE); vicinity of Butibum River, *Hartley 11634* (A, LAE); Masba Creek, ca. 3 miles S. of Pindiu, *Hoogland 8873* (A, CANB, K, LAE); Sattelberg, *Weinland 312* (BRI, WRSL); Sattelberg, Kekagalla, *Lauterbach 510* (WRSL, lectotype & isolectotype); Matap, *Clemens 41091* (A). GULF: ca. 1 mile E. of

junction of Vailala and Lohiki rivers, *Schodde & Craven* 4328 (A, CANB); hill on southwest margin of junction of Kapau and Tauri rivers, *Schodde & Craven* 4635 (A, CANB, LAE). CENTRAL: Dieni, Ononge Road, *Brass* 3879 (A, BRI, NY); Mafulu, *White* 572 (BM). NORTHERN: Pongani Valley, vicinity of Dareki Village, *Pullen* 5721 (CANB); between Budi and Anara barracks, *Hoogland* 4622 (A, CANB, K). MILNE BAY: junction Ugat and Mayu rivers, *NGF* 28928 (*Streimann*) (A); Mayu River, ca. 15 km. WNW. of Biniguni, *Pullen* 8363 (CANB); north slopes, Mt. Dayman, *Brass* 23535 (A, CANB, LAE, US), 23657 (A, CANB, LAE, US).

3. *Airosperma fuscum* S. Moore, *Jour. Bot.* **65**: 266. 1927 (as *fusca*); in C. T. White, *Jour. Arnold Arb.* **10**: 268. 1929 (as *fusca*).

The type of *Airosperma fuscum* is *Brass* 1050, the only collection seen by Moore, collected at Hohoro, Vailala River, Gulf District, Papua, from a weak shrub 1 meter tall growing on ridges in open rain forest at an altitude of 300 feet. The label of the holotype describes the flowers as white with pink centers, the fruits as yellow. In the sense of its type, *A. fuscum* appears to be reasonably distinct from *A. psychotrioides*, especially in its leaf blades, which may be more than 2 cm. wider and more strongly obovate, and in its inflorescences with as many as 100 flowers. Moore further differentiated *A. fuscum* on the basis of its leaves drying darker and its flowers with pink centers; in those two features I have found numerous collections intermediate between *A. fuscum* and *A. psychotrioides* (*sensu typorum*). To judge from the Papuan collections at hand, it is probable that additional populations of the *A. psychotrioides* alliance will be found in southeastern New Guinea. No collections as yet approach the type of *A. fuscum* in every regard, but additional material from that type locality would greatly help in determining the proper taxonomic status of *A. fuscum*, very possibly supporting its recognition at the rank of species. Some aspects of the floral morphology of the present species are discussed under *A. psychotrioides*.

SPECIMEN EXAMINED. **Papua New Guinea.** GULF: Hohoro, Vailala River, *Brass* 1050 (BM, holotype; A, BRI, K, isotypes).

4. *Airosperma ramuense* Lauterb. & K. Schum. in K. Schum. & Lauterb. *Fl. Deutschen Schutzgeb. Südsee*, 566. 1900 (as *ramuensis*); Valetou, *Bot. Jahrb.* **61**: 32. 1927 (as *ramuensis*); Merr. & Perry, *Jour. Arnold Arb.* **26**: 14. 1945. FIGURES 3, 4.

This species, the second described by Lauterbach and Schumann, was based on a single collection, *Rodat & Klink* 206, from the Bismarck Mountains (Western and Eastern Highlands of Papua New Guinea). I have not examined the holotype, which presumably was deposited in the Berlin Herbarium and is now destroyed; if no isotypes exist, then designation of a neotype will be required. However, based on the excellent original description, I have been able confidently to refer a number of more modern collections to *Airosperma ramuense* and to distinguish that taxon from the two preceding species. Inflorescences of *A. ramuense* frequently have more than 50 flowers (usually about 100), and calyces hardly 2 mm. long. In *A. psychotrioides*

the inflorescences have up to 50 flowers; in *A. psychotrioides* and *A. fuscum* the calyces are longer than 2 mm., frequently as long as 6 mm. Those same differences were emphasized by Lauterbach and Schumann and by Valetton (1927, cited above). Attention has also been drawn to the generally larger leaves of the present species, which often dry nearly black; however, I have found too much variation in leaf size, shape, and drying quality to regard such characters as being very useful in drawing up an analytical key to *A. ramuense* and *A. psychotrioides*.

From label data, the species may be described as a shrub to nearly 2 meters tall, growing in lowland or hillside rain forests at altitudes from 30 to 610 meters. The few collections available suggest that the species may be found in flower or fruit throughout the year. The fruits are described as greenish, becoming purple at maturity, and thus contrasting with those of *Airosperma psychotrioides*, which are frequently described as bright blue.

Only specimens from the Sepik area of Papua New Guinea can confidently be referred to *Airosperma ramuense*. One collection from the Central District, *Brass 3884*, was included in the present species by Merrill and Perry (1945, cited above), but it is well outside its otherwise recorded range. It is composed of flowering material resembling *Airosperma ramuense* but differs from the other specimens examined in its somewhat longer (to 30 cm.) leaves, which are oblong in outline, and in its calyces, the lobes of which may be proportionately longer. Furthermore, the inflorescences are noted as being axillary, on branchlets, or "low down on the stem." These lateral inflorescences have peduncles (modified axillary branchlets?) to 2 cm. long, a feature not observed in any other collection here assigned to the genus *Airosperma*. The flowers of *Brass 3884* are 5-merous, while those of specimens from the Sepik area are usually 4-merous. A new species may be represented here, but I cannot describe it formally without more material. It should be noted that the pollen from *Brass 3884* is essentially identical with that of the one other specimen of *A. ramuense* examined, *NGF 39326* (FIGURES 3, 4).

SPECIMENS EXAMINED. Papua New Guinea. WEST SEPIK: Kriisa-Vanimo Road, *NGF 39326* (*Streimann & Kairo*) (A, LAE). EAST SEPIK: Prince Alexander Range, SE. of Mt. Turu, vicinity of Ambakanja Village, *Pullen 1524* (CANB); head of Giligama Creek, between Kuminim and Lawon villages, W. of Wewak, *Pullen 1357* (CANB). CENTRAL: Dieni, Ononge Road, *Brass 3884* (A, NY).

5. *Airosperma trichotomum* (Gillespie) A. C. Sm. Jour. Arnold Arb. 26: 108. 1945, *ibid.* 36: 288. 1955; J. W. Parham, Pl. Fiji Is. 187. 1964, ed. 2. 264. 1972. FIGURE 5.

Psychotria Seem. Bonplandia 9: 257. 1861.

Psychotria insularum sensu A. Gray, Proc. Am. Acad. 5: 319. 1862, Bonplandia 10: 36. 1862; Seem. Viti, 437. 1862; non A. Gray, 1858.

Abramsia trichotoma Gillespie, Bishop Mus. Bull. 91: 29. fig. 31. 1932; Fosberg, Bull. Torrey Bot. Club 67: 422. 1940, Sargentia I: 125. 1942.

This species was well described by Gillespie under *Abramsia* and was

accompanied by a lengthy discussion concerning the possible tribal relationships of that genus. Similar, although much expanded, commentary was offered by Smith in 1945, at which time he transferred Gillespie's genus to *Airosperma*, where it belongs. As interpreted here, *Airosperma trichotomum* is positively referable only to the island of Viti Levu, Fiji, where it has been collected many times.

The type of *Abramsia trichotoma* is *Gillespie 3388*, cited below. In his published account, Gillespie gave the locality of the type collection as "Viti Levu, Naitasiri Province, vicinity of Nasinu, 14 kilometers (9 miles) from Suva." However, labels (in Gillespie's hand) accompanying the holotype and isotypes give the locality as the slopes of Mt. Lomalangi ("Loma Langa"), vicinity of Nandarivatu, November 12, 1927; notes with one isotype (uc) give the altitude as 1000 meters. Since collecting numbers adjacent to *Gillespie 3388* (and gathered on the same day) are also from the Nandarivatu area (A. C. Smith, pers. comm.), the label data must be taken as correct.

Notes accompanying other collections portray this species as a shrub or small tree, occasionally to a height of 15 meters, growing in dense or secondary forests on wooded ridges or along streambanks at altitudes from 15 to 1250 meters. The flowers are described as white or yellow, the fruits as green, becoming white and sometimes tinged with yellow. Fruiting specimens have been gathered throughout the year, but I have seen no flowering material taken between the months of May and October. Native names recorded are "maskarawa" (*Smith 4426*), "malinimbia" (*Gillespie 2652*), and "silasila" (*St. John 18285*); notes with the last collection further state that the plant is used locally as a cathartic.

This and the following species differ from the New Guinean representatives of *Airosperma* in their smaller stipules, broader corolla limbs, anthers without conspicuously apiculate apices, and larger fruits borne on pedicels that elongate as the fruits mature. The present species is very closely allied to *A. vanuense*, differing in its shorter corollas, which are essentially glabrous within. A close relationship between the Fijian taxa is also suggested by their intectate pollen; the pollen of the Papuan species is variously tectate (FIGURES 1-6). In this and another study (Darwin, 1977), pollen was found to be exceedingly helpful in suggesting that Fijian species of some Malesian Rubiaceae may be traceable to one ancestral population. Such pollen characters will undoubtedly prove useful in similar studies of Pacific Rubiaceae.

SPECIMENS EXAMINED. **Fiji.** Viti Levu. Mba: Mt. Koroyanitu (Mt. Evans), *Fiji Dept. Agr. 14148* (BISH); slopes of Mt. Nairoso, eastern flank of Mt. Evans Range, *Smith 4074* (A, BISH, BRI, K, NY, US), *4426* (A, BISH, BRI, K, NY, US); Nauwanga, *Degener 14549* (A, BISH, NY, UC, US), *14740* (A, BISH, NY, US); vicinity of Nandarivatu, *Degener 14807* (A, NY, US), *Degener & Ordonez 15542* (A, BISH, BRI, NY, UC, US), *Parks 20577* (UC); slopes of Mt. Lomalangi, *Gillespie 3388* (BISH, holotype of *Abramsia trichotoma*; BISH, GH, UC, isotypes), *3686* (BISH, UC, US); Mt. Lomalangi, *Gillespie 4065* (BISH, GH, UC), *4364* (BISH, UC), *Greenwood 872* (A, K, UC), *Tohill 266* (K), *267* (K); hills E. of Nandala Creek, ca. 3 mi. S. of Nandarivatu, *Smith 5935* (A, BISH, BRI, K, NY, US); Navai Ranges, *Fiji Dept. Agr. 2319* (*B. E. Parham*) (A); west and south slopes of Mt. Tomanivi

(Mt. Victoria), *Smith 5743* (A, BISH, BRI, K, US); Mt. Tomanivi (Mt. Victoria), *Degener et al. 32080* (BISH), *32086* (BISH). NANDRONGA and NAVOSA: northern portion Rairaimatuku Plateau between Nandrau and Nanga, *Smith 5517* (A, BISH, BRI, K, NY, US). SERUA: hills W. of Waivunu Creek between Ngaloa and Korovou, *Smith 9473* (BISH, US); Ngaloa Nature Reserve, *Fiji Dept. Agr. 16592* (BISH). NAMOSI: near summit of Mt. Naitarandamu, *Gillespie 3315* (BISH, NY, UC); northern base of Korombasambasanga Range, drainage of Wainavidrau Creek, *Smith 8634* (BISH, GH, NY, UC, US); vicinity of Namosi, *Gillespie 2652* (BISH), *Parks 20275* (BISH, UC, US), *Seemann 250* (GH, K); Vui Voma, *Fiji Dept. Agr. 11680* (BISH, BRI). NAITASIRE: Wainimala Valley, Rarandawai to Nairairai-kinasavu, Wainisavulevu Creek, *St. John 18285* (A, BISH); Waimanu region, southeastern Nasle, *Fiji Dept. Agr. 15427* (BRI, MASS); track to Mendrausuthu Range, *Fiji Dept. Agr. 15025* (A, BRI, UC). TAILEVU: Ndakuivuna, *Fiji Dept. Agr. 11016* (BISH). VITI LEVU, without further locality, *Tohill 268* (K). FUI, without further locality, *Fiji Dept. Agr. L. 13370* (Berry) (BRI).

6. *Aiosperma vanuense* S. Darwin, sp. nov.

FIGURE 6.

Frutex (vel arbor gracilis?) praeter inflorescentiam et partes juveniles plus minusve glaber; ramulis subteretibus apicem versus 1-2 mm. diametro fuscis; stipulis maturis persistentibus membranaceis ovatis vel late deltoideis ad 1.5 mm. longis apiculatis sed saepissime demum bifidis vel erosis, extus puberulis pilis minutis et dispersis intus pubescentiis densioribus et ad basem cum aliquot glandibus gracilibus circiter 0.2×0.1 mm.; petiolis gracilibus semiteretibus vel aliquantum canaliculatis 5-40 mm. longis ad medium circiter 1 mm. latis glabris; foliorum laminis membranaceis ellipticis vel oblongis vel aliquantum oblanceolatis 5-15 \times 2-8 cm. apice acutis saepe obtuse vel acutissime acuminatis basi anguste cuneatis et in petiolum decurrentibus, integris, supra glabris vel pilis minutis appressis et dispersis subtus pilis frequentioribus in costa et nervis, costa conspicua supra prominula et canaliculata subtus elevata, nervis secundariis utrinsecus 8-9 late patentibus et utrinque prominulis, nervis tertiariis et rete venularum utrinque subplanis; inflorescentiis terminalibus sessilibus sparsim puberulis pilis dispersis appressis albis vel stramineis ad 0.1 mm. longis, cymosis plerumque basi trichotomis ramificatione opposita inordinatescenti, sub anthesi 1.5-3.5 \times 2-6 cm. et 30-50-floribus, bracteis subulatis vel linearibus ad 1 mm. longis apice acutis, pedicellis 1-3 mm. longis (sed sub fructu multo longioribus?); calycis limbo ad 1.5 mm. lato, calycis parte discreta ad 1 mm. longa cupulata et minute 5-denticulata, extus minute puberula intus glabra; corolla hypocraterimorpha vel anguste infundibulari, limbo 4.5-8 mm. lato, tubo 5-8 mm. longo ad medium 0.8-1.2 mm. lato extus glabro vel pilis dispersis intus glabro sed sub fauce hirsuto-villoso pilis albis laxis ad 1 mm. longis, corollae lobis 5 in aestivatione contortis ovatis 2-3.5 \times 1-2 mm. apice acutis basi subcordatis intus minute et dense puberulis vel glabris; staminibus 5 sub corollae fauce insertis, filamentis circiter 0.5 mm. longis, antheris plus minusve dorsifixis clavatis circiter 2×0.8 mm. apice rotundatis vel emarginatis basi loculis in filamentum decurrentibus; ovario (hypanthio) subgloboso vel ellipsoideo 0.5-1 \times 0.5 mm. minute puberulo biloculari, ovulis in quoque loculo solitariis et prope verticem loculi affixis, juxta dissepimentum aliquantum complanatis;

disco circiter 0.5 mm. alto in centro depresso; stylo ad 4 mm. longo filiformi vel subclavato glabro, stigmatibus bifido in alabastro ad 0.5 mm. longo glabro, ultra corollae tubum vix exserto. Fructus jam ignoti vel fortasse ad speciem praesentem non referentes.

Airosperma vanuense is thus far known with certainty from only two collections from the island of Vanua Levu, Fiji. The type collection, cited below, was gathered in the province of Mathuata, near the Wainunu-Ndreketi Divide, May 17, 1934, from a shrub 3 meters tall growing in a dense forest at an altitude of 200-300 meters. The flowers are nearly mature in the holotype.

I am able to separate *Airosperma vanuense* from *A. trichotomum* on the basis of two floral characters. In the present species the corolla tubes are 5-8 mm. long, vs. only 1-2 mm. in *A. trichotomum*. Corolla tube length is undoubtedly a highly variable character in some Rubiaceae, apparently associated with various pollination adaptations in some species. However, in this instance the tube length is correlated with differences in pubescence: the corolla throats in *A. vanuense* are densely villose-hirsute with white hairs to 1 mm. long, while those of *A. trichotomum* are glabrous within. Pubescent corolla throats, as far as I am able to determine, are found in all New Guinean species of *Airosperma*, but none of those species approaches *A. vanuense* in the length of the corolla tube.

Since the diagnostic features of *Airosperma vanuense* are entirely floral characters, it is not possible for me to assign certain fruiting collections to this species without making undue assumptions. The abundant flowering material of *Airosperma* from Viti Levu is all readily assignable to *A. trichotomum*, and the fruiting specimens from the same island probably represent the same species. However, only two flowering collections are currently known from Vanua Levu; as a result, it is possible that some fruiting collections of *Airosperma* from that island may represent *A. trichotomum* rather than *A. vanuense*. Such fruiting collections, for the present probably best regarded as "aff. *vanuense*," include the following: Mt. Vatunivuamonde, Savu Savu Bay region, *Degener & Ordonez 13964* (A, BISH, NY, UC, US); vicinity of Drayton Peak, *Bierhorst F154* (MASS); Taveuni, Mt. Manuka, *Smith 796* (BISH, GH, US), *8214* (BISH, GH, NY, UC, US). More field work and additional collections (especially from Vanua Levu) are required before the ranges of *A. trichotomum* and *A. vanuense* can be determined with accuracy.

SPECIMENS EXAMINED. **Fiji. Vanua Levu.** MATHUATA: Wainunu-Ndreketi Divide, *Smith 1849* (GH, holotype; BISH, NY, UC, US, isotypes). THAKAUNDOVE: NAVAVAU, *Fiji Dept. Agr. 16046* (BISH).

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ELEUTHEROCOCCUS VS. ACANTHOPANAX

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IN RESPONSE TO a growing interest in the use of ginseng, chemists and physicians have investigated the chemistry and the physiological activities of crude drugs prepared from the roots and bark of *Panax ginseng* C. A. Meyer and other araliaceous plants. Included in these studies have been the Chinese drugs known as *Wu-chia-p'i*, which are prepared from the bark of different species of *Eleutherococcus*. The investigations have resulted in the isolation of sitosterol glycosides from *Eleutherococcus senticosus* (Rupr. & Maxim.) Maxim., and in the discovery of similar physiological responses induced by these glycosides and the ginsenosides of *P. ginseng* (Brekham, 1969; Anonymous, 1976). Because of these similarities, extracts from species of *Eleutherococcus* have been used as substitutes for ginseng. Communicating the results of the chemical and physiological studies has often proved difficult and confusing since species of *Eleutherococcus* have sometimes been included in the genus *Acanthopanax*, and the nomenclature has been unstable. A summary of the taxonomy of these two genera and necessary nomenclatural changes are presented here in order to clarify this situation and to provide a more stable and less confusing nomenclature.

A survey of the pertinent literature indicates that *Eleutherococcus* Maxim. (typified by *E. senticosus*) is the earliest validly published name for the genus that some authors have called *Acanthopanax* (Decaisne & Planchon) Miquel (typified by *A. spinosus* (L. f.) Miquel). Decaisne and Planchon (1854) used *Acanthopanax* as a subgenus of *Panax* L., and later Miquel (1863) raised the subgenus to generic level. Harms (1894) combined *Acanthopanax* and *Eleutherococcus*, but he used *Acanthopanax* as the generic name and recognized *Eleutherococcus* at sectional rank. Harms's treatment has been followed by Rehder (1940, 1949), Li (1942), horticultural authors, and floristic botanists in China and Japan. However, in 1924 Nakai recognized both *Acanthopanax* and *Eleutherococcus* as distinct genera, and his treatment has been adopted by Poyarkova (1973).

The characters utilized by Poyarkova to separate the two genera are "ovary 2-locular, styles 2; fruit with 2 stones; petioles glabrous or scarcely pubescent, articulate with rachis" for *Acanthopanax*, and "ovary 5-locular, styles 5, fruit with 5 stones; petioles not articulate, densely pubescent" for *Eleutherococcus*. These characters may hold for distinguishing the two species (one placed in each genus) that occur in the relatively limited area of the Soviet Far East, which constitutes the periphery of the generic range, but they are of no generic value when species from over the entire geographic range are considered. Even for the small number of Japanese species, Nakai (1924)

remarked that the "characters distinguishing *Eleutherococcus* from *Acanthopanax* are neither the cohesiveness of the styles nor the presence of articulation in the flowers. . . . The seeming articulation appears in the dried specimens by the contraction of tissue . . . [but is a] . . . false articulation." Nakai separated the genera by utilizing the number of "styles and the number of cells in the ovary as well as the shape of the pyrenes." He attributed 2 styles, 2 or 3 ovary cells, and flat pyrenes with roundish ventral sides to *Acanthopanax*, and 5 styles, 3 to 6 ovary cells, and pyrenes with an acute or somewhat acute ventral side to *Eleutherococcus*.

Like the characters used by Poyarkova, Nakai's characters do not hold when all of the taxa attributed to the two genera are examined. In all species the endocarps mature separately into hard shells, each covering an individual seed to form a pyrene. The shape of the ventral (adaxial) side of the pyrene depends upon the number of ovary cells. The variation in the number of cells in the ovaries (and, in turn, in the number of pyrenes) is correlated with the number of styles—observations of one flowering branch of *Eleutherococcus trifolius* (L.) S. Y. Hu has shown some flowers with 2 or 3 styles (these united up to the middle) and others with 6 (these free to the base).

When all of the species attributed to the two genera are examined, there is not one constant character that can be used to separate *Eleutherococcus* from *Acanthopanax*. The genus is a natural one consisting of spinose shrubs with compound leaves, sessile or pedicellate flowers arranged in simple, solitary or racemose umbels or heads, and flowers with 2- to 6-celled ovaries. *Eleutherococcus* (from the Greek *eleuthero*, free, and *kokkos*, seed, in allusion to the separated pyrenes) is the correct generic name.

Rehder's treatment (1940, 1949) of the genus and its sections is followed here with two exceptions. The unarmed, arboreous species with trifoliolate leaves, corymbose-paniculate umbels, and drupes consisting of 2 dorsiventrally flattened pyrenes are placed in *Evodiopanax* Nakai (see Ohwi, 1965). Another unarmed, arboreous species with (3-, 4-, or) 5-foliolate leaves and loosely arranged corymbose-paniculate umbels is left in *Kalopanax* (*K. sciadophylloides* (Franchet & Savatier) Harms). A total of fifteen species and seven varieties from China, Korea, and Japan are transferred below from *Acanthopanax* to *Eleutherococcus*, and one variety from *Acanthopanax* to *Evodiopanax*. Important literature is cited to provide access to descriptions of the taxa as well as more complete references.

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Bentham & Hooker f. Gen. Pl. **1**: 941. 1867; Nakai, Jour. Arnold
Arb. **5**: 9. 1924, Fl. Sylv. Kor. **16**: 26. 1927.

Panax subgen. *Acanthopanax* Decaisne & Planchon, Revue Hort. **1854**:
105. 1854.

Acanthopanax (Decaisne & Planchon) Miquel, Ann. Mus. Bot. Lugd.-Bat.
1: 10. 1863; Harms in Engler, Nat. Pflanzenfam. III. **8**: 49. 1894; Rehder,
Man. 676. 1940, Bibliogr. 492. 1949; Li, Sargentia **2**: 69. 1942; Ohwi,
Fl. Japan (Eng. ed.) 664. 1965; Anonymous, Ic. Corm. Sin. **2**: 1035.
1972.

Acanthopanax sect. *Eleutherococcus* (Maxim.) Harms in Engler, Nat. Pflanzenfam. III. 8: 49. 1894.

Eleutherococcus divaricatus (Sieb. & Zucc.) S. Y. Hu, comb. nov.

Panax divaricatus Sieb. & Zucc. Abh. Bayer. Akad. Math.-Phys. Kl. 4(2): 200. 1845 (as *divaricatum*).

Acanthopanax divaricatus (Sieb. & Zucc.) Seemann, Jour. Bot. London 5: 239. 1867; Li, Sargentia 2: 76. 1842.

Eleutherococcus giraldii (Harms) Nakai var. **pilosulus** (Rehder) S. Y. Hu, comb. nov.

Acanthopanax giraldii Harms var. *pilosulus* Rehder, Jour. Arnold Arb. 9: 99. 1928; Li, Sargentia 2: 81. 1942.

Eleutherococcus gracilistylus (W. W. Sm.) S. Y. Hu, comb. nov.

Acanthopanax gracilistylus W. W. Sm. Notes Bot. Gard. Edinburgh 10: 6. 1917.

Eleutherococcus gracilistylus var. **pubescens** (Pampanini) S. Y. Hu, comb. nov.

Acanthopanax spinosus (L. f.) var. *pubescens* Pampanini, Nuovo Giorn. Bot. Ital. II. 17: 678. 1911.

Acanthopanax gracilistylus W. W. Sm. var. *pubescens* (Pampanini) Li, Sargentia 2: 85. 1942.

Eleutherococcus henryi Oliver var. **faberi** (Harms) S. Y. Hu, comb. nov.

Acanthopanax henryi (Oliver) Harms var. *faberi* Harms, Mitt. Deutsch. Dendrol. Ges. 27: 12. 1918; Li, Sargentia 2: 75. 1942.

Eleutherococcus lasiogyne (Harms) S. Y. Hu, comb. nov.

Acanthopanax lasiogyne Harms in Sargent, Pl. Wils. 2: 563. 1916; Li, Sargentia 2: 78. 1942.

Eleutherococcus nodiflorus (Dunn) S. Y. Hu, comb. nov.

Acanthopanax nodiflorus Dunn, Jour. Bot. London 47: 199. 1909.

Acanthopanax gracilistylus W. W. Sm. var. *nodiflorus* (Dunn) Li, Sargentia 2: 86. 1942.

Eleutherococcus phanerophlebius (Merr.) S. Y. Hu, comb. nov.

Acanthopanax phanerophlebius Merr. Sunyatsenia 2: 12. pl. 6. 1934.

Eleutherococcus rufinervis (Nakai) S. Y. Hu, comb. nov.

Acanthopanax rufinervis Nakai, Fl. Sylv. Kor. 16: 25. 1927 (as *rufinerve*).

Eleutherococcus seoulensis (Nakai) S. Y. Hu, comb. nov.

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ARNOLD ARBORETUM
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A NEW SPECIES OF CESTRUM (SOLANACEAE) FROM SOUTHERN COLOMBIA

ARMANDO T. HUNZIKER

DURING A BRIEF VISIT to the National Herbarium of Colombia, Bogotá, my attention was drawn by the curious morphology of an unnamed collection of *Cestrum*. After a thorough analysis of its peculiarities, I have come to the conclusion that it represents an undescribed species. Its essential characteristics are noted in the following description.

*Cestrum morae*¹ A. Hunziker, sp. nov.

FIGURE 1.

Arbor cauliflorus 5 m. altus. Folia magna, glaberrima, manifeste petiolata; laminae ellipticae vel oblongo-ellipticae ad apicem acuminatae vel breviter cuspidatae, basi ± obtusiusculae, 30–34 cm. longae et 19.3–19.8 cm. latae, nervo mediano supra tenui impresso subtus valde prominente, nervis lateralibus utrinque ca. 20 adscendentibus supra impressis subtus valde eminentibus et nervis secundariis numerosis, utrinque bene conspicuis dense reticulatis; petioli suberosi 4–4.7 cm. longi. Inflorescentiae laxae 20–28 florum; axes glabri 14.5–26 cm. longi, fertiles in tertia vel octava parte distali; bracteae lineares, angustae, (6.5–)11–15(–18) mm. longae, (0.25–)0.5–0.6(–1) mm. latae. Calyx 4.5–5.8 mm. longus et ca. 2 mm. latus, extus pilis minutissimis argentatis praeditus. Corolla extus glabra, alba, 37–39 mm. longa; tubus 31–32 mm. longus; lobi 6–7 mm. longi. Stamina aequalia ca. 30 mm. longae; filamenta ad ca. 4/5 longitudine tubo adnata (24–25 mm.), 4–7 mm. longe libera, ad insertionem non dentata et non gibbosa, valde pilosa; pars adnata superne dense pilosa, ceterum parvissime puberula; antherae parvae, orbiculatae, ca. 0.6–0.7 mm. longae. Ovarium diminutum, depressum, glabrum, ca. 0.5 mm. longum et ca. 1 mm. latum, stipite (ca. 0.8 mm. altus) brevior; stylus filiformis ca. 28–29 mm. longus, apice minutissime pubescens, stamina superans; stigma exsertum. Baccae non suppetunt.

TYPE COLLECTION. Colombia, Dpto. Nariño, Municipio de Altaquer, entre Junin y Buenavista, 700 m. alt., *L. E. Mora* 4278, 21 Nov. 1967 (COL 113604, two leaves and one inflorescence; COL 113605, two inflorescences).

OBSERVATIONS. A distinctive species, unique in its cauliflory, with inflorescence axes 14.5–26 cm. long. Its large leaves and long corollas (to almost 4 cm.) are two additional features not frequently encountered in the genus.

¹The specific epithet honors the collector of the only specimen known up to this time, Professor Luis Eduardo Mora, presently Director of the Botany Department, Instituto de Ciencias Naturales, Universidad Nacional, Bogotá, Colombia.



FIGURE 1. *Cestrum morae*: A, inflorescence, $\times 0.73$; B, leaf, upper surface, $\times 0.4$; C, flower, longitudinal section, $\times 2.7$; D, gynoecium, basal portion, $\times 21$; E, calyx, articulation with axis, $\times 7.5$; F, flower, upper part, $\times 4.3$.

The most closely related species appears to be *Cestrum diversifolium* Francey, from Colombia (Antioquia) and Ecuador;² in addition to lacking cauliflory and having comparatively small leaves (less than 5 cm. long), this particular species differs in its somewhat smaller flowers with ovoid ovaries, and in its gibbous filaments that are slightly indented at the point of insertion on the corolla tube.

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The author wishes to thank the authorities of the Instituto Colombiano de Ciencias Naturales (Bogotá) for the facilities made available to him, and for the loan of an important set of specimens; furthermore, he gratefully acknowledges the unfailing assistance of Dr. Gustavo Lozano during his stay at the institution. Thanks are due also to Dr. Bernice G. Schubert for reviewing the manuscript, and to Mrs. N. M. de Flury for her work on the illustration.

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²Francey, 1935, p. 321.

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NOTICES

Volume 61, number 2, of the *Journal of the Arnold Arboretum* will be published simultaneously with number 3 during the summer of 1980. Both issues will be exclusively devoted to P. F. Stevens's "A Revision of the Old World Species of *Calophyllum* L. (Guttiferae)."

Because of continually increasing production costs, the Editorial Committee of the *Journal of the Arnold Arboretum* is requesting authors to help defray publication expenses. Beginning with manuscripts received and accepted for publication as of March, 1980, a page charge will be levied. Acceptance of manuscripts for the Journal will, however, continue to be based solely on appropriateness and scientific merit, not on an author's ability to meet page costs. Information on page charges and general editorial policies can be obtained from the Managing Editor.

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COVER: The shoots and fruits (about natural size) and a single trichome (magnified nearly 160 times) of a Fijian endemic, *Calophyllum leucocarpum* A. C. Smith, form the basis of this year's stylized cover design. A row of trichomes is used in the device on the back cover, while a cluster of leaves appears on the offprints. As in recent years, the designs, based on holotype material in the herbarium of the Arnold Arboretum, were drawn by Karen Stoutsenberger.

Calophyllum L. (Guttiferae) is a wide-ranging genus of tropical forest trees in both the New and Old Worlds, and some species are of considerable economic importance as sources of valuable timber. Its use on the cover of this volume of the *Journal of the Arnold Arboretum* is appropriate since the April and July numbers are devoted to P. F. Stevens's revision of the Old World representatives of this genus.—S. A. S.

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A REVISION OF THE OLD WORLD SPECIES OF
CALOPHYLLUM (GUTTIFERAE)

P. F. STEVENS

WHEN I ARRIVED in Lae, Papua New Guinea, in May, 1970, as a junior and rather raw Forest Botanist, the question arose as to which economically important group of plants I should revise. M. J. E. Coode suggested the Guttiferae, although he later admitted that it was hardly the group to give to somebody with little taxonomic experience, or even to anyone with whom one may later wish to communicate in a civilized fashion. However, a revision of the Papuasian species of *Calophyllum* L., the genus of the Guttiferae with the most species attaining loggable size, duly appeared (Stevens, 1974a), and my interest in the genus as a whole was stimulated. When I moved to the Arnold Arboretum of Harvard University, I was able to extend my studies on the genus; the resulting revision of the Old World taxa is presented here. The relatively few New World species will shortly be studied.

Calophyllum, the largest genus in the Calophylloideae, can be readily recognized by its opposite leaves with closely and regularly parallel veins that alternate with latex canals; flowers that usually appear to be hermaphroditic; ovary with a single, basal, anatropous ovule; and fruit that is drupelike. These characters, apart from the second, are derived ones (although it should be noted that fruit structure in other Calophylloideae is poorly known), and *Calophyllum* is probably strictly monophyletic—i.e., it includes only (and all) the extant derivatives of a single lineage.

Superficially, the species are all rather similar; once seen, the genus should not be subsequently misidentified. Nevertheless, there are over 200 names available for species in the Old World alone. Although the natural tendency is to work on other, more obviously tractable genera, careful study of taxa like *Calophyllum* is needed to lay the foundations for future, more specifically evolution-oriented studies that are, in turn, essential before evolution in tropical rain forests can be appreciated.

The questions that I asked myself as I extended my studies were three. Is it or is it not possible to recognize taxa throughout the range of the genus in the Old World? If it is possible, how did the taxa that I had previously recognized in Papuasias relate to these? Are there relationships between the

patterns of morphological variation in *Calophyllum* and ecological or other variables that suggest ideas relating to the evolutionary history of some of the species?

In the course of the examination of about 7000 numbers of the genus from the Old World, as well as field work in Malesia in 1975/76, the questions were resolved in somewhat unexpected ways. Species, based on discontinuities in the variation pattern of morphological characters, have been recognized throughout the range of the genus, although the taxonomy of the genus in Madagascar and Vietnam, in particular, is still poorly understood. No super-specific taxa, even informal ones, can be maintained. One hundred and seventy-nine species have been described, although some are poorly known and are merely given a number; varieties are recognized in eight species. Although in a few cases deliberately narrow or conservative species limits have been adopted, field experience, as well as the distinctness of most taxa, suggest that the number of recognized taxa is not too high. There will be reductions, but more taxa remain to be described.

Characters from all organ systems have been used in the classification, and preliminary observations made on lamina anatomy are mentioned in a number of cases. A few of the characters studied are of particular interest. It was, perhaps, to be expected that a survey of the fruits of the genus would be of considerable systematic importance (see Smith & Darwin, 1974; Stevens, 1974a), but the variation in seedlings and young plants surpassed all expectations and provided much information of systematic significance. This variation, which is greater in the young plant than in the seedling, and greater in the seedling than in the germinating plant, is as extensive as that in any comparable group of plants. Additional variation in "growth characters" occurs in the adult plant as well; this, too, is of considerable systematic importance and has rarely been reported before. An additional suite of highly important characters, totally ignored for the better part of a century, has been provided by a study of the often rather bizarre hair types. Finally, polyembryony has been discovered in a few taxa.

Most of the taxa that I had recognized in Papuasias stood up to the closer and wider examination possible in this study; no Papuan taxon has an unexpected range in West Malesia. Indeed, insofar as there is a major dividing line within *Calophyllum* in the Indo-Malesian region, it occurs between New Guinea and Borneo. The area from Sulawesi to Samoa forms one region, while that from Borneo and the Philippines to India forms another.

Little that is definite can be said with regard either to the selective value of the characters observed or to the evolutionary history of the genus or any of its species. However, I have attempted to put our knowledge of the genus into biogeographic, ecological, and evolutionary frameworks, more in the hope of stimulating further work than in an attempt to answer specific questions. It is clear that many of the taxa recognized do have particular ecological preferences and discrete geographic ranges, and the kind and amount of variation in seedling and growth characters, in particular, may relate to both the current ecology of individual species and the process of diversification within the genus. The suspicion that apomixis occurs in some taxa opens

another, possibly very important, line of inquiry. The importance of the question that is so apparent in the field—how several apparently similar species can grow in one place—is manifest to those interested in tropical ecology. The question remains unanswered, but it now can be phrased much more exactly.

The present treatment can, however, be considered only provisional, even in the context of the recognition of morphologically definable species. The genus has been woefully undercollected in the past throughout much of its range, and we still do not know the basic morphology of many taxa, much less understand their infraspecific variation or details of their distribution patterns. Study is still needed, much of it in the field, and extensions of our knowledge of several suites of characters, especially those concerning growth and anatomy, are immediate desiderata; we must find out much more about the ecology and breeding systems of the species in the genus.

Study of the other genera of the Calophylloideae is planned. With this, as well as with studies by S. W. Jones, J.-F. LeRoy, and N. K. B. Robson of other genera in the Guttiferae, variation in *Calophyllum* will be placed in a more general context, and phylogenetic analysis of this variation may become possible. In the absence of this wider context, however, phylogenetic analysis is premature.

TAXONOMIC HISTORY

Linnaeus included two species of *Calophyllum*, *C. inophyllum*¹ and *C. calaba*, in the first edition of *Species Plantarum*. The protolog of *C. calaba* contains references to three currently recognized species, but it was not until Willdenow (1811) described *C. apetalum* that the elements in *C. calaba* began to be disentangled. Confusion over the correct use of the name still persists; *C. calaba* should be typified on the element from Sri Lanka in the protolog (Stevens, 1980b).

Subsequent to those of Linnaeus, the first taxa still referable to *Calophyllum* were described by Willdenow (1811). The majority of taxa in India and Ceylon were recognized early by Wight (1839, 1840) and Thwaites (1858), while Choisy (1849, in a preprint of an article eventually appearing in 1851) described a number of taxa based on specimens from Wallich's herbarium. Choisy's work was not very satisfactory, and although Planchon and Triana (1862a) managed to disentangle the relationships between the names, specimens cited, and descriptions in Choisy's treatment, the nomenclatural consequences of Choisy's work still haunt workers on the genus. The other major early worker on *Calophyllum* was Miquel (1854, 1859, 1861), who described a number of taxa from western Malasia.

Planchon and Triana (1862a; see discussion after *Calophyllum teysmannii* for publication date of their work) first revised the genus, and despite their evident trepidation in disentangling Choisy's work and the problems caused by the poor material available to them, they more than succeeded in their

¹Authorities for Indo-Malesian taxa are given in the species accounts.

modest aim of facilitating the task of subsequent monographers. They described nine species from the Old World as new and recognized a total of 29 species from this region, not including doubtful or incompletely known taxa. Only two of the species they recognized are not maintained as formal taxa in this revision, but almost a third of the names that they used are nomenclaturally incorrect. Unfortunately, they could not incorporate some of the taxa described by Miquel in their revision, and subsequent workers have not examined the material on which Miquel based his names; not surprisingly, Miquel's names are the earliest for three common Malesian species.

After Planchon and Triana's publication, there was little work of any note on the genus for almost thirty years. Anderson and Hooker described a number of Indian taxa (Anderson, 1874), while Pierre (1885) named and illustrated a number of taxa from mainland Southeast Asia.

Vesque (1889, 1893) was the second and last person to revise the genus; he examined the anatomy and indumentum of many species (see Vesque, 1889, for illustrations), and in his contribution to *Monographiae Phanerogamarum* (1893), he incorporated detailed descriptions of the hairs and lamina anatomy in the species descriptions. He recognized four sections—*Inophyllum* Vesque, *Microphyllum* Vesque, *Apetalum* Vesque, and *Hypodermata* Vesque—in the Old World, in part delimited on tepal ("sepal" plus "petal") number. The sections were subdivided informally on anatomical and/or morphological characters. Species from the New World were not assigned to sections. In the Old World Vesque recognized 35 species, with 17 additional species being less well known and not assigned to sections; his species limits basically followed those of Planchon and Triana. Like Clarke (1894), I do not know on what specimens Vesque (1893) based his anatomical work; it was clearly not always or not only on those specimens designated by an exclamation mark in his publication.

Subsequent to Vesque's publications, work on *Calophyllum* has been local in scope. Henderson and Wyatt-Smith's excellent study (1956) of the Malayan species is the most important in this time, although—despite the authors' unrivaled field knowledge of the genus—they were careful to point out the provisional nature of their account. They found that bark and slash characters were often helpful in recognizing a species, that the leaves, although superficially so similar, were often diagnostic of a species, and that a supraspecific classification based on tepal number was impossible to employ. They recognized 46 taxa, of which they described 20; 43 of these taxa are maintained here at some level, although often with different names. Whitmore (1973) basically followed Henderson and Wyatt-Smith's work.

There is little other recent work of note. Perrier de la Bâthie (1951) wrote an account of the Madagascan species, while Maheshwari (1960) provided a somewhat cursory treatment of those from India. Pitard (1910) and Gagnepain (1943) dealt with the genus in the Vietnam-Cambodia area; unfortunately, the new names proposed by the latter are invalid since the descriptions are in French. Recent accounts of the members of the genus in Papuasias (Stevens, 1974a) and the South Pacific region (Smith & Darwin, 1974) paid considerable attention to the structure of the fruit for the first time; in neither were

sections recognized. Stevens (*op. cit.*) also gave brief details of the lamina anatomy of the Papuan species and described the germination and young plant of some species.

VARIATION IN THE GENUS AND ITS USE IN CLASSIFICATION

GERMINATION AND YOUNG PLANT

In the main part of this paper, accounts of germination, the seedling,² and the growth of the young plant are given for 36 species (33 primarily Malesian species, two from Sri Lanka, and one from the Mascarenes), and details of some of these stages are recorded for several others. The initial indications of the taxonomic importance of these early stages of growth, which resulted from observations on eight Papuan species (Stevens, 1974a), are fully confirmed. Even species with the same growth patterns in their initial stages (see below) can be distinguished by the use of such additional characters as leaf shape and size and the color of the young leaves—characters that are not discussed in detail here; as a result, most species are recognizable from a very early age. The variation found has helped to clarify some taxonomic problems, for example, the limits of *Calophyllum rigidum* and *C. venulosum*, the relationships between *C. venulosum*, *C. grandiflorum*, and *C. wallense*, and between *C. teysmannii* and *C. sclerophyllum*. However, there is great need for much more comparative data that should be gathered both in the botanic garden and in the wild. Some of the characters apparent in these early stages are discussed below.

It will be realized, from reading the accounts, that for a number of species progeny of only a single tree has been observed. A further complicating factor is that in most cases the observations were made in the wild, with germination and the young plants occurring under a variety of conditions; these factors are discussed below. Despite these caveats, there seems to be little infraspecific variation in many characters of these early stages. The main exceptions are variation in the number of pairs of leaves in the seedling and in their disposition (rather less variation), as well as in the presence of scale leaves in both axillary and terminal innovations³ in the young plant. However, in *Calophyllum soulattri*, and perhaps also in *C. tetrapterum*, there is infraspecific variation both in germination and in the growth of the young plant; this situation requires more study.

Interspecific variation in germination, the seedling, and the growth of the young plant can be accommodated in fifteen classes (FIGURE 1, a-o; TABLE 1). The differences between some of the classes are clearly slight and may prove to be unimportant when more data accumulate. The seedlings all conform to the *Heliciopsis* type and subtype (de Vogel, 1980).

²The seedling is defined here as the plantlet after germination when growth in length ceases for the first time.

³An innovation is the extension growth produced between two successive periods of rest.

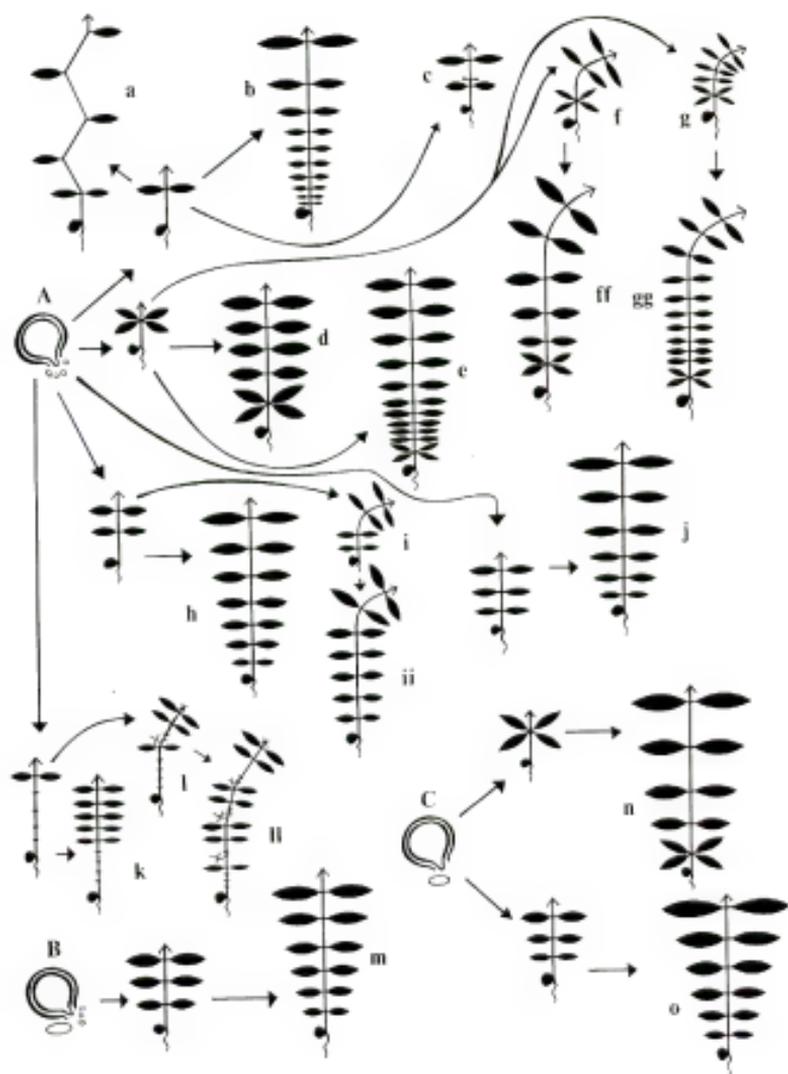


FIGURE 1. Germination, seedlings, and young plants. Capital letters denote germination types, lower case letters show young plant types (double letters denote older stages), the seedling types are unmarked. For further explanation, see text.

TABLE 1. Species of *Calophyllum* known to have early growth conforming to the types shown in Figure 1.

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- a. *Calophyllum sclerophyllum*.
 - b. *Calophyllum calaba* var. *bracteatum*, *C. grandiflorum*, *C. moonii*.
 - c. *Calophyllum scribblitifolium*.
 - d. *Calophyllum biflorum*, *C. euryphyllum*, *C. ferrugineum* var. *ferrugineum* and var. *oblongifolium*, *C. sundaicum*, *C. teysmannii* var. *teysmannii* and var. *inophylloide*, *C. tomentosum*, *C. wallichianum* var. *wallichianum* and var. *incrassatum*.
 - e. *Calophyllum brassii*, *C. soulattri* (part), *C. venulosum* (only one seedling known).
 - f. *Calophyllum robustum*, *C. rupicola* variant.
 - g. *Calophyllum gracilipes*, *C. recurvatum*.
 - h. *Calophyllum blancoi* (?), *C. obliquinervium* (growth slow, but habitat dry), *C. tetrapterum* var. *tetrapterum*.
 - i. *Calophyllum rigidum* (seedling internode 0.5-2.7 cm. long).
 - j. *Calophyllum alboramulum* (seedling internodes ca. 1 cm.), *C. papuanum*, *C. pauciflorum*, *C. pisiferum* (two or three pairs of seedling leaves), *C. suberosum*.
 - k. *Calophyllum nodosum*.
 - l. *Calophyllum pulcherrimum*.
 - m. *Calophyllum inophyllum*, *C. tacamahaca*.
 - n. *Calophyllum soulattri* (part), *C. streimannii*, *C. waliense* (seedling internode ca. 1.5 cm. long).
 - o. *Calophyllum neo-ebudicum*, *C. peekelii*.
-
-

GERMINATION. Germination in *Calophyllum* is cryptocotylar: the cotyledons remain more or less enclosed in the stone, and the hypocotyl is short. This germination type is likely to be constant throughout the genus. The radicle may emerge in as few as ten days after the fruit falls to the ground in species with thin stone walls, or in as much as three months in species with thicker walls. The radicle is at, or near, the base of the fruit and may emerge during germination in one of three ways.

In the majority of species for which germination is known, the radicle breaks through the stone just to one side of the base (FIGURE 1, A). In species with thick-walled stones, such as *Calophyllum euryphyllum*, the wall adjacent to the radicle is thinner than that elsewhere (FIGURE 6, b), thus facilitating emergence of the radicle. Similar areas of thinner wall can be seen in other species with thick-walled stones (e.g., *C. goniocarpum*, *C. trachycaule*, and *C. vexans*), which presumably germinate in the same way.

A few species with moderately thick to thick stone walls have a basal plug that is pushed out by the radicle during germination (FIGURE 1, C). This plug can be seen both in a longitudinal section of the stone as oblique lines (FIGURE 6, i) and in the surface view of the cleaned stone, usually as a circular area that is lighter in color than the rest of the stone and is sharply demarcated from it. Species with basal plugs do not necessarily have thicker stone walls than those without them; thus *Calophyllum euryphyl-*

lum, which lacks a plug, has much thicker walls than the variant of *C. soulattri*, which has one.

In *Calophyllum tacamahaca* the basal plug is pushed out by the radicle, but the adjacent wall of the stone is also broken (FIGURE 1, B). This is possibly due to the fact that the radicle faces further away from the base of the fruit than is usual in the genus.

SEEDLING. The number and arrangement of the seedling's leaves are of considerable systematic importance (the seedling stages are unlettered in FIGURE 1). However, there is some intraspecific variation in the number of pairs of seedling leaves: *Calophyllum pisiferum* has two or three pairs; *C. papuanum* has two, three, or four. In some species that have two pairs, the internode between these leaves is clearly shorter than subsequently developed internodes, and the four seedling leaves may appear to be verticillate. In some other species the two pairs of leaves are separated by well-developed internodes, while yet other species may be intermediate in this character, as is possibly the case in *C. rigidum*. *Calophyllum teysmannii* nearly always has two pairs of leaves pseudoverticillately arranged, but occasional seedlings have three or more pairs separated by well-developed internodes.

The lowest pair(s) of seedling leaves may be small and soon fall off; this situation is especially common in taxa with three or more pairs. However, such small leaves cannot be confused with the scale leaves of species like *Calophyllum pulcherrimum*.

YOUNG PLANT. After a period when there is no growth, a bud on the seedling grows out and produces one or more pairs of leaves before growth stops again. There is considerable taxonomically useful interspecific variation at this stage also.

The terminal bud is usually functional. The plant is erect, and the leaves are opposite; all leaves are fully expanded, each pair being separated by well-developed internodes. The single example (*Calophyllum sclerophyllum*) in which the young plant has alternate leaves needs confirmation.

In several species the internodes of the young plants are short, often less than 1.5 cm. long; only after some time are internodes of greater length produced. The development of such short internodes is genotypically controlled in *Calophyllum soulattri* (Stevens, 1974) and probably also in *C. brassii*, *C. gracilipes*, *C. grandiflorum*, *C. recurvatum*, and *C. venulosum*; in all of these species each flush may consist of only a single pair of leaves, and the increase in height of the plant is slow. However, young plants of many species may appear to grow like this when occurring in unfavorable habitats, and the young plants of species with small fruits may initially produce rather short internodes. As a result, observation of this character is difficult.

Species with either long or short internodes may have an initially more or less plagiotropic stem. The leaves tend to be arranged in two ranks along the stem because of twisting both in the internodal regions and of the petioles. Subsequent straightening of the axis generally occurs within 15 cm. of the stem apex.

In those species in which the terminal bud does not function, growth is by the development of an axillary bud that first produces one or two pairs of scale leaves separated by short internodes, and then pairs of expanded leaves separated by longer internodes; this growth pattern is then repeated and the whole axillary shoot system is more or less plagiotropic. Although it is not clear that the axillary buds in young plants of *Calophyllum pulcherrimum* (in which the adult plant characteristically has such a growth pattern) always produce the first flush, functional terminal buds are absent in plants of slightly greater size on up to the adult. In *Mesua nagassarium* (Burman f.) Kostermans, also of the Guttiferae, the mature plant of which has a similar growth pattern to that of *C. pulcherrimum*, the terminal bud of the seedling is not functional, and growth is by development of axillary buds (pers. obs.).

ARCHITECTURE

Little is known about the developmental stages between the young plant and the flowering and fruiting adult plant, so the diversity of the genus in terms of architectural models (Hallé, Oldeman, & Tomlinson, 1978) is unclear. However, growth of all species appears to be discontinuous, and branching is rhythmic. Most species probably conform to Rauh's model, in which the trunk and branches are orthotropic and the inflorescences are axillary. Species such as *Calophyllum alboramulum* differ only in having terminal inflorescences; they conform to Scarrone's model. Those species in which the stem is initially plagiotropic appear to conform to two subtypes of Troll's model, those that have a functional terminal bud (e.g., *Calophyllum gracilipes*) and those that do not (e.g., *C. pulcherrimum*).

HABIT, TRUNK, AND BARK

There are numerous characteristics of the trunk and bark that help one to distinguish between and recognize species in the field. Henderson and Wyatt-Smith (1956) have compiled a useful table of miscellaneous field data, including these characters, for the species from Malaya and Singapore.

Species of *Calophyllum* are usually trees, often with a clean, straight bole (FIGURE 2, a, e). Species such as *C. nodosum* (FIGURE 2, c) may form shrubs, but there is considerable infraspecific variation in habit. Some species, such as *C. rufigemmatum*, habitually reach a larger size than others. Observations on the way the branches are held are few, but there is clearly interesting variation. Species such as *C. peekellii* have erect branches, twigs, and leaves, while in species such as *C. pulcherrimum* and *C. rigidum* at least the smaller branches are pendulous.

Throughout the genus, presence or absence of stilt roots, flying buttresses, or plank buttresses tends to be rather constant within a species. Knee roots, loop roots, or pneumatophores (FIGURE 2, b) are uncommon, occurring only in swamp-dwelling taxa. Although the presence of such characters is often constant in a species, pneumatophores may be found in plants of *C. soulattri* growing in swamps, but do not occur in plants growing elsewhere—a not uncommon phenomenon.

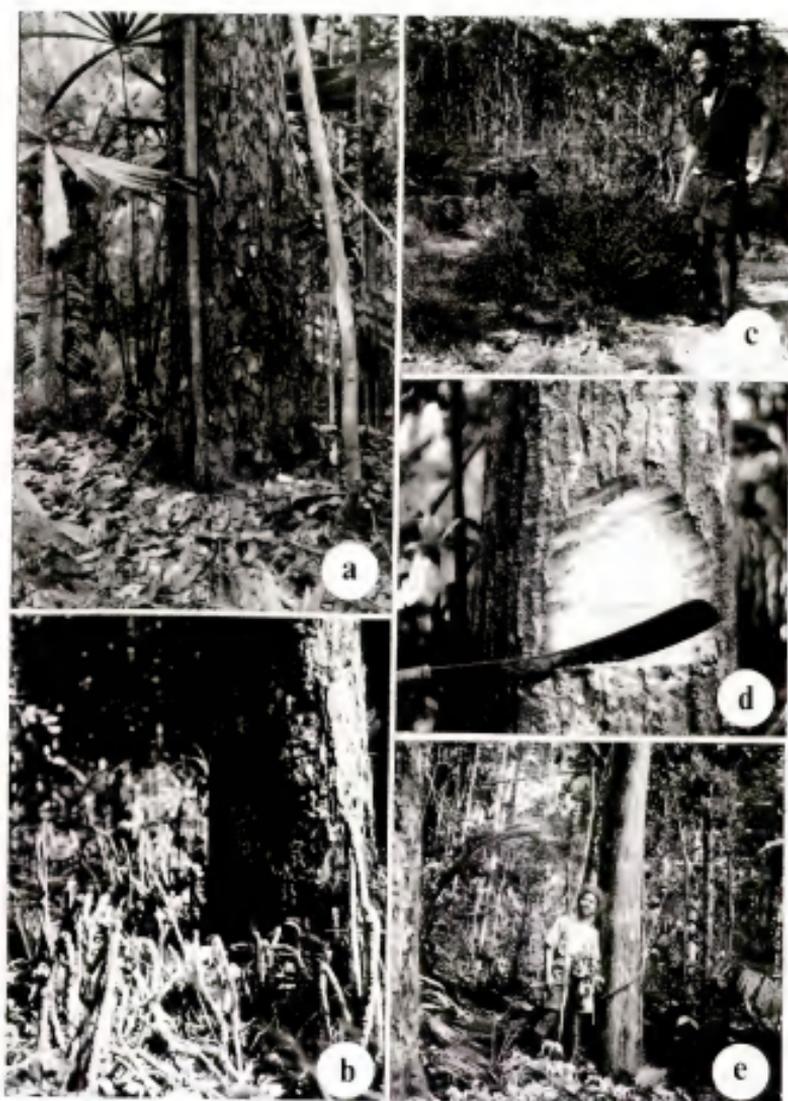


FIGURE 2. Habit, trunk, and bark. a, *Calophyllum teysmannii* var. *inophylloide*; b, *C. ardens* (note pneumatophores); c, *C. nodosum*; d, e, *C. aff. castaneum* (d, note boat-shaped fissures). (Photographs, P. S. Ashton.)

The most useful bark characters include color and texture of the outer bark, color of the inner surface of the outer and of the under bark, and color, amount, opacity, and stickiness of the latex. Plants of many species of *Calophyllum* have distinctive, diamond- to boat-shaped fissures (FIGURE 2, d), especially when young; the fissures may become deeper and confluent with age. The bark of other taxa may be smooth, smooth except for vertical lines of lenticels, or exfoliating in flakes or scales (FIGURE 2, a).

Unfortunately, many of these characters are qualitative. Trunks of *Calophyllum roseocostatum* and *C. tetrapterum* of about the same size have yellowish bark with discrete, diamond- to boat-shaped fissures, yet they are not identical; latex color confirms identification based on the subtle differences between the two. Furthermore, bark color and texture vary considerably with age in some taxa; thus the bark of *C. teysmannii*, although initially smooth, later becomes deeply furrowed, while the bark of such taxa as *C. wallichianum* var. *incrassatum* and especially *C. collinum* remains fairly smooth even in moderate-sized trees. The color of the latex in twigs and fruits often differs from that of the trunk, and this difference may be responsible for some of the infraspecific variation recorded for latex color. It is difficult to interpret other people's field notes; hence, the description of the bark and trunk characters prefacing each species should be treated with caution.

LEAF ARRANGEMENT AND SHOOT GROWTH

In the arrangement of leaves and the growth of the shoots, there are numerous taxonomically important characters, practically all of which have been overlooked in earlier studies.

The leaves are nearly always opposite and decussate, as is characteristic of most of the Guttiferae, but leaves of *Calophyllum caledonicum* may be opposite, truly whorled in threes (cf. Planchon & Triana, 1862b), alternate, or adjacent (in pairs at a node, but not opposite). All these arrangements may occur on a single shoot, although the leaves are usually wholly decussate, or rarely wholly whorled. Sporadic variants with the leaves in whorls of three also occur elsewhere: I have seen seedlings of *C. pulcherrimum* with such whorled leaves. More important variation occurs in young plants of *C. sclerophyllum*, in which the leaves are borne singly and the stem is zigzag; the adult plant has decussate leaves (see also above). This observation needs confirmation since it is uncommon for any Guttiferae outside the Kielmeyeroideae to have alternate leaves at any stage of their life history (see Engler, 1925; Willis, 1974). Exceptions occur in some West African species of *Psorospermum* Spach (Hypericoideae) such as *P. alternifolium* Hochr. (N. K. B. Robson, pers. comm.) and perhaps in seedlings of *Paramammea* Leroy (Calophylloideae; Leroy, 1977).

The internodes on each innovation are usually of similar length, and leaves at each node are fully expanded. However, there is consistent variation in internode length along each innovation and/or in the development of the leaves in some species.

In a number of species the first pair(s) of leaves of the axillary innovations

are reduced to scales and are separated from the main stem and from each other by very short internodes that are usually less than 5 mm. long; the other pairs of leaves of the innovation are fully expanded and are separated by well-developed internodes. Although scale leaves are usually supposed to be absent in the Guttiferae (see, for example, Hutchinson, 1969), they occur in a number of western Malesian species of *Calophyllum*, primarily in the *C. garcinioides*, *C. pulcherrimum*, and *C. pyriforme* groups. (The first and last of these groups have functional terminal buds; in the *C. pulcherrimum* group the terminal bud rarely functions, and growth is primarily by the development of axillary buds.) These scale leaves are caducous and are best recognized on herbarium specimens by the scars that they leave (FIGURE 7, b); in species with stout stems and infrequent branching, they are difficult to observe.

Intraspecific variation in the presence of scale leaves may occur (e.g., in *Calophyllum macrocarpum*, *C. pisiferum*, and *C. tetrapterum*). Scale leaves occur at least sometimes on axillary innovations of very young plants in several species (e.g., *C. biflorum*, *C. rigidum*, *C. novoguineense*, and *C. tomentosum*), but are lacking on adult plants of these species. They are found on terminal innovations of young plants of *C. scriblitifolium*, but whether or not they occur in mature plants is unknown; they are occasionally found on young plants of *C. recurvatum* but not in the adult plant. There are also the fairly general tendencies for the first internode of the innovation to be shorter than the others and for the first pair of leaves to fall off early. Although more observations on young plants—as well as on adult material—at a suitable stage (just after an innovation has begun to grow) are needed, the presence of scale leaves and associated short internodes is an important taxonomic character and is very useful in identifying sterile material.

The first-developed internode of axillary innovations in *Calophyllum pervillei* and *C. milvum* and its relatives (all from Madagascar), and in *Calophyllum praetermissum* (Borneo), is notably longer than the others; subsequent internodes are approximately equal in length (FIGURE 3, c). A similarly long "basal" internode occurs in *Calophyllum* sp. 61⁴ (FIGURE 3, e), but this internode is not the first produced in the innovation. In other species the last internode of an innovation may be so reduced as to be almost absent (e.g., only 1.5 mm. long); the four leaves of the terminal group then appear to be pseudoverticillate (*C. verticillatum* and *C. chapelieri*, both from Madagascar). Less extreme reduction occurs in such species as *C. cuneifolium* (Sri Lanka), *C. obliquinervium* (West Malesia), and *C. ceriferum* (Vietnam). The seedling of *C. obliquinervium* does not have pseudoverticillate leaves (see above), but details are unknown for the other species.

Some of the variation described above correlates with certain more dynamic aspects of shoot development that, unfortunately, are very poorly known. Although in many species of *Calophyllum* each innovation consists of several pairs of leaves (FIGURE 3, a), some species, probably including all those with

⁴Species with numbers, but no names, are not described formally; the number refers to the Species Accounts.



FIGURE 3. Shoot growth. Arrows denote start of most recent innovation. For explanation, see text.

well-marked horizontal lines at the nodes (FIGURE 7, a; see also below), usually produce only one or two (rarely more) pairs of leaves per innovation (FIGURE 3, c). Such species include *C. aureobrunnescens*, *C. calaba*, *C. euryphyllum*, *C. leleanii*, *C. moonii* (young plant also), *C. papuanum*,⁵ *C. pauciflorum*,

⁵Observations on these species kindly confirmed by K. Damas and E. E. Henty (pers. comm.).

C. persimile (young plant also), *C. rufigemmatum*, *C. soulattri* (young plant also),⁵ *C. suberosum*, *C. teysmannii* var. *teysmannii* and var. *bursiculatum*, and *C. vexans*. It is interesting to note that although adult plants of *C. teysmannii* var. *inophylloide* produce many leaves each flush, this is not so in the young plant; plants of *C. wallichianum* var. *incrassatum* apparently show similar variation. The taxa that produce few leaves each flush seem to do so largely independent of the vigor of the plant.

Hallé *et al.* (1978) distinguish two types of branch development, prolepsis and syllepsis, that are often correlated with the morphology of the shoot. Both types occur in *Calophyllum*, although there is no easily observable morphological correlation. At least sometimes in *C. inophyllum* and *C. brasiliense* Camb., axillary shoots are sylleptic, developing without an obvious pause and also contemporaneously with the axis from which they arise; however, the first internode of such shoots is not notably elongated as seems to be common in sylleptic shoots. *Calophyllum depressinervosum*, *C. nodosum* (FIGURE 3, b), and *C. pulcherrimum* all have proleptic shoots; the shoots develop from buds that have undergone a period of rest, and there are basal scales. All taxa that are recorded as having such basal scales probably show this type of growth pattern (see also FIGURE 3, c). In all taxa that produce a single pair of leaves per innovation (and in many that produce several pairs), the buds are proleptic in the timing of their development, but there are no basal scales; the first internode of the axillary innovation may be slightly shorter than the first internode produced by the terminal bud (FIGURE 3, a, c). Finally, in *C. praetermissum* and *C. milvum* (in the latter only probably), the first internode produced by the proleptic axillary bud is notably longer than those subsequently produced (FIGURE 3, d).

INDUMENTUM AND HAIR TYPE

With the possible exception of the poorly known *Calophyllum* sp. 73, the buds of which consist of imbricate scales (see below), all species have some indumentum, at least on their buds. In some species that have scale leaves at the bases of the innovations, the terminal buds tend to be glabrous, or to have hairs only at the edges of the bud scales. In these species, there can be great variation in the development of the indumentum on the terminal bud either on different specimens (*C. garcinioides*) or on a single specimen (*C. nodosum*). In specimens of *C. depressinervosum* from Borneo, the lateral buds also tend to be glabrous. Generally speaking, the more coriaceous and less leaflike outer pair of bud scales have obvious indumentum.

A number of species characteristically have indumentum that is either very well (e.g., *Calophyllum molle*) or very poorly developed (e.g., *C. inophyllum*), or distributed distinctively on the plant (e.g., *C. insularum*). However, many species (e.g., *C. collinum*, *C. rubiginosum*, *C. soulattri*, and *C. teysmannii*) display considerable infraspecific variation in the development and distribution of indumentum. In *C. euryphyllum* and *C. robustum* the indumentum of young plants observed is less well developed than that of adults, although a single individual has not been followed throughout its life.

Of much greater taxonomic importance is hair structure. Vesque (1893)

described in detail the hairs of 31 of the 35 species that he treated; he had illustrated hairs of 27 species in his earlier (1889) work. Hair structure has otherwise been almost completely ignored, although, as will become apparent below, it shows a great deal of taxonomically important variation.

A microscope is needed to observe hair structure, since in many species the hairs are only about 40 μm . long. Hairs can be scraped from the terminal bud and mounted in water. Since they are brittle, they often break; thus Vesque did not describe the interesting basal portion of the hairs of *Calophyllum soulattri* (his *C. spectabile*) or *C. pentapetalum* (his *C. amplexicaule*, *C. buxifolium*, and *C. pseudotacamahaca*). In the present study hairs were examined by means of both ordinary and polarized light; the specimens examined covered both the morphological variation and the geographic distribution of the species.

Describing the hairs is difficult because their shape is basically irregular. Terms currently used for different hair types (Payne, 1978) offer little help, yet there is no point in coining new terms. In all species the hairs are basically uniseriate, and in many they are more or less adaxially curved. Even in species with long, apparently straight hairs, the cell arrangement at the very base may give an indication of this adaxial curvature (e.g., *Calophyllum cucullatum*, FIGURE 22, a, b). Some cells near the base are usually papillate; the papillae of individual cells project and are often restricted to, or better developed on, the abaxial surface. Rather short (less than 300 μm .), adaxially curved hairs with basal papillae (FIGURE 9) are the most common type in the genus. In a few species with small hairs, the papillae cover the hair and make the cell arrangement beneath invisible (*C. subsessile*, FIGURE 29, n). Even in some species with long hairs, all the cells may be papillate, although there is often infraspecific variation in the development of these papillae (*C. venulosum*, FIGURE 29, o-q, s-u).

Some species (e.g., *Calophyllum bracteatum*, FIGURE 13, e-g; *C. teysmannii*, FIGURE 25, l, m) have hairs with one, or sometimes more, basal branch(es); these branches are formed from at least one cell. The apex of the hair sometimes appears to be forked because of a large apical papilla or branch. In the group of taxa related to *C. undulatum*, the branch at the base is often unusually prominent, and the hair may be almost mesifixed (FIGURE 33, q). Some species (e.g., *C. alboramulum*, FIGURE 9, a-d) have several branches or large papillae. In others (e.g., *C. hosei*, FIGURE 26, p, q) the hairs may be almost stellate. It should be emphasized that the distinction between papillae and branches is not clear cut, and species that habitually have strongly papillate hairs will often have a few branched ones as well.

The basal cells of the hairs tend to be narrow, while the distal cells are usually somewhat wider, becoming narrower and longer toward the apex. The basal cells usually have thicker walls than do the other cells; very occasionally, as in *Calophyllum pyriforme* (FIGURE 27, b), all the cells have unthickened walls. In some species, especially those with longer hairs, the occurrence of thin-walled apical cells seems to be an inconstant character, but in others, such as *C. coriaceum* (FIGURE 19, a-c) and *C. tomentosum* (FIGURE 11, l), the apical cells are habitually little thickened. The unthickened,

air-filled cells at the tips of the hairs of *C. costulatum* give the terminal bud a pale color, but in most cases the brown cell contents, probably tannins, make the bud darker.

The transition between the thicker-walled basal cells and the thinner-walled, longer, apical cells is usually gradual. However, in *Calophyllum rubiginosum* the apical cells are much broader, and in shorter hairs "stalk" and "head" are clearly distinguishable. Some hairs of *C. insularum* show an abrupt transition between swollen, rather thin-walled, apical cells and smaller cells with thicker walls. In *C. rufigemmatum*, as well as in *C. ferrugineum* and some of its immediate relatives, the cells toward the base are short, thick walled, and as is usual, slightly birefringent under polarized light; the two apical cells are much elongated, broader, very thick walled, and strongly birefringent (FIGURE 18, k, n). *Calophyllum castaneum* and some of its relatives are similar, although the thickening of the apical cells is less evident.

The cell walls are usually oriented transverse to the long axis of the hair. However, in *Calophyllum cucullatum*, *C. rufigemmatum*, and a few other species, a single cell wall is rather consistently oblique.

Apart from the papillae, the surface of the hair varies from smooth to rugulose. Surface ornamentation is especially prominent in *Calophyllum undulatum* and its relatives, *C. thorelii*, *C. robustum*, and some other taxa. In species such as *C. robustum*, the cell surface may be striate.

There may be considerable variation in the hairs from a single terminal bud, since they are often densely packed and show variable development. This factor, coupled with the general irregularity of hair structure, can cause every hair on a slide to differ. Some of this variation is taxonomically helpful, since it may suggest a hair type common elsewhere in the species or in a related one (e.g., *Calophyllum goniocarpum*, *C. neo-ebudicum*, *C. leptocladum*, and *C. venulosum*). On the other hand, *C. soulattri* and *C. leleanii*, which have been frequently confused, have basically different hair types, despite occasional reduced hairs found in the former that suggest the hairs of the latter.

I have emphasized the structure of the hairs on the terminal bud, since in many species hairs are not commonly found elsewhere. However, because most species have naked buds (i.e., there are no bud scales), it is perhaps not surprising that relatively little variation is found when different parts of the plant are examined. Although the characteristically bifurcate hairs of *Calophyllum collinum* are more common on the terminal bud than elsewhere, this is a difference of degree only. Some specimens of *C. rubiginosum* have dimorphic hairs—albeit of the same basic type—on the stem; that this dimorphism is not apparent on the terminal bud is probably due to the spatial constraints there. The hairs on the inflorescence are of the same basic type as those on the terminal bud, although they tend to be smaller and less papillate or branched and to have thinner walls (e.g., FIGURE 27, cf. o, p). Hairs on the ovary and stamens are still more simple in structure.

Intraspecific variation in hair type is generally variation on a theme. In some taxa, such as *Calophyllum biflorum* and *C. teysmannii*, the hairs range from a structure similar to a morulus (moruloid) ca. 30 μ m. across to distinctive

hair types over 1 mm. long; similar reduced types occur on young plants of *C. euryphyllum* and *C. robustum*. All such moruloid hairs are superficially similar, although there may be differences in the ornamentation of the cell wall.

Despite the problems dealt with above, hair structure basically correlates with taxonomic groupings. In some cases where there is considerable variation in hair type (e.g., *Calophyllum canum*, *C. scriblitifolium*, and perhaps also *C. polyanthum*), the limits of the species are unclear. On the other hand, there is relatively little variation within *C. soulattri*, despite the broad limits adopted here for that species. Species believed to be related on other morphological grounds usually have similar hair structure, and infraspecific variation is not discontinuous. Hair type is thus a valuable aid in the circumscription of taxa, in identification (especially of sterile material), and in suggesting and confirming relationships.

TWIG AND BUD

Characters of the twig, such as thickness, angling, presence of horizontal lines at the nodes (see above; FIGURE 7, a), color on drying, development and persistence of the indumentum, and hair type, are all useful in characterizing a species, although there is considerable variation in many of these characters. The axillary buds are usually small and inconspicuous, although in species such as *Calophyllum rigidum* those that give rise to inflorescences are notably plump. In a few species (e.g., *C. rupicola*), the axillary buds are supra-axillary in position. There are sometimes two buds in the uppermost leaf axils (e.g., *C. euryphyllum*, *C. bifurcatum*); the upper bud of the pair is the larger.

The shape and size of the terminal bud is fairly constant within a species and is of great help in identifying sterile material. The terminal bud is naked in most species and is nearly always densely covered with crustaceous to tomentose indumentum. In *Calophyllum papuanum* and its relatives the bud is strongly flattened since the blades of the leaves forming it are somewhat expanded (FIGURE 4, a). In several species the bud is enclosed by scales that do not expand, and in the imperfectly known *Calophyllum* sp. 73, the scales are clearly decussate and glabrous. The bud may be borne a little way above the uppermost pair of expanded leaves on a short length of stem that develops before growth ceases. This underdeveloped internode is conspicuous in some species, and it becomes of normal length when growth resumes.

In a few species the terminal bud dies. Axillary buds then take over, and branching tends to be profuse. Such nonfunctional terminal buds occur in *Calophyllum pulcherrimum*, in which the axillary innovations have basal scales, and in the very different *C. savannarum*, in which the axillary innovations lack basal scales (FIGURE 4, d); they probably occur in additional species as noted in the descriptions, but field observations are lacking.

The terminal bud and the associated pair of uppermost axillary buds are usually exposed, but they are enclosed and protected by the bases of the

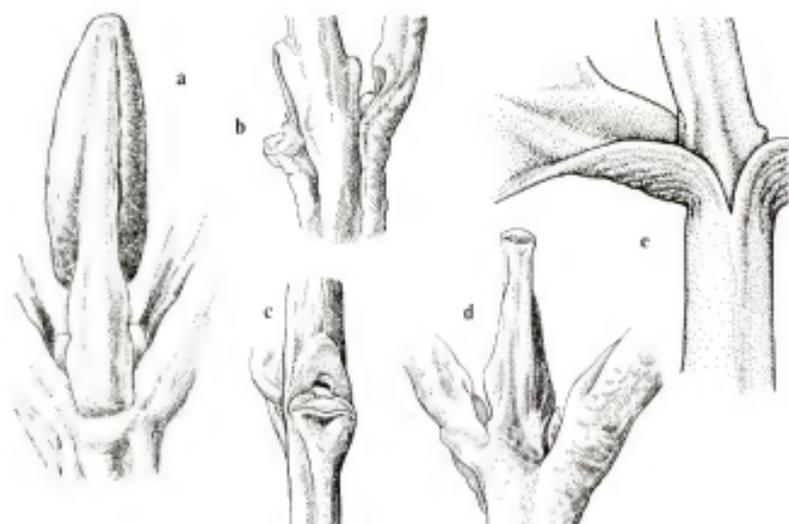


FIGURE 4. Bud and twigs, $\times 3$. a, *Calophyllum papuanum* (NGF 7277), terminal bud. b-d, *C. savannarum* (bb 30477): b, c, node from side and front; d, apex of stem. e, *C. teysmannii* var. *bursiculatum* (S 17230), node from side.

surrounding leaves in species with pseudoverticillate leaves. In a few taxa (e.g., *Calophyllum teysmannii* vars. *teysmannii* and *bursiculatum*, and *C. paniculatum* variants), the uppermost pair of leaves tends to remain erect, and the terminal bud is enclosed by the space formed by the opposing concave petioles. In *C. savannarum* the terminal buds presumably fall off very early (I have seen no specimens with buds), and the axillary buds are enclosed in a pocket formed by a concavity of the stem, which is swollen at the nodes, and an opposing concavity in the petiole base (FIGURE 4, b, c). This condition also occurs in the related *C. articulatum*, which, however, has functional terminal buds.

LEAF

The leaves are always petiolate, albeit sometimes very shortly so. Many species can be recognized by differences in the dried lamina, but the characters are difficult to describe accurately, and some experience is needed to appreciate them.

Lamina shape is generally fairly useful; many species have basically ovate, obovate, or elliptic leaf blades, with only a moderate amount of variation in the shape of the apex. The base of the lamina may vary considerably; for example, from cordate to acute or cuneate in *Calophyllum soulattri*, *C. pentapetalum* (FIGURE 30, h-o), and *C. venulosum* (FIGURE 30, a-g). Especially in *C. moonii*, *C. venulosum* var. *tenuivenium*, *C. vergens*, *C. calaba* var.

bracteatum, *C. macrocarpum*, *C. rigidum*, and *C. lanigerum* var. *austrocoriaceum*, leaf shape and size may differ considerably between young and adult plants. The general tendency for the leaf blades of the young plant to be longer and narrower than those of the adult is carried to an extreme in the last four taxa mentioned above (to 25 by 2 cm. in *C. calaba* var. *bracteatum*, and 50 by 5.4 cm. in *C. lanigerum* var. *austrocoriaceum*).

Important, but more or less qualitative, characters include the texture of the dried lamina, whether or not the whole blade has dried flat, the way the margins dry, the color of the upper and lower surfaces, and the prominence of the midrib, venation, and sometimes also the latex canals, which are usually hardly visible. These characters often reflect anatomical differences (Stevens, 1974a). Reference is made to the color groups in Dade's chart (as given in Stearn, 1973, pp. 240, 241) matched by the dried blade; Ridgway's (1912) charts were used in the matching process, but the detailed data that were collected for all species are not included here. When measuring venation density, one must take care not to confuse latex canals with veins⁶ (Stevens, 1974a) and not to take measurements on poorly developed or damaged leaves. The course of the marginal vein(s) is usually obscured by thickening, although in some taxa (and to a varying degree) a submarginal vein may be distinguishable, as in *C. tetrapterum* var. *obovale*. In this and other taxa the marginal thickening is often well developed and may be up to 1 mm. wide. In some species, notably *C. garcinioides*, there are obliquely and irregularly ascending latex canals on the lower surface of the blade that are superimposed on the normal series of latex canals that alternate with the veins.

Characters similar to those described above are useful in the identification of living material, although they may then appear different. The midrib in a dried leaf may be angled, although it is rounded in a living leaf; raised venation may be invisible. The young leaves may have a distinctive color; thus those of *Calophyllum enervosum* have a broad, red stripe down the middle, and those of *C. rigidum* are white. Variation in this character occurs within *C. teysmannii* var. *inophylloide*. Such characters are usually not mentioned in the accounts or the discussion, but attention should be paid to them by collectors in order to build up a body of reliable observations.

GALLS

Galls, usually on the leaf but sometimes also affecting the stem, have been described from several species in the genus, but no correlation of gall type with taxonomy has been noticed before. However, different types of gall do not occur randomly. Large, pustular galls (FIGURE 5, g) occur on both *Calophyllum chapelieri* and the related *C. verticillatum*, while disc-shaped ones are found on *C. vernicosum* (all three species from Madagascar). *Calophyllum trapezifolium*, from Sri Lanka, has a spherical gall that is bilabiate

⁶Rameji (1967) studied venation development in leaves of *Calophyllum inophyllum*. He found that the marginal veins formed first; then the secondaries, alternate ones of which differentiated to form the latex canals; and finally the tertiaries, which linked the secondary veins and were usually invisible in the adult leaf.

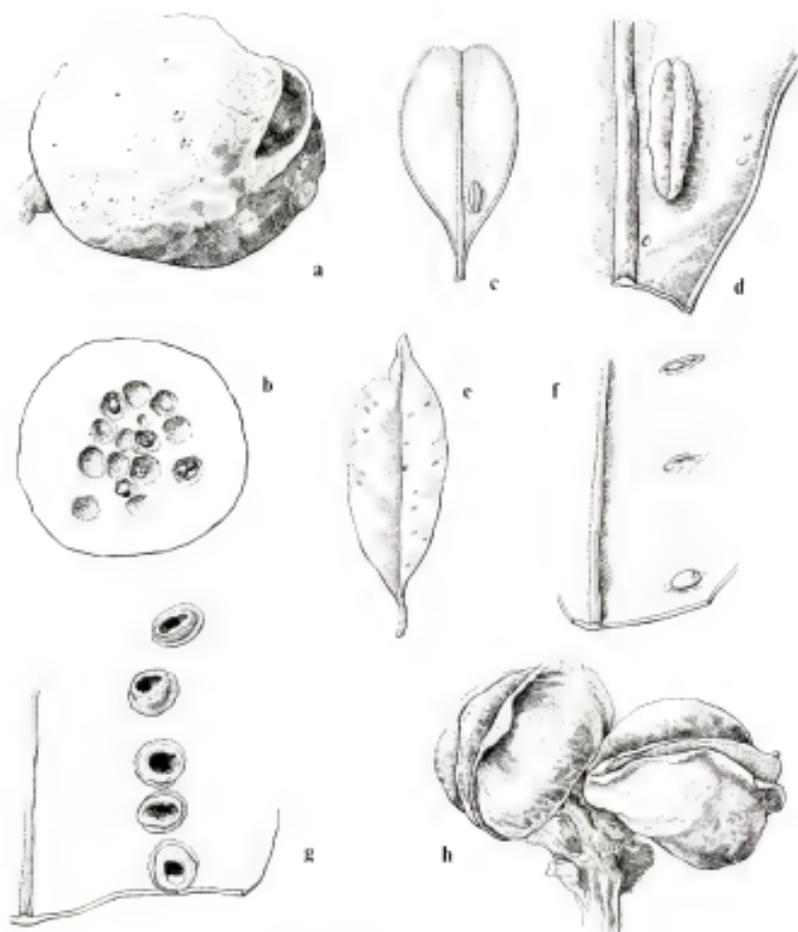


FIGURE 5. Galls. a, b, *Calophyllum trapezifolium* (Kostermans 23599), apex of twig, $\times 2$; a, from outside; b, transverse section. c, d, *C. teysmannii* cf. var. *inophylloide* (Stevens *et al.* 275), underside of leaf: c, $\times 0.5$; d, $\times 2$. e, f, *C. whitfordii* (Williams 639), underside of leaf: e, $\times 0.5$; f, $\times 3$. g, *C. chapelieri* (herb. d'Aleizette *s.n.*), underside of leaf, $\times 2$. h, *C. teysmannii* var. *teysmannii* (Meijer 7057), apex of twig, $\times 2$.

at the apex (FIGURE 5, a, b); this gall is also found on not-quite-typical specimens of the related *C. walkeri*. Both varieties of *C. teysmannii* have a distinctive bilabiate gall (FIGURE 5, h) apparently caused by coccids; similar galls occur on *C. aureum* and specimens tentatively, but perhaps incorrectly, assigned to *C. fraseri*. Slitlike galls (FIGURE 5, d) also frequently appear on *C. teysmannii*.

Small, conoid galls probably produced by gall midges occur mainly on several species from Papuaia, the Pacific, and the Philippines (FIGURE 5, f). They are common on *C. whitfordii* in the Philippines, but are extremely rare on *C. blancoi*, with which the former has been confused. On Fiji they are common only on *C. leptocladum*, a species superficially similar to *C. whitfordii*, but are not known from *C. leucocarpum*, the other small-leaved species that occurs there.

Little is known about the organisms causing these galls. Anthony (1976) described the galls and their causative agents on species of *Calophyllum* from Singapore, and there is some additional information in Docters van Leeuwen-Reijnvaan and Docters van Leeuwen (1926, 1941). This subject would undoubtedly repay further study.

INFLORESCENCE

The inflorescence is determinate (cymose) in all species, with both the main axis and any lateral axes being terminated by flowers. Most species that have terminal inflorescences often have additional inflorescences from the upper leaf axils; since branches are subtended by leaves, and flowers by bracts, the distinction between stem and inflorescence may be unclear. Terminal inflorescences tend to have many flowers, but those of *Calophyllum rotundifolium* have only one or two flowers and lack an axis.

Axillary inflorescences show interspecific differences in size, branching, and disposition of flowers along the axis. There may be from one (*Calophyllum insularum*) to numerous (*C. paniculatum*) flowers per inflorescence; an axis is nearly always present, but it may be absent in the poorly known *C. rufinerve* and some specimens of *C. soulattri* from Papuaia. Although the branching of the inflorescence tends to be a variable character, most species have either branched inflorescences, with or without an additional pair of flowers (developed from supernumerary buds) causing the node to have a flabellate appearance, or unbranched inflorescences, usually without additional flowers. In many species with axillary inflorescences, individual specimens have terminal ones. Solitary, axillary flowers occur only exceptionally, as in *C. calaba* var. *calaba* and *C. rubiginosum*; such flowers are larger than those in normal inflorescences.

The variation in the arrangement of flowers along the axis is similar to that of the leaves along the stem, although the two are not always the same in a species. Species with scales at the bases of the axillary innovations have axillary inflorescences, each with a very short basal internode; the flowers at the lowest node are often not developed. The Papuaian *Calophyllum bifurcatum* and *C. insularum* apparently have scales at the base of the innovations (in the latter not always), yet their inflorescences have a well-developed basal internode. Species in which the axillary innovations have a long basal internode have inflorescences with a correspondingly long basal internode, and some species with "whorled" leaves along the stem (*C. chapellieri* and *C. verticillatum*, for example) have flowers in fours along the inflorescence axis, the internode between adjacent pairs of flowers not developing. However, a number of Malesian species tend either to have

flowers in fours along the axis, or to have terminal groups of five flowers (e.g., *C. costulatum*, *C. heterophyllum*, and *C. rigidum*), but these species lack "whorled" leaves on the twigs.

Bracts are usually small and deciduous, but in a few species they are notably foliaceous and persistent. The length of the pedicel and whether or not it is incrassate in fruit both tend to show considerable infraspecific variation, although some species (e.g., *Calophyllum castaneum* and *C. poilanei*) have notably short pedicels, and others (for example, *C. recurvatum* and *C. mukunense*) have pedicels that always become incrassate in fruit.

FLOWER

The flowers of most species of *Calophyllum* from the Old World appear to be hermaphroditic, the exception being those of some species from Papuaia, which are dioecious and/or gynodioecious (Stevens, 1974a). In staminate or pistillate flowers, pistils or stamens, respectively, are usually present, albeit smaller than usual. However, more observations on the distribution of staminate and pistillate flowers—and on all other aspects of reproductive biology—are badly needed.

There has been much discussion in the past as to whether or not one can recognize sepals and petals in *Calophyllum*, or even if there are any sepals at all in some species (see, for example, Choisy, 1823; Wight, 1840; Vesque, 1893). The morphological distinction between the various members of the perianth has generally been admitted to be slight, as Vesque (1893), Engler (1923), Henderson and Wyatt-Smith (1956), and others have noted. Vesque (1893) used the term "sepals" for the parts of the perianth that were in opposite pairs (he thought that there were only two pairs), and "petals" for the parts that were whorled.

Usually only the outer pair of perianth parts is notably thicker than the others, and they completely enclose the bud; however, in a few species (such as *Calophyllum polyanthum* and some of its relatives) the outer pair is much smaller than the others and does not enclose the bud. In all species the outermost pair is the same color as the inner pair(s), although the color may be modified by indumentum. In size, shape, and sometimes even texture, this outer pair is no more different from the next pair than that pair is from the others. Thus, for descriptive purposes, all are called tepals. Although there are usually only four outer tepals arranged decussately in pairs, with any additional inner tepals being in more or less imbricate whorls of four, a few species (e.g., *C. walkeri* and occasionally *C. blancoi*) have three pairs. Such species would have six sepals in Vesque's (1893) terminology.

Tepal number, shape, size, and indumentum are all of some use in characterizing species; all, however, are variable in some species, and their use as diagnostic or differential features is limited by the paucity of material at anthesis and the often considerable distortion that occurs on drying.

The number of stamens varies considerably in some species, and as more flowering material is collected this variability will doubtless be shown to be greater. It is a tedious (but necessary—see Davis & Heywood, 1963) job counting the up to 600 or so stamens that occur in species such as

Calophyllum blancoi and *C. molle*, and stamen number is not much use as an aid in identification, but within rather broad limits many species have characteristic stamen numbers (see the species pairs *C. molle*/*C. rubiginosum*, *C. canum*/*C. lowii*, *C. recedens*/*C. vernicosum*). The filaments are often somewhat connate at the base—notably so in species such as *C. recurvatum*. The phalangiata arrangement of the stamens, common in many Guttiferae, is not marked in *Calophyllum*, although phalangiata stamens have been illustrated or reported (see, for example, J. J. Smith, 1920; Robson, 1976). The tendency of the stamens to be in four groups may be due not so much to differential connation of the filaments as to the removal of the four innermost tepals during dissection of the flower, this causing four areas of weakness in the tissue on which the androecium is borne; however, studies on the floral anatomy of the genus are needed. Anther size and shape is, again within rather broad limits, characteristic for each species. The presence of indumentum on the anthers of some species is an interesting and hitherto unreported character, but this varies infraspecifically in *C. canum*. A single collection from Malaya has hairs on the filaments (see under *C. rufigemmatum*).

Although the ovary is sometimes hairy, it is generally glabrous; the ovule is basal, anatropous, and almost without exception solitary. The style is nearly always glabrous, but in staminate flowers of *Calophyllum vexans*, although the ovary itself is glabrous, there are a few hairs on the style. The stigma is usually more or less peltate and radiate or irregularly lobed, although in a few species it is slightly expanded or more or less infundibular.

FRUIT AND SEED

The fruits of nearly all species of *Calophyllum* are drupaceous when mature, having a skin, a more or less succulent layer, and a stone; inside the stone is a single seed. In those species where there is no stone in the mature fruit (e.g., *C. eputamen* (FIGURE 6, f), *C. parviflorum*), a thin stone is visible in the young fruit. Corner (1976) described the structure of the fruit of *C. inophyllum*; the fruits of all species appear to be similar in structure. The skin and the fleshy layer are both derived from the carpel wall, but the stone (the endocarp of most workers—see, for example, Cambessèdes, 1828; Smith & Darwin, 1974) develops from the outer part of the seed. Inside the stone is aerenchymatous tissue that is strongly developed in the young fruits of apparently all species but is generally not obvious in ripe fruits. However, in *C. inophyllum* and *C. tacamahaca* in particular, the aerenchymatous tissue (the spongy layer of the descriptions below) persists in the ripe fruit.

The embryo fills the cavity of the stone and consists mainly of two large cotyledons that, although closely adpressed, remain readily distinguishable. The minute radicle points to one side of the base of the fruit, as would be expected of a seed developing from an anatropous ovule. Reports of the radicle facing the top of the seed, away from the "micropyle" (e.g., Bentham, 1863; Cambessèdes, 1828, *pl. 17, c*), are incorrect; this mistake is due to confusion of the pointed cotyledonary end of the seed of *Calophyllum inophyllum* with the radicle (see, for example, Miers, 1855). In those few

species known to have polyembryonic seeds, the embryos are of various sizes and are much intertwined. The embryo is usually whitish, but in *C. suberosum* it is a rather frightful purple. Generally, however, collectors have not mentioned embryo color.

Most earlier workers paid little attention to the structure of the fruit, probably because of the paucity of mature fruits. However, there is much useful interspecific variation in size, shape, and surface of the dried fruit (FIGURE 6, e, g, h), as well as in thickness of the various layers and in texture of the fleshy layer when dry. Fruit characters are usually constant within a species; however, there is considerable intraspecific variation in *Calophyllum macrocarpum* (FIGURE 28, g, h) and *C. soulattri*, at least as presently circumscribed.

There are large air spaces in the fleshy layer (mesocarp—the "outer layer" of the descriptions) of some species when dry. These spaces may be under

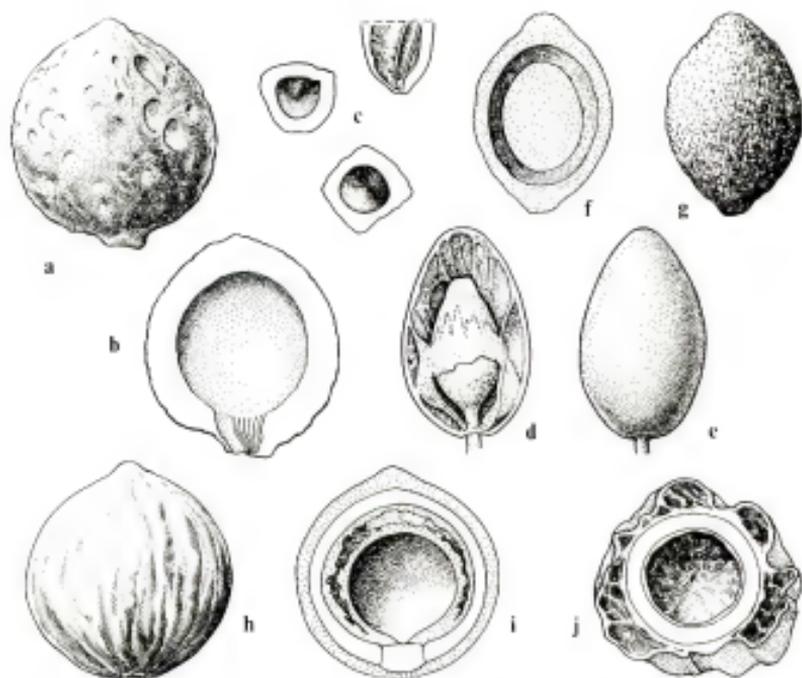


FIGURE 6. Fruits. a, b, *Calophyllum papuanum* (NGF 10331), stone, $\times 1$: a, from outside; b, longitudinal section. c-e, *C. goniocarpum* (bb 33914), $\times 0.75$: c, stone, longitudinal and two transverse views; d, fruit with stone exposed; e, fruit, from outside. f, g, *C. eputamen* var. *eputamen* (Coode et al. 4243), fruit, $\times 0.75$: f, longitudinal section; g, from outside. h, i, *C. peekelii* (NGF 18330), $\times 0.5$: h, from outside; i, longitudinal section. j, *C. macrocarpum* (FRI 10926), transverse section, $\times 0.5$.

the skin, adjacent to the stone, or throughout the outer layer and completely disorganizing it (FIGURE 6, cf. d, i, j). The development of these spaces in older fruits may result in strikingly different, strongly wrinkled submature and smooth mature fruits, as in *Calophyllum dioscurii* and *C. incumbens*; the skin of fruits with large air spaces under it is, not surprisingly, brittle. However, how the air spaces form is not known, and their taxonomic significance is not always clear, owing to the paucity of material with fully ripe fruits (see especially *C. neo-ebudicum* and *C. vittense*).

The stone furnishes numerous characters of systematic use. It is angled in *Calophyllum trachycaule* and a few closely related species (FIGURE 6, c); and either rounded or angled (the latter only at higher altitudes) in *C. papuanum*. A number of species have two to four radiate markings coming from the apex of the stone (FIGURE 17, h); these are especially noticeable in the *C. venulosum* complex. However, this character is not always easy to observe, especially in those taxa in which the outer layer does not detach cleanly from the stone. Other useful characters of the stone include apex shape (rounded, pointed, or retuse), surface texture (smooth or rough—FIGURE 6, a), and presence or absence of a basal plug. Compared to the rest of the stone, the basal part is often paler in color and somewhat different in texture in several West Malesian species (e.g., *C. rufigemmatum* and *C. dasypodum*), but a true plug (i.e., a circular area that is demarcated by a line of weakness in the stone and that is pushed out by the radicle during germination) is, except in *C. inophyllum* and *C. tacamahaca*, so far known only from Papuanian and Pacific species. There is infraspecific variation in the presence of a plug in *C. soulattri* as delimited here.

ANATOMY

WOOD. The literature on the wood anatomy of *Calophyllum* is rather scattered, but it appears that interspecific differences are minimal, even when very different species from widely different areas are compared. Authors studying the anatomy of species from the same area have found practically no differences between them (Moll & Janssonius, 1906; Pearson & Brown, 1932). The following description of the wood anatomy has been drawn up mainly from the references cited below (see also Vestal, 1937; Lakhanpal & Awasthi, 1965; Lakhanpal, 1970).

Vessels (lacking to) 2 to 12/sq. mm., 300–1250 by (30–)150–350 μ m. across, usually single, scattered, sometimes in oblique lines, perforation plates simple, pits bordered where adjacent to tracheids and simple or sometimes slightly bordered where adjacent to rays and wood parenchyma, walls ca. 4 μ m. thick; tracheids vasicentric; fibers 450–1680 by 6–20 μ m. across, with walls 2–5 μ m. thick; rays 8 to 15/mm., heterogeneous, with erect central cells and procumbent marginal cells, uniseriate, sometimes partly biseriate or exceptionally triseriate, 140–500 μ m. tall; parenchyma in apotracheal bands, interrupted or not, (1 or) 2 to 9 cells wide, sometimes with crystals, bands varying considerably in density (see Prakash, 1966, for interspecific variation in *C. inophyllum*), paratracheal to almost aliform parenchyma also reported (Fundter & Wisse, 1977).

(Details taken from the following species: *Calophyllum milvum* (Madagascar; Lecomte, 1922); *C. inophyllum*, *C. polyanthum*, *C. soulattri*, *C. calaba* var. *bracteatum*, and *C. apetalum* (India to Burma; Gamble, 1881; Pearson & Brown, 1932; Chowdhury & Ghosh, 1958); *C. calaba* var. *bracteatum* and *C. inophyllum* (Vietnam; Lecomte, 1926); several species of uncertain identity (Malaya; Desch, 1941); *C. inophyllum*, *C. calaba* var. *bracteatum*, *C. dasypodum*, and *C. venulosum* var. *venulosum* (Java; Moll & Janssonius, 1906); *C. canum* and *C. obliquinervium* (Sabah; Burgess, 1966); *C. ?blancoi* and *C. inophyllum* (Philippine Islands; Kanehira, 1924); *C. papuanum* and *C. pauciflorum* (Papuasias; van der Graaff & Baas, 1974); and *C. inophyllum*, *C. insularum*, and *C. ?sil* (Papuasias; Fundter & Wisse, 1977)).

LEAF. Vesque (1889, 1893) illustrated and described the lamina anatomy of the species that he recognized, and Stevens (1974a) gave brief descriptions for the Papuasian species; Schofield (1968) described the petiolar and nodal anatomy of two species; recently D'Arcy and Keating (1979) described the lamina anatomy of species of *Calophyllum* from Panama, including species introduced from the Old World. A number of characters are helpful in delimiting species, including height of the epidermal cells; presence, height, and lignification of the hypodermis; characters associated with the vascular bundles, latex canals, and midrib; width of the marginal thickening, and number of vascular bundles and latex canals that it encloses; and thickening and lignification of the walls of the spongy mesophyll. When most of the spongy mesophyll has lignified walls, the layer of cells adjacent to the lower epidermis often remains unligified, as in *Calophyllum teysmannii* var. *bursiculum*, *C. garcinioides*, *C. rugosum*, and *C. sakarium*. Additional latex canals may occur; in *C. pauciflorum* (Stevens, 1974a) and in *C. trapezifolium* and related species (Vesque, 1893), they are found in the lignified tissue below the vascular bundles; in *C. garcinioides* they are found adjacent to the lower epidermis; and in *C. sakarium* the vascular tissue in alternate vascular bundles is largely replaced by a large latex canal.

Details of the lamina anatomy are given for a few species below; however, although a general anatomical survey of the genus would be of interest, it is outside the scope of the present study. Anatomical characters often help in delimiting some species (Vesque, 1893; D'Arcy & Keating, 1979), but problems may result from infraspecific variation and the unwitting study of juvenile foliage (Stevens, 1974a).

POLLEN

Erdtman (1971) described the pollen of *Calophyllum inophyllum* as being (2- or) 3-colporate, suboblate to prolate-spheroidal, and with a diameter of about 38 μm . Yi-Zhen (1979) gave palynological details of *C. inophyllum*, *C. membranaceum*, and *C. thorelii* (probably *C. polyanthum*) that agree with Erdtman's account; he described the pollen walls as being finely reticulate and at least weakly 2-layered. Preliminary observations on pollen from species from throughout the range of the genus suggest that there is little variation in basic pollen type, although there appears to be some in details of surface

ornamentation; Anderson and Muller (1975) found the pollen of the different peat swamp-dwelling species of northwestern Borneo to be similar. A more comprehensive survey of pollen is underway (Banerjee & Stevens, in prep.).

CHEMISTRY

Hegnauer (1966) has summarized the early chemical work on the genus. There has also been a considerable amount of more recent work, and species from throughout the range of the genus (America, Madagascar, India and Sri Lanka, Southeast Asia, Malesia, Australia) have been surveyed for many types of compounds. Although the broad picture of the variation of some classes of compounds is becoming apparent, the taxonomic implications of this variation is unclear. Interspecific chemical variation in the species from any one area is unknown, and the amount of infraspecific variation is also practically unknown (see also below) except for that occurring in taxa from Sri Lanka (see Sultanbawa, 1973; Gunsekara *et al.*, 1977).

The esters of fatty acids, and also the free acids themselves, are found in large amounts in the seeds. Oleic, linoleic, stearic, and palmitic acids are the main compounds involved, and they are probably found throughout the genus.

Saponins occur in the leaves of *Calophyllum inophyllum* and *C. brasiliense*, and cyanogenetic glucosides have also been reported. Tannins are fairly general in the genus, especially in the bark, and Ashton (1964) noted that the proteins occurring in gelatin solution were readily precipitated by ground-up leaves of several species of the genus that grow in Brunei. Ethereal oils also occur in the genus.

A considerable variety of xanthenes is found in the wood and also in the bark. (Xanthenes are found in some diversity only in the Guttiferae and Gentianaceae.) One of these, jacareubin, occurs in all but one⁷ of the species of the genus so far analyzed, but is very uncommon elsewhere, being known only from a single species of *Mesua* L. (Carpenter, Locksley, & Scheinmann, 1969). Jacareubin is of interest in being a morellin analogue; morellin is an active principle in gamboge, which comes from *Garcinia morella* Desr. (a member of the Clusioidae - Garcinieae) and other species of that genus. There has been discussion as to whether or not jacareubin always occurs in *Calophyllum inophyllum* and other species, or if it appears only with age (Al-Jeboury & Locksley, 1971; Kumar, Ramachandran, & Sultanbawa, 1976); there may also be infraspecific variation in other xanthenes in *C. inophyllum*. References to other works in which xanthenes have been isolated and characterized may be found in Gunsekara *et al.* (1977) and Bhanu and Scheinmann (1975).

The latex of *Calophyllum* is extremely rich in complex coumarin derivatives: 4-phenyl or 4-alkyl coumarins, hydroxy acids, or cyclohexadienone derivatives with phenyl analogues (Gautier, Kunesch, & Polonsky, 1972). The structures of many substances of this type have been proposed (see Gunsekara *et*

⁷The exception in *Calophyllum* is *C. moonii* (Gunsekara *et al.*, 1977, as *C. soulattri*).

al., 1977, for references). Kawazu, Ohigashi, and Mitsui (1968) found three complex coumarin derivatives in the leaves of *Calophyllum inophyllum* to have piscidial activity, and several 4-*n*-propylcoumarins found in *Mammea americana* L. (Calophylloideae) have considerable insecticidal activity (Crombie *et al.*, 1972).

CYTOLOGY AND BREEDING SYSTEMS

Only a single chromosome number is known from the genus, $2n = 32$ in *Calophyllum inophyllum* (Darlington & Wylie, 1955).

In the majority of species, the flowers appear to be hermaphroditic. However, dioecy or some other type of breeding system occurs in the Papuanian species *Calophyllum papuanum* and its relatives and in *C. leleanii* (Stevens, 1974a, the latter as *C. solomonense*). Flowers in the genus are generally reported to be sweetly scented, and to judge by seed set of an isolated tree of *C. papuanum*, the pollen vector may travel 50 meters or so (cf. Stevens, 1974a). The flowers are not obviously adapted to an oligolectic pollinator.

Hybridization may occur; however, close analysis of the situations in which it is suspected is clearly needed. Apparent hybrids between *Calophyllum inophyllum* and *C. paniculatum*, *C. inophyllum* and *C. chapelieri* (both Madagascar), *C. ferrugineum* and *C. teysmannii* (Malaya), *C. teysmannii* and *C. biflorum* (Sarawak), and *C. inophyllum* and *C. caledonicum* (New Caledonia) are discussed under the second-named member of each species pair; see also *C. verticillatum* and *C. parviflorum*.

Polyembryony occurs in three small-seeded species from West Malesia—this is the first report of its occurrence in the genus. It can be recognized by the occurrence of up to six naked embryos forming a close-knit mass in place of the normal single embryo. Polyembryony has been found in *Calophyllum rupicola* (FRI 20873, Malaya), *C. depressinervosum* (SAN 17093, Brunei), and *C. nodosum* (S 25720, Sarawak; Stevens *et al.* 881A, Sabah). In the case of *C. nodosum*, fruits from three adjacent trees were polyembryonic, and up to three embryos were germinating at one time, although one was much larger than the others. The causes of this polyembryony are unknown, but in view of the reports of apomixis elsewhere in the family (see references in Maguire, 1976; also Planchon & Triana, 1862b), apomictic polyembryony is suspected. (It may be noted that polyembryony also occurs in *Mesua*; e.g., in *M. nuda* Kostermans ex T. C. Whitmore—pers. obs.)

From this summary, it is clear that observations on cytology, the breeding system, and hybridization will greatly increase our understanding of the taxonomy and evolution of the genus.

CLASSIFICATION OF THE GENUS

The recognition of taxa in any group in which the members have many characters in common is something of a problem, and the suspicion that some species of *Calophyllum* may be apomictic has not eased the situation. The heightened similarities caused by ecological convergence, particularly

notable in the small-leaved montane species (see *C. clemensorum* and *C. vergens*), make it very easy for one to be misled by superficial resemblances, and misidentifications are numerous in the literature. Specimens cited under a taxon described from Malesia should have been referred to four other taxa, while specimens of a fifth taxon were annotated with the same name but not cited; the five taxa are not closely related. A particularly good example of confusion caused by close superficial similarity is the recognition that two species were included in my original concept of *C. suberosum* (Stevens, 1974a; see *C. persimile* below).

DELIMITATION OF SUPRASPECIFIC TAXA

Vesque (1893), in part following such earlier workers as Choisy (1823, 1824) and Planchon and Triana (1862a), recognized sections and smaller, but informal, groupings in his classification of the genus; these were based mainly on tepal (sepal and petal) number, the presence or absence of a hypodermis, and other details of anatomy, hair structure, and inflorescence type. Anatomical characters, of course, cannot be used by themselves to delimit taxa (but see Vesque's section *Hypodermata*), and none of these characters correlates particularly highly with other ones; nor, indeed, is the distinction between the various states of each character very sharp (see the preceding discussion). Hence supraspecific taxa are not recognized here.

One of the more distinctive groups of taxa is that centered around *Calophyllum pyriforme*. All taxa in this group have similar, stipitate fruits with a fibrous outer layer and a very thin-walled stone, as well as axillary innovations and inflorescences with basal scars. However, these characters are found individually in other species or species groups. Thus, there are two other main groups of species with axillary innovations and inflorescences like those of the *C. pyriforme* group; one is centered on *C. nodosum* and the other on *C. garcinioides*, but neither is otherwise obviously related to the *C. pyriforme* group (for instance, they have very different inflorescences and fruits). Unfortunately, germination, seedlings, and young plants are known in only one of the groups, and here only in two species (*C. nodosum*, *C. pulcherrimum*); when they are more widely known, they may help to delimit these and other groups of related species.

All that can be recognized above the species level are groups of taxa, the members of which are clearly more related to one another than to any other taxa or groups of taxa.

DELIMITATION OF TAXA AT AND BELOW THE RANK OF SPECIES, AND ITS IMPLICATIONS

Studies of any widespread lowland Malesian group that are finished in under a lifetime of field work must necessarily use morphological characters as the main criteria for the recognition of species. Population size and structure is unknown in *Calophyllum*, and it is unlikely that there will be direct evidence bearing on the size of interbreeding populations or the location of intrinsic sterility barriers throughout the genus. It is premature to attempt to circumscribe taxa on the basis of possession of unique, derived characters; not only is the relationship of *Calophyllum* to other genera of the Guttiferae

unclear (see below), but knowledge of the basic morphology of many of the taxa included in the genus is still poor.

A complaint about the morphological species concept is its element of arbitrariness and inconsistency (although similar complaints can be leveled against other species concepts—see, for example, Sokal & Crovello, 1970), and this is perhaps particularly true when one is dealing with taxa that inhabit different areas. At the present level of knowledge of the genus in most of Malesia, it is easier to recognize slight differences that are correlated with geography than comparable differences between plants in a single locality. Hence, the occurrence of not very different, but non-intergrading, taxa at one locality may be overlooked. The ranking of variation that is correlated with geography has been ably discussed by van Steenis (1957), who listed four criteria to help in this endeavor: comparison of the differentiating characters of the taxa under discussion with those of well-established taxa in the same genus; careful observation; comparison of the variation between the allopatric taxa with that in allied species that have a wide, continuous range ("deductive analogy"); and experimental taxonomy.

Only the first criterion helps directly in establishing the rank of such taxa. "Deductive analogy" is difficult in practice, even if one has correctly identified closely related taxa; a wide-ranging species may show variation in characters the extreme states of which, if not connected by intermediates, would define perfectly "good" species. One cannot reliably extrapolate from one case to another. Experimental taxonomy may produce evidence bearing on the genotypic or phenotypic basis of the characters under discussion, and so reinforce the second criterion, but much evidence will concern an event of a type for which it is difficult to predict an outcome—hybridization if the two taxa were to become sympatric.

If two geographically separated taxa that are recognized as subspecies (or varieties, if subspecies are not being recognized) are later found to grow together and yet to remain distinct, the tendency will be for the same two taxa to be called species. A test for a biological species is being applied in an otherwise morphological context. Darwin's (1859) ideas on evolution did not suggest that the species was more "real" than other taxonomic ranks, nor were his ideas so interpreted by many leading botanical systematists of the day (see Bentham, 1874). Nevertheless, the temptation to treat the rank of species as essentially different from other ranks, or to admit a type of evidence—that is not allowed elsewhere—as deciding specific or infra-specific rank (e.g., van Steenis, 1957; Shelter *et al.*, 1973) has become deeply ingrained in systematics, largely because of the findings of genetics.

As recent work increasingly suggests (see Raven, 1976; Cronquist, 1978; and Levin, 1979, for references), it may be hazardous to assume that the limits of a species that was defined on morphological criteria will correlate with data from ecology, breeding systems, evolution, or geography. However, this does not mean to say that morphology is a biologically inert and meaningless property of an organism; other species concepts face the same problem of non-correlation. A species defined as a group of individuals exchanging genes only within the group has no further *necessary* properties. Suggestions

that a species so defined has properties more like those of an individual than those of a class (philosophically defined—see, for example, Hull, 1978) do not alter this fact. The biological (Mayr, 1969) and evolutionary (Simpson, 1961) species concepts suffer from the same problems, and they, too, are impossible to apply directly to any medium- or large-sized taxonomic group of Malesian plants. The morphological species concept has the virtue of being eminently operational in a situation where the level of knowledge is not far advanced, and of course later on as well.

The species recognized here are delimited by discontinuities in the variation of several of the morphological characters discussed above; varieties show comparable discontinuous variation in only one or two such characters. The extent of the discontinuities and the characters involved affect the rank at which taxa are recognized. Species are often constant over large areas, or if variable, they do not intergrade with others. The limited field observations made suggest that species have relatively invariable and often distinctive bark characters (see also Henderson & Wyatt-Smith, 1956), fruit, germination, and seedling types. Most species have a discrete geographic range (as do varieties), and many have clear ecological preferences. Species that on morphological grounds are thought to be related often differ in both geographic range and ecological preference. Although many species grow together, hybridization is not notably common. Thus, the morphological species in many cases seems to correlate with other types of information, but it must be remembered that morphological evidence has been paramount in species delimitation. As was suggested above, correlations with these other types of information are in a way fortuitous, albeit highly satisfying, but conflicts between the taxon limits that they suggest and those implied by morphological characters must be expected as more becomes known.

The variation in characters of anatomy, fruit, germination and seedling, and bark sometimes may seem not to have been treated satisfactorily. This is not willful inconsistency: in the present state of knowledge of the genus, these characters may be of limited use when unsupported by characteristics that are observable on all, or many, specimens.

As will be clear from the extensive discussion after many species, the rank and even the limits of some taxa remain problematic. Although I have seen over 70 taxa in the field, and the other taxa are delimited by gaps in the variation similar, as far as is possible, to those that separate the taxa that I have seen in the field, such extrapolation is clearly hazardous (cf. Lewis, 1955, quoted favorably by van Steenis, 1959, who suggested that one should somehow allow for "the variation possible" in a species). I have kept doubtfully distinct taxa separate and have fully, but not formally, described taxa that may eventually be worth recognizing but that are poorly known and have no names at present. In all cases, problems are fully discussed, which should make any future adjustments in rank easier (see also Smith, 1979).

Most characters useful in delimiting species nevertheless show considerable infraspecific variation in some taxa; these taxa can still be separated by use of other characters, which themselves break down elsewhere. However,

one cannot argue that, if a given character does not separate a given pair of taxa, or varies at a level below the rank of the taxon under consideration, it therefore cannot be used to separate any taxa at that rank. If such variation is not too frequent, the character may be treated more carefully elsewhere, although not discarded; it is the pattern of variation in the problem under immediate consideration that matters. Many of the vegetative characters (including color of the dry lamina, prominence of venation, and density of indumentum) that make even sterile material fairly easily assignable to a species, especially if the provenance of the specimen is known to within two thousand kilometers or so, are essentially qualitative. Other characters, such as twig thickness and venation density, are quantifiable, but they tend to vary considerably depending on the state of growth of the individual from which the specimen was taken. Although descriptions have been based on plants that can produce flowers, it has not always been possible to exclude specimens from juvenile plants. This may make species boundaries appear to be more vague than they are.

Confirmation that apomixis occurs in *Calophyllum* will be of little help in deciding at which rank to recognize taxa. The types of variation patterns in apomictic groups are as varied as the groups themselves, and they often cannot be incorporated satisfactorily in the normal taxonomic framework. However, it is perhaps unexpected that two of the taxa of *Calophyllum* in which possibly apomictic polyembryony has been detected are closely related, wide ranging, and relatively invariable; they may even grow together on occasion. Systematists working on tropical groups should of course be on the lookout for apomixis, since it may occur quite widely (see Kaur *et al.*, 1978).

These several caveats should be borne in mind when reading the species accounts. It is clear that the inference of evolutionary processes from taxonomic patterns is fraught with problems and with numerous possibilities of circular argument.

EVOLUTION, DISTRIBUTION, AND ECOLOGY

FOSSIL RECORD OF THE GENUS

Prakash (1975) has summarized the literature dealing with the fossil record of the Guttiferae, and that relevant to *Calophyllum* is evaluated here. The record of fruits of *Calophyllum* from the middle Eocene in Rajasthan, India (Lakhanpal & Bose, 1951), must be treated with caution, since although they were compared to those of *C. trapezifolium* (properly *C. austroindicum*), they have no characters that unmistakably mark them as belonging to *Calophyllum*.

Leaves of *Calophyllum*, possibly from the lower to middle Eocene, have been reported from Assam (Bhattacharyya, 1967). Foliar remains of *Calophyllum* have been found in several places in Malesia. *Calophyllum nathorstii* Geyley was found near Palembang, Sumatra, in rocks of the younger Neogene (possibly Pliocene; Krausel, 1929), as well as in Miocene coal of Labuan

(Geyler, 1887; a second, unnamed species that was compared with *C. inophyllum* was also found there). Remains of what is quite possibly a species of *Calophyllum* occur in Tertiary sediments of Java (Göppert, 1854, as *Musophyllum truncatum* Göppert).

The genus *Calophylloidendron* Lakhanpal & Awasthi, based on fossil wood, seems similar to *Calophyllum*. Three species, *Calophylloidendron cuddalorensis* Lakhanpal & Awasthi, *C. eoinophyllum* Prakash, and *C. indicum* Lakhanpal & Awasthi, have been described. Remains of the genus have been found in sediments of Upper Miocene age in Assam (Prakash, 1971), the Mio-Pliocene boundary near Pondicherry, India (Lakhanpal & Awasthi, 1965; the comparison of *Calophylloidendron indicum* with the extant *Calophyllum apetalum* is not justified), and the Mio-Pliocene boundary in Assam (Prakash, 1966; the best record).

Calophyllum pollen of late Miocene age is known from Brunei (Muller, 1972; Anderson & Muller, 1975); the genus was then an important component of the peat swamps, and the flora of these swamps seems to be similar to that of swamps found in the same area today. *Calophyllum* pollen may occur in the Eocene in India (as *Calophyllumpollenites rotundus* Sah & Kar; Sah & Kar, 1974), but the record must be confirmed.

There are few early records of the genus elsewhere. *Calophyllum pliocenicum* Krasser was reported from the Pliocene of Brazil (Krasser, 1903; Krasser thought that it was very close to *C. calaba* (= *C. brasiliense*). *Calophyllum calabiformis* Berry was described from the Miocene of Trinidad (Berry, 1925). Wood possibly comparable with that of *Calophyllum* or *Mesua* has been described from the lower Miocene of Egypt (as *Guttiferoxylon fareghense* Krausel; see Prakash, 1975).

RELATIONSHIPS OF CALOPHYLLUM AND MAJOR PATTERNS OF EVOLUTION IN THE GENUS

The immediate relatives of *Calophyllum* in the Calophylloideae - Calophylleae are *Mammea* L. (including *Ochrocarpus* Thouars), *Paramammea* Leroy, *Mesua* (including *Kayea* Wall.), and *Poeciloneuron* Bedd.; this last genus is rather distinct in details of wood anatomy (Baretta-Kuipers, 1976). Although *Mammea* has been placed in the Clusioideae by Robson (in Heywood, 1978) in the belief that the united cotyledons were a swollen hypocotyl,⁸ it is correctly placed in the Calophylloideae (e.g., Planchon & Triana, 1862b; Brandza, 1909; pers. obs.; unpublished studies by S. W. Jones). All these genera have basal ovules. *Mesua* is an Indo-Malesian genus; *Mammea* extends from Africa and Madagascar (de Wilde, 1956; cf. Kostermans, 1961) to Indo-Malesia, with a single species (*Mammea americana*) in tropical America; *Paramammea* occurs on Madagascar; *Poeciloneuron* includes two species, both from western India. *Mesua* has a mid-Tertiary fossil record (Prakash,

⁸Leroy (1975, 1977) distinguishes *Ochrocarpus* from *Mammea* by its embryo, which lacks any trace of organization, and its latex canals; in both characters *Ochrocarpus* is similar to *Garcinia*. The broad circumscription of *Mammea* adopted here is for convenience only; as Leroy (1977) notes, representatives of this group on Madagascar are still poorly understood.

1975) in India; earlier records of both *Mammea* (Late Cretaceous!) and *Mesua* need to be confirmed. The other tribe in the Calophylloideae is the Endodesmieae (see Engler, 1925), characterized by a single apical ovule. It includes two monotypic, West African genera, *Endodesmia* Benth and *Lebrunia* Staner (Staner, 1934). Some of the characters separating these genera are listed in TABLE 2.

Although it is clear from TABLE 2 that *Calophyllum* is easily distinguishable from the other Calophylloideae by its single basal ovule and its nearly always strictly parallel venation, its exact relationship to any of these genera, including members of the Endodesmieae, is unclear. Most chemical and palynological data are presently restricted to the three larger genera of the Calophylleae, *Calophyllum*, *Mammea*, and *Mesua*, but it is hoped that further studies on the subfamily will permit a resolution of the relationships of all the genera.

Vesque (1889, 1893) placed the species of *Calophyllum* in a more or less evolutionary arrangement. He considered that *C. inophyllum* was "le groupe nodal primaire"—a group lacking obvious epharmonic characters that would adapt it to extreme conditions. However, if the lack of bud scales and the presence of a basal plug in the stone are derived characters, *C. inophyllum* may be a member of a not notably primitive group of taxa that diversified most in eastern Malesia (see also below). Moreover, the members of the various groups of species that Vesque recognized in the Old World often do not seem immediately related. Thus, the members of one of his groups (*C. soulattri* (his *C. spectabile*), *C. walkeri*, *C. cerasiferum*, and *C. sclerophyllum*) have a hypodermis, but little else, in common.

Several methods are currently used to assign evolutionary polarity to characters; that is, to determine which character state is advanced and which is primitive. This is not the place to review the value of such methods, except to note that the one that appears to be by far the most satisfactory, out-group comparison, cannot be used here because it is not yet clear what the sister group of *Calophyllum*—and the sister group of this larger group—is, an all-too-common complaint in botanical systematics (Stevens, unpubl. ms.). To compare variation within the Calophylloideae or Guttiferae as a whole is a less rigorous form of out-group comparison that can be used here *faute de mieux*. The suggestion that the common state of a character can be considered primitive within a group in the absence of other evidence (e.g., Estabrook, 1977) is unacceptable since the commonness of a derived character state in a group depends on the subsequent diversification of the monophyletic line that it characterizes (e.g., Stebbins, 1974; Judd, 1979; Stevens, unpubl. ms.). Functional considerations have been much used, as by Vesque (1893), but there is no reason why a character state that is believed to have some adaptive value should be considered derived when compared with the state that has no apparent adaptive value (e.g., Davis & Heywood, 1963). Nevertheless, derived and primitive states are suggested for some characters in TABLE 3 by using these and other suspect criteria. This table is perhaps most useful in stimulating discussion, especially since no polarity has been suggested for the majority of characters.

It would be premature to suggest detailed relationships of the taxa here.

TABLE 2. Some characters distinguishing genera in the Calophylloideae.*

	<i>Calophyllum</i>	<i>Mesua</i>	<i>Mammea</i>	<i>Paramammea</i>	<i>Pociloneron</i> †	<i>Endodesmia</i> ‡	<i>Lebrunia</i>
HAIRS UNISERIATE	+	-	-	?	-	-	-
BUD SCALES PRESENT	-(+)	+ (always)	+	+	+	+	+
VENATION OBVIOUSLY RETICULATE	- (+, very rare)	+	+	+	+	-(+)	+
INFLORESCENCE TERMINAL	-(+)	-,+	- (+, very rare)	-	+,-	+	-
FLOWERS PERFECT	+(-)	+	-(+)	-	+	+	+
"SEPAL" NUMBER	4(2)	4	2	2	2,5	5	4
STAMENS CONSPICUOUSLY CONNATE	-(+)	-	-,+	+	-	+	-
ANTHERS WITH TERMINAL INTRORSE PORE	-	-	-	-	+	-	-
STYLES DEEPLY DIVIDED	-	-	-	+(-)	+	-	-
STYLES LONG	+(-)	+	-	+	+	+	+
OVULE, LOCULUS, AND SEED NUMBER	1; 1; 1	4-8; 1,2; 1 or more	4; 1,2,4; 1 or more	6-10; 6-10; up to 8	4; 2; 1	1; 1; 1	1; 1; 1
OVULE POSITION	Basal	Basal	Basal	Basal	Basal	Apical	Apical
PEDICEL FLESHY IN FRUIT	-	-	-	-	-	+	-
FRUIT DEHISCENT	-	-(+)	-(+)	-	+	-	-

*Data from Staner, 1934; Perrier de la Bâthie, 1948; de Wilde, 1956; Spirlet, 1966; Leroy, 1977, and pers. comm.; Stevens, 1974b, and pers. obs. of all genera except *Paramammea*.

†The two species of *Pociloneron*, *P. indicum* Bedd. and *P. pauciflorum* Bedd., may not be very closely related. The flowering specimen of *P. pauciflorum* seen (*Brause 210*) has two small, outer, persistent tepals, two large, inner, subsistent tepals, and six large, inner, deciduous tepals; the anthers are not locellate (in both species the anthers dehisce, at least initially, by introrse, apical pore slits); and there are colleterlike structures in the leaf axil. For palynological differences, see Seetharam & Pocock, 1978.

‡*Endodesmia calophylloides* has stipulelike structures.

TABLE 3. Possible primitive and derived states of some morphological characters in *Calophyllum*.

SEEDLING AND YOUNG PLANT	
1.	Seedling leaves separated by well-developed vs. shortened internodes.
2.	Leaves opposite vs. alternate.
3.	Growth orthotropic vs. plagiotropic.
4.	Young plant initially with well-developed vs. shortened internodes.
TRUNK AND BARK	
5.	Trunk lacking buttresses, knee roots, or pneumatophores vs. with these structures present.
LEAF ARRANGEMENT AND SHOOT GROWTH	
6.	Internodes separating expanded leaves all of similar length vs. variation within an innovation.
7.	Scale leaves present vs. absent.
HAIR TYPE	
8.	Hairs adaxially curved, rather short, and papillate at base vs. other types.
TWIG AND BUD	
9.	Terminal bud functional vs. abortive.
10.	Terminal bud strongly flattened (with partly expanded blade) vs. more or less rounded.
11.	Terminal bud not enclosed in petiole bases of last pair of leaves vs. enclosed.
12.	Axillary buds not enclosed in pockets formed by stem and petiole base vs. enclosed.
LEAF	
13.	Acute-cuneate-rounded at base vs. cordate or narrowly attenuate.
14.	Midrib raised vs. broadly depressed.
INFLORESCENCE	
15.	Terminal vs. axillary.
16.	Branched and/or flabellate vs. unbranched and with flowers in pairs.
17.	Flowers many vs. few or one.
18.	Axis present vs. absent.
19.	Internodes of approximately equal length vs. some much shorter than others.
FLOWER	
20.	Perfect vs. staminate or pistillate.
21.	Tepals 8 vs. consistently fewer or more than 8.
22.	Hairs on inside of outer tepals absent vs. present.
23.	Ovary or anthers glabrous vs. pubescent.

TABLE 3 (continued).

FRUIT

24. Stone with basal plug lacking vs. present.
25. Embryo whitish vs. purple.

Groups of taxa that can be recognized are discussed below and in the species accounts. Since there is no obviously "primitive" species of *Calophyllum*, the species accounts start with *C. alboramulum*, a taxon with terminal branched inflorescences and thin-walled stones, neither an obviously specialized character. If the presence of bud scales is considered unspecialized (an interesting suggestion; they are common in the Calophylloideae as a whole), *C. garcinioides* or *Calophyllum* sp. 73 might be also considered taxa with several apparently unspecialized characters.

All these putatively primitive taxa are Indo-West Malesian, but the distribution of "primitive" taxa is not necessarily the same as the place of origin of the genus. The same can be said for the equation of the present area of greatest diversity of the genus (and its immediate relatives), also Indo-West Malesia, with place of origin. Although *Calophyllum* may have originated in the Indo-Malesian tropics—possibly by the late Eocene—and spread from there, this is only a tentative hypothesis and lacks critical support.

GENERAL DISTRIBUTIONAL PATTERNS OF TAXA AND CHARACTERS

The New World species must be mentioned briefly to place the discussion in context.

Vesque (1893) recognized only four species from the New World, and there are clearly not many species there. The variation shown is correspondingly less than in the Old World: there is no variation in the distribution of leaves along the stem; there are no bud scales; the inflorescences are habitually axillary and often branched; dioecy probably occurs in some species—e.g., *Calophyllum brasiliense* (Pennington & Sarukhán, 1968); hair structure is basically similar (Vesque, 1893; pers. obs.); fruit variation is slight, although basal plugs (*Fanshaw 2439*—*C. brasiliense*) and thin areas near the base (*Krukoff 7268*—*C. ellipticum* Rusby) occur. The wood anatomy of New World species (Greene, 1932) is similar to that of Old World species. D'Arcy and Keating (1979) noted that *C. longifolium* Willd., from Panama, was similar to *C. soulattri* in details of lamina anatomy; from the data that they and Vesque (1890, 1893) give, species from the two hemispheres are similar in lamina anatomy. The New World species may be derived from a single ancestor originally from the Old World; *Calophyllum* has been in America at least since the Miocene (see above).

In the Old World, *Calophyllum* has a fundamentally Indo-Malesian distribution pattern, with extensions to Madagascar and Fiji. The genus is basically restricted to humid, closed, lowland to colline or sometimes montane rainforest, although a few species grow in drier or more open habitats. Van Steenis

(1949) noted that in Malesia rather young individuals may flower and fruit when in the open, but there are no early successional species in the genus.

MAP 1 shows the regional distribution of *Calophyllum* species in the Southeast Asian/Australian region; distribution maps of individual species are included in species accounts.

Calophyllum inophyllum is clearly a highly vagile strand species (which sometimes also grows inland), and it occurs throughout the range of the genus in the Old World. It shows a certain amount of geographically correlated variation. The Mascarene endemic *C. tacamahaca* seems to be closely related to it, and is perhaps derived from it (see also below).

The origin and relationships of the other endemic species in Madagascar and the Mascarenes are problematic. Perrier de la Bâthie (1948) thought that the species in Madagascar were derived from *Calophyllum inophyllum*; the adaptive radiation that had occurred suggested to him that *Calophyllum* arrived in the oldest of the seaborne invasions of the island. Raven and Axelrod (1974) consider that the genus arrived there by long-distance dispersal. The species growing in Madagascar and the Mascarenes show a moderate amount of diversity, but I know of no unique character that distinguishes them as a group from the rest of the genus. Although several other taxa have distribution patterns like that of *Calophyllum* (see Perrier de la Bâthie, 1948; DeJardin *et al.*, 1973, for examples), little is known about the causes. *Calophyllum tacamahaca*, from the Mascarenes, is probably a local derivative of *C. inophyllum*, while the affinities of *C. eputamen* and the related *C. parviflorum* are unclear.

India and Sri Lanka have no species in common apart from *Calophyllum inophyllum*, although *C. austroindicum*, from the Western Ghats, may be related to the complex of five species in Sri Lanka centered on *C. trapezifolium*. *Calophyllum polyanthum* occurs in the Western Ghats and in northeastern India and elsewhere, a common distribution pattern. *Calophyllum calaba*, from Sri Lanka, is part of a complex also occurring from Vietnam to Australia; there are numerous similar examples, as a glance at *Flora Malesiana* will show.

Many of the species from mainland Southeast Asia are poorly known. *Calophyllum poilanei* and *C. membranaceum* are distinctive species without obvious relationships; *C. rugosum* is perhaps related to the Malayan *C. rotundifolium*, and *C. parkeri* to *C. fraseri* and *C. garcinioides*, both Malesian. There are a few widespread species, and the local *C. lineare* is very closely related to one of them (*C. pisiferum*). The other species are poorly understood or are members of taxonomically difficult complexes that extend into India (*C. polyanthum*) and, perhaps, Malesia (as *C. symingtonianum*).

The species of *Calophyllum* growing from the Isthmus of Kra in southern Thailand to the Pacific and northern Australia can be considered together.

MAP 1. Distribution of *Calophyllum* in Southeast Asia, Malesia, and Australia. Figures within areas: above line, endemic species; below line, total number of species. Figures on lines separating areas: number of species in common between two areas.

Although Malesia as a phytogeographic unit may not include the area from the Solomon Islands eastward (e.g., van Steenis, 1950), the tropical Pacific flora is basically an attenuated Malesian one (van Balgooy, 1960), and the few Australian species of *Calophyllum* can also be included here; they, too, are tropical taxa. The central part of this region has usually been divided into three provinces (van Steenis, 1949, 1950, 1979; van Balgooy, 1960; van Steenis & Schippers-Lamertse, 1965): South Malesia includes the islands from the Tanimber Islands to Java; East Malesia is bounded on the west by Zollinger's line (i.e., it includes the Celebes and the Kei Islands); and West Malesia includes the rest of Malesia.

However, as is clear from reading van Steenis (1950) and van Steenis and Schippers-Lamertse (1965) in particular, the South Malesian Province is separated because its flora is depauperate, although basically West Malesian, and has an admixture of species that do not grow elsewhere in Malesia but occur further to the north. The East and West Malesian provinces, on the other hand, are defined by the large number of genera that occur in only one province, and by the high species-level endemicity in both. Recently, van Balgooy (1976) has proposed combining the West and South Malesian provinces into an extended West Malesian Province (subsequent reference to West Malesia will be in this sense), returning more to the ideas of Merrill (1923) and other earlier workers.

The distribution both of species and of distinctive characters within *Calophyllum* follows this east-west division of Malesia. Only six species (of which *Calophyllum inophyllum* is one) are found in both areas (MAP 1). The variable *C. calaba* var. *bracteatum* grows from Timor westward, and var. *australianum* occurs in Australia; it is clearly a species with wide ecological amplitude that also can grow in drier areas. *Calophyllum soulattri* occurs throughout Malesia; it has small, dark blue to black fruits and is probably dispersed by birds. *Calophyllum laticostatum*, which occurs in New Guinea and possibly also in the Philippines, and *Calophyllum* sp. 129, found on the Moluccas and an island off southwestern Borneo, are related to one another and may have eastern affinities. *Calophyllum wallichianum* var. *incrassatum* is basically West Malesian but may occur on Sulawesi.

Only nine species of *Calophyllum* are recorded from the erstwhile South Malesian Province. *Calophyllum dasypodum*, *C. dioscurii* (known from only a single, sterile specimen in Java), and *C. venulosum* are all restricted to West Malesia. Two species are endemic. *Calophyllum grandiflorum* is related to *C. venulosum*. *Calophyllum archipelagi* is probably related to the predominantly East Malesian *C. laticostatum* and joins the already fairly substantial list of Java-Lesser Sunda Islands endemics (van Steenis, 1979). The widespread, predominantly West Malesian *C. tetrapterum* is known from Bawean and Karimundjawa islands only; the plants of the latter island often have Bornean affinities (van Steenis & Schippers-Lamertse, 1965). *Calophyllum calaba* is predominantly West Malesian; *C. inophyllum* and *C. soulattri* are widespread. Hence, the affinities of *Calophyllum* in South Malesia are predominantly to the north and west. The climate of the Lesser Sunda Islands is rather dry, and Kalkman (1955) showed that the West Malesian floristic

element decreased in importance from west to east in these islands (see also van Steenis, 1979).

The Sulawesi-Moluccas region has more species with affinities to the east than to the west. *Calophyllum celebicum* may be most similar to the West Malesian *C. teysmannii* var. *inophylloide*, but *C. undulatum* and *C. articulatum* are related to eastern species. In addition, six species reach their westerly limit here. However, many species from this crucial area are poorly understood, *C. soulattri* is very variable, and there may be additional undescribed taxa; recent collections from Sulawesi kindly sent to me by G. Musser proved embarrassingly difficult to identify.

Taxa from the Philippines show relationships with those of both West and East Malesia. The relationship with East Malesian taxa, which caused the Dickerson-Merrill modification of Wallace's line so that it passed to the west of the Philippines (e.g., Merrill, 1926), has been emphasized recently by B. L. Burt (e.g., in Ashton & Ashton, 1972, and in R. M. Smith, 1977). *Calophyllum* sp. 121 is perhaps related to the East Malesian *C. neo-ebudicum*. The conoid galls found on the leaves of *C. whitfordii*, in particular, are most common in East Malesian and Pacific species. However, the link with West Malesia is numerically stronger, since five species occur on Borneo and/or Palawan, as well as on that part of the Philippines that has always been insular.

The distribution of five distinctive character states (MAP 2) confirms this basic east-west division and reflects the occurrence of different groups of species in the two areas (cf. Stevens, 1974a). Species that have stones with basal plugs are probably under-recorded. Species with blue to blackish fruits are predominantly East Malesian; about 14 such species occur in New Guinea, but there are only four in West Malesia (*C. polyanthum* and *C. austroindicum*, from southwestern India, may also have blue fruits, but the observations must be reconfirmed). Although it is not known with certainty which character states are derived, none of the "East Malesian" character states is necessarily primitive (see above).

Despite the lack of clear evidence, *Calophyllum* probably moved from West to East Malesia as continental drift brought the Australian plate near Southeast Asia 15 to 20 million years ago (Raven & Axelrod, 1974; van Balgooy (1976) and van Steenis (1979) suggest that there may have been earlier floristic contact). Diversification in East Malesia has been subsequent to this movement.

The difference between the species of *Calophyllum* in the two halves of Malesia may be a partial reflection of this circumstance, East Malesia being colonized by only a few taxa. As has long been known (e.g., Merrill, 1926), many of the islands in West Malesia were interconnected at various times during the Pleistocene, and others were much less isolated then; most of the Philippine Islands remained separate, although Palawan was connected to Borneo. There was a similar extension of land in East Malesia, although islands such as New Britain, Sulawesi, and the Moluccas have always been isolated. Hence, the two halves of Malesia have remained separate, but the greater affinities of the species from Sulawesi and the Moluccas with East,

rather than West, Malesian species and the relationships of those from the Philippines still pose problems.

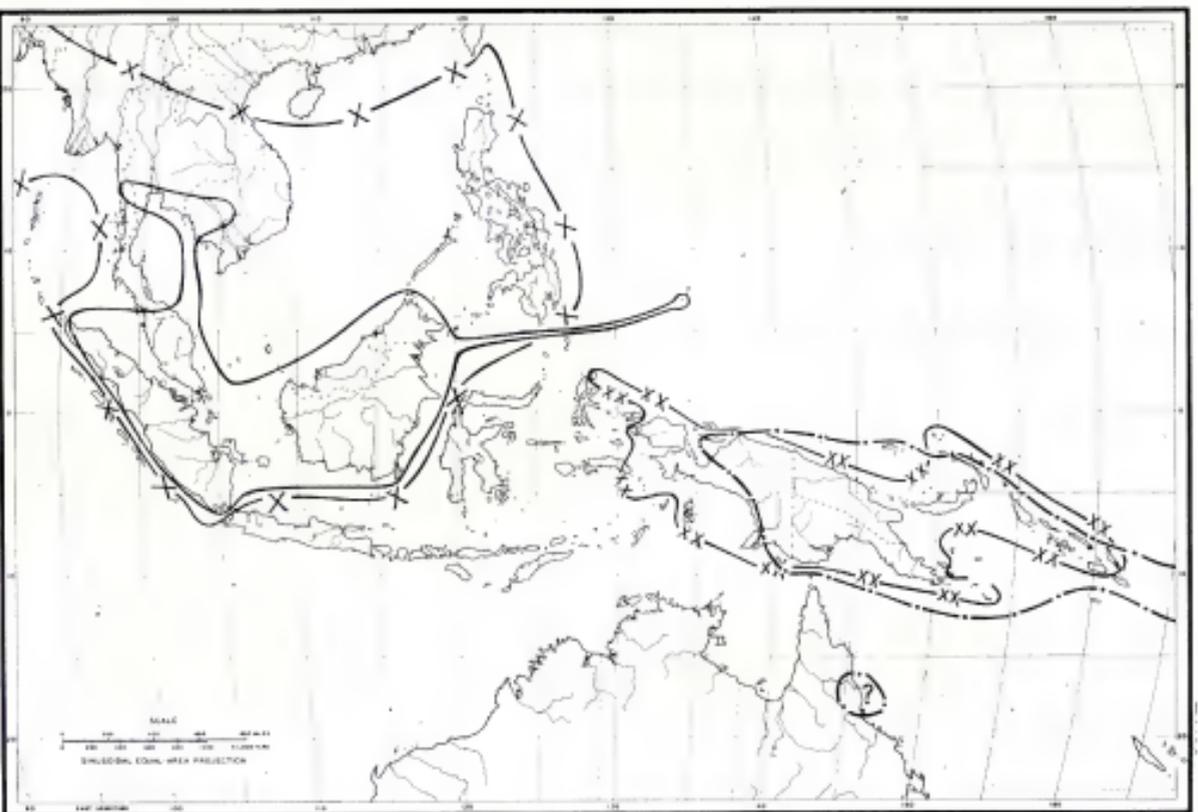
Within the West Malesian area, 28 species are centered on the Sunda Shelf, occurring on mainland Sumatra and/or Malaya as well as on Borneo, and several others are clearly related to this element. The relationships of the Malay *Calophyllum*-flora are at least as much with that of the relatively distant Borneo as with the closer Sumatra, a not uncommon pattern (Keng, 1970; see also the accounts of *C. alboramulum* and *C. fraseri*). Endemicity is high in Borneo, less high—and mainly in montane species—in Malaya, and low in Sumatra. Within the East Malesia-Pacific region, endemicity is highest in New Guinea, but local endemics occur throughout the area.

Guppy (1906) suggested that *Calophyllum burmannii* (properly *C. cerasiferum*) and *C. spectabile* (properly *C. vitiense*), both from Fiji, were dispersed there by fruit pigeons, rather than being derived from the local *C. inophyllum*, also from Fiji; Smith and Darwin (1974) thought that at least some species in the Fiji-Samoa area might have arisen from *C. inophyllum*. Although *C. vitiense* and *C. cerasiferum* may be derived from a taxon other than *C. inophyllum*, all three taxa have stones with basal plugs; such taxa preponderate in East Malesia and the Pacific, so the origin of *C. inophyllum* itself may have been in this general area. If the suggested relationship of *C. leucocarpum* to Papuasian species is correct, there may be three independent lines of the genus on Fiji, probably reaching the archipelago by island-hopping in the general path Solomon Islands-New Hebrides-Fiji (Smith, 1979).

ECOLOGY

Several taxa of *Calophyllum* in Indo-Malesia have wide ecological ranges. These species often, but not always, occupy a wide geographic range, but the amount of morphological variation within the taxa differs. The widespread, predominantly West Malesian *C. pisiferum*, *C. rupicola*, *C. biflorum*, *C. canum*, *C. tetrapterum* var. *tetrapterum*, *C. soulattri*, *C. teysmannii* vars. *teysmannii* and *inophylloide*, and *C. venulosum* show considerable morphological variation, which at least in *C. canum*, *C. pisiferum*, *C. rupicola*, *C. soulattri*, *C. teysmannii* var. *teysmannii*, and *C. venulosum* is partly correlated with ecology. Unfortunately, details of the ecology of the highly variable *C. blancoi* in the Philippines are practically unknown. The Papuasian *C. sil* and *C. vexans* also show a considerable amount of infraspecific and ecological variation and likewise inhabit a considerable area; morphological variation is correlated with geography in both species. *Calophyllum* sp. 151 (a local species), *C. depressinervosum*, *C. pulcherrimum* (all basically West Malesian), *C. papuanum*, *C. peekelii*, and *C. neo-ebudicum* (all basically East Malesian) grow in a variety of habitats but show less infraspecific variation.

MAP 2. Distribution of five character states in Malesian species of *Calophyllum*: —, scales at bases of axillary innovations and inflorescences; — X —, terminal inflorescences (to India and possibly the Comores); — XX —, angled stones and/or flattened terminal buds; — · —, plugs at bases of stones (to Fiji and Samoa, excluding widespread *C. inophyllum* and its derivative, *C. tacamahaca*; also in South America).



A few Bornean species (e.g., *Calophyllum hosei*, *C. scriblitifolium*, and perhaps *C. sclerophyllum*) grow both in peat swamps and in the apparently very different kerangas forests on leached, arid sands. Such distributions are rather common (Brunig, 1974) and reflect certain essential ecological similarities, such as extreme oligotrophy, in the at first sight rather disparate environments.

Four out of the eight species (*Calophyllum neo-ebudicum*, *C. peekelii*, *C. soulattri*, and *C. vexans*) from the Solomon Islands have wide ecological tolerances, perhaps a reflection of the depauperate flora there (Whitmore, 1969).

Most Malesian taxa have more restricted ecological ranges. Many grow in more or less well-drained, mixed dipterocarp forest and in its East Malesian equivalent. Within this broadly defined habitat, a few species such as *Calophyllum macrocarpum* seem to prefer stream sides (without being rheophytes); others, like the four species from the Solomon Islands studied by Greig-Smith, Austin, and Whitmore (1967), may show more subtle preferences (but see Stevens, 1974a; also below). *Calophyllum nodosum* occurs most frequently in forests growing on rather acid soils and is locally abundant in extreme kerangas vegetation; it also grows in submontane vegetation. It shows considerable variation in foliar characters but little in those of flower or fruit. *Calophyllum obliquinervium* also grows most commonly in forests on rather acid soils; it grows in a number of other habitats but shows little variation.

Several species (e.g., *Calophyllum collinum*, *C. costatum*, *C. exiticostatum*, *C. incumbens*, *C. milvum*, *C. papuanum*, *C. polyanthum*, *C. symingtonianum*, *C. trapezifolium*, *C. thorelii*, *C. undulatum*, and *C. vitiense*) grow in colline forest up to about 1300 meters in altitude. Another group of species, including *C. cerasiferum*, *C. garcinioides*, *C. hirasimum*, *C. rigidulum*, *C. rotundifolium*, *C. pauciflorum*, and *C. walkeri*, occurs predominantly above 1300 meters. As might be expected, the species that grow at high altitudes tend to have rather short, broad, thick leaves that are not much pointed at the apex. Since most of these taxa in Malesia seem to be independently derived from lowland taxa (cf. Whitmore, 1973), they have little else in common; the species growing at high altitudes in Sri Lanka are closely related to each other. There is no noticeable increase in indumentum with altitude.

Some species grow in other, rather specific habitats. Several West Malesian species (e.g., *Calophyllum ardens*, *C. sclerophyllum*, *C. sundaicum*, *C. scriblitifolium*, and probably also *C. praetermissum*) grow in peat swamps, and others like *C. lowii* and *C. mukunense* grow in "periodically inundated" forest. The only fairly well-collected East Malesian species that habitually grows in swamps or periodically inundated ground is *C. suberosum*. A few species that have restricted distributions grow in forest over limestone or ultramafic rock. *Calophyllum aurantiacum* and *C. calcicola* have been recorded only from the former, while *C. complanatum*, *C. sakarium*, and *Calophyllum* spp. 98 and 143 have been recorded only from the latter. A number of additional species sometimes grow over ultramafic rock. A few species grow in drier forests: *C. calaba* var. *calaba* from Sri Lanka is the best example,

and *C. sil* (from Australasia) is usually found in gallery forest. Three taxa are rheophytes: *C. pisiferum* (not always, and only in mainland Southeast Asia), the closely related *C. lineare*, and the typical form of *C. rupicola*. *Calophyllum inophyllum* is characteristically a strand plant; it shows a certain amount of ecogeographic variation.

In many places, especially swamp forest, well-drained lowland forest, and ridges in lowland to montane forest, several species of *Calophyllum* may grow together (that is, within a few meters of each other), and where two of these habitats abut, even more species may be involved. Such concentrations of species have been observed in the swamp forests of southern Johore (Malaya) and near Kuching (Sarawak); in ridge forests throughout Malesia—notably Malaya, Sarawak, and Sabah (even on ultramafic rock); and in mixed forests in Papua New Guinea (there is a particularly interesting area in lowland forest around Kiunga, where at least 12 species of *Calophyllum* occur) and New Britain.

EVOLUTION

The discussion in the preceding section in a way epitomizes the problems that arise in discussing the evolution of the genus. Although species may have very distinct ecological preferences, this is not always so, and obvious "adaptations," even to very different habitats, are few. Possible exceptions are the small, broad, thick leaves of the montane species, the narrow leaves of the rheophytic species, and the stilt roots of many of the swamp-dwelling species. There are no major discontinuities in the pattern of morphological variation in the genus (see also van Steenis, 1968), and even if all the species in the genus except for two were unknown, these two would probably still be placed in the same genus. The variation in the genus is almost kaleidoscopic (Cullen, 1968) and on a rather restricted theme, yet numerous taxa can be recognized. These taxa frequently grow together (the "sympatry" of the following discussion) although they do not often hybridize.

It is very difficult to understand both the evolution and the maintenance of this species diversity. Much of the variation appears to be without adaptive significance and so might seem to confirm some of van Steenis's ideas on evolution in the tropics (see van Steenis 1977, 1978, and references therein; Fedorov, 1977, also leans toward such a view). However, this position can be supported only by a much more detailed knowledge of plant groups than is currently available, and the only reasonable position in the absence of such knowledge is that of an agnostic. One cannot expect a revision like the present one to resolve this important issue, but the suggestions made below may bear closer examination.

The morphological variation of the seedling and young plant in *Calophyllum* is considerable; the pigmentation of the young leaves also varies at this stage. Although there is some variation in fruit structure that is connected with germination, there is little variation in embryo morphology. The stem anatomy of the seedling has not been examined, but there is certainly less variation in lamina anatomy at this stage than occurs in the adult (see also

Stevens, 1974a). There is no obvious correlation of the variation of these young stages with ecological parameters.

Unfortunately, few genera have been studied in comparable detail. *Diospyros* shows much variation in germination and seedling, and Wright (1904) keyed out the species from Sri Lanka using characters of fruit and seedling. Maury (1978) studied many aspects of the fruit, germination, and young plants of the Dipterocarpaceae and found extensive variation. However, this variation was mostly at the sectional level and in characters of fruit, germination, and seedling; she noted (1979) that species in some genera can be recognized even when still young plants. De Vogel (1980) does not mention any comparable examples.

There is considerable selection pressure on a plant in the early stages, and the environmental requirements for germination and establishment are often very precise. Grubb (1977) has particularly emphasized the importance of the "regeneration niche" (the environment of the very young plant) in the maintenance of species diversity, even suggesting that species in such genera as *Diospyros*, *Rinorea* Aublet, *Shorea* Roxb. ex Gaertner, and *Eugenia* L. (*Syzygium* Gaertner) may differ by only a single character in the regeneration niche.⁹

However, it might also be argued that relatively little variation is likely at this stage, with physical factors such as temperature and humidity showing relatively less variation during times when germination is possible compared to later stages. Character complexes adapted to the conditions occurring then will not change readily; at least, there will not be a complete reorganization, since a major change would destroy the developmental pattern at a vulnerable stage. Similarly, genes acting late in development will often not show their effects at these earlier stages (Stebbins, 1950, 1974).

Study of *Calophyllum* may produce evidence relevant to this problem. It is possible that some of the characters apparent throughout the life of the plant are important only at the younger stages, being selectively neutral later on. Young plants of *C. pulcherrimum*, *C. robustum*, and *C. rigidum* all have plagiotropic leading axes, and the adults have more or less pendulous branches. One might ask at what stage, if any, this is of functional significance (see Givnish, 1978, for discussion on the possible selective advantage of compound leaves; in some respects a plagiotropic axis is functionally equivalent to a compound leaf). Other characters, like leaf number and disposition in the seedling, and the initial period of slow growth as well as the distinctive leaf shape in the young plant can be of significance only at early stages. In this context, the populations of *C. soulattri* from Manus to the Solomon Islands should be compared with those from elsewhere in Papuaia, since the only major differences between the two appear to be in fruit, seedling, and young plant. Another interesting case is *C. sclerophyllum*, which is sometimes superficially similar to *C. teysmannii* var. *inophylloide*, although

⁹White (1962, 1978) noted that species of *Diospyros* in Africa belong to many sections, and sympatric species are not usually closely related; species in genera like *Shorea* L. are delimited on characters other than those of the regeneration niche.

the seedlings, young plants, and anatomy of the two are very different. Finally, one of the more important distinctions between *C. persimile* and *C. suberosum* seems to be in the seedling and young plant. Thus, variation in the "regeneration niche" may be of considerable importance in both the development and maintenance of diversity in *Calophyllum*.

In the adult plant, the considerable variation in the disposition of the leaves along each innovation, the branching pattern (monopodial vs. sympodial), and the way the leaves (notably erect in some taxa, such as *Calophyllum peekelii*, but usually spreading to pendent) and branches are held must all affect how leaves intercept light. Again, comparison with other tropical genera is difficult because such characters are not often observed, but similar variation seems to occur in tropical montane Ericaceae (Stevens, 1980a).

In two cases the growth pattern of the plant may be connected with its preferred habitat. The trunk is less strongly orthotropic in *Calophyllum inophyllum* than in other species, and individuals may start to lean when only a few meters tall. This relatively weak orthotropy, doubtless aided by wave action, may cause the trunk to become procumbent on the beach, the branches being more or less erect, but *C. inophyllum* is sometimes an erect tree in closed forest. In open, kerangas vegetation shrubs of *C. nodosum* only 30 cm. tall may bear fruits, the terminal bud is frequently not functional, and branching is profuse. However, like other species with the same branching pattern, *C. nodosum* may also be a sizable tree; species with functional terminal buds may also be shrubs.

The variation in hair type is considerable, although it is variation on a rather limited theme. Hairs seem to protect the resting bud, since in those species in which the buds are covered by thick perulae, or protected in pockets formed from the stem and petiole (e.g., *Calophyllum savannarum*), the buds tend to be glabrous. The brown contents of the hairs, more obvious in some species than in others, are probably tannins—protectants against some generalized herbivores; in some species with notably thin-walled apical cells, the contents may be more readily exposed and so be more effective deterrents. In other species the apical cells seem to be empty. The very thick walls of the apical cells of *C. rufigemmatum* clearly increase the physical protection of the bud, as may the small, but very papillate and thick-walled, hairs of species such as *C. subsessile* and *C. persimile*.

Although the fruit is always drupaceous, variation is considerable. Possible dispersal agents are summarized here; however, careful observations are still sadly lacking. A few species are habitually or occasionally dispersed by water, several are eaten by mammals (bats, squirrels, or monkeys), and others are eaten by birds. Blue-fruited species preponderate in East Malesia, and these may be dispersed by birds. There are few arboreal mammals in this region, and birds are attracted to blue (among other colors), so the diversification of the genus may be connected with an increase in importance of bird-dispersal of the seeds. Unfortunately, I do not know of other groups that have more blue-fruited taxa in East Malesia than in West Malesia.

Closely related species usually differ only slightly in hair type, fruit structure, germination, and young plant. Such species are usually allopatric, and they

may also be ecologically differentiated. Examples are listed in TABLE 4, although this table should really be treated as a list of cases worthy of closer investigation. As noted above, variation within many species shows a pronounced correlation with geography, and the varieties of most species that are so subdivided usually grow in different areas (intraspecific variation in both *C. teysmannii* and *C. tetrapterum* is not quite so clear-cut).

Many of the observations and suggestions made above are compatible with the idea that speciation in *Calophyllum* is basically allopatric; sympatry occurs only after subsequent divergence. Morphological confusion nearly always occurs between allopatric, rather than sympatric, taxa; hybridization between sympatric taxa is not common. Closely related taxa are separated by eco-geographic barriers, whether or not there are also reproductive barriers. This series of generalizations agrees with observations on West Malesian Dipterocarpaceae (Ashton, 1977, 1978), *Diospyros* in humid tropical Africa (White, 1962, 1978; the sympatric taxa often belong to different supraspecific taxa), and *Drimys* J. R. & G. Förster in Papuaia (Vink, 1970); it disagrees with Fedorov's ideas on speciation (Fedorov, 1966). The four species of *Calophyl-*

TABLE 4. Geographic and ecological preferences of closely related taxa of *Calophyllum*.

MADAGASCAR
<i>C. verticillatum</i> / <i>C. chapelieri</i> . Usually grow in different places, but some overlap; intermediates?
SRI LANKA
<i>C. walkeri</i> / <i>C. trapezifolium</i> / <i>C. cuneifolium</i> / <i>C. thwaitesii</i> / <i>C. vergens</i> . First three have largely different altitudinal limits; <i>C. vergens</i> and <i>C. trapezifolium</i> at least sometimes grow in same general area.
<i>C. calaba</i> var. <i>calaba</i> / var. <i>worthingtonii</i> . Ecological differentiation, but possible rare overlap.
INDIA-CHINA
<i>C. polyanthum</i> / <i>C. touranense</i> / ? <i>C. balansae</i> . Largely grow in different areas; variation within <i>C. polyanthum</i> has pronounced geographic component.
VIETNAM-MALESIA
<i>C. calaba</i> var. <i>bracteatum</i> / var. <i>cuneatum</i> / var. <i>E.</i> / var. <i>australianum</i> . Var. <i>cuneatum</i> ecologically separated; vars. <i>E.</i> and <i>australianum</i> geographically separated.
<i>C. pisiferum</i> / <i>C. dispar</i> / <i>C. lineare</i> . Never grow together, but no obvious ecological preferences; taxonomy of group not satisfactory.
WEST MALESIA
<i>C. ferrugineum</i> / <i>C. biflorum</i> / <i>C. sundaicum</i> / <i>C. costulatum</i> . The three varieties of <i>C. ferrugineum</i> grow in different areas, var. <i>orientale</i>

TABLE 4 (continued).

- ecologically differentiated as well; *C. sundaicum* ecologically differentiated; *C. biflorum* largely geographically separated; *C. costulatum* poorly known; *C. ferrugineum* var. *ferrugineum* and *C. biflorum* grow together in hill forest, S. Johore; *C. ferrugineum* var. *ferrugineum*, *C. sundaicum*, and *C. costulatum* (variant) grow together in swamp forest, S. Johore.
- C. wallichianum* var. *wallichianum*/var. *incrassatum*/var. *tahanense*. Vars. *wallichianum* and *incrassatum* basically geographically separated, var. *tahanense* in part ecologically.
- C. gracilipes*/*C. recurvatum*/*C. aurantiacum*. *C. gracilipes* and *C. recurvatum* geographically separated, *C. aurantiacum* ecologically.
- C. roseocostatum*/*C. stiptatum*/*C. elegans*/*Calophyllum* sp. 65/?*C. pyriforme*. No two taxa found in one place, but both *C. roseocostatum* and *C. elegans* occur near Kuching.
- C. venulosum* var. *venulosum*/var. *tenuivenium*/*C. subsessile*/*C. grandiflorum*. No taxa in this complex grow together, yet no major geographic isolation.
- C. nodosum*/*C. depressinervosum*/*C. pulcherrimum*. Usually grow apart, although sometimes not far distant; all grow together at Sabal Tapang, Sarawak; *C. nodosum* often on more acid soil than other two, which differ notably in fruit.
- C. teysmannii*/*C. sclerophyllum*. Largely ecologically isolated; when growing together (swamps, Johore), form of *C. teysmannii* involved is that least similar to *C. sclerophyllum*; varieties of *C. teysmannii* not sympatric.

EAST MALESIA

- C. undulatum*/*C. parvifolium*/*C. caudatum*/*C. novoguineense*/*C. bicolor*/*C. confusum*/*C. bifurcatum*/*C. leucocarpum*. Geographically separated, although *C. novoguineense* and *C. bicolor* grow together near Kiunga.
- C. trachycaule*/*C. goniocarpum*/*C. piluliferum*/*C. heterophyllum*/*Calophyllum* sp. 143/*C. rufinerve*. Largely geographically separated, but *C. trachycaule* and *C. goniocarpum* grow together near Kiunga, *Calophyllum* sp. 143 and *C. goniocarpum* in same area near Buso; taxonomy of group poorly understood.
- C. laticostatum*/*C. insularum*/*Calophyllum* sp. 129/*C. sil*/*C. collinum*. First three geographically separated and closely related; second two less closely related; *C. sil* sensu stricto ecologically differentiated; *C. collinum* and *C. laticostatum* sympatric at Kiunga.
- C. papuanum*/*C. pauciflorum*/*C. vexans*. Largely geographically separated, also ecologically; *C. papuanum* and poorly understood form of *C. vexans* grow together near Kiunga.
- C. suberosum*/*C. persimile*. Ecologically separated; considerable differences in young plants.
- C. neo-ebudicum*/*C. cerasiferum*/*C. vitiense*. *C. cerasiferum* usually at highest altitudes, otherwise no major geographic separation.

lum that Grieg-Smith *et al.* (1967) thought were examples of closely related species having different niches are perhaps better considered as examples of not immediately related species that frequently can grow together. These species—*C. soulattri*, *C. vexans* (their *C. cerasiferum*), *C. neo-ebudicum* (their *C. vitiense*), and *C. peekelii* (their *C. kajewskii*)—quite frequently grow together, as can be seen from the data given by Grieg-Smith *et al.*, and as I have observed in New Britain.

It is difficult to compare the amount of differentiation between allopatric and sympatric taxa within a genus, let alone between different genera (see also below), but in both *Calophyllum* and *Drimys* even sympatric taxa may be rather similar (variation in seedlings and young plants of *Drimys* is not great (pers. obs.)).

However, current knowledge of *Calophyllum*, and of most tropical groups, rather vitiates this type of analysis. As mentioned above, subtle, but discontinuous, sympatric variation may escape recognition because of the small sample size from most localities and the practical limits on field work in the area; geographically correlated variation may be overemphasized because of patchy collecting. The variation of *C. biflorum* and *C. teysmannii* var. *inophylloide* on Gunong Matang, Sarawak, is pertinent here, since the differences between the two "forms" of each of these taxa on this hill are similar to those that characterize allopatric varieties in other species. Although this variation seems to intergrade with that in the rest of the taxa, field experience throughout Borneo might show that all specimens could be referred to these two "forms"; the separation of *C. persimile* from *C. suberosum* was suggested by similar field observations. Hence any explanation of the patterns observed in terms of processes can only be speculative, but one can at least identify areas for future work.

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¹⁰AAU, B, BISH, BKF, BM, BO, BRI, C, CAL, CANB, CHR, DNA, E, F, G, GH, K, KEP, KLU, L, LY, M, MASS, MAU, MICH, MD, NSW, NY, P, PERTH, PNH, SAN, SAR, SING, SYD, TAI, U, UC, US, W, WRC (abbreviations follow Holmgren & Keuken, 1974).

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SYSTEMATIC TREATMENT

Calophyllum L. Sp. Pl. 1: 513. 1753, Gen. Pl. ed. 5. 229. 1754; Lam. Encycl. Méth. Bot. 1: 552. 1785; Juss. Gen. Pl. 286. 1791; Willd. Sitz-ber. Ges. Naturf. Fr. Berlin Mag. 5: 78. 1811; Choisy, Mém. Soc. Hist. Nat. Paris 1: 228. 1823, in DC. Prodr. 1: 562. 1824; Endl. Gen. Pl. 1028. 1840; Choisy, Descr. Guttif. Inde, 41. 1849; Miq. Fl. Nederl. Indië 1(2): 509. 1859; Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 241. 1862; Bentham in Bentham & Hooker f. Gen. Pl. 1: 175. 1862; T. Anderson in Hooker f. Fl. Brit. India 1: 271. 1874; Vesque, Epharמוש 2: 6. 1889; King, Jour. Asiatic Soc. Bengal, II. 59: 172. 1890; Vesque in C. DC. Monogr. Phanerog. 8: 529. 1893; Trimen, Handb. Fl. Ceylon 1: 98. 1893; Engler in Engler & Prantl, Nat. Pflanzenfam. 3(6): 220. 1895; Pitard in Lecomte, Fl. Gén. Indo-Chine 1(4): 316. 1910; Ridley, Fl. Malay Penin. 1: 181. 1922; Engler in Engler & Prantl, Nat. Pflanzenfam. ed. 2. 21: 192. 1925; Gagnep. Fl. Gén. Indo-Chine Suppl. 1(3): 268. 1943; Perrier de la Bâthie, Fl. Madagascar Comores, Fam. 136: 3. 1951; Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 285. 1956; Maheshwari, Bull. Bot. Survey India 2: 139. 1960; Backer & Bakh. f. Fl. Java 1: 384. 1963; A. C. Sm. & Darwin, Jour. Arnold Arb. 55: 216. 1974; P. F. Stevens, Austral. Jour. Bot. 22: 349. 1974. TYPE: *Calophyllum inophyllum* L.¹¹

Ponna Rheede ex Ludwig, Defin. Gen. ed. 3. 239. 1760. *Nomen superfluum*.

Calaba Plum. ex Adanson, Familles 2: 446. 1763. *Nomen superfluum*.

Augia Lour. Fl. Cochinch. 337. 1790, *pro minore parte*.

Balsamaria Lour. *Ibid.* 467. TYPE: *Balsamaria inophyllum* Lour.

Apoterium Blume, Bijdr. Nederl. Indië 1(5): 218. 1825. TYPE: *Apoterium sulatri* Blume.

¹¹ *Calophyllum* is usually typified by *C. calaba*, but that species does not agree with the generic description in Linnaeus, Gen. Pl. ed. 5. 229. 1754. Fuller details will be given in a later article.

Evergreen trees or shrubs, sometimes buttressed or with stilt or loop roots; bark often with characteristic diamond-shaped fissures becoming confluent with age; latex present, nearly always colored. Twigs \pm flattened and angled; terminal buds usually naked, sometimes with scales, rarely aborting and not functional; indumentum of uniseriate hairs usually at least on buds. Leaves decussate in adult plants, very rarely alternate in young plants, petiolate; lamina entire, \pm coriaceous, with close parallel venation alternating with and usually more prominent than latex canals. Inflorescences terminal and/or axillary, with (1 to) 3 to numerous flowers, branched or not, axes terminated by flowers; bracts usually deciduous. Flowers pedicellate, usually hermaphroditic; tepals 4 to 16, outer one or two pairs rarely much different from the rest; stamens numerous, at most obscurely fasciated, the filaments usually only slightly connate at base, the anthers small, basifixed, dehiscing by long, lateral slits; ovary unilocular, with single basal, anatropous ovule, the style present, the stigma \pm expanded, often peltate. Fruit drupelike, the pericarp consisting of exocarp and well-developed, fleshy to fibrous mesocarp, the testa consisting of stony layer and usually transient spongy layer; seed single (except in polyembryonic taxa), radicle just to one side of base of fruit, cotyledons large. Germination cryptocotylar, epicotyl short. $2n = 26$ (one species).

About 187 species, 179 in the Old World, predominantly Indo-Malesian, ca. 8 species in the New World, from Mexico and the Caribbean to Argentina. Most species are small to medium sized or sometimes large trees of humid, tropical, predominantly lowland rain forest, but some species grow in mid-montane or more seasonal forest.

The wood of the larger species is used quite often in construction; where *Calophyllum* is abundant (e.g., Malaya, the Solomon Islands), it is an important component of the timber trade. The fruits of a number of species yield an oil that is of some economic use, either as a medicine or in lamps (see especially *C. inophyllum*). *Calophyllum* has been used in canoe manufacture throughout its range, the seaside *C. inophyllum* being particularly prized in this respect, and in the era of sail several species furnished masts and spars. Local names given to the species usually seem to have little specificity; the generic name, "binta(n)gor," is much used in West Malesia, often being qualified (e.g., "bintangor batu" is the local species with hard wood).

GUIDE TO USE OF KEYS AND DESCRIPTIONS

The characters used and their terminology have been extensively discussed in the preceding pages. However, certain aspects bear repeating and expanding here. Venation density should be measured in the middle part of the leaf away from any area of damage. Venation prominence is a qualitative character; however, FIGURE 7, a and c, gives an approximate indication of the extent of the variation. Deciding whether or not the lamina immediately adjacent to the midrib is raised and is thus apparently continuous with the midrib is sometimes not easy; FIGURE 7, c should help. It is easy to overlook the

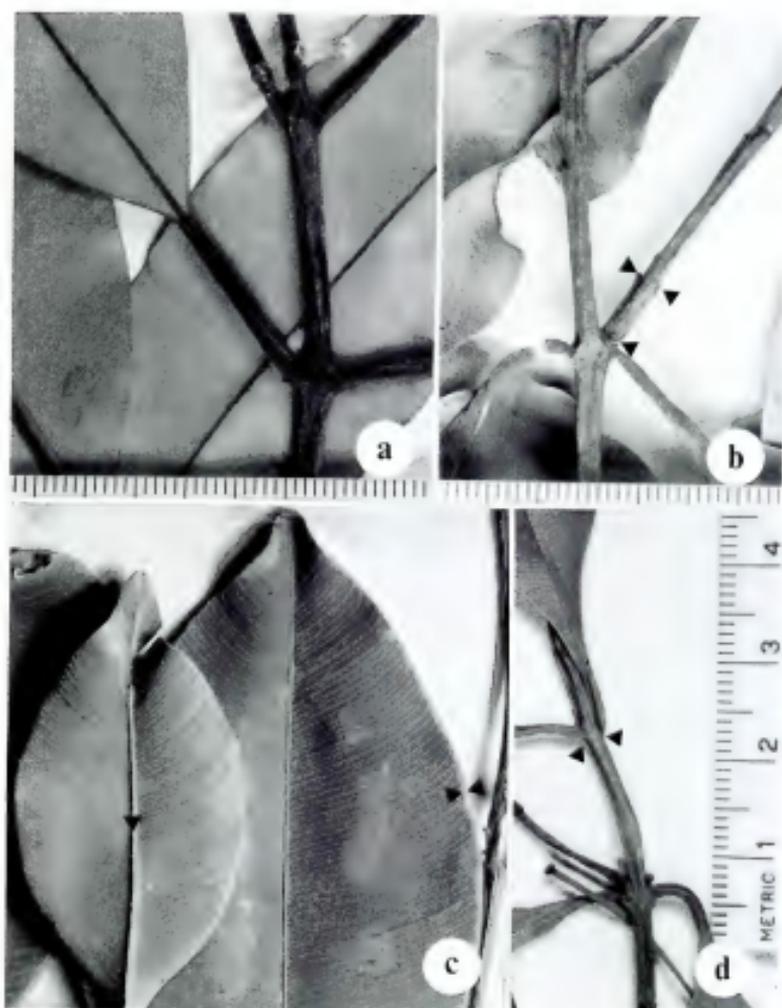


FIGURE 7. Some characters as shown on dried specimens. a, *Calophyllum rufigemmatum* (FRI 13796), node with transverse line, lamina at lower left, obscure venation. b, *Calophyllum* sp. 65 (S 23854), scars left by scales at base of axillary innovations (arrows). c, *C. pulcherrimum* (Shah & Shukor 2370, leaf on left), midrib proper (tip of arrow) surrounded by raised lamina; *C. tetrapterum* var. *obovale* (S 27894, leaf on right), midrib sharply demarcated from surrounding lamina, thickened lamina margin (double arrow). d, *C. tetrapterum* var. *tetrapterum* (S 23286), nodes lacking transverse lines or markings (arrows).

scales that are sometimes present at the bases of the axillary innovations (FIGURE 7, b).

The species descriptions are generally equivalent. Parentheses enclose less commonly encountered variation. The descriptions of the bark are uneven, with much information having been taken from field labels and should be read with caution; descriptions for the species that I have seen are somewhat more comparable. Measurements were taken from dried specimens, unless otherwise mentioned, although flowers were boiled in water before measurements were taken. It is not easy to see the obscure horizontal lines that occur at most nodes in some species (FIGURE 7, a, d), and they are noted only when they have been seen; since I became aware of them only at a rather late stage in the revision, they are probably underrecorded (as perhaps in the Madagascan taxa). The color of the dried petiole is mentioned only when it contrasts very strongly with that of the stem, and the whitish, probably waxy, covering of the dried leaves of a few species is mentioned only when it occurs. A few species have leaves that dry longitudinally concave, or sometimes boat shaped; this is mentioned only when it is prominent. Unusually well-developed marginal thickening (FIGURE 7, c), prominence of the latex canals, and notably thin petioles or pedicels are mentioned only when they occur. The number of flowers in an inflorescence is usually an uneven one, and the number of tepals in a flower is usually even, but this fact is not mentioned in the descriptions for the sake of brevity. The pedicel generally thickens somewhat in fruit, but in a few species this is exceptionally notable and is mentioned in the descriptions, as are a few cases of possible elongation of the pedicel after anthesis. Unless mention is made to the contrary, it can be assumed that all tepals are fringed with hairs but are otherwise glabrous, that all stamens are glabrous and have filaments that are slightly connate at the base, and that all ovaries are glabrous. Plugs at the base of the stone are recorded only when they occur; these, too, are probably underrecorded.

Full literature citations have been given for each name (except for *Calophyllum inophyllum*) so that the reader can find his way through the often confusing earlier literature. All specimens cited have been seen, unless otherwise indicated. Usually only a single well-distributed specimen has been cited for each locality, exceptions being newly described taxa, where more are listed, and taxa recently treated satisfactorily, where fewer are given. All altitudes and distances have been converted to the metric system, except in the citation of types. Where the collections are part of institutional series, they are cited under the series, not under the collector; the collector's name is added only in the citation of type collections. The abbreviations of these institutional series basically follow those suggested by Jacobs (1968).¹² Local

¹²However, I have cited CF numbers as KEP (Malaya; they are part of the same series) and SF numbers as SFN (Singapore; later labels bear the abbreviation SFN). I may also seem to have been rather overconfident in assigning some collections that were made in Sarawak and Sabah to their respective institutional series (S and SAN). Other abbreviations used here are FHI (Forest Herbarium, Ibadan, Nigeria), SF (Service Forestière) and RN (Resources Naturelles) (both Madagascar), MAU (Mauritius), CP (Ceylon Plants), FHP (Flora of Hassan Project, India), BSI (Botanical

names are usually not given because of the problems mentioned earlier; people interested in such names should write to the author for a list. Herbarium abbreviations follow those in Holmgren and Keuken (1974).

KEYS

The keys presented below have been made as practicable as possible, hence the emphasis on vegetative characters and also the rather frequent keying out of a number of taxa more than once. A single key to all the species recognized has not been presented, since if the characters used were those on the ordinary specimen the key would be so long due to multiple entries that it would be very unpleasant to use. Characters of inflorescence, flower, and fruit, which often most readily characterize a species, are not observable on most specimens, and a key using such characters would allow identification of only a minority of the specimens. A multiple-entry key could be produced, although many characters do not lend themselves readily to the either/or scoring necessary for such a key and many taxa are incompletely known; in addition, its use would be difficult if the user treated it as a key with single character dichotomies, as I suspect would be the case.

Therefore, seven keys are presented. The areas they cover are: 1) Africa, Madagascar, and the Mascarenes; 2) Sri Lanka and peninsular India; 3) mainland Southeast Asia (Burma, Thailand, and the Nicobar Islands, to China); 4) Malaya and Sumatra to the Lesser Sunda Islands; 5) Borneo; 6) the Philippine Islands to the northern Pacific; and 7) Sulawesi to Australia and the southern Pacific.

Survey of India), CCC (Canton Christian College, China), KLU (University of Malaya, Kuala Lumpur), NGBF (New Guinea Biological Foundation), and FDA and FDF (Fiji Departments of Agriculture and Forestry, respectively—see A. C. Smith, 1979). A complete identification list can be obtained from the author.

1. Key to Species of *Calophyllum* in Africa, Madagascar, and the Mascarenes

1. Innovation with terminal 2 (or 3) pairs of leaves almost pseudovercillate.
 2. Lamina (2-)3-5.3(-8) cm. long; inflorescence usually 5-flowered. 34. *C. verticillatum*.
 2. Lamina at least 8.5 cm. long; inflorescence with 7 to 11 flowers. 33. *C. chapelieri*.
1. Innovation with each pair of leaves clearly separated by internode.
 3. Lamina rather thinly coriaceous, drying dull greenish brown, closely undulate at margin, with at least 13 veins/5 mm.; flower with 4 tepals [introduced]. 21. *C. soulatrii*.
 3. Lamina rarely thinly coriaceous, if so then venation density less, otherwise not as above; flower (where known) with (7 or) 8 or more tepals.
 4. Lamina shallowly cordate at base; petiole almost absent. 27. *C. lingulatum*.
 4. Lamina at most rounded at base; distinct petiole usually present.
 5. Axillary innovation with leaves \pm restricted to top half, basal internode much longer than others [lamina less than 7 cm. long, venation usually \pm obscure].
 6. Terminal bud 5-7 mm. long. 26. *C. milvum*.
 6. Terminal bud 1-4 mm. long.
 7. Lamina broadly rounded at base [stone wall less than 0.3 mm. across]. 28. *C. humbertii*.
 7. Lamina cuneate to acute at base.
 8. Fruit \pm spherical, stone wall ca. 2 mm. thick; terminal bud 1-2 mm. long. 30. *C. pervillei*.
 8. Fruit ovoid, or stone wall less than 0.5 mm. thick, or terminal bud 3-4 mm. long. 30. *C. aff. pervillei*.
 5. Axillary innovation with leaves \pm regularly scattered along its length, basal internode not notably longer than others.
 9. Terminal bud 3.5-4 mm. long; lamina 4.3-7.8 cm. long; inflorescence apparently terminal [imperfectly known; Comoro Islands]. 40. *C. comorense*.
 9. Usually not this combination of vegetative characters; inflorescence rarely terminal.
 10. Terminal bud less than 4 mm. long; lamina usually less than 6 cm. long.
 11. Venation on lower surface of lamina \pm flat to impressed, edges of midrib subimpressed; fruit with strongly fibrous outer layer, fibers persisting around stone. 35. *C. fibrosum*.
 11. Venation on lower surface of lamina usually \pm raised, edges of midrib raised; fruit lacking persistent fibers.

- 12. Lamina 0.9-3.7 cm. long, with 13 to 19 veins/5 mm. 31. *C. drouhardii*.
- 12. Lamina usually more than 2.5 cm. long, with up to 12 (to 14) veins/5 mm.
 - 13. Lamina 5-11 cm. long, acuminate at apex, angle of divergence of venation 60-75°. 42. *C. vernicosum*.
 - 13. Lamina to 6 cm. long, acute to rounded at apex, angle of divergence of venation 30-60(-65)°.
 - 14. Angle of divergence of venation 20-40°; lowest internode of inflorescence ca. 2.5 cm. long [fruit unknown]. 29. *C. laxiflorum*.
 - 14. Angle of divergence of venation at least 50°; lowest internode of inflorescence at most 1(-1.5) cm. long. *C. aff. pervillei*.
- 10. Terminal bud at least 4 mm. long; lamina often more than 6 cm. long.
 - 15. Lamina obovate to elliptic, with 4 to 8 (to 10) veins/5 mm., venation clearly raised; pedicel (1.5-)2.5-4.5 cm. long [usually seaside plant]. 38. *C. inophyllum*.
 - 15. Lamina usually ovate to elliptic or oblong, with (5 to) 7 or more veins/5 mm., venation often not very clearly raised; pedicel up to 2.5(-3.5) cm. long.
 - 16. Lamina acute to acuminate at apex.
 - 17. Terminal bud 1.1-2.4 cm. long; lamina somewhat more than 3 times longer than broad. 32. *C. paniculatum*.
 - 17. Terminal bud less than 8 mm. long; lamina somewhat less than 3 times longer than broad.
 - 18. Lamina acuminate at apex, with 8 to 18 veins/5 mm.; fruit with outer layer 1.6-2.5 mm. thick, the stone wall 0.3-0.6 mm. thick, lacking basal plug. 41. *C. recedens*.
 - 18. Lamina acute at apex, with (6 to) 8 to 11 veins/5 mm.; fruit with outer layer 2.5-4 mm. thick, the stone wall 0.9-1.5 mm. thick, with basal plug. 39. *C. tacamahaca*.
 - 16. Lamina obtuse to rounded or retuse at apex.
 - 19. Lamina drying ± flat, midrib depressed; fruit with stone wall at most 0.2 mm. thick.
 - 20. Lamina 5.7-17.5 cm. long; twigs 2.5-5 mm. across; outer layer of fruit at least (?-3) mm. thick. 36. *C. eputamen*.
 - 20. Lamina 2-4.8(-7.5) cm. long; twigs 1.3-3 mm. across; outer layer of fruit less than 1 mm. thick. 37. *C. parviflorum*.
 - 19. Lamina usually drying with recurved margin, often longitudinally concave toward center, midrib above usually with at least margins raised; fruit with stone wall at least 1 mm. thick. 32. *C. aff. paniculatum*.

2. Key to Species of *Calophyllum* in Sri Lanka and Peninsular India

1. Inflorescences terminal [lamina at least 6 cm. long].
 2. Lamina rounded to cordate at base; indumentum tomentose. 89. *C. cordato-oblongum*.
 2. Lamina acute at base; indumentum puberulent. 4. *C. polyanthum*.
1. Inflorescences axillary.
 3. Terminal bud 1.2-2 cm. long; fruit with stone retuse at apex. 25. *C. moonii*.
 3. Terminal bud less than 1 cm. long; fruit with stone rounded to acute at apex.
 4. Leaves varying greatly in size along each twig [internodes less than 2 cm. long]. 20. *C. bracteatum*.
 4. Leaves not varying greatly in size along each twig.
 5. \pm Persistent, conspicuous, tomentose indumentum on terminal bud, stem, and inflorescence axis [lamina ovate to elliptic, with 5 to 11 (to 13) veins/5 mm., angle of divergence 45-65°]. 11. *C. tomentosum*.
 5. Transient to \pm persistent, puberulent to subtomentose (very rarely tomentose) indumentum, inconspicuous on stem and usually restricted to base of inflorescence axis.
 6. Lamina at least 7 cm. long, with 5 to 8 (to 10) veins/5 mm., veins prominent on both surfaces; pedicels 1.5-5 cm. long; stone with basal plug. 38. *C. inophyllum*.
 6. Lamina less than 7(-10) cm. long, venation density and prominence variable; pedicels 0.4-2.6(-3.5) cm. long; stone lacking basal plug.
 7. Twigs strongly flattened; internode often more than 2 cm. long; uppermost pair of axillary buds often erect and conspicuous, ca. $\frac{1}{4}$ - $\frac{1}{2}$ length of terminal bud; internodes often more than 2 cm. long.
 8. Lamina rounded (slightly retuse) at apex, shallowly cordate at base. 17. *C. vergens*.
 8. Lamina acute to retuse at apex, acute to cuneate (rarely rounded) at base.
 9. Pedicel at anthesis less than 0.5 mm. across, in fruit less than 1 mm. across; flower with 4 tepals; fruit with thin outer layer becoming \pm disorganized by air spaces. 19. *C. calaba*.
 9. Pedicel at anthesis more than 0.7 mm. across, in fruit ca. 1.5 mm. across; flower with ca. 8 tepals; fruit with well-developed, compact outer layer. 14. *C. trapezifolium*.
 7. Twigs usually at most slightly flattened; uppermost pair of axillary buds rarely erect or conspicuous; internode usually less than 2 cm. long.
 10. Lamina with 3 to 7 (to 9) veins/5 mm., venation prominent, angle of divergence (25-)35-40° [terminal internode of innovation about $\frac{1}{2}$ length of others]. 15. *C. cuneifolium*.
 10. Lamina often with more dense venation, venation prominent or not, angle of divergence usually more than (40-)50°.

11. Lamina with up to 6 (rarely 8) veins/5 mm., venation subapparent above, subobscure below, latex canals often impressed; inflorescence with 5 to 7 flowers. 13. *C. thwaitesii*.
11. Lamina with 5 to 14 (rarely to 17) veins/5 mm., venation not more obvious on upper surface than on lower, latex canals rarely impressed; inflorescence with 7 to 19 flowers.
12. Twig \pm 4-angled; flower with 10 to 15 tepals; pedicel in fruit (2-)2.5-5 mm. across. 12. *C. walkeri*.
12. Twig strongly 4-angled to subulate; flower with 4 to 10 tepals; pedicel in fruit ca. 2 mm. or less across.
13. Lamina usually rounded at base, midrib on upper surface abruptly narrowed from base; all internodes of innovation approximately same length; fruit less than 1.5 cm. long. 18. *C. apetalum*.
13. Lamina usually narrowly cuneate to acute at base, midrib on upper surface narrowing gradually from base; terminal internode of innovation sometimes about $\frac{1}{2}$ length of others; fruit ca. 3 cm. long. 16. *C. austroindicum*.

3. Key to Species of *Calophyllum* in Mainland Southeast Asia (Burma, Thailand, and the Nicobar Islands, to China)

1. Twigs (1.5-)2.5-5 mm. across, very strongly 4-angled to subulate, \pm nitid [indumentum often tomentose].
2. Twigs with prominent leaf scars; petiole 2-5 mm. long. 174. *C. poilanei*.
2. Twigs lacking prominent leaf scars; petiole at least 10 mm. long.
3. Twigs drying blackish; internode 0.5-2.5(-5) cm. long. 83. *C. macrocarpum*.
3. Twigs drying brownish; internode 2-7 cm. long.
4. Lamina with 6 to 11 veins/5 mm.; fruit spherical, ca. 1.5 cm. long [inflorescences terminal and axillary]. 10. *C. dongnaiense*.
4. Lamina with 10 to 16 veins/5 mm.; fruit ovoid to ellipsoid, 2.5-3 cm. long, sharply pointed at apex [inflorescence position unknown]. 170. *Calophyllum* sp.
1. Twigs often less than 2.5 mm. across, if more then not strongly 4-angled or subulate, rarely nitid.
5. Inflorescences terminal (and sometimes axillary).
6. Lamina retuse to subacute at apex.

7. Twigs 2.5-3.2 mm. across, drying blackish; basal internode of axillary inflorescence to 1 mm. long. 71. *C. parkeri*.
7. Twigs 1.2-2 mm. across, usually drying brownish or grayish; basal internode of axillary inflorescence (0.5-)1 cm. or more long.
8. Terminal bud 2.5-5 mm. long; lamina with \pm obscure venation usually more obvious on upper surface. 154. *C. rugosum*.
8. Terminal bud 1.3-2 mm. long (unknown in *C. balansae*); lamina with apparent venation not notably more obvious on upper surface.
9. Lamina flat at margin, angle of divergence of venation 30-55°. 97. *C. ceriferum*.
9. Lamina \pm undulate and recurved at margin, angle of divergence of venation 60-70°. 6. *C. balansae*.
6. Lamina acute to acuminate at apex.
10. Lamina often drying bicolored [gray-olivaceous above, sabelline below], midrib on upper surface surrounded by raised blade, indistinct; fruit ellipsoid, usually deeply wrinkled. 3. *C. thorelli*.
10. Lamina usually not drying notably bicolored, midrib on upper surface surrounded by raised blade or not; if fruit deeply wrinkled then not ellipsoid.
11. Venation density on upper surface of lamina apparently twice that on lower. 3. *C. thorelli* group "s".
11. Venation density same on both surfaces of lamina.
12. Midrib on upper surface of lamina surrounded by raised blade, indistinct.
13. Terminal bud 3-7 mm. long; lamina with (6 to) 8 to 11 veins/5 mm. 7. *C. symingtonianum*.
13. Terminal bud 2.3-4 mm. long; lamina with 4 to 8 veins/5 mm. 8. *C. dryobalanoides*.
12. Midrib on upper surface of lamina not surrounded by raised blade, distinct.
14. Lamina with 9 to 16 (to 21) veins/5 mm., attenuate at base [fruit finely wrinkled, outer layer 1.5-3 mm. thick]. 4. *C. polyanthum*.
14. Lamina with 6 to 10 (to 14) veins/5 mm., acute to cuneate at base.
15. Petiole 0.7-2.5 cm. long; lamina coriaceous, margin slightly undulate but not recurved or slightly so; fruit finely wrinkled, outer layer 3-5.5 mm. thick. 5. *C. touranense*.
15. Petiole 0.3-0.9(-1.3) cm. long; lamina thinly coriaceous, margin undulate and recurved; fruit coarsely wrinkled, outer layer ca. 1 mm. thick. 6. *C. balansae*.
5. Inflorescences axillary.
16. Axillary innovation with basal scars; lamina with indistinct venation and \pm impressed latex canals. 58. *C. depressinervosum*.

16. Axillary innovation nearly always lacking basal scars; lamina with \pm distinct venation, latex canals impressed or not.
17. Lamina obovate to elliptic, at least 7 cm. long; pedicel (1.5-)2.5-4.5 cm. long [lamina with 4 to 8 (to 10) veins/5 mm., stone with basal plug; seaside tree]. 38. *C. inophyllum*.
17. Lamina ovate to elliptic (rarely obovate), often less than 7 cm. long; pedicel less than 1.5(-2.5) cm. long.
18. Lamina narrowly elliptic, ca. 10 times longer than broad. 103. *C. lineare*.
18. Lamina broader, less than 5 times longer than broad.
19. Lamina with 12 to 25 veins/5 mm.
20. Lamina often more than 7 cm. long, rather closely undulate at margin; inflorescence branched; outer layer of fruit at least 1 mm. thick. 21. *C. soulattri*.
20. Lamina often less than 7 cm. long, rather distantly undulate at margin; inflorescence unbranched; outer layer of fruit less than 1 mm. thick. 19. *C. calaba*.
19. Lamina with up to 12 veins/5 mm.
21. Lamina drying notably bicolored, coriaceous, latex canals impressed or not; bud often supra-axillary. 101. *C. rupicola*.
21. Lamina not drying notably bicolored, thinly coriaceous, latex canals rarely impressed; bud not supra-axillary.
22. Lamina rounded to acute at apex; stem often short-tomentose. 102. *C. pisiferum*.
22. Lamina acute to acuminate at apex; stem at most puberulent.
23. Terminal bud 2-4 mm. long; lamina ca. 2 times longer than broad; bracts inconspicuous, deciduous; flowers with 4 (to 9) tepals. 100. *C. tetrapterum*.
23. Terminal bud 3.5-7 mm. long; lamina ca. 3 times longer than broad; bracts often foliaceous and persistent; flower with 8 (to 12) tepals. 175. *C. membranaceum*.

4. Key to Species of *Calophyllum* in Malaya, Sumatra, and the Sunda Islands

1. Axillary innovation with basal scars; twigs less than 3 mm. across [species sometimes with basal scars, but with thicker twigs, key out in second half of couplet].
2. Lamina with indistinct venation, drying almost completely flat, attenuate at base. 74. *C. enervosum*.
2. Lamina with \pm distinct venation, often drying definitely undulate and/or recurved at margin, usually other than attenuate at base.

3. Terminal bud glabrous, clearly composed of several pairs of decussate scales. 73. *Calophyllum* sp.
3. Terminal bud with indumentum, only one pair of reduced leaves or scales visible.
4. Lamina (5-)8-15 cm. long, latex canals not impressed; terminal bud 2.5-7 mm. long.
5. Lamina often drying \pm broadly concave, with 10 to 19 veins/5 mm.; inflorescences terminal (and also axillary). 72. *C. flavoramulum*.
5. Lamina not drying broadly concave, with (7 to) 9 to 14 veins/5 mm.; inflorescences axillary. 70. *C. fraseri*.
4. Lamina 3.2-8 cm. long (rarely to 13 cm., then latex canals on lower surface impressed); terminal bud less than 4 mm. long.
6. Midrib on upper surface of lamina usually surrounded by raised blade, inconspicuous, on lower surface inconspicuous.
7. Lamina drying cinnamon-sabelline on lower surface, latex canals often impressed. 58. *C. depressinervosum*.
7. Lamina drying umber to sabelline on lower surface, latex canals not impressed.
8. Lamina usually bluntly acuminate at apex; fruit at least 1.4 cm. long, \pm ovoid. . . . 60. *C. pulcherrimum*.
8. Lamina more or less rounded at apex; fruit less than 1 cm. long, spherical. 57. *C. nodosum*.
6. Midrib on upper surface of lamina not surrounded by raised blade, distinct, on lower surface conspicuous.
9. Twigs less than 2 mm. across; lamina drying bicolored [gray-brown above, yellow-brown below]; fruit less than 1.3 cm. long. 101. *C. rupicola*.
9. Twigs (1.5-)2 mm. or more across; lamina drying \pm same color on both surfaces; fruit at least 1.5 cm. long.
10. Lamina retuse to subacuminate at apex, with (9 to) 11 to 17 (to 22) veins/5 mm.; fruit ellipsoid. 88. *C. hosei*.
10. Lamina rather bluntly acuminate at apex, with 8 to 10 veins/5 mm.; fruit \pm pyriform. 66. *C. stipitatum*.
1. Axillary innovation lacking basal scars, or twigs more than 3 mm. across.
11. Lamina cordate to auriculate at base.
12. Lamina suborbicular, venation more prominent on upper than lower surface; inflorescence reduced to 1 or 2 flowers. 155. *C. rotundifolium*.
12. Lamina nearly always at least twice as long as broad, venation not more prominent on upper than lower surface; inflorescence with at least (1 to) 3 flower(s).
13. Lamina 15-36 cm. long; pedicel at anthesis 3-7.5 cm. long. 91. *C. grandiflorum*.

13. Lamina to 15(-23.5) cm. long; pedicel at anthesis less than 3 cm. long.
14. Twigs up to 1.5 mm. across, drying brown; fruit less than 1 cm. long. 19. *C. calaba*.
14. Twigs at least 2 mm. across, drying yellowish to grayish; fruit at least 1.5 cm. long.
15. Midrib strongly depressed only at base of lamina; inflorescence with (3 to) 5 (to 11) flowers. 90. *C. venulosum*.
15. Midrib strongly depressed for at least the lower ¼ of lamina; inflorescence with 5 to 17 flowers.
16. Twigs rounded to obscurely 4-angled; basal internode of inflorescence to 2 mm. long. 93. *C. mukunense*.
16. Twigs strongly 6-angled; basal internode of inflorescence 2-4 cm. long [cultivated specimens of *C. venulosum* from Bogor key out here]. 92. *C. sessile*.
11. Lamina broadly rounded to attenuate at base.
17. Lamina at maturity tomentose or sparsely tomentose on entire lower surface.
18. Inflorescences terminal (sometimes also from uppermost leaf axils); fruit furfuraceous.
19. Terminal bud 4-8 mm. long; twigs drying yellowish. 158. *C. rubiginosum*.
19. Terminal bud ca. 1.4 cm. long; twigs drying dark brown. 54. *Calophyllum* sp.
18. Inflorescences axillary; fruit not furfuraceous.
20. Lamina with (8 to) 11 to 17 veins/5 mm.; ovary tomentose. 159. *C. molle*.
20. Lamina with (3 to) 5 to 8 (to 11) veins/5 mm.; ovary glabrous. 104. *C. dispar*.
17. Lamina at maturity at most puberulent on lower surface.
21. Inflorescences terminal (sometimes also arising from uppermost leaf axils).
22. Lamina retuse at apex, 2-5 cm. long; uppermost pair of axillary buds erect, ca. ½ length of terminal bud; bracts foliaceous, persistent. 157. *C. aureum*.
22. Lamina usually acute to acuminate at apex, at least 3.5 cm. long; uppermost pair of axillary buds relatively short; bracts not foliaceous and persistent.
23. Lamina 3.5-6.7 cm. long, with (9 to) 11 to 16 veins/5 mm. 156. *C. aureobrunnescens*.
23. Lamina 5-19.5 cm. long, with 5 to 12 veins/5 mm.
24. Petiole ca. 1 mm. across; lamina ovate to subelliptic, to 9 cm. long. 6. *C. symingtonianum*.
24. Petiole at least 2 mm. across; lamina elliptic to oblong or subobovate, at least (6-)8.5 cm. long.
25. Lamina very coriaceous, broadly rounded toward apex, finally shortly acute; terminal bud 1-1.8(-2.7) cm. long. 47. *C. coriaceous*.
25. Lamina coriaceous, acuminate at apex; terminal bud 6.5-10 mm. long. 1. *C. alboramulum*.

21. Inflorescences axillary (rarely terminal).
26. Lamina very strongly revolute at margin when dry, thickly coriaceous. 49. *C. scriblitifolium*.
26. Lamina not very strongly revolute at margin, thickly to thinly coriaceous.
27. Terminal bud (0.8-)1-3 cm. long.
28. Lamina drying closely undulate at margin; uppermost pair of axillary buds erect; inflorescence with strong lateral branches. 21. *C. soulattri*
28. Lamina not drying closely undulate at margin; uppermost pair of axillary buds rarely erect; inflorescence usually without strong lateral branches.
29. Terminal bud (3-)4.5-10(-11) mm. long; lamina with veins diverging at 40-70°; axillary bud often notably plump, sometimes supra-axillary. 23. *C. rigidum*.
29. Terminal bud (0.8-)1-3 cm. long; lamina with veins diverging at (60-)70-85°; axillary bud rarely plump and/or supra-axillary.
30. Midrib on upper surface of lamina strongly sulcate, margins raised, narrowing gradually from base.
31. Lamina often drying nitid, with (10 to) 12 to 17 (to 21) veins/5 mm.; inflorescence rarely branched or flabellate; fruit pointed at apex. 50. *C. canum*.
31. Lamina drying dull, with 10 to 15 veins/5 mm.; inflorescence usually branched and/or flabellate; fruit rounded at apex. 51. *C. lowii*.
30. Midrib on upper surface of lamina raised (not notably sulcate) and/or abruptly narrowing near base.
32. Lamina with 5 to 11 veins/5 mm., venation very distinct. 45b. *C. lanigerum* var. *austrorcoriaceum*.
32. Lamina with 11 to 18 veins/5 mm., venation usually rather indistinct.
33. Inflorescence axis 0.3-1.3 cm. long; hairs with large, thick-walled apical cells; fruit with stone wall (0.8-)1.3-2 mm. thick. 44. *C. rufigemmatum*.
33. Inflorescence axis 1.7-7 cm. long; hairs lacking large, thick-walled apical cells; fruit with stone wall 0.3-0.8(-1) mm. thick. 43. *C. wallichianum*.
27. Terminal bud less than 0.9 cm. long.
34. Lamina retuse to obtuse at apex.
35. Twigs drying shiny; lamina with 3 to 6 veins/5 mm.; flower with (8 to) 12 tepals; fruit ± beaked at apex. 169. *C. subhorizontale*.

35. Twigs not drying shiny; lamina usually with more than 6 veins/5 mm.; flower with 4 to 8 (to 12) tepals; fruit \pm rounded at apex.
36. Venation on upper surface of lamina clearly denser than on lower [indumentum brown, usually tomentose; basal internode of inflorescence (0.2-)1-5 cm. long; inner surface of outer layer of fruit shiny, striate]. 84. *C. ferrugineum*.
36. Venation same density on both surfaces of lamina.
37. Midrib on upper surface of lamina surrounded by raised blade, indistinct.
38. Lamina to 6(-8.3) cm. long, coriaceous; tree without stilt roots. 151. *Calophyllum* sp.
38. Lamina 5.7-21 cm. long, very coriaceous; tree with stilt roots. 81. *C. sclerophyllum*.
37. Midrib on upper surface of lamina not surrounded by raised blade, distinct.
39. Lamina with (3 to) 5 to 11 veins/5 mm., usually \pm thinly coriaceous.
40. Indumentum subtomentose, conspicuous on young stem and inflorescence axis; lamina less than 6 cm. long. 102. *C. pisiferum*.
40. Indumentum puberulent, inconspicuous; lamina at least 7 cm. long. 38. *C. inophyllum*.
39. Lamina with (8 to) 10 to 18 veins/5 mm., (thinly) coriaceous.
41. Twigs less than 1.5 mm. across; lamina with midrib on upper surface often disappearing below apex, \pm flat; fruit ca. 7 mm. long, smooth. 177. *C. exiticostatum*.
41. Twigs usually more than 1.5 mm. across; lamina with midrib on upper surface continuing to apex, usually raised; fruit more than 1 cm. long, wrinkled or smooth.
42. Lamina often with either clearly thickened margin at least 0.3 mm. wide or submarginal vein; fruit smooth or faintly striate. 78. *C. teysmannii*.
42. Lamina not as above; fruit wrinkled.
43. Lamina with 8 to 12 veins/5 mm., drying grayish sepia, the margin discolored, brownish; inflorescence with flowers in pairs. 87. *C. biflorum*.
43. Lamina with 10 to 18 veins/5 mm., not drying grayish sepia or with discolored margin; inflorescence with flowers tending to be in groups of four.
44. Plant with pale brown, tomentose indumentum; basal internode of inflorescence 1.7-5.2 cm. long; fruit spherical, drying closely wrinkled. 86. *C. costulatum*.
44. Plant with brown, subtomentose to puberulent indumentum; basal internode of inflorescence (0.15-)0.4-1.8 cm. long; fruit ellipsoid, drying distantly wrinkled. 85. *C. sundaicum*.
34. Lamina acute to acuminate (rarely cuneate) at apex.

45. Midrib on upper surface of lamina depressed, narrowing gradually from base [lamina elliptic, with (4 or) 5 to 9 veins/5 mm.]. 130. *C. archipelagi*.
45. Midrib on upper surface of lamina with at least margins raised, sometimes narrowing gradually from base.
46. Twigs 2.5-7 mm. across, drying blackish or shiny.
47. Twigs 4-alate, drying blackish (rarely brown); petiole (1.2-)3.5-7 cm. long. 83. *C. macrocarpum*.
47. Twigs with raised lines, but not alate, drying brown to yellowish; petiole 0.6-1.5 cm. long. 169. *C. subhorizontale*.
46. Twigs less than 3.5 mm. across, if more then drying neither blackish nor shiny.
48. Lamina thinly coriaceous, often drying greenish brown, closely undulate at margin; uppermost pair of axillary buds erect, conspicuous; inflorescence branched. 21. *C. soulattri*.
48. Lamina not as above; uppermost pair of axillary buds rarely erect and conspicuous; inflorescence rarely branched.
49. Lamina elliptic to oblong, venation on upper surface apparently twice as dense as on lower surface; basal internode of inflorescence (0.2-)1-5 cm. long; inner surface of outer layer of fruit striate. 84. *C. ferrugineum*.
49. Lamina variously shaped, the venation on both surfaces usually of same density, if not then basal internode of inflorescence less than 1 cm. long; inner surface of outer layer of fruit not striate.
50. Twigs drying yellowish, whitish, or grayish.
51. Petiole (0.8-)1-2.5 cm. long; lamina drying \pm concave, with very distinct venation. 90b. *C. venulosum* var. *tenuivenium*.
51. Petiole to 1.5 cm. long; lamina not drying concave, venation distinct or not.
52. Lamina abruptly acuminate at apex; blackish-drying petiole contrasting sharply with pale twig; outer layer of fruit 1-1.8 mm. thick. 106. *C. dioscurii*.
52. Lamina acute at apex; petiole and stem not strongly contrasting in color; outer layer of fruit less than 1 mm. thick.
53. Lamina with 12 to 20 veins/5 mm.; inflorescence with (5 to) 7 or more flowers. 19. *C. calaba*.
53. Lamina with 6 to 13 veins/5 mm.; inflorescence with up to 5 (to 7) flowers.
54. Lamina with 6 to 9 veins/5 mm., midrib on upper surface not surrounded by raised blade; anthers with hairs. 150. *C. gracillimum*.
54. Lamina with 8 to 13 veins/5 mm., midrib on upper surface surrounded by raised blade; anthers glabrous. 151. *Calophyllum* sp.

50. Twigs drying brownish.
55. Lamina usually drying bicolored [olivaceous-sepia above and cinnamon-honey below]; inflorescence axis and pedicel puberulent, the latter incrassate in fruit. 105. *C. incumbens*.
55. Lamina rarely drying bicolored; inflorescence usually glabrescent toward apex, pedicel usually glabrous, rarely incrassate in fruit.
56. Midrib on upper surface of lamina narrowing gradually from base, strongly sulcate at first; inflorescence axis 3-5.5 cm. long.
57. Hairs curved, papillate on one side. 101. *C. aff. rupicola*.
57. Hairs \pm erect, branched. 48. *C. dasypodium*.
56. Midrib not as above; inflorescence axis usually less than 2 cm. long.
58. Lamina with (3 to) 5 to 9 (to 11) veins/5 mm., rather thinly coriaceous.
59. Terminal bud (3.5-)4.5-7 mm. long; lamina 6-15 cm. long; outer layer of fruit (0.5-)1-1.8 mm. thick. 104. *C. dispar*.
59. Terminal bud 2-4.5 mm. long; lamina 3-7.5 cm. long; outer layer of fruit 0.2-0.5 mm. thick. 102. *C. pisiferum*.
58. Lamina with at least 7 veins/5 mm., thinly coriaceous to coriaceous.
60. Lamina with 10 to 17 veins/5 mm., veins sometimes apparently twice as dense on upper surface as on lower, angle of divergence 40-70°; terminal bud with dark brown, tomentose indumentum. 23. *C. rigidum*.
60. Lamina not as above; terminal bud with grayish to brown, crustaceous to short-tomentose indumentum.
61. Lamina with 12 to 20 veins/5 mm., drying \pm sepia, dull, concolorous. 19. *C. calaba*.
61. Lamina with up to 14 veins/5 mm., drying other than dull sepia, often bicolored or with pale margin.
62. Lamina drying bicolored [gray-brown above, yellow-brown below], lower surface often puberulent; bud often clearly supra-axillary; fruit often ovoid. 101. *C. rupicola*.
62. Lamina drying bicolored or not, lower surface glabrous; bud rarely clearly supra-axillary; fruit usually spherical.
63. Terminal bud 4.5-7 mm. long; lamina rather thickly coriaceous. 70. *C. fraseri*.

63. Terminal bud 2-4 mm. long; lamina coriaceous or thinly coriaceous.
usually pale; fruit less than 1.2 cm. long. 100. *C. tetrapterum*.
64. Twigs 1.2-1.5 mm. across, not strongly 4-angled; margin of lamina not
notably pale; fruit ca. 1.7 cm. long. 9. *Calophyllum* sp.

5. Key to Species of *Calophyllum* in Borneo

1. Lamina at least sometimes cordate or auriculate at base.
 2. Midrib on upper surface of lamina depressed; inflorescences terminal and often axillary, axillary inflorescence with basal internode less than 2 mm. long. 93. *C. mukunense*.
 2. Midrib on upper surface of lamina not depressed; inflorescences occasionally terminal, usually axillary, axillary inflorescence with basal internode more than 3 mm. long.
 3. Axillary shoot lacking basal scars; flower usually with 4 tepals; outer layer of fruit more than 1.5 mm. thick. 90a. *C. venulosum* var. *venulosum*.
 3. Axillary shoot nearly always with basal scars; flower with 4 or 7 or more tepals; outer layer of fruit ca. 1 mm. or less thick.
 4. Lamina 9.5-14.8 cm. long, midrib on upper surface surrounded by raised blade; flower with 4 tepals. 59. *C. complanatum*.
 4. Lamina 1.2-8.5 cm. long, midrib on upper surface not surrounded by raised blade; flower with at least 7 tepals.
 5. Lamina very coriaceous, venation on upper surface rather obscure; inflorescence axillary; flower with 8 tepals. 94. *C. calcicola*.
 5. Lamina coriaceous, venation on upper surface prominent; inflorescence terminal and axillary; flower with (8 to) 11 to 13 tepals. 99. *C. clemensorum*.
1. Lamina broadly rounded to acute or decurrent at base.
 6. Terminal bud at least 1 cm. long (if no bud because inflorescence terminal, see couplets 17(2), 23(1)-25(1), 36(1), 42(1), 47(1), 48(2), 61(1), and 67(1)).
 7. Lamina broadly recurved toward margin [lamina very coriaceous; plant of peat swamps]. 49. *C. scriblitifolium*.
 7. Lamina not broadly recurved toward margin.
 8. Lamina usually thinly coriaceous and closely undulate at margin; inflorescence branched; pedicel relatively long and slender; fruit less than 1.5 cm. long. 21. *C. soulattri*.
 8. Lamina usually coriaceous, not closely undulate at margin; inflorescence rarely branched; pedicel not relatively long and slender; fruit (where known) usually more than 1.5 cm. long.

9. Midrib on upper surface of lamina broadly depressed, narrowing gradually from base. 129. *Calophyllum* sp.
9. Midrib on upper surface of lamina not broadly depressed, narrowing gradually from base or not.
10. Hairs with 2 to 4 much-expanded apical cells, the walls birefringent under polarized light.
11. Lamina not cucullate at base, with 7 to 15 veins/5 mm.; pedicels 0.4-2.5 cm. long. 45b. *C. lanigerum* var. *austrororiaceum*.
11. Lamina slightly cucullate at base, with 11 to 22 veins/5 mm.; pedicel 0.2-0.5 mm. long.
12. Twigs 1.5-3 mm. across; terminal bud to 1.5 cm. long. 52. *C. castaneum* (variant).
12. Twigs 3.5-5.5 mm. across; terminal bud at least 2 cm. long. 52. *C. castaneum*.
10. Hairs lacking much-expanded apical cells, the walls at most slightly birefringent under polarized light.
13. Anthers and ovary with hairs; fruit (not yet known in Borneo) with walls at least 1 mm. thick [lamina slightly cucullate at base]. 159. *C. molle* (variant).
13. Anthers nearly always and ovary always glabrous; fruit with stone walls less than 1 mm. thick.
14. Lamina often slightly cucullate at base, venation notably fine and clear; hairs not branched, all cells (\pm) papillate. 52. *C. woodii*.
14. Lamina not slightly cucullate at base, venation not notably fine and clear; hairs various, but not as above.
15. Twigs 1.8-3 mm. across; margin of lamina (\pm) closely undulate.
16. Hairs papillate at base; lamina not drying notably bicolored, usually shiny on upper surface; flowers with 4 (to 8) tepals. 50. *C. canum*.
16. Hairs strongly branched; lamina drying notably bicolored, not shiny on upper surface; flowers with 8 to 12 tepals.
17. Twigs drying brown, puberulent when young; inflorescence axillary. 2. *C. blancoi* group "e".
17. Twigs drying blackish, rather persistently subtomentose; inflorescence terminal. 2. *C. blancoi* group "f".
15. Twigs 3-5 mm. across; margin of lamina distantly undulate.
18. Inflorescence branched; fruit smooth, stone wall less than 0.2 mm. thick. 51. *C. lowii*.
18. Inflorescence nearly always unbranched; fruit wrinkled, stone wall more than 0.2 mm. thick. 43. *C. wallichianum*.

6. Terminal bud less than 10 mm. long.
19. Twigs with two prominent V-shaped transverse lines at nodes, otherwise subterete; lamina broadly rounded at base.
 78b. *C. teysmannii* var. *bursiculum*.
19. Twigs with at most obscure transverse lines at nodes, flattened and/or angled; lamina rarely broadly rounded at base.
20. Uppermost internode of innovation at most half as long as others.
21. Axillary innovation with (sub)basal scars.
22. Lamina subacuminate at apex, midrib on upper surface sharply raised; terminal bud sharply pointed; fruit (?)pointed at apex. 67. *C. elegans*.
22. Lamina acuminate at apex, midrib on upper surface not sharply raised; terminal bud not sharply pointed; fruit rounded at apex. 66. *C. stipitatum*.
21. Axillary innovation lacking basal scars.
23. Lamina with pale marginal band at least 0.4 mm. wide. 100b. *C. tetrapterum* var. *obovale*.
23. Lamina lacking marginal band.
24. Lamina acute to acuminate [inflorescence terminal]. 160. *C. obliquinervium*.
24. Lamina rounded to retuse at apex.
25. Inflorescence terminal; venation on upper surface of lamina apparently twice as dense as on lower. 161. *C. sakarium*.
25. Inflorescence axillary; venation same density on both sides of lamina.
26. Twigs drying finely reticulate; lamina with 3 to 5 veins/5 mm. 75. *C. confertum*.
26. Twigs not drying finely reticulate; lamina with 6 to 9 veins/5 mm. 76. *C. praetermissum*.
20. Uppermost internode of innovation about same length as others.
27. Midrib on upper surface of lamina surrounded by raised blade, midrib itself rarely much further raised, midrib on lower surface depressed or not.
28. Lamina very coriaceous, often spotted on lower surface; fruit more than 2.4 cm. long [trunk with stilt roots]. 81. *C. sclerophyllum*.
28. Lamina coriaceous, usually not spotted on lower surface; fruit (where known) less than 2 cm. long [stilt roots rare at most].
29. Lamina 7-15 cm. long, midrib on lower surface raised, 25 veins/5 mm. [fruit not known]. 56. *C. glaucescens*.
29. Lamina up to 8(-10.5) cm. long, midrib on lower surface nearly always \pm depressed, fewer than 13 (to 17) veins/5 mm.

30. Lamina drying orange-brown on lower surface, veins invisible below in both fresh and dried leaf, latex canals often \pm impressed above. 58. *C. depressinervosum*.
30. Lamina usually drying grayish brown (rarely orange-brown) on lower surface, veins visible below in both fresh and dried leaf, latex canals not impressed above.
31. Fruit spherical, less than 1 cm. long, stone wall ca. 0.2 mm. thick [throughout Borneo]. 57. *C. nodosum*.
31. Fruit ovoid, more than 1.2 cm. long, stone wall 0.3-0.5 mm. thick [mostly western Borneo]. 60. *C. pulcherrimum*.
27. Midrib on upper surface of lamina not surrounded by raised blade, midrib itself raised or not, midrib on lower surface usually raised.
32. Lamina usually obovate, or oblong-elliptic, rounded to retuse (rarely bluntly pointed) at apex.
33. Leaf inserted on stem at \pm right angle; lamina very coriaceous, drying flat, venation obscure. 162. *C. ardens*.
33. Leaf usually ascending; lamina variable in texture, usually not drying flat, venation usually apparent on at least one surface.
34. Lamina with obvious (0.3-1 mm. wide) band of marginal thickening, discoloration, or distinct submarginal vein; trunk often with spurs or stilt roots.
35. Lamina with discolored margin, veins visibly continuing to margin; fruit wrinkled, inner surface of outer layer striate and usually shiny. 87. *C. biflorum*.
35. Lamina with thickened margin, or with submarginal vein, veins not visibly continuing to margin; fruit smooth or not, the inner surface of outer layer rarely striate, never shiny.
36. Twigs less than 2(-2.5) mm. across; terminal bud 1.5-4 mm. long; fruit less than 1.5 cm. long, outer layer less than 0.5 mm. thick. 100b. *C. tetrapterum* var. *obovale*.
36. Twigs (1.3-2.5 mm. or more across; terminal bud (2-)4 mm. or more long; fruit more than 1 cm. long, outer layer more than 0.5 mm. thick.
37. Terminal bud enclosed by petiole bases; lamina with 4 or 5 (to 7) veins/5 mm.; lowest internode of inflorescence 3-7.5 cm. long [spurs and stilt roots apparently absent]. 82. *C. havilandii*.
37. Terminal bud enclosed by petiole bases or not; lamina with (4 to) 7 or more veins/5 mm.; lowest internode of innovation less than 3 cm. long [spurs and/or stilt roots often present].

38. Older twigs drying rather pale yellowish brown and contrasting with darker petioles; fruit ovoid, less than 1.7 cm. long, sharply pointed at apex, sharply wrinkled when dry. 77. *C. andersonii*.
38. Older twigs not drying notably paler than petioles; fruit usually subspherical to ellipsoid, at least 1.7 cm. long, rounded at apex, \pm smooth when dry.
39. Lamina often punctate below, drying olivaceous; trunk with stilt roots up to 3 m. or so [seedling with one pair of leaves; young plant with alternate leaves]. 81. *C. sclerophyllum*.
39. Lamina not punctate below, drying brown; trunk with stilt roots up to 1 m., or stilt roots lacking [seedling with two pairs of leaves; young plant with opposite leaves]. 78. *C. teysmannii*.
34. Lamina lacking obvious thickened or discolored margin or distinct submarginal vein; trunk rarely with spurs or stilt roots.
40. Axillary shoot with (sub)basal scars; lowest internode of axillary inflorescence usually less than 5 mm. long.
41. Lamina 1-4 cm. long; fruit unknown, probably less than 1.5 cm. long. 61. *Calophyllum* sp.
41. Lamina more than (2.5-)4 cm. long; fruit more than 1.5 cm. long.
42. Inflorescence terminal and axillary; flower with 12 or more tepals; fruit subspherical, wrinkled. 69. *C. garcinioides*.
42. Inflorescence axillary; flower with 4 or 8 tepals; fruit ellipsoid or pyriform, smooth or shallowly wrinkled.
43. Lamina with (9 to) 11 to 17 (to 22) veins/5 mm.; flower with 4 tepals; fruit ellipsoid. 88. *C. hosei*.
43. Lamina with 6 to 11 veins/5 mm.; flower with 8 tepals; fruit pyriform. 67. *C. elegans*.
40. Axillary shoot lacking (sub)basal scars; lowest internode of axillary inflorescence usually more than 5 mm. long.
44. Lamina (2.5-)3.5-6.5(-9) cm. long; terminal bud to 3 (very rarely -7) mm. long; fruit either furfuraceous or 1 cm. or less long.
45. Twigs and midrib short-tomentose; lamina with at least 14 veins/5 mm., midrib often disappearing ca. 3 mm. below apex.

46. Twigs slightly flattened; terminal bud 2-3 mm. long; midrib on lower surface of lamina only slightly raised. 177. *C. exiticostatum*.
46. Twigs strongly flattened; terminal bud 3-6.5 mm. long; midrib on lower surface of lamina strongly raised. 19c. *C. calaba*.
45. Twigs and midrib furfuraceous to puberulent; lamina with 3 to 9 veins/5 mm., midrib not disappearing below apex.
47. Venation on upper surface of lamina apparently twice as dense as on lower [inflorescence terminal]. 161. *C. sakarium*.
47. Venation same density on both sides of lamina.
48. Lamina \pm cuneate at base, with rather obscure venation; inflorescence axillary, axis less than 1.7 cm. long. 167. *C. aurantiacum*.
48. Lamina broadly rounded at base, with distinct venation; inflorescence terminal and axillary, axis at least 2 cm. long. 98. *Calophyllum* sp.
44. Lamina usually over 5 cm. long; terminal bud more than 3 mm. long; fruit not furfuraceous, over 1 cm. long.
49. Lamina rather thinly coriaceous, with 5 to 10 veins/5 mm.; fruit at least 2.5 cm. long [usually seaside tree; trunk often not vertical]. 38. *C. inophyllum*.
49. Lamina usually coriaceous, with (7 to) 9 or more veins/5 mm.; fruit less than 2.5(-3) cm. long [not seaside tree; trunk usually vertical].
50. Venation on upper surface of lamina apparently twice as dense as on lower.
51. Lamina sharply recurved at margin; inflorescence axis at least 2 cm. long. 84c. *C. ferrugineum* var. *orientale*.
51. Lamina not sharply recurved at margin; inflorescence axis less than 2 cm. long. 23. *C. rigidum* (variant).
50. Venation same density on both sides of lamina.
52. Lamina rather closely undulate at margin, usually drying yellowish brown; inflorescence with relatively short basal internode and relatively long lateral branches [pedicel notably long (up to 3 cm.) and slender; fruit spherical, smooth]. 21. *C. soulattri*.
52. Lamina not closely undulate at margin, usually drying other than yellowish brown; inflorescence lacking relatively short basal internode, rarely branched.

53. Indumentum tomentose, conspicuous (on stem, terminal bud, and often midrib of lower surface of lamina).
54. Lamina 3.8-12.5(-15) cm. long, drying chestnut brown; apical cells of hairs notably expanded. 45a. *C. lanigerum* var. *lanigerum*.
54. Lamina 12.5-18 cm. long, drying olivaceous-brown; apical cells of hairs not notably expanded. 53. *Calophyllum* sp.
53. Indumentum inconspicuous, crustaceous to subtomentose.
55. Lamina often obovate; fruit spherical, smooth, outer layer not detaching cleanly from stone. 78. *C. teysmannii*.
55. Lamina oblong-elliptic; fruit \pm ellipsoid, wrinkled, outer layer detaching cleanly from stone.
56. Lamina drying \pm flat; lowest internode of inflorescence 0.4-1.8 cm. long [usually in peat swamps, rarely in kerangas; latex yellow]. 85. *C. sundaicum*.
56. Lamina usually undulate at margin; lowest internode of inflorescence (0.35-)0.7-3.2 cm. long [rarely in peat swamps, usually in kerangas or mixed dipterocarp forest; latex usually white]. 87. *C. biflorum*.
32. Lamina ovate to oblong-elliptic (very rarely subovate), \pm acuminate at apex.
57. Twigs at least 3 mm. across, 4-subalate to alate, drying black, rarely brown; petiole (1.5-)3 cm. or more long. 83. *C. macrocarpum*.
57. Twigs often less than 3 mm. across, rarely 4-alate or drying black; petiole shorter.
58. Lamina margin with clear thickening at least 0.3 mm. wide or with distinct submarginal vein.
59. Lamina thinly coriaceous; fruit less than 1.5 cm. long, outer layer with air spaces developing. 100b. *C. tetrapterum* var. *obovale*.
59. Lamina coriaceous; fruit over 1.5 cm. long, outer layer compact. 78c. *C. teysmannii* var. *inophylloide*.
58. Lamina margin neither clearly thickened nor with distinct submarginal vein.
60. Axillary shoot with (sub)basal scars.
61. Latex canals irregularly ascending across veins on lower surface of lamina; inflorescence terminal. 69. *C. garcinoides*.

61. Lamina lacking irregularly ascending latex canals on lower surface; inflorescence axillary.
62. Lamina 11.5-23 cm. long, lower surface subsersistently and shortly tomentose. 63. *C. pyriforme*.
62. Lamina less than 11.5(-13) cm. long, lower surface glabrous.
63. Terminal bud and stem tomentose.
64. Terminal bud (3.5-)4.5-7 mm. long; lamina 6-13 cm. long; outer layer of fruit (0.5-)1-1.5 mm. thick. 104. *C. dispar*.
64. Terminal bud 2-4.5 mm. long; lamina 3-7.8 cm. long; outer layer of fruit 0.2-0.5 mm. thick. 102. *C. pisiferum*.
63. Terminal bud and stem with puberulent to crustaceous indumentum.
65. Venation on both surfaces of lamina inconspicuous (also in living leaf), latex canals sometimes impressed above; fruit spherical. 58. *C. depressinervosum*.
65. Venation on at least one surface of lamina prominent (also (?always) in living leaf), latex canals not impressed above; fruit stipitate.
66. Midrib on upper surface of lamina not sharply raised, often drying reddish brown; internode 1-5 cm. long. 64. *C. roseocostatum*.
66. Midrib on upper surface of lamina sharply raised and/or not drying reddish brown; internode 1-3.5 cm. long. 65. *Calophyllum* sp.
60. Axillary shoot lacking (sub)basal scars.
67. Inflorescence terminal, sometimes also from uppermost leaf axils.
68. Twigs drying yellowish; anthers with hairs; fruit ellipsoid. 158. *C. rubiginosum*.
68. Twigs drying blackish, brown, or gray; anthers glabrous; fruit subspherical.
69. Lamina with 9 to 19 veins/5 mm.; fruit less than 1.5 cm. long. 160. *C. obliquinervium*.
69. Lamina with 4 to 10 veins/5 mm.; fruit more than 1.5 cm. long.
70. Lamina drying grayish brown above; inflorescence axis and pedicel puberulent. 168. *C. griseum*.
70. Lamina not drying grayish brown above; inflorescence axis and pedicel glabrous. 1. *C. alboramulum*.
67. Inflorescence axillary, if exceptionally terminal then also from axils along twig.

71. Lamina often drying yellowish brown, thinly coriaceous, margin closely undulate; inflorescence branched and/or flabellate; fruit smooth. 21. *C. soulattri*.
71. Lamina usually drying other than yellowish brown, often coriaceous, margin variably undulate; inflorescence neither branched nor flabellate; fruit nearly always wrinkled or furfuraceous.
72. Terminal bud, and sometimes also twigs, with (dark) brown, tomentose indumentum.
73. Lamina coriaceous, margin not undulate, venation on upper surface apparently twice as dense as on lower [fruit 1.2-1.6 cm. long, the outer layer 1-2.5 mm. thick, compact]. 23. *C. rigidum*.
73. Lamina (thinly) coriaceous, margin \pm undulate, venation same density on both surfaces.
74. Twigs little flattened, strongly 4-angled to subulate; fruit furfuraceous.
75. Lamina strongly recurved at margin; twigs 2.5-3.7 mm. across; filaments \pm connate. . . 166. *C. recurvatum*.
75. Lamina not strongly recurved at margin; twigs 0.6-2.5 mm. across; filaments connate for up to 0.8 mm. only. 165. *C. gracilipes*.
74. Twigs not as above; fruit not furfuraceous.
76. Lamina 9-22 cm. long; fruit at least 1.3 cm. long.
77. Lamina thinly coriaceous, closely undulate at margin; fruit pyriform. 63. *C. pyriforme*.
77. Lamina coriaceous, not closely undulate at margin; fruit \pm spherical. 52. *C. woodii*.
76. Lamina less than 13 cm. long; fruit less than 1 cm. long.
78. Terminal bud (3.5-)-4.5-7 mm. long; lamina 6-13 cm. long; outer layer of fruit (0.5-)-1-1.5 mm. thick. 104. *C. dispar*.
78. Terminal bud 2-4.5 mm. long; lamina 3-7.8 cm. long; outer layer of fruit 0.2-0.5 mm. thick. 102. *C. pisiferum*.
72. Terminal bud and twigs lacking tomentose indumentum.
79. Lamina coriaceous, often shiny, venation often subobscure below; pedicel puberulent, usually incrassate and to 2 mm. across in fruit; outer layer of fruit 1-1.8 mm. thick, with air spaces developing under skin. 105. *C. incumbens*.
79. Lamina coriaceous or not, rarely shiny, venation \pm apparent below; pedicel glabrous to subtomentose, incrassate in fruit or not; outer layer of fruit not as above.
80. Twigs drying whitish to yellowish; lamina 3-9(-10.5) cm. long, strongly acuminate at apex.
81. Petiole 3.5-6 mm. long; lamina with 12 to 20 (to 28) veins/5 mm.; fruit strongly wrinkled, at least when young, outer layer developing large air spaces. 106. *C. dioscurii*.
81. Petiole 7-18 mm. long; lamina with 8 to 14 veins/5 mm.; fruit almost smooth, outer layer compact. 107. *C. banyengii*.

80. Twigs drying brownish to blackish; lamina usually not as above.
82. Lamina (3.3–)9–22 cm. long, with 10 to 18 (to 22) veins/5 mm.; inflorescence axis, pedicel, and back of at least outer pair of tepals puberulent; fruit ovoid. 50. *C. canum*.
82. Lamina usually less than 12.5 cm. long, with up to 12 (to 18) veins/5 mm.; upper part of inflorescence axis, pedicel, and back of outer pair of tepals usually glabrous; fruit spherical to ellipsoid (not known in *Calophyllum* sp. 164).
83. Lamina drying bicolored, tawny brown below; fruit spherical, ca. 1.2 cm. long, the outer layer detaching cleanly from stone, 1.3–2 mm. thick, compact. 163. *Calophyllum* sp.
83. Lamina not drying bicolored, other than tawny brown below; fruit not as above.
84. Terminal bud 1.3–2 mm. long, underdeveloped internode beneath bud 1–6 mm. long; lamina with 13 to 18 veins/5 mm.; anthers less than 0.4 mm. long. 164. *Calophyllum* sp.
84. Terminal bud usually longer, underdeveloped internode usually shorter than bud; lamina usually with fewer than 12 veins/5 mm.; anthers at least 0.5 mm. long.
85. Venation often rather obscure; fruit furfuraceous. 165. *C. gracilipes*.
85. Venation rather clear; fruit not furfuraceous.
86. Lamina ca. 3 times longer than broad, the midrib narrowing gradually from wide base, depressed; pedicel and back of outer pair of tepals puberulent. 48. *C. dasypodum*.
86. Lamina usually less than 2½ times longer than broad, the midrib narrowing quickly near base and/or not very wide at base, not depressed; pedicel and back of outer pair of tepals glabrous.
87. Lamina thinly coriaceous, clearly acuminate at apex; fruit spherical.
. 100a. *C. tetrapterum* var. *tetrapterum*.
87. Lamina coriaceous, ± obscurely acuminate at apex; fruit ellipsoid. 87. *C. biflorum*.

6. Key to Species of *Calophyllum* from the Philippine Islands to Botel Tobago
and the Northern Pacific

1. Axillary innovation with basal scars; axillary inflorescence with basal internode less than 2 mm. long [terminal bud 1–2.5 mm. long]. 62. *C. pelewense*.

1. Axillary innovation lacking basal scars; inflorescence with basal internode usually more than 2 mm. long.
2. Terminal internode of innovation nearly always much shorter than others; lamina obovate to elliptic, acuminate at apex, angle of divergence of venation 35-50°. 160. *C. obliquinervium*.
2. Terminal internode of innovation about same length as others; lamina not as above, angle of divergence of venation usually more than 50°.
 3. Lamina broadly rounded to cordate or auriculate at base; petiole less than 6 mm. long.
 4. Lamina 1.3-2.7 cm. long, with 13 to 17 veins/5 mm. 171. *C. brachyphyllum*.
 4. Lamina more than 3 cm. long, if less then with fewer than 13 veins/5 mm.
 5. Inflorescence terminal; outer layer of fruit 0.2-0.4 mm. thick, becoming disorganized by air spaces [lamina up to 5.8(-8) cm. long, margin flat]. 96a. *C. pentapetalum* var. *pentapetalum*.
 5. Inflorescence axillary; outer layer of fruit at least 1 mm. thick, ± compact.
 6. Lamina with (3 or) 4 to 8 veins/5 mm., venation clear. 90a. *C. venulosum* var. *venulosum*.
 6. Lamina with at least 8 veins/5 mm., venation rather obscure.
 7. Uppermost pair of axillary buds less than 1/3 length of terminal bud, inconspicuous; lamina sparsely tomentose over entire lower surface. 95. *Calophyllum* sp.
 7. Uppermost pair of axillary buds ca. 1/3 length of terminal bud, conspicuous; lamina tomentose on (also near) midrib on lower surface. 21. *C. soulattri*.
 3. Lamina rounded to attenuate at base; petiole often more than 6 mm. long.
 8. Lamina broadly rounded and cucullate at base, midrib at first broad but abruptly narrowed at base; twigs drying blackish; indumentum tomentose. 55. *C. cucullatum*.
 8. Lamina rarely broadly rounded and not cucullate at base, midrib at most subabruptly narrowed at base; twigs drying blackish to yellowish; indumentum tomentose or various.
 9. Lamina 1.4-3 cm. long, very coriaceous, with 13 to 16 veins/5 mm., margin plane, midrib on lower surface ± depressed. 172. *C. rigidulum*.
 9. Lamina usually larger, if as small then with fewer than 13 veins/5 mm., midrib on lower surface usually not depressed.
 10. Lamina thinly coriaceous, closely undulate at margin, with 5 to 8 veins/5 mm., the venation prominulous above, obscure below, the latex canals impressed above; inflorescence with 3 to 5 flowers; fruit furfuraceous. 165. *C. gracilipes*.
 10. Lamina ± coriaceous, otherwise not as above; inflorescence usually with more than 5 flowers; fruit not furfuraceous.

11. Inflorescences terminal (also axillary).
12. Terminal bud 1-4 mm. long; lamina acute to rounded at apex, drying flat; twigs not drying notably yellowish. 96. *C. pentapetalum*.
12. Terminal bud 2.5-20 mm. long; lamina \pm acuminate (rarely rounded) at apex, not drying flat; twigs sometimes drying notably yellowish.
13. Terminal bud 2.5-4.5(-6) mm. long; lamina drying concolorous, often nitid; hairs papillate [lamina often with conoid galls]. 153. *C. whitfordii*.
13. Terminal bud 6-20 mm. long; lamina usually drying bicolored, rarely nitid; hairs usually branched [lamina very rarely with conoid galls]. 2. *C. blancoi*.
11. Inflorescences axillary.
14. Midrib on upper surface of lamina surrounded by raised blade, rather indistinct; twigs drying blackish; terminal bud (1.5-)2-3 mm. long, perhaps not functional. 68. *C. oliganthum*.
14. Midrib on upper surface of lamina not surrounded by raised blade; twigs rarely drying blackish; terminal bud more than 3 mm. long, probably functional.
15. Midrib on upper surface of lamina narrowing gradually from base, \pm strongly sulcate or depressed.
16. Twigs strongly angled, short-tomentose. 48. *C. dasypodum*.
16. Twigs rarely strongly angled, inconspicuously puberulent.
17. Lamina elliptic, midrib on upper surface depressed; fruit ca. 1.5 cm. long. 128. *C. laticostatum*.
17. Lamina ovate to elliptic, midrib on upper surface sulcate to almost flat; fruit 1.9-2.3 cm. long. 121. *Calophyllum* sp.
15. Midrib on upper surface of lamina not narrowing gradually from base, \pm strongly raised.
18. Terminal bud ca. 4 mm. long; lamina with 5 or 6 veins/5 mm., the venation apparent above, obscure below, the latex canals \pm impressed on lower surface; inflorescence with ca. 5 flowers. 178. *Calophyllum* sp.
18. Terminal bud usually longer than 4 mm.; lamina usually with denser venation, the venation \pm apparent on lower surface, whether or not latex canals impressed; inflorescence usually with more than 5 flowers.
19. Uppermost pair of axillary buds erect, $\frac{1}{3}$ - $\frac{1}{2}$ length of terminal bud; lamina often closely undulate at margin; inflorescence usually branched and/or with flowers arranged flabel-lately; flower with 4 tepals; fruit smooth. 21. *C. soulattri*.

19. Uppermost pair of axillary buds less than $\frac{1}{3}$ length of terminal bud, usually \pm spreading; lamina not usually closely undulate at margin; inflorescence rarely branched or with flowers arranged flabellately; flower with (4 to) 8 or more tepals; fruit only rarely smooth when ripe.
20. Lamina rounded to retuse or subacute at apex, drying \pm concolorous, with 4 to 10 veins/5 mm. 38. *C. inophyllum*.
20. Lamina acuminate at apex, often drying bicolored, with 5 to 18 (to 20) veins/5 mm. 2. *C. blancoi*.

7. Key to Species of *Calophyllum* from Sulawesi to Australia and the Southern Pacific

1. Lamina 32-45 by 9-11 cm., with 3 to 5 veins/5 mm.; twigs strongly angled [poorly known species]. 179. *C. macrophyllum*.
1. Lamina smaller, usually with less dense venation; twigs usually not strongly angled.
2. Terminal bud strongly flattened transversely, leaf blades clearly visible [hairs much branched to stellate].
3. Lamina (2.4-)-6.5-17(-22) cm. long; ovary tomentose; outer pair of tepals at least 5 mm. long; anthers in staminate flower 2.3-5.5 mm. long. 135. *C. papuanum*.
3. Lamina to 12.5 cm. long; ovary glabrous; outer pair of tepals less than 5 mm. long; anthers in staminate flower 1.5-2.7 mm. long.
4. Lamina subacute to rounded at apex, 2.5-5.5(-9.5) cm. long; tepals (rarely 7 or) 8; anthers in staminate flower 0.7-1.7 mm. long. 136. *C. pauciflorum*.
4. Lamina acute to acuminate at apex, 3.4-12.5 cm. long; tepals 4 to 8; anthers in staminate flower 1.8-2.6 mm. long. 137. *C. vexans*.
2. Terminal bud not strongly flattened transversely, leaf blades not clearly visible.
5. Terminal bud less than 4 mm. long, or sometimes apparently absent.
6. Terminal bud apparently absent, underdeveloped internode 3-7(-13) mm. long; lamina with 5 to 7 veins/5 mm., angle of divergence of venation 45-60°. 117. *C. savannarum*.
6. Terminal bud present, underdeveloped internode inconspicuous; venation not as above.
7. Lamina gradually long-acuminate-caudate at apex.
8. Lamina with 6 to 8 veins/5 mm.; axillary innovation with basal scars. 112. *C. bifurcatum*.
8. Lamina with (7 to) 9 to 16 veins/5 mm.; axillary innovation lacking basal scars.
9. Lamina \pm nitid, margin closely undulate, midrib on upper surface raised, surrounding lamina also raised,

- midrib on lower surface with \pm depressed edges. 111. *C. undulatum*.
9. Lamina dull, margin not closely undulate, midrib on upper surface raised, but surrounding lamina not raised, midrib on lower surface not with depressed edges. 110. *C. caudatum*.
7. Lamina retuse to subabruptly acuminate at apex.
10. Lamina broadly rounded to cordate at base.
11. Lamina very coriaceous; axillary bud recessed into stem and petiole base. 116. *C. articulatum*.
11. Lamina coriaceous; axillary bud exposed.
12. Lamina with 4 to 7 veins/5 mm.; pedicel 2.2-3.5 cm. long. 113. *C. parvifolium*.
12. Lamina with 12 to 16 veins/5 mm.; pedicel 0.3-1 cm. long. 19e. *C. calaba* var. *E*.
10. Lamina other than broadly rounded to cordate (an occasional leaf broadly rounded) at base.
13. Lamina with 5 to 9 (to 11) veins/5 mm.; fruit 5-7 mm. long, the stone wall ca. 0.1 mm. thick, not angled. 108. *C. novoguineense*.
13. Lamina with (8 to) 10 or more veins/5 mm.; if fruit less than 1 cm. long then the stone wall ca. 0.2 mm. thick, angled.
14. Lamina 2.2-5.5 by 0.5-1.5 cm.; fruit with angled stone. 143. *Calophyllum* sp.
14. Lamina 2.7-9 by 1.2-4.5 cm.; fruit with rounded stone.
15. Twigs drying yellowish brown; fruit ca. 1.6 cm. long, outer layer less than 1 mm. thick. 152. *C. leptocladum*.
15. Twigs drying dark brown to blackish; fruit 2.3-2.8 cm. long, outer layer 2-3.5 mm. thick.
16. Lamina ca. 2 times longer than broad; fruit drying wrinkled, stone wall 1.3-1.5 mm. thick. 146. *C. morobense*.
16. Lamina ca. 3 times longer than broad; fruit drying smooth, stone wall 0.2-0.3 mm. thick. 114. *C. confusum*.
5. Terminal bud more than 4 mm. long, always present.
17. Midrib on upper surface of lamina raised, often not clearly distinct from lamina, surrounding lamina also raised.
18. Lamina (thinly) coriaceous; twigs up to 3.5 mm. across.
19. Uppermost pair of axillary buds erect; fruit less than 2 cm. long. 21. *C. soulattri*.
19. Uppermost pair of axillary buds spreading; fruit ca. 5 cm. long. 176. *C. echinatum*.
18. Lamina thickly coriaceous; twigs (1.5-)3-7 mm. across.
20. Twigs 5-7 mm. across; lamina ovate, 2-2½ times longer than broad; trunk with stilt roots, the sap clear yellow, sticky. 148. *C. suberosum*.

20. Twigs (1.5-)3-5 mm. across; lamina elliptic to oblong (rarely subovate), (2-)2½-3 times longer than broad; trunk without stilt roots, the sap opaque yellow, fluid. 149. *C. persimile*.
17. Midrib on upper surface of lamina raised or not, clearly distinct from lamina, surrounding lamina not raised.
21. Lamina usually more than 9 cm. long, with (3 or) 4 to 9 (to 11) veins/5 mm., venation apparent; inflorescence axis (1.3-)3 cm. or more long; pedicel (0.4-)1-4.5(-6.3) cm. long.
22. Lamina less than 2(-2½) times longer than broad, drying other than sepia on upper surface and smooth even under strong magnification, midrib on upper surface often rather quickly narrowed at base. 38. *C. inophyllum*.
22. Lamina usually ca. 3 times longer than broad, drying sepia on upper surface and minutely bullate under strong magnification, midrib on upper surface gradually narrowing from base. 118. *C. vitiense*.
21. Not as above.
23. Midrib on upper surface of lamina broadly depressed, at least in bottom ⅓, margins not raised; terminal bud plump, conspicuous.
24. Midrib on upper surface of lamina usually narrowing in lower ca. ⅓; flower with (9 to) 12 (to 16) tepals. 122. *C. caledonicum*.
24. Midrib on upper surface of lamina narrowing gradually from base; flower with 4 to 8 (to 12) tepals.
25. Lamina narrowly ovate to elliptic, usually drying nitid, midrib and venation notably richer brown than rest; stone with basal plug. 12. *C. neo-ebudicum*.
25. Lamina narrowly elliptic to obovate, midrib and venation not notably different color from rest; stone without basal plug [fruit not known in *C. carrii*].
26. Lamina obovate, ± retuse at apex, thickened margin 0.3-1 mm. wide; tepals (6 to) 8. 123. *C. carrii*.
26. Lamina usually ± elliptic, ± rounded to acute at apex, thickened margin variable; tepals (where known) 4 to 6.
27. Lamina often less than 2½ times longer than broad, midrib on upper surface 0.25-0.6 mm. wide at midpoint; terminal bud 0.5-1(-1.3) cm. long. 127. *C. sil.*
27. Lamina at least 2½ times longer than broad, midrib on upper surface 0.2-1.6 mm. wide at midpoint; terminal bud (0.8-)1-2.7 cm. long.

28. Lamina with 6 to 11 veins/5 mm.; pedicels 0.7-1.3 cm. long; outer layer of fruit thin, disorganized by air spaces [flower unknown]. 129. *Calophyllum* sp.
28. Lamina with (9 to) 11 to 20 veins/5 mm.; pedicel 0.2-0.8(-1.1) cm. long; outer layer of fruit (?0.5-)-1-3 mm. thick, not disorganized by air spaces. 128. *C. laticostatum*.
23. Midrib on upper surface of lamina with raised margins even near base; terminal bud plump or not.
29. Inflorescence reduced to solitary flower; flower bud obpyriform; outer pair of tepals with indumentum on both surfaces [lamina ovate, long-acuminate, with (13 to) 16 to 19 (to 22) veins/5 mm.].
. 173. *C. insularum*.
29. Inflorescence with more than one flower; flower bud (where known) spherical to ellipsoid; outer pair of tepals nearly always glabrous inside.
30. Lamina usually broadly rounded to cordate at base; petiole less than 8 mm. long.
31. Terminal bud to 5.5 mm. long, probably not functional; axillary innovation with basal scars; lamina acuminate-caudate at apex [flower not known]. 112. *C. bifurcatum*.
31. Terminal bud at least 5 mm. long, functional; axillary innovation lacking basal scars; lamina acute at apex.
32. Uppermost pair of axillary buds $\frac{1}{3}$ - $\frac{1}{2}$ length of terminal bud, erect and conspicuous; inflorescence branches conspicuous, ca. $\frac{1}{3}$ or more length of main axis; fruit less than 1.5 cm. long, stone wall less than 0.3 mm. thick. 22. *C. brassii*.
32. Uppermost pair of axillary buds shorter, \pm spreading, inconspicuous; inflorescence branches, if any, relatively shorter; fruit more than 1.5 cm. long, stone wall at least 1 mm. thick [presently unidentifiable sterile material from Irian Jaya and westward keys out here].
33. Lamina with 4 to 7 veins/5 mm., venation apparent; stone not angled, with basal plug. 133. *C. wallense*.
33. Lamina with 9 to 17 veins/5 mm., venation subobscure; stone angled, lacking basal plug. 142. *C. goniocarpum*.

30. Lamina rarely broadly rounded at base; petiole often more than 8 mm. long.
34. Twigs 3.5-6.5 mm. across, almost square or \pm 4-ate, often drying blackish; lamina thickly coriaceous.
35. Terminal bud 0.7-0.9 cm. long; fruit less than 2.5 cm. long, stone wall less than 0.1 mm. thick, basal plug lacking. 80. *C. celebicum*.
35. Terminal bud 0.9-1.5 cm. long; fruit at least 4.5 cm. long, stone wall 3-5 mm. thick, basal plug present. 131. *C. peekelii*.
34. Twigs usually thinner, if as thick then not almost square or alate, usually drying brownish; lamina thickly coriaceous or not.
36. Lamina retuse to acute at apex.
37. Lamina usually less than 8 cm. long.
38. Tepals 8, outer pair puberulent on back; fruit 2.8-3.5 cm. long [Australia]. 125. *C. costatum*.
38. Tepals 4 to 6, outer pair glabrous on back [flowers of *C. collinum* not known] and/or fruit less than 2.2 cm. long [Papuaia]. 124. *C. collinum*.
39. Lamina with 6 to 11 (to 14) veins/5 mm.; inflorescence with terminal flowers \pm in groups of five; ripe fruit not known, but probably with angled stone. 140. *C. heterophyllum*.
39. Lamina with 9 to 20 veins/5 mm.; inflorescence with terminal flowers in groups of three; fruit with rounded stone.
40. Internode 0.4-2 cm. long; hairs on terminal bud with several branches, often bifurcated at apex; inflorescence lacking persistent foliaceous bracts; fruit with outer layer 1.5-3 mm. thick, \pm compact. 124. *C. collinum*.
40. Internode 1-6 cm. long; hairs on terminal bud with at most one or two branches, not bifurcated at apex; inflorescence usually with persistent foliaceous bracts; fruit with outer layer thin and disorganized by air spaces. 138. *C. hirasimum*.
37. Lamina usually more than 8 cm. long.
41. Hairs much branched, often \pm persistent over entire lower surface of lamina; uppermost pair of axillary buds 3-10(-14) mm. long, spreading, conspicuous; fruit 2.8-6 cm. long. 134. *C. euryphyllum*.

41. Hairs rarely much branched, very rarely persistent on lower surface of lamina; uppermost pair of axillary buds erect to spreading, rarely so conspicuous; fruit less than 3.2 cm. long.
42. Lamina with 4 to 10 (to 12) veins/5 mm., venation usually apparent on at least one surface.
43. Lamina broadly rounded (also apiculate) at apex, margin sharply and rather strongly recurved; fruit ca. 2 cm. long, stone wall less than 0.05 mm. thick. 79. *C. aerarium*.
43. Lamina not broadly rounded at apex, margin slightly recurved; fruit variable in size, stone wall more than 0.2 mm. thick [not known in *C. heterophyllum*].
44. Terminal bud 0.6-1(-1.2) cm. long; lamina less than 10 cm. long; inflorescence with terminal flowers \pm in groups of five. 140. *C. heterophyllum*.
44. Terminal bud 0.8-2 cm. long; lamina usually more than 10 cm. long; inflorescence with terminal flowers in groups of three. 132. *C. leleanii*.
42. Lamina with (6 to) 10 or more veins/5 mm., venation often \pm obscure on one or both surfaces.
45. Lamina usually rather thinly coriaceous, margin closely undulate; uppermost pair of axillary buds \pm adpressed to terminal bud, conspicuous; inflorescence branched and/or flabellate; fruit with thick, compact outer layer. 21. *C. soulattri*.
45. Lamina not as above; uppermost pair of axillary buds variable; inflorescence unbranched or with inconspicuous lateral branches; outer layer of fruit often not compact.
46. Inflorescence lacking axis; fruit ca. 5 mm. long [poorly known species]. 141. *C. rufinerve*.
46. Inflorescence with axis; fruit at least 1.5 cm. long.
47. Inflorescence axis, pedicel, and back of outer tepals farinose-puberulent; flower with 8 tepals; fruit with stone neither angled nor with basal plug. 126. *C. obscurum*.
47. Inflorescence glabrous or pubescent, back of outer tepals glabrous; flower with 4 to 12 tepals; fruit with stone either angled or with basal plug.
48. Flower with 8 to 12 tepals; stone rounded, basal plug present. 120. *C. cerasiferum*.
48. Flower with 4 (rarely 5) tepals; stone angled, basal plug absent.
49. Lower surface of lamina subpersistently tomentose; pedicel tomentose, 2.5-6 mm. long. 139. *C. trachycaule*.

49. Lower surface of lamina with inconspicuous indumentum; pedicel glabrous, 5-9 mm. long (to 18 mm. in fruit). 142. *C. goniocarpum*.
36. Lamina acute to acuminate at apex.
50. Terminal bud 1.6-3.3 cm. long; midrib on lower surface of lamina strongly angled. 24. *C. robustum*.
50. Terminal bud to 1.5 cm. long; midrib on lower surface of lamina rounded to subangled.
51. Lamina usually thinly coriaceous, margin closely undulate; inflorescence branched and/or flabellate; fruit spherical, the outer layer thick, compact, the stone thin, unmarked [uppermost pair of axillary buds usually erect and conspicuous]. 21. *C. soulattri*.
51. Lamina not as above; inflorescence usually unbranched; fruit not as above.
52. Inflorescence without axis; pedicel pilose; fruit ca. 0.5 cm. long [poorly known species]. .141. *C. rufinerve*.
52. Inflorescence with axis; pedicel usually glabrous; fruit (0.7-)1 cm. or more long.
53. Indumentum dense, tomentose, persisting on terminal bud, stem, lower surface of lamina (frequently), inflorescence axis, and pedicel.
54. Lamina with 4 to 9 veins/5 mm., usually drying bicolored [brown to vinaceous-olivaceous above, honey to sabelline below]; fruit less than 1 cm. long. 109. *C. bicolor*.
54. Lamina with 12 to 20 veins/5 mm., not drying notably bicolored; fruit more than 2 cm. long. 139. *C. trachycaule*.
53. Indumentum usually other than tomentose, pedicel and lower surface of lamina glabrous or almost so.
55. Lamina very coriaceous, margin almost plane, midrib narrowed gradually from base, sharply raised, venation obscure on both surfaces; fruit ellipsoid, stone sharply pointed at apex. 147. *C. acutiputamen*.
55. Lamina not as above; fruit spherical to ellipsoid, stone at most obtusely pointed at apex.
56. Terminal bud 4.5-5 mm. long; lamina with 7 to 9 veins/5 mm., venation obscure, latex canals impressed below; pedicel at anthesis 1-3 mm. long. 115. *C. leucocarpum*.
56. Terminal bud usually longer than 5 mm.; lamina with (6 to) 8 to 22 veins/5 mm., venation \pm apparent, latex canals not impressed below; pedicel at anthesis (where known) more than 3 mm. long.

57. Flower (where known) with 8 or more tepals and/or fruit with basal plug.
58. Terminal bud 2-5 mm. long; lamina with midrib 0.1-0.2(-0.3) mm. wide at midpoint. 146. *C. morobense*.
58. Terminal bud (0.4-)0.6-1.6 cm. long; lamina with midrib (0.1-)0.2-0.5(-0.8) mm. wide at midpoint.
59. Midrib on upper surface of lamina rather narrow and \pm raised even at base. 145. *C. streimannii*.
59. Midrib on upper surface of lamina broad and \pm depressed at base.
60. Twigs not often drying coarsely striate; lamina usually drying olivaceous-umber and nitid, midrib and veins notably browner than rest of lamina. 119. *C. neo-ebudicum*.
60. Twigs soon becoming coarsely striate; lamina drying dull sepia, midrib darker, veins not discolored. 120. *C. cerasiferum*.
57. Flower (where known) with ca. 4 tepals and/or fruit lacking basal plug.
61. Lamina with 12 to 22 veins/5 mm.; outer layer of fruit developing air spaces, stone clearly angled. 144. *C. piluliferum*.
61. Lamina with (6 to) 8 to 12 (to 16) veins/5 mm.; outer layer of fruit rarely developing air spaces, stone at most obscurely angled.
62. Petiole 0.6-0.8 mm. across; lamina with midrib on upper surface 0.1-0.15 mm. wide at midpoint; fruit with outer layer 2.6-4 mm. thick, stone wall 0.2-0.3 mm. thick. 114. *C. confusum*.
62. Petiole 1-1.5 mm. across; lamina with midrib on upper surface 0.3-0.6(-0.7) mm. wide at midpoint; fruit with outer layer 0.5-2.7 mm. thick, stone wall 0.2-2.2 mm. thick.
63. Lamina drying dark auburn above; pedicel 7-11 mm. long; fruit ca. 1.2 cm. long. 19f. *C. calaba* var. *australianum*.
63. Lamina drying sepia to sabelline-olivaceous above; pedicel 2-8.5 mm. long; fruit 1.8-2.7 cm. long. 137. *C. vexans*.

SPECIES ACCOUNTS

1. *Calophyllum alboramulum* P. F. Stevens, sp. nov.

FIGURE 8, a.

Calophyllum sp. 23, M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 327, pl. 1D, 13, 1956; Kochummen, Malayan Forest Rec. ed. 2, 17: 214, 1965; T. C. Whitmore, Tree Fl. Malaya 2: 195, 1973.

A speciebus aliis *Calophylli* in ramulo in siccitate albescenti, folia plus minusve elliptica circa 8.5–16 cm. longa venulis lateralibus subdistantibus prominentibus e costa (60–)65–75° divergentibus, inflorescentia terminali, et fructu subsphaerico circa 2.5 cm. longo in siccitate albescenti reticulato-rugosoque putamine parietibus minoribus quam 0.1 mm. crassis, differt.

Tree 12–33 meters tall, d.b.h. to 120 cm.; trunk without buttresses, but sometimes with spurs; outer bark gray to yellowish, more or less smooth, cracked or with lenticels in lines, inner surface orange; under bark greenish or dark green-red; inner bark pale red; latex yellow, opaque, sticky.

Twigs flattened, 2.5–3.7 mm. across, rounded or obscurely 4-angled, drying blackish and pruinose when young, yellowish brown to whitish yellow when older, transiently brown-farinose; axillary innovations lacking basal scars; internodes 1–4.5 cm. long; upper pair of axillary buds ± rounded, 1–3 mm. long, erect; terminal bud plump, 6.5–10 mm. long, with crustose, brown

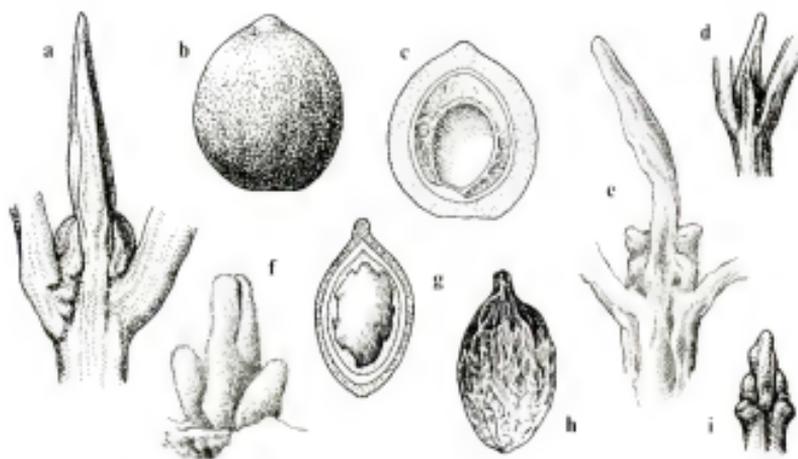


FIGURE 8. a, *Calophyllum alboramulum* (Stevens et al. 81), terminal bud, $\times 3$. b–d, *C. touranense*. b, c, fruit (Clemens 4162), $\times 0.75$: b, from outside; c, longitudinal view. d, terminal bud (Poilane 7179), $\times 3$. e, *Calophyllum* sp. 9 (bb 5467), terminal bud, $\times 6$. f, *C. vergens* (Kostermans 24469), terminal bud, $\times 6$. g–i, *C. austroindicum*. g, h, fruit (Kostermans 26139), $\times 0.75$: g, longitudinal section; h, from outside. i, terminal bud (Kostermans 26264), $\times 3$.

indumentum (hairs, FIGURE 9, a-d), underdeveloped internode to 4 mm. long. Petiole 1.8-3.5 cm. long, more or less concave above, convex below, glabrescent; lamina elliptic to oblong- or obovate-elliptic, (6-)8.5-16-(19.5) by (2.2-)3.5-8.2 cm., acuminate (rarely subrounded) at apex, cuneate to subacute at base, slightly undulate and not recurved to slightly so at margin, coriaceous, drying olivaceous above and sabelline-olivaceous below, farinose on midrib below when young, the midrib above gradually narrowed from base, at first subdepressed, 0.2-0.45 mm. wide at midpoint, becoming raised toward apex, below strongly raised and striate, the venation on both sides apparent, raised, 5 to 19 veins/5 mm., angle of divergence (60-)65-75°. Inflorescences terminal and from adjacent foliate axils, with numerous flowers, the axis to 10 cm. long, branched, flabellate, sparsely puberulent, lowest internode ca. 3 cm. long; bracts unknown; pedicels 5-7 mm. long, puberulent. Flower (?)hermaphroditic; tepals 8, the outer pair broadly ovate or oblong, 3.7-4.3 by 3.5-4.3 mm., puberulent on back toward base, the next pair elliptic, 7-7.5 by 4.5-5 mm., sometimes subfarinose toward base, the inner ones oblong-elliptic, 8.5-9.5 by 4-4.7 mm.; stamens ca. 250, the filaments to 7 mm. long, the anthers suboblong, (0.5-)0.7-1 mm. long, retuse at apex; ovary ca. 2.5 mm. long, the style ca. 5 mm. long, the stigma subpeltate, ca. 1 mm. across, obscurely 3-radiate. Fruit spherical to subobovoid, 2.3-2.5 by ca. 2 cm., rounded to apiculate at apex, drying whitish to yellowish, shallowly and closely reticulate; outer layer not detaching cleanly from stone, 1.2-1.5 mm. thick, compact; stone subspherical, ca. 1.8 by 1.7 cm., rounded at apex, the walls less than 0.1 mm. thick, smooth, (?)unmarked; spongy layer thin.

TYPE: Brunei, Andalau Hills F.R., 250 feet [75 m.], 22 July 1954, *KEP 80090* coll. *Wyatt-Smith* (holotype, *KEP*).

DISTRIBUTION. Southern Malaya (Johore), northwestern Borneo (MAP 3).

SELECTED SPECIMENS SEEN. **Malaya.** JOHORE: Jemaluang F.R., 9 m., *KEP 73459* (*KEP*); Lenggong F.R., 35 m., *Stevens et al. 55* (A); G. Arong F.R., 15 m., *Stevens et al. 81* (A), 30 m., *KEP 84581* (*KEP*); Endau Road, 30 m., *KEP 70059* (*KEP*, SING); Mersing, Sungei Sarah, 45 m., *KEP 92167* (*KEP*). **Borneo.** SARAWAK. 1st Division: G. Buri, Ulu Semunjan, 150 m., *S 36738* (SAR), 300 m., *S 36746* (SAR). 4th Division: Lambir Hills, Miri, *Ashton 6000* (A). 5th Division: Ulu Medamit, Limbang, 305 m., *S 32348* (BO, L, SAN, SAR, SING). BRUNEI: Andalau Hills F.R., 75 m., *KEP 80089* (?*KEP*); Belait, *S 1642* (*KEP*, L); Kuala Belalong, 305 m., *Ashton s.n.*, Oct. 1959 (SAR). Sine loco [?Brunei], *KEP 32579* (K, *KEP*).

ECOLOGY. Locally common in fairly well-drained, mixed dipterocarp forest, to 305 m. alt. Flowering in September (flower scented); fruiting in July (fruit green at first, turning glaucous purple).

GERMINATION AND YOUNG PLANT. The radicle almost certainly breaks through the stone to one side of the base. The seedling has three pairs of leaves separated by rather short internodes 0.5-1.5 cm. long; the lowest pair of

leaves often falls off well before the others. Internodes produced during subsequent growth are long (soon becoming 7 cm. or more), the terminal bud is functional, and the plant is erect. (*Stevens et al.* 55.)

Calophyllum alboramulum is a very distinctive species with its pale-drying twigs, rather large, elliptic leaf blades with relatively distant venation, terminal inflorescences with puberulent indumentum, and sharply wrinkled and pale-drying fruits with thin-walled stones. The olivaceous leaves with their sabel-line-colored margins are also distinctive, as are the white twigs of the young plants. The fruits of the type specimen are reported to be glaucous purple, but this should be confirmed; purple-fruited *Calophyllum* species are uncommon in West Malesia. The epithet *alboramulum* alludes to the whitish color of the twigs, as does the Malay name for this species, "bintangor puteh."

The specimens cited from Borneo and Malaya are very similar, and the distribution of the species is almost a textbook illustration of a type of Borneo-Malay affinity (cf. MAP 3 with Keng, 1970, *figs.* 3, 4). Henderson and Wyatt-Smith (*loc. cit.*) were loath to describe this species formally since they had only sterile material from Malaya; however, Wyatt-Smith had unknowingly collected fruiting material (the type) in Brunei! Fertile material of *Calophyllum alboramulum* still has not been collected in Malaya.

KEP 80089 (from Brunei) is included in *Calophyllum alboramulum* only with hesitation. It has leaf blades rounded at the apices and petioles up to 3.5 cm. long, and its latex was reported as being brown and clear.

2. ***Calophyllum blancoi*** Planchon & Triana, *Ann. Sci. Nat. Bot.* IV, 15: 262. 1862; Vesque in C. DC. *Monogr. Phanerog.* 8: 598. 1893; Merr. *Philip. Jour. Sci. C.* 3: 420. 1908; Whitford, *Philip. Bur. Forestry Bull.* 10 (Forests Philip. 2): 60. *pl.* 55. 1911; Merr. *Enum. Philip. Fl. Pl.* 3: 78. 1923; Keith, *N. Borneo Forest Rec. ed. 2.* 2: 314. 1952 ("sp. cf. *blancoi*"); Perry, *Med. Pl. E. SE. Asia*, 174. 1980. TYPE: Philippine Islands, 1857, *Llanos s.n.* (holotype, σ).
- C. racemosum* Merr. *Philip. Jour. Sci. C.* 5: 198. 1910; *Enum. Philip. Fl. Pl.* 3: 80. 1923. TYPE: Philippine Islands, Leyte, between Ormoc and Dolores, 100 m., *FB 12620* coll. *Rosenbluth* (isotypes, κ , us).
- C. glabrum* Merr. *Philip. Jour. Sci. C.* 7: 92. 1912; *Enum. Philip. Fl. Pl.* 3: 79. 1923. TYPE: Philippine Islands, Luzon, Bontoc subprovince (Mountain Province), Bauco, ca. 1650 m., 13 June 1911, *Vanoverbergh 1251* (n.v.).
- C. ferrugineum* Merr. *Philip. Jour. Sci. C.* 10: 324. 1915, non Ridley, 1910; Merr. *Enum. Philip. Fl. Pl.* 3: 79. 1923. TYPE: Philippine Islands, Luzon, Laguna Province, near San Antonio, Feb. 1913, *BS 20545* coll. *Ramos* (isotypes, κ , us).
- C. flavocorticum* Elmer, *Leafl. Philip. Bot.* 7: 2682. 1915 ("C. *flavo-cortica*"). TYPE: Philippine Islands, Mindanao, Agusan, between Duros and Cabadbaran (Mt. Urdaneta), Cawilanan, 3500 feet [1067 m.], Sept. 1912, *Elmer 14311* (isotypes, A, BISH, BM, BO, C, E, F, FI, G, GH, K, L, LY, MO, NY, P, U, us , W).
- C. mindanaense* Elmer, *Leafl. Philip. Bot.* 7: 2684. 1915; Merr. *Enum.*

Philip. Fl. Pl. 3: 80. 1923. TYPE: Philippine Islands, Mindanao, Davao del Sur Province, Todaya (Mt. Apo), trail to Mt. Calelan, 3750 feet [1143 m.], May 1909, *Elmer 10597A* (lectotype, A; isolectotypes, BISH, BM, BO, E, F, FI, G, GH, K, L, LY, MO, P, US, W).

C. megistanthum Quis. & Merr. Philip. Jour. Sci. 37: 170. 1928. TYPE: Philippine Islands, Luzon, Isabela Province, San Mariano, 335 m., 15 March 1926, *BS 47137* coll. Ramos & Edaña (isotypes, A, B, K, UC, US).

C. changii Robson in H.-L. Li *et al.* Fl. Taiwan 2: 621. 1976. TYPE: Formosa, Botel Tobago, 22 April 1962, *Chang 2737* (holotype, TAI; isotype, L).

C. wallichianum auct., non Planchon & Triana; Vidal, Rev. Pl. Vasc. Filip. 54. 1886; Vesque in C. DC. Monogr. Phanerog. 8: 599. 1893, *pro parte*; Merr. Philip. Bur. Forestry Bull. (Rep. Invest. Java) 1: 40. 1903, Philip. Jour. Sci. 1(suppl.): 97. 1906; *C. pseudowallichianum* Engler in Engler & Prantl, Nat. Pflanzenfam. ed. 2. 21: 196. 1925, *nomen*.

C. spectabile auct., non Willd.; A. Gray, U. S. Expl. Exped. 15(1): 218. 1854, *pro parte*; Merr. Philip. Jour. Sci. C. 3: 78. 1908.

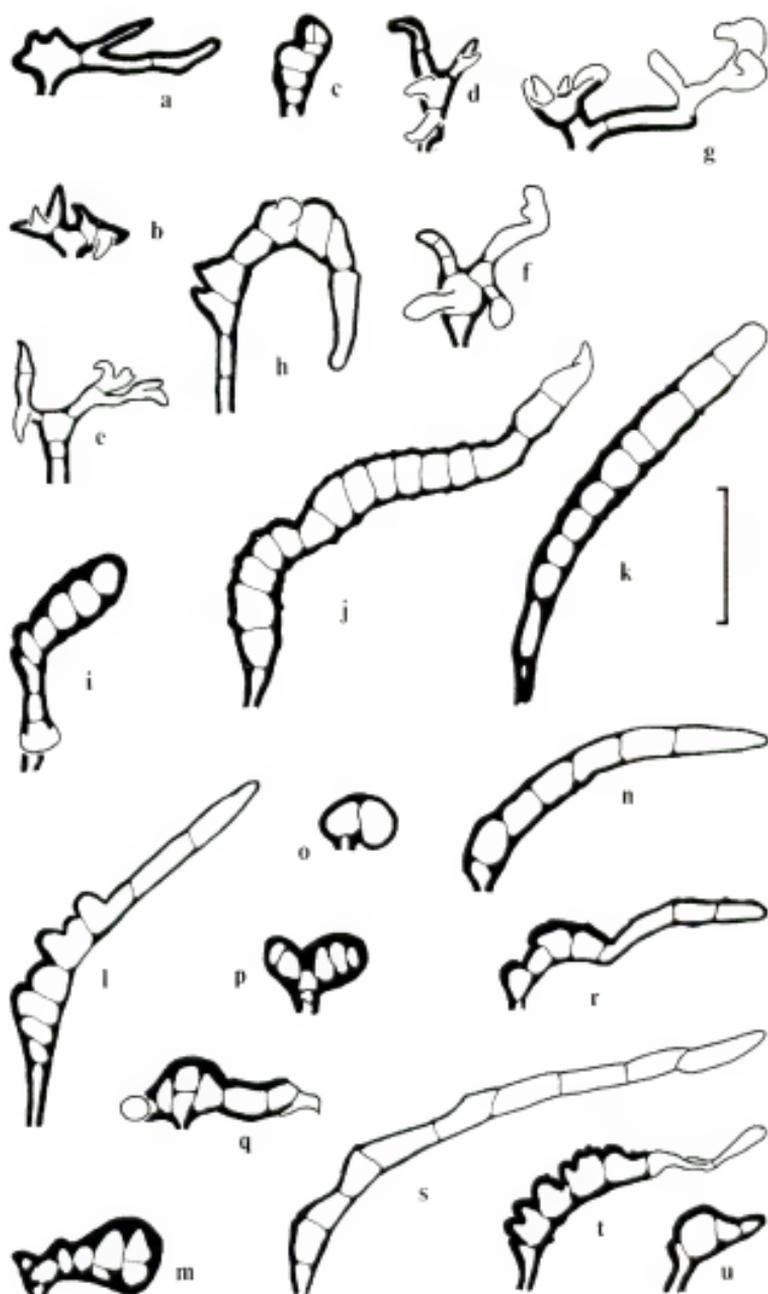
C. whitfordii auct., non Merr.; Merr. Enum. Philip. Fl. Pl. 3: 81. 1923, *pro minore parte*.

C. sp. aff. borneense Vesque and *C. sp. ?canum* Hooker f.; Keith, N. Borneo Forest Rec. ed. 2. 2: 314. 1952.

?Calophyllum sp. Merr. Philip. Bur. Forest Bull. (Rep. Invest. Java) 1: 40. 1903.

Tree 5-40 meters tall, d.b.h. to 40 cm.; trunk without buttresses; outer bark yellowish (dark gray-brown), hoop marked or not, with vertical lines of lenticels or rather distant boat-shaped fissures, flaking or not, inner surface mottled yellow-orange; under bark deep red; inner bark red to (?)yellow; latex opaque yellow, not sticky.

Twig \pm flattened, 1.2-4.5(-5) mm. across, 4-angled, sometimes with additional raised lines, drying brown to yellowish, farinose to tomentose when young, often glabrescent; axillary innovations lacking basal scars; internodes (0.4-)1-6 cm. long; uppermost pair of axillary buds rounded, to 3 mm. long, suberect, inconspicuous; terminal bud plump, 0.6-2 cm. long, with subcrustose to tomentose, grayish to brown indumentum (hairs, FIGURES 9, e-g; 10, b-f), underdeveloped internode to 2(-5) mm. long. Petiole 0.5-4 cm. long, often rather narrowly but deeply concave above, convex below, sometimes with persistent indumentum; lamina elliptic to suboblong, rarely obovate, (3-)4.7-25(-30) by (1-)1.8-8.2 cm., acuminate at apex, acute to cuneate or often abruptly attenuate at base, \pm undulate and recurved at margin, coriaceous (rarely very coriaceous), usually drying bicolored (e.g., \pm olivaceous-buff—frequently with grayish, waxy covering—above, usually sabelline below) (rarely nearly concolorous), glabrous, transiently farinose on midrib below, or subpersistently tomentose on entire lower surface, the midrib above usually rather abruptly narrowed at or near base, flat to depressed at first, becoming raised, sometimes narrowing gradually from base and \pm depressed, 0.1-0.4 (-0.5) mm. wide at midpoint, below raised, striate, the venation above and below \pm apparent, raised (very rarely impressed), 5 to 18 (to 22) veins/5 mm., angle of divergence (50-)60-80(-85) $^{\circ}$. Inflorescences terminal and/or

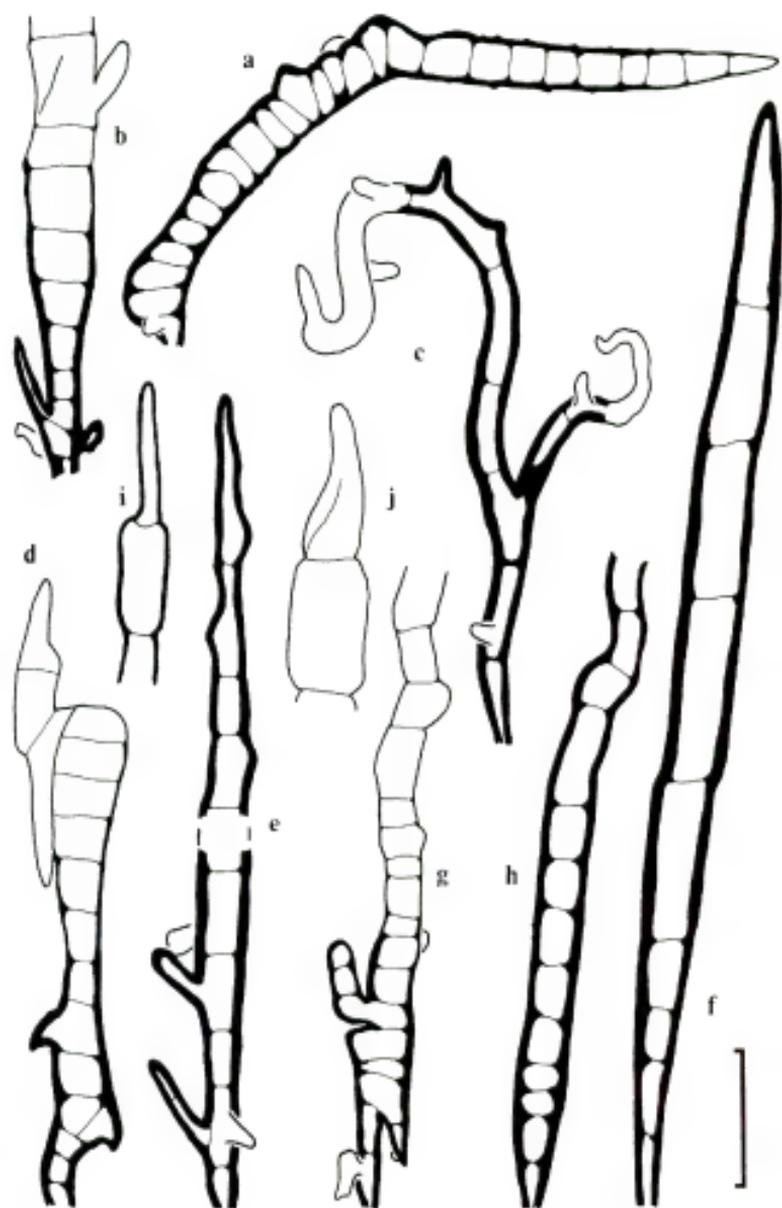


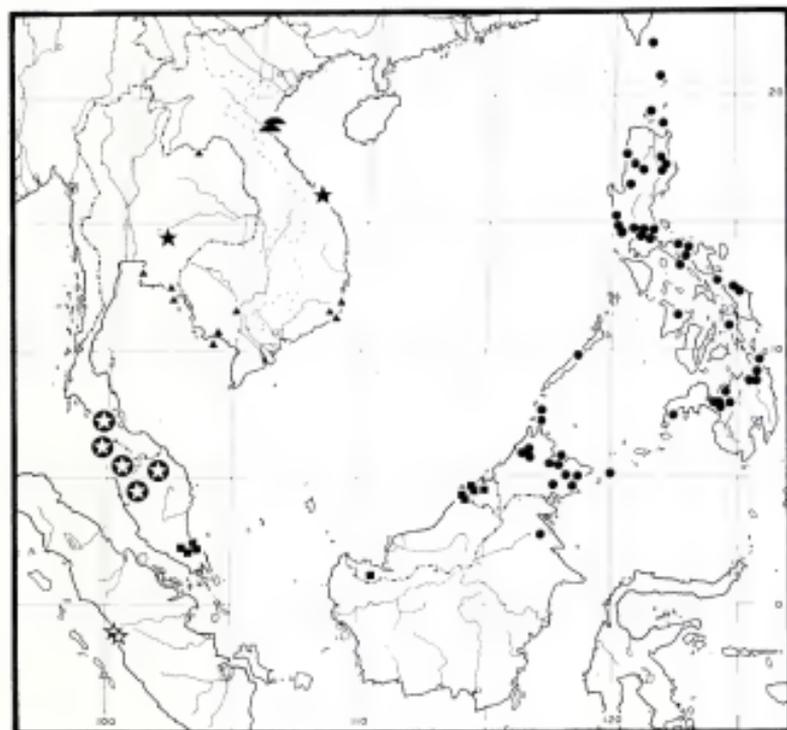
axillary, with 9 to numerous flowers, to twice branched and flabellate when terminal, the axis (1-)2-16 cm. long, puberulent to tomentose (rarely glabrous toward top), lowest internode (0.4-)1-8 cm. long; bracts to 1.5 cm. long, subsistent; pedicel 0.6-4 cm. long, puberulent to tomentose (rarely glabrous). Flower (?)hermaphroditic; tepals 8 to 16, the outer pair broadly ovate, (1.2-)4-11.5 by (1-)4-9.5 mm., usually puberulent to short-tomentose on back, at least toward base, the inner ones elliptic to obovate, 5-25 by 2-15 mm., with the outer pair sometimes puberulent to short-tomentose on back, when many tepals outer pair broadly ovate-elliptic, next pair suboblong and largest, inner ones oblong-obovate, smaller; stamens (105 to) 140 to 620, the filaments 2-6 mm. long, the anthers elliptic to oblong, 0.5-2.2 mm. long, \pm retuse at apex; ovary 1.5-5 mm. long, the style 2-10 mm. long, the stigma \pm peltate, 0.5-2.5 mm. across, 3- or 4-radiate. Fruit ovoid to subspherical, 1.25-2.2 by 1-1.7 cm., acute to apiculate, drying brown to blackish, rather closely and sharply wrinkled; outer layer usually not detaching cleanly from stone, 0.3-1 mm. thick, compact (rarely with large air spaces developing); stone ellipsoid to subspherical, 1.1-1.8 by 0.9-1.4 cm., rounded to apiculate at apex, the walls 0.05-0.3 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Taiwan (Lanyu Islands), the Philippine Islands, and northeastern Borneo (MAP 3).

SELECTED SPECIMENS SEEN (letters refer to discussion in text below). **Taiwan.** LANYU ISLANDS: Taitung, *Chang* 2737 (g) (L, TAI). **Borneo and adjacent islands.** SABAH. Kudat: Banggi Is., 60 m., *SAN* 25769 (f) (K, KEP, L, SAN, SAR, SING); Karakit Tg., 15 m., *SAN* 69427 (f) (SAN). Ranau: inside Sabah Natl. Park, Lohan, Kinabalu, 1372 m., *SAN* 44643 (e) (K, L, SAN, SAR); Mile 5 $\frac{1}{4}$, Poring Road, Ranau, 1431 m., *SAN* 44734 (e) (K, L, SAN, SAR); Mt. Tamboyukan, 1889 m., *SAN* 68554 (e) (SAN); Kg. Paranchangan, 457 m., *SAN* 76707 (e) (K, SAN, SAR); Bukit Kulong, 457 m., *SAN* 49764 (e) (K, L, SAN, SAR). Labuk & Sugat: Mile 9 $\frac{1}{2}$, Telupid, near Sg. Meliau, *SAN* 61520 (e) (A, SAN); Sungei Sapi, *SAN* 36306 (e) (A, K, L, SAN, SING); Mile 5 $\frac{1}{4}$, Sabah Foundation logging area, *SAN* 75808 (e) (SAN). Sandakan: Sepilok F.R., *A* 2564 (e) (A, BO, K, KEP, L, P, SING, US); Sungei Dagat 1961 logging area, *SAN* 27855 (e) (SAN); Segaluid, Teck Fatt logging area, Mile 6, 24 m., *SAN* 76377 (e) (SAN); along Sibuga Road, *SAN* 35794 (e) (K, KEP, L, SAN, SING); Bettotan, 48 m., *SAN* 4536 (e) (A, K, SING); outside plantation area, Gum-Gum, *SAN* 81205 (e) (SAN). Lahad Datu: Lumangas Is., 3 m., *A* 141 (f) (BO, BRI, K, KEP, L, P, SING, US); Sungei Panyang, 8 km. SW. of Lahad Datu, 15 m., *SAN* 16129 (e) (K, KEP, SING); Kennedy Bay, 180 m., *SAN* 33394 (e) (K, L, SAN, SING); Silam, Block 24, Mile 10, *SAN* 59247 (e) (SAN). Semporna: Pulau Gaya, *SAN* 48802 (f) (K, L, SAN); Selangan Is., F.R., *A* 2441 (f) (BO, K, KEP, L, SING). **KALIMANTAN.**

FIGURE 9. Hairs (on terminal bud, unless otherwise stated). a-d, *Calophyllum alboramulum*: a-c, *Stevens et al.* 81; d, *S* 1642, axillary bud. e-g, *C. blancoi*: e, *BS* 26407; f, *BS* 47295; g, *PNH* 78233. h-k, *C. thorelii*: h, *Poilane* 9600, axillary bud; i, j, *Kerr* 9556; k, *Poilane* 6245. l, m, *C. dryobalanoides*: l, *Poilane* 16740; m, *Pierre* 22. n, *C. balansae*, *Bon* 2074, axillary bud. o-r, *C. touranense*: o, *Poilane* 27759; p-r, *Poilane* 27748. s-u, *C. aff. thorelii*: s, u, *Poilane* 23733; t, *Chevalier* 38687. Scale = 60 μ m.





MAP 3. Distribution of *Calophyllum alboramulum* (squares), *C. blancoi* (circles), *C. thorelii* (triangles), *C. touranense* (solid stars), *C. balansae* (semicircles), *C. symingtonianum* (stars in solid circles), and *Calophyllum* sp. 9 (open stars) in Malasia.

Timur: Boelongan, Mara, 100 m., *bb 10834* (e) (BO). **Philippine Islands.** PALAWAN: Mangsi Is., *Wright s.n.* (?e) (US); Palawan, sine loco, *BS 587* (a) (BO, GH, LY, NY, US). BATANES. Itbayat Is.: sine loco, *PNH 79430* (?g) (PNH). Camiguin Is.: Mt. Malebsing, 427 m., *BS 79250* (?g) (NY, SING); Balatubat, 366 m., *BS 79263* (?g) (NY). Calayan Is.: sine loco, 47 m., *PNH 79825* (d) (PNH). LUZON. Ilocos Norte: Burgos, *BS 27348* (a) (F, MO). Ilocos Sur: sine loco,

FIGURE 10. Hairs (on terminal bud, unless otherwise stated). a, *Calophyllum dongnaiense* (notably birefringent, *Pierre 3644*). b-f, *C. blancoi*: b, *PNH 10549*, apical ca. 230 μm . of large, collapsed cells not drawn; c, *A 141*; d, *BS 47137*, base of inflorescence and stem; e, *PNH 10549*, base of inflorescence, hair ca. 720 μm . long; f, *FB 25321*, sometimes papillate. g, *C. aff. thorelii* (*Poilane 23891*), hair ca. 470 μm . long. h, i, *C. dongnaiense* (*Pierre 3644*), hair to 640 μm . long. j, *C. aff. dongnaiense* (*Poilane 32327*), apex only, basal part with thick-walled, epapillate cells (hair to ca. 1060 μm . long). Scale = 60 μm .

FB 7130 (a) (MO, US). Mountain: Bontoc, *Vidal 2122* (a) (K); Bontoc subprov., *Vanoverbergh 1251* (i) (C, G, GH, L, MO, P, W). Ifugao: Banaue, Mt. Taggutu, *PNH 72412* (i) (A, L). Liwang, Poitan, 457 m., *PNH 97519* (i) (L, PNH), Bayninan, 1219 m., *PNH 80554* (i) (A, L). Benguet: Benguet, *FB 29788* (?a) (BM, UC); Baguio, *Elmer 8852* (g) (A, BO, E, F, FI, G, K, NY, US), *FB 21293* (i) (US); sine loco, *Merrill 1745* (i) (BM, BO, G, GH, MO, NY, P, SING). Cagayan: Mt. Babatngin, 610 m., *BS 79434* (?i) (BO, NY, SING); Peñablanca, *BS 76932* (i) (K, MICH, NY, SING); sine loco, *FB 26885* (?d) (NY). Isabela: Mt. Moises, *Clemens 16936* (i) (BM, NY, UC), 1036 m., *BS 47295* (?g) (A, K, NY, SING, UC, US); Sierra Madre, San Mariano, 150 m., *PNH 78163* (d) (A, BO, SING), 335 m., *BS 47137* (c) (A, B, K, UC, US), Sangcad, 945 m., *PNH 78233* (d) (A, L). Aurora: Baler, Principe, *Merrill 1039* (?a) (K, NY, US). Zambales: Subig, *Merrill 1760* (a) (K, NY, US); Botolan, *Merrill 2991* (?d) (BM, K, US); sine loco, *FB 27834* (b) (A). Nueva Ecija: Mt. Umingan, *BS 26407* (i) (A, P, US); sine loco, *FB 22382* (a) (G, MO), *FB 22396* (?g) (US). Bataan: Lamao, *FB 350* (a) (A, LY, P, UC, US); Lamao R., Mt. Mariveles, *Williams 544* (a) (A, NY, SING). Rizal: Montalban, *Loher 12958* (?g) (BM, M, UC), 12501 (?a) (A, UC); Morong, Antipolo, *FB 452* (a) (K, NY, US), Bosoboso, *FB 1174* (a) (BM, BO, F, G, K, NY, P, SING, US); San Mateo, Manila, *Vidal 54bis* (a) (K); Mt. Lumutan, *BS 29754* (i) (A, NY, US); sine loco, *Loher 13384* (d) (M, UC). Laguna: San Antonio, *BS 20556* (?g) (BM, P, US), *BS 20545* (b) (K); Pangil, 270 m., *PNH 74253* (g) (PNH); Mt. Makiling, *PNH 8180* (a) (A); Santa Maria, *FB 10113* (a) (BO, LY). Quezon: Guinayangan, *Vidal 643* (a) (A, FI, K); Llavac, Real, 270 m., *PNH 41784* (equals *Lagrimas s.n.*, 29 March 1961) (b) (L, PNH); Kinatukutan, *FB 30661* (g) (NY, SING, UC); 100 m., *FB 30677* (a \leq b) (NY); sine loco, *BS 1274* (i) (BM, BO, G, GH, MO, NY, P, SING). Camarines: Sipaco, Lagonoy, 495 m., *FB 30311* (a) (NY, UC); Pasacao, *Ahern 122* (a) (US); sine loco, *FB 21743* (b) (US), *FB 21685* (i) (K, US). Sorsogon: Irosin (Mt. Bulusan), *Elmer 15586* (d) (A, BM, BO, C, F, FI, G, GH, K, MO, NY, P, U, US), *Elmer 15621* (g) (A, BM, BO, C, F, FI, G, K, NY, P, U, UC, US, W). SAMAR: San Jose, Catubig R., 50 m., *Sablaya 19* (h) (A, F, K, MO, P); Catarman, *Vidal 634bis* (h) (A); sine loco, *BS 17532* (d) (K, US). LEYTE: Ormoc, Lake Danao, *PNH 11924* (d) (A, BO, SING, US); sine loco, *Wenzel 780* (h) (A, BM, F, G, GH, MO). PANAY: Capiz, Mt. Macosolon, *BS 30757* (?d) (A, UC); sine loco, *FB 25362* (?a) (A, BO, K, UC). MINDANAO. Surigao: Mt. Kabatuan, 768 m., *PNH 10549* (coriaceous a) (A, L, PNH). Agusan: Cabadbaran (Mt. Urdaneta), 305 m., *Elmer 13268* (?d) (A, BISH, BM, BO, C, E, F, FI, G, K, LY, MO, NY, P, U, US, W); Tungao, San Mateo, Butuan, 300 m., *PNH 42532* (d) (L, SING); Diuata Mts., 1036 m., *BS 83715* (d) (NY). Bukidnon: Quilayong, 610 m., *FB 29621* (?d) (UC); Mt. Camates, *BS 38692* (?a) (A). Davao del Sur: Todaya, Mt. Apo, 1143 m., *Elmer 11749* (?d) (A, BISH, BM, E, F, FI, G, GH, K, LY, MO, NY, US, W). Lanao: Cristina Falls, *Ebala 1188* (d) (A, PNH, SING); Siggapod, 40 m., *FB 31186* (d) (NY); Kulasinan, *FB 31190* (d) (MICH, NY); Lake Lanao, *Clemens 1009* (d) (F, O). Zamboanga: Sax R., 150 m., *Williams 2346* (d) (GH, K, NY, US); Port Banga, *FB 9415* (d) (LY, SING); sine loco, *FB 9491* (?i) (NY, US). SULU ARCHIPELAGO. Tarawakan: Tawitawi, *PNH 38806* (?a) (A, BISH, SING, K).

ECOLOGY. Usually in well-drained forests (sometimes in swampy forests in Sabah), to 1900 m. alt. Flowering February to June, rarely in January, August, September, November, and December; fruiting throughout the year, no month predominating (fruits of group "f" black or bluish, those of group "e" green).

From the Philippine Islands, *Ahern* 53, a close match with the type, has galls on the lower surface of the lamina; these galls are small, conical swellings ca. 1.5 mm. tall; similar galls occur on *BS* 79263 (?group b).

GERMINATION AND YOUNG PLANT. The radicle almost certainly breaks the stone to one side of the base. The seedling has two pairs of leaves separated by an internode ca. 1 cm. long (*SAN* 27855). Internodes produced during subsequent growth are well developed, the plant is erect, and the terminal bud is functional. (Pers. obs.; all details from form "c".)

LOCAL USES. In the Philippines the latex is used to treat wounds, boils, tumors, and other swellings, and to alleviate asthma (Perry, *loc. cit.*).

Calophyllum blancoi is quite a variable species, but it can be recognized by its plump, often quite long, terminal bud and its medium-sized to large leaf blades that are often clearly attenuate at the base and that dry more or less bicolored. Its inflorescences are often terminal, and the flowers have 8 to 16 tepals. The fruits dry sharply and closely wrinkled, the outer layer does not usually detach cleanly from the stone and is less than 1 mm. thick, and the stone walls themselves are less than 0.3 mm. thick. The hairs are usually erect and notably branched (FIGURES 9, e-g; 10, b-f). The epithet commemorates F. M. Blanco, who wrote the first flora of the Philippine Islands.

The above description of the bark is based primarily on the form common in Sabah (see below). Limited data from the Philippine Islands suggest that the bark of *Calophyllum blancoi* there is similar.

Calophyllum blancoi is similar in a number of respects to *C. thorelli*. However, in *C. thorelli* the hairs are papillate rather than branched (see FIGURE 9, e-k), the midrib on the upper surface of the lamina is surrounded by raised blade, there are only eight—or rarely ten—tepals, and the outer layer of the fruit detaches cleanly from the 0.4-0.5 mm. thick stone. However, this similarity may be only superficial and needs further examination. (The differences between the taxa are summarized in TABLE 5.)

Several species of *Calophyllum* from the Philippine Islands were described as being close to *C. blancoi*; they were separated on details of leaf shape, size, and indumentum, inflorescence position, and tepal number and size. Although a number of groups can be delimited within *C. blancoi*, some being the basis of these early names, the characters separating the taxa are minor, most overlapping between groups or varying within a single collection or between collections that are similar in all other respects. Specimens intermediate between the groups are also common. At first sight it seems ridiculous to include *C. megistanthum*, which has leaf blades up to 30 cm. long and dried flowers up to 4 cm. across (as large as those of any other species in the genus), in the same species as specimens like *BS* 47295 (placed in group "g"), which has leaf blades less than 7.5 cm. long and flowers less than 1 cm. across, but no other conclusion seems possible at present. Of greater concern, the specimens of *C. blancoi* from northeastern Borneo form two very distinct groups that I would not have hesitated to describe as separate species had I been working on Bornean material alone; one group (e) has

green fruits, while the other (*f*) has blue. The two groups are apparently independently related to the *C. blancoi* complex on the Philippine Islands.

The groups recognized within *Calophyllum blancoi* are briefly characterized below, and pertinent details of nomenclature given. The lower case letters refer to the list of specimens cited.

GROUP a (*Calophyllum blancoi* sensu stricto; *C. wallichianum* auct., non Planchon & Triana).

Twigs drying brown (yellowish), short-tomentose when young. Lamina 7.5–21 by 3–5(–6) cm., cuneate at base, slightly undulate and recurved at margin, drying bicolored, subglabrous when mature, midrib raised above, (10 to) 12 to 16 veins/5 mm. Inflorescences usually terminal and axillary (rarely only axillary), axis usually short-tomentose; bracts not noticeable. Tepals (8 to) 12; stamens 190 to 480, anthers 1–2.2 mm. long. Fruit sharply wrinkled; outer layer lacking air spaces.

The common form on Luzon. Elsewhere uncommon and specimens often atypical.

Specimens such as *Merrill 1760*, *FB 8467*, and *FB 25362* have well-developed and subsistent indumentum on their leaf blades as in group "b". *PNH 10549* (from Mindanao) has very coriaceous leaf blades, and although its indumentum is not well developed, the axillary inflorescences are like those of *C. ferrugineum*, having a long basal internode. *PNH 38806* (from the Sulu Archipelago) in facies and indumentum is rather like group "c", but it has over 400 stamens, about double the number in that group. *BS 38692* (from Mindanao) is intermediate between groups "a" and "i", although the typical form of neither group is known from Mindanao.

GROUP b (*Calophyllum ferrugineum* Merr.).

Twigs drying brown or yellowish, tomentose at least when young. Lamina 8.5–21 by 4–7.5 cm., cuneate to ± attenuate at base, undulate and recurved at margin, drying bicolored, with subsistent, tomentose indumentum on lower surface, midrib raised above, 8 to 15 veins/5 mm. Inflorescences terminal and axillary, axis tomentose; bracts to 1.5 cm. long, deciduous shortly before anthesis. Tepals 11 to 16; stamens ca. 620, anthers 1–1.5 mm. long. Fruit sharply wrinkled; outer layer lacking air spaces.

Known only from southern Luzon.

FB 21743 and *BS 20545* have leaf blades only up to ca. 10 by 5 cm.; there are only 5 to 9 veins/5 mm., and they tend to be impressed. Other specimens have larger leaves and more dense venation that tends to be raised.

GROUP c (*Calophyllum megistanthum*).

Twigs drying yellowish, subglabrous. Lamina 16–30 by 5.2–8.2 cm., cuneate at base, narrowly recurved and slightly undulate at margin, drying bicolored, ± glabrous when mature, midrib raised above, 8 to 10 veins/5 mm. Inflorescences axillary and terminal, axis subglabrous; bracts unknown, not persistent. Tepals 14 to 16; stamens at least 550, anthers ca. 1.7 mm. long. Fruit unknown.

Known from only a single collection from Luzon.

The inflorescence axis of the type specimen of *Calophyllum megistanthum*

TABLE 5. Comparison of *Calophyllum blancoi*, *C. thorelii* sensu stricto, *C. polyanthum*, *C. touranense*, and *C. balansae*.

	<i>C. blancoi</i>	<i>C. thorelii</i>	<i>C. polyanthum</i>	<i>C. touranense</i>	<i>C. balansae</i>
HAIRS HABITUALLY BRANCHED	+	-	-	-	-
TWIGS 4- OR 6-ANGLED	4 (6)	6	4	4, 6	4
BASE OF LAMINA ATTENUATE	+(-)	-(+)	+(-)	-(+)	-
LAMINA DRYING BICOLORED	+(-)	+	-	-	-
MIDRIB ON UPPER SURFACE SURROUNDED BY RAISED LAMINA	-	±	-	-	-
VENATION DENSITY (veins/5 mm.)	5 to 18 (to 22)	9 to 16	9 to 16 (to 21)	6 to 10 (to 14)	6 to 10
TEPAL NUMBER	8 to 16	8 to 10	(7 or) 8 (to 12)	9 to 13	8 to 12
FRUIT COARSELY RETICULATE	+	+	-	-	±
THICKNESS OF OUTER LAYER (mm.)	0.3-1	ca. 1	1.5-3	3-5.5	ca. 1
OUTER LAYER DETACHING CLEANLY FROM STONE	-	+	-	-	±
THICKNESS OF STONE WALL (mm.)	0.05-0.3	0.4-0.5	0.4-0.7	(0.3-)0.6-1.1	0.3-0.5

is up to 23 cm. long, although there are only 9 to 15 flowers. Like those in specimens of group "b", the lowest flowers are borne some way (at least 3 cm.) from the base of the inflorescence. The "six-merous flowers" to which Quisumbing and Merrill (*loc. cit.*) drew attention are like those of some specimens of groups "a" and "b", in which three successive pairs of tepals enclose one or more whorls each usually of four tepals. Despite the size of the flowers, the pollen is the same size as that in other members of the *C. blancoi* complex.

GROUP d (*Calophyllum racemosum*; *C. flavocorticum*, ?*C. mindanaense*).

Twigs usually drying yellowish, subglabrous. Lamina (6-)13-22 by (2.5-) 5.3-9.5 cm., usually attenuate at base, undulate and sharply and strongly recurved at margin, often drying bicolored, subglabrous when mature, midrib raised above, (5 to) 9 to 15 (to 22) veins/5 mm. Inflorescences axillary (terminal), axis without prominent indumentum; bracts small, not persistent. Tepals 8 to 12; stamens (175 to) 300 to 400, anthers 0.7-1.5 mm. long. Fruit sharply wrinkled; outer layer lacking air spaces.

Throughout the Philippine Islands.

Although many specimens of this group are quite distinctive, some are more or less transitional to groups "a", "g", and "i". The leaf blades of specimens from Rizal Province, Luzon, are more notably coriaceous than those of the others.

I have not seen the type specimen of *Calophyllum racemosum*; that of *C. flavo-corticum* (Elmer 14311) is very similar to *Clemens 1009*. Merrill (*loc. cit.*) thought that the latter was a particularly robust specimen of *C. racemosum*. The specimen of Elmer 10597A at the Arnold Arboretum is designated the lectotype of *C. mindanaense*, since Elmer (*loc. cit.*) considered that number to be the more typical specimen of the two that he cited (the other was Elmer 11749). In their rather depressed midribs, and their terminal as well as axillary inflorescences, both specimens perhaps approach group "i".

GROUP e.

Twigs drying brown, puberulent when young. Lamina 8-17 by 2.3-5 cm., attenuate at base, rather closely undulate and slightly recurved at margin, drying bicolored, glabrous when mature, midrib raised above, 9 to 14 veins/5 mm. Inflorescences axillary, axis puberulent; bracts soon deciduous. Tepals 8 (to 12); stamens 130 to 230, anthers 0.8-1 mm. long. Fruit sharply wrinkled; outer layer lacking air spaces.

Common in northeastern Borneo.

Nearly forty numbers of this form have been collected, but despite the considerable altitudinal (almost sea level to ca. 1900 meters)—and, to a lesser extent, geographic—range over which they have been collected, there is little variation.

GROUP f.

Twigs drying blackish, ± tomentose. Lamina 7.5-18.3 by 1.8-4.3 cm., cuneate to acute at base, strongly and closely undulate, slightly recurved

at margin, drying bicolor, indumentum not conspicuous, midrib raised above, 9 to 19 veins/5 mm. Inflorescences terminal, axis puberulo-tomentose; bracts small, deciduous. Tepals 10; stamens 250 to 270, anthers 0.5-0.7 mm. long. Fruit smooth; outer layer with large air spaces.

Known only from islands off northeastern Borneo.

Specimens of group "f" are perhaps most similar to groups "a" and "d"; in the latter group *FB 9415* (from Mindanao) is perhaps the closest match with group "f".

GROUP g (*Calophyllum changii*).

Twigs drying brown to yellow, the indumentum inconspicuous. Lamina (3.5-5.7-12.5 by 2.7-4.9 cm., attenuate at base, moderately undulate and recurved at margin, often drying bicolor, indumentum not persistent, midrib raised, 6 to 14 veins/5 mm. Inflorescences usually axillary, axis with inconspicuous indumentum; bracts small, deciduous. Tepals 8 to 10; stamens ca. 215, anthers 0.8-1.2 mm. long. Fruit sharply wrinkled; outer layer without air spaces.

Known only from Luzon.

A very heterogeneous group. *Elmer 13268* and *BS 30757* (both cited under group "d") are more or less intermediate between that group and group "g". Other specimens from the northern part of the Philippine Archipelago, such as *BS 79434*, are like *Calophyllum balansae*, since their leaf blades do not dry notably bicolor. However, they have branched hairs, yellowish-drying twigs, coriaceous leaves, and larger inflorescences, and the resemblance appears to be superficial only. Some of the smaller-leaved specimens placed in group "g" have been confused with *Calophyllum whitfordii* (q.v.).

GROUP h.

Twigs drying brown to yellowish, the indumentum inconspicuous. Lamina (4.7-6.3-14 by (1.6-2-4.9 cm., more or less attenuate at base, undulate and recurved at margin, drying bicolor, indumentum inconspicuous, midrib raised above, (10 to) 12 to 19 (to 22) veins/5 mm. Inflorescences terminal, axis with inconspicuous indumentum; bracts small, deciduous. Tepals (8 to) 10 (or 11); stamens 140 to 180, anthers 0.5-0.7 mm. long. Fruit sharply wrinkled; outer layer without air spaces.

Known only from Samar and Leyte.

Flowering specimens of this group are superficially similar to the form of *Calophyllum polyanthum* (*C. elatum* sensu stricto) from the Western Ghats of India. The branched hairs of group "h" have almost completely unthickened cell walls; the unbranched, but papillate, hairs of *C. polyanthum* have thickened cell walls.

GROUP i (*Calophyllum glabrum*).

Twigs drying brown, the indumentum inconspicuous. Lamina (4.5-6.3-11 by (1.3-1.8-4 cm., cuneate to subattenuate at base, subundulate and narrowly recurved at margin, often drying bicolor, midrib above depressed for most of its length, 14 to 22 veins/5 mm. Inflorescences axillary or terminal, axis with inconspicuous indumentum; bracts inconspicuous, deciduous. Tepals

8 to 14; stamens 145 to 410, anthers 0.6–1.2 mm. long. Mature fruit unknown.

Known only from Luzon.

Specimens of group "i" from Cagayan and Quezon provinces tend to have a less depressed midrib than the others. *BS 1274* (Quezon) has flowers with only eight tepals, the outermost pair of which is not notably smaller than the others.

Calophyllum glabrum was described as having quite glabrous inflorescences; however, there is short but definite indumentum on the inflorescence axes of the specimens seen. The specimen number of the type of *C. glabrum* is *Vanoverbergh 1251*; specimens with this number seem to have been collected on three different dates. Merrill (*loc. cit.*) gives the date of collection as June 13, 1911, but also mentions that a specimen in young fruit was collected in August of that year. The duplicates seen of *Vanoverbergh 1251* were collected on April 28, 1914.

3. *Calophyllum thorelii* Pierre, Fl. Forest. Cochinch. 1: *pl. 103*. 1885; Vesque in C. DC. Monogr. Phanerog. 8: 601. 1893; Pitard in Lecomte, Fl. Gén. Indo-Chine 1(4): 322. 1910; Craib, Fl. Siam. Enum. 1: 122. 1931; Gagnep. in Humbert, Fl. Gén. Indo-Chine Suppl. 1: 269. 1943; Pham & Nguyễn, Cây-Cỏ Miền Nam Việt-Nam, 179. *bang 62bis E*. 1960; Pham, Cây-Cỏ Miền Nam Việt-Nam. ed. 2. 2: 301. *fig. 1970*. TYPE: Cochinchine [Vietnam], in montibus Dinh ad Baria Galliae, 300 m., Mars 1867, *Pierre 34* (lectotype, ♀; isolectotypes, ♂♂, ♂).

?*C. thorelii* Pierre var. *oxycarpum* Gagnep. in Humbert, Fl. Gén. Indo-Chine Suppl. 1: 270. 1943. *Nomen invalidum*.

Tree 6–20 meters tall, d.b.h. to 25 cm.; trunk without buttresses; outer bark fissured; latex yellow.

Twigs slightly flattened, 2.5–3(–4.5) mm. across, ± 6-angled, drying blackish, grayish puberulent when young; axillary innovations lacking basal scars; internodes 1–3.5 cm. long; uppermost pair of axillary buds rounded, ca. 1.5 mm. long, subspreading; terminal bud plump, ca. 1.3 cm. long, with short, grayish indumentum (hairs, FIGURE 9, h–k), underdeveloped internode ca. 1 mm. long. Petiole 1.7–3.6 cm. long, broadly concave to V-shaped above, convex below, usually glabrescent; lamina elliptic to ovate or oblong, (7.5–) 10.5–17 by (2.5–) 3.2–6.5 cm., acute to acuminate at apex, acute to cuneate or attenuate at base, strongly undulate but not recurved at margin, marginal thickening up to 0.4 mm. wide, coriaceous to very coriaceous, drying gray-olivaceous above with margins and midrib ± sabelline, sabelline below, glabrous when mature or subpersistently gray-puberulent on midrib on both surfaces, the midrib above narrowing ± quickly near base, subdepressed to subraised (surrounding lamina ± raised), 0.2–0.6 mm. wide at midpoint, below raised, angled toward apex, striate toward base, the venation above and below apparent, raised, 9 to 16 veins/5 mm., angle of divergence 65–70(–80)°. Inflorescences terminal and from adjacent foliate axils, with numerous flowers, often flabellate, once- (rarely twice-) branched, with branches to 3 cm. long, the axis to 12 cm. long, densely puberulent, lowest internode 0.5–3 cm. long; bracts ovate to elliptic, 0.4–1.8 cm. long, not

persistent; pedicels 1-1.5 cm. long, puberulent. Flower (?)hermaphroditic; tepals 8 to 10, the outer pair ovate to orbicular, 4.5-6.5 by 4.5-5.5 mm., puberulent on back, the inner ones obovate-oblong, 8-11 by 2-7.5 mm., with the two outer puberulent in strip down back; stamens 140 to 275, the filaments to 6 mm. long, the anthers elliptic to suboblong, 0.7-1.3 mm. long, retuse at apex; ovary 1.5-2.5 mm. long, the style 5-5.5 mm. long, the stigma peltate, 1-1.5 mm. across, \pm radiate. Fruit ovoid to ellipsoid, 2-3 by 1.1-1.6 cm., \pm acute at apex, drying blackish to pruinose-vinaceous brown, deeply wrinkled or \pm deeply striate; outer layer detaching \pm cleanly from stone, 0.4-1 mm. thick, compact; stone \pm ellipsoid, 1.7-2.5 by 1-1.4 cm., \pm apiculate, the walls 0.4-0.5 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Vietnam to Thailand (MAP 3).

SELECTED SPECIMENS SEEN (letters refer to discussion in text below). Vietnam: Nhatrang, Massif du Hòn Bà, "au Rotins," 1000 m., *Chevalier* 38687 (?s) (A, P); Haut Donnai, Pnomh Sapoum près de la station Agricole de Blao, 1000-1100 m., *Poilane* 23733 (s) (K, P), *Poilane* 23734 (o) (P); Braian près de Djiring, 1700 m., *Poilane* 23891 (o) (A, BO, K, P), 1500 m., *Poilane* 24270 (P); Phu Thoc, Giang Dong, *Pierre* 1393 (BM, K, P); presq'île Nui Hon Heo, près de Nhatrang, 700 m., *Poilane* 6399 (K, P); Phanrang, Ca-na, 700 m., *Poilane* 9395 (P, SING); Lagi, SE. reserve Cay Sangh, *Evrard* 2281 (P); Annam, Din Thuan, *Magnein* 38 (P). Cambodia: Sama Piphek, *Hahn* 26 (P); Pnomh Penh, *Béjaud* 463 (P); Nord Kampok, *Poilane* 14774 (P). Laos: Vientiane, Ban Sa Phan Meuk, *J. E. Vidal* 1389 (P); environs de Vientiane, *J. E. Vidal* 793B (P). Thailand: Chantaburi, Kao Sabap, 50 m., *Kerr* 9556 (A, K, L, P); Lem Sing, 50 m., *Kerr* 9638 (C, K, P); entrance to Chantaburi R., on path leading to Prachadu (Pagoda), 12 m., *Collins* 563 (K, US); Pra Chedi Mt. Kow Kleo Park, 325 m., *Maxwell* 75-210 (AAU); Nong Ta kroom, Sriracha Forest, *Collins* 1127 (C, US); Koh Chang Is., *Maxwell* 74-404 (AAU).

ECOLOGY. Lowland or colline forest, 12-700(-1500) m. alt. In Cambodia, a component of annually burned savannah vegetation; in Thailand in evergreen (or bamboo) forest. Flowering January to April, occasionally in November (flower scented); fruiting in March and April.

LOCAL USES. The wood is generally useful in construction, including that of boats and masts, apparently being resistant to the attacks of borers (*Pierre, loc. cit.*). The "flowers [are] very fragrant & used by the ladies" (*Collins* 1127).

Calophyllum thorelii can be recognized by its leaves that dry bicolored (gray-olivaceous with more or less sabelline margins and midrib above, and sabelline below), its terminal, puberulent inflorescence, its flowers with eight to ten tepals, and its fruits that dry wrinkled and have an outer layer ca. 1 mm. thick that detaches cleanly from the 0.4-0.5 mm. thick stone (but see below). The epithet *thorelii* commemorates Dr. C. Thorel, a French doctor.

Calophyllum thorelii seems to be most closely related to *C. blancoi* and perhaps also to *C. polyanthum*; the differences between these species are listed in TABLE 5.

Two groups of specimens are included in *Calophyllum thorelii* only provi-

sionally; they have not been incorporated into the description. Specimens marked "o" in the list above have terminal buds ca. 5 mm. long, four-angled stems, shortly tomentose indumentum with hairs clearly of a structure different from those of *C. thorelii* sensu stricto (FIGURE 10, g), petioles 6.5–1.3 cm. long, and fruits with an outer layer having a shiny inner surface. The invalid name *C. thorelii* var. *oxycarpum* was based on specimens of this type. Specimens marked "s" in the list have terminal buds 5–7 mm. long, twigs slightly angled and only 1.3–1.7 mm. across, leaf blades not drying notably bicolored and having latex canals on the upper surface almost as prominent as the veins, and fruits having stones with walls 1.2–1.5 mm. thick; the hairs (FIGURE 9, s–u) are not notably different from those of the typical form. Flowers of neither group are known. However, it is probable that the groups will have to be recognized formally when better known. At Pnomh Sapoun specimens referable to groups "s" and "o" seem to grow in close proximity, while the typical form and group "o" both grow near Braian.

Within *Calophyllum thorelii* sensu stricto there is some variation in leaf texture and in inflorescence and flower size; for example, the specimens from Laos are robust and have very coriaceous leaf blades. However, in all specimens the hair type, leaf venation and midrib, and inflorescence and flower are similar; the color of the dried lamina is the same; and the distribution of the indumentum is also similar, although there is some variation as to the degree of its development.

Calophyllum thorelii has been lectotypified by the sheet of *Pierre 34* at Paris. This is the only fruiting specimen of the three numbers that Pierre (*loc. cit.*) cited (*Pierre 34* (also given as 384), 1393, and 2097). Although Pierre's notes at Paris are attached to the sheet of *Pierre 2097*, *Pierre 34* also clearly agrees with the description, and since characters of the fruit are important in separating *C. thorelii* from related taxa, lectotypification by a fruiting specimen is appropriate.

4. *Calophyllum polyanthum* Wall. ex Choisy, *Descr. Guttif. Inde*, 43. 1849, *Mém. Soc. Phys. Hist. Nat. Genève* 12: 423. 1851; Wall. *Catal.* 4844. 1831, *nomen*; Planchon & Triana, *Ann. Sci. Nat. Bot.* IV. 15: 278. 1862; Bedd. *Fl. Sylvat.* 3: xxii. 1871; T. Anderson in Hooker f. *Fl. Brit. India* 1: 274. 1874; Kurz, *Jour. Asiatic Soc. Bengal*, II. 43: 88. 1874, *Forest Fl. Brit. Burma* 1: 95. 1877; Gamble, *List Trees Darjeeling Distr.* 7. 1878; Theobald, *Burma* 2: 636. 1883; Vesque, *Epharosis* 2: t. 6. 1889, in C. DC. *Monogr. Phanerog.* 8: 555. 1893; Prain, *Bengal Pl.* 1: 246. 1903; Brandis, *Indian Trees*, 54. 1907; A. M. & T. M. Cowan, *Trees No. Bengal*, 17. 1929; Craib, *Fl. Siam. Enum.* 1: 121. 1931; Kanjilal *et al.* *Fl. Assam* 1: 114. 1934; Sastri *et al.*, *Wealth India* 2: 19. 1950; Maheshwari, *Bull. Bot. Survey India* 2: 144. 1960; Dutt *et al.* *Indian Forester* 100: 65. 1974. TYPE: India, Assam, Sillet, 1832, *Wallich dist.* 4844 (holotype, σ ; isotypes, BM, FI, G, GH, K, P).

C. amoenum Choisy, *Descr. Guttif. Inde*, 41. 1849, *Mém. Soc. Phys. Hist. Nat. Genève* 12: 421. 1851, *excl. spec. cit.* TYPE: sine loco [India], *Griffith s.n.* (lectotype, σ).

- C. elatum* Bedd. Fl. Sylvat. 1: pl. 2. 1869, *ibid.* 3: xxii. 1871; Someren, Forest Trees Mysore Coorg, 4. 1879; Brandis, Indian Trees, 54. 1907; Gamble, Fl. Pres. Madras 1: 76. 1915; Sastri *et al.* Wealth India 2: 18. 1950; Maheshwari, Bull. Bot. Survey India 2: 146. pl. 3. 1960; Somasundaram, Handb. Trees So. States, 54. 1963; Troup, Silv. Indian Trees, ed. 2. 1: 227. 1975. TYPE: India, Anamallays, *Beddome 35* (lectotype, CAL, B.V.).
- C. smilesianum* Craib, Kew Bull. 1924: 84. 1924; Kerr, Fl. Siam. Enum. 1: 122. 1931; Gagnep. in Humbert, Fl. Gén. Indo-Chine Suppl. 1: 270. 1943. TYPE: Siam, Kao Keo Kang, Dan Sui, ca. 1300 m., April 1922, *Kerr 5792* (holotype, κ ; isotypes, ϵ , ρ).
- C. smilesianum* Craib var. *lutea* Craib, Kew Bull. 1924: 86. 1924; Kerr, Fl. Siam. Enum. 1: 122. 1931; Gagnep. in Humbert, Fl. Gén. Indo-Chine Suppl. 1: 271. 1943. TYPE: Siam, Doi Pahom Pok, Mg. Fang, ca. 1600 m., 1 April 1921, *Kerr 5180* (holotype, κ).
- C. williamsianum* Craib, Kew Bull. 1924: 86. 1924; Kerr, Fl. Siam. Enum. 1: 122. 1931; Gagnep. in Humbert, Fl. Gén. Indo-Chine Suppl. 1: 270. 1943. TYPE: Siam, Nan, Doi Tiu, ca. 1100 m., 8 March 1921, *Kerr 5038* (holotype, κ ; isotypes, ϵ , ρ).
- C. angustifolium* auct., non Roxb.; Dalzell & Gibson, Bombay Fl. 32. 1861; Cleghorn, Forests Gardens S. India, 11. 1861; Drury, Handb. Indian Fl. 1: 143. 1863.
- C. bracteatum* auct., non Thwaites; Bedd. Trans. Linn. Soc. 25: 211. 1865.
- C. tomentosum* auct., non Wight; T. Anderson in Hooker f. Fl. Brit. India 1: 274. 1874, *pro parte*; Vesque in C. DC. Monogr. Phanerog. 8: 552. 1893, *pro parte*; Cameron, Forest Trees Mysore Coorg, 17. 1894; Talbot, Trees Bombay Pres. ed. 2. 30. 1902; Bourdillon, Forest Trees Travancore, 27. 1908; Cooke, Fl. Pres. Bombay 1: 80. 1909; Talbot, Forest Fl. Bombay 1: 100. 1909; Bor, Man. Indian Forest Bot. 202. 1953.
- C. balansae* auct., non Pitard; Gagnep. in Humbert, Fl. Gén. Indo-Chine Suppl. 1: 271. 1943, *pro parte*; Pham & Nguyễn, Cây-Cỏ Miền Nam Việt-Nam, 179. *bang 57bis A.* 1960; Pham, Cây-Cỏ Miền Nam Việt-Nam, ed. 2. 22: 302. *fig. 1970, pro parte.*
- C. thorelii* auct., non Pierre; Hu *et al.*, Bull. Fan Mem. Inst. Biol. Bot. 8: 338. 1938; Auctt., Ic. Corm. Sin. 2: 883. 1972.

Tree 7-45 meters tall, d.b.h. to 160 cm.; trunk without buttresses; outer bark yellowish, gray to brown, or black, deeply fissured, with oblong flakes; inner bark yellow, reddish, or reddish brown with whitish bands; latex white, amber colored, or clear brown.

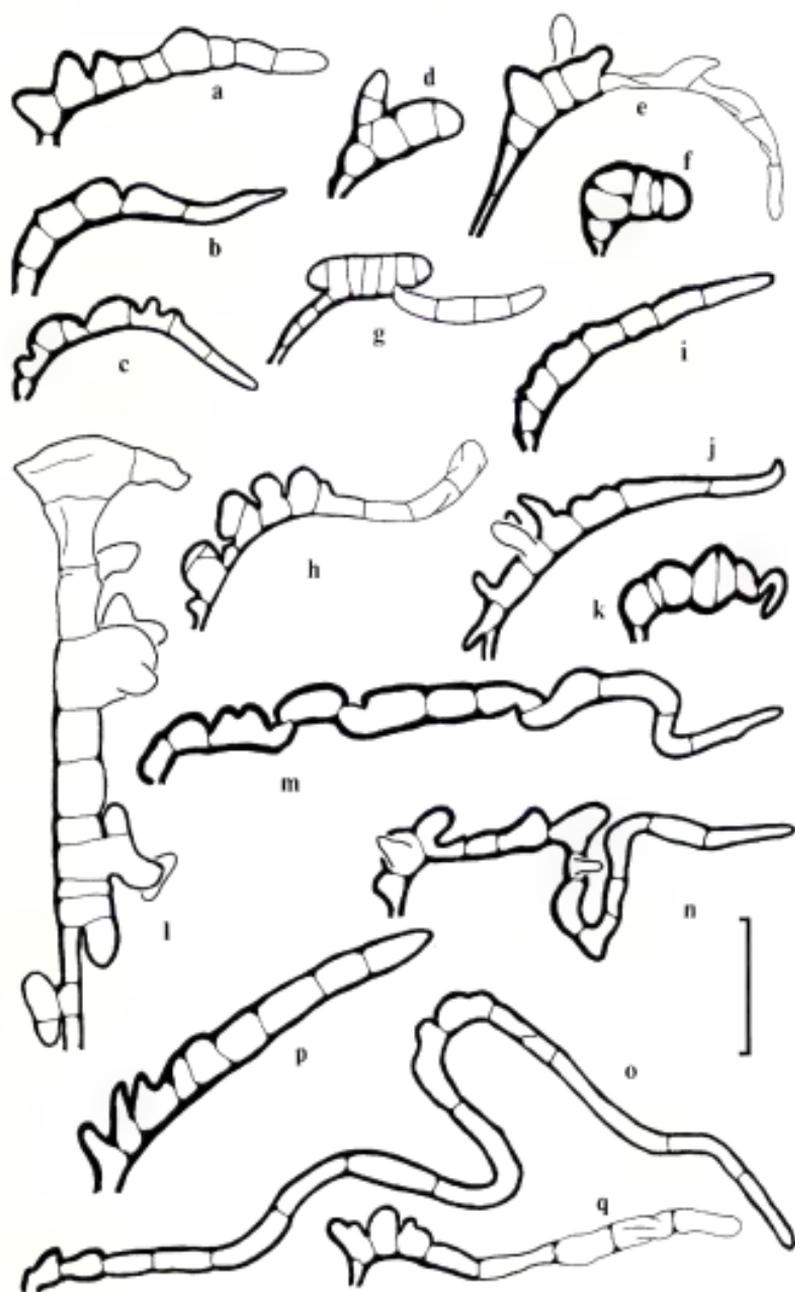
Twigs slightly to strongly flattened, 1.5-3(-4.5) mm. across, obscurely to sharply 4-angled, drying brown to blackish, puberulent when young; axillary innovations lacking basal scars; internodes 0.5-4(-5) cm. long; uppermost pair of axillary buds \pm rounded, to 1.5 mm. long, suberect, inconspicuous; terminal bud plump, 7-10(-14) mm. long, with subcrustaceous to puberulent, gray to brown indumentum (hairs, FIGURE 11, d-k), underdeveloped internode to 2.5 mm. long. Petiole 0.7-1.8(-2.2) cm. long, broadly concave above, convex below, soon glabrescent; lamina ovate to elliptic, 5-16(-19) by 1.8-6 cm., acuminate at apex, (abruptly) attenuate to acute at base, narrowly recurved and undulate at margin, coriaceous, drying dark olive-buff to sepia above and amber or sabelline to sepia below, sparsely puberulo-farinose on midrib

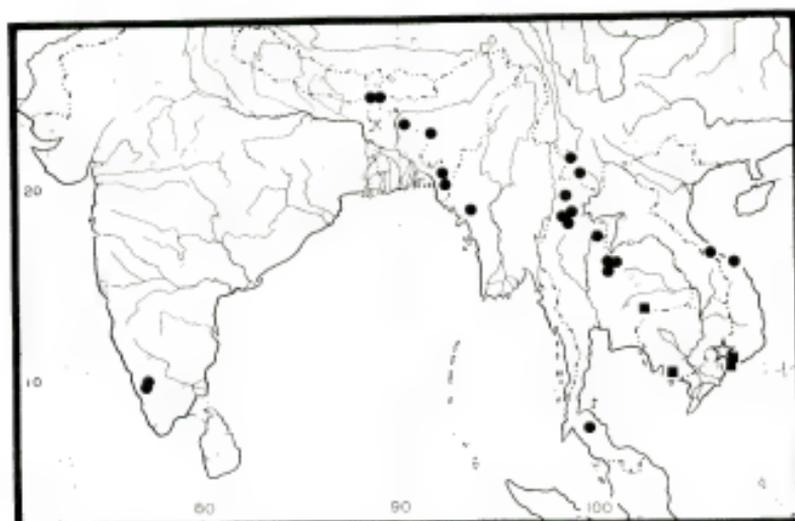
below when young, the midrib above usually gradually narrowed from base, raised, or at least margins raised, 0.2–0.5 mm. wide at midpoint, below raised, striate, the venation above and below apparent, raised, 9 to 16 (to 24) veins/5 mm., angle of divergence (65–)70–85°. Inflorescences terminal and from adjacent foliate axils, with many flowers, flabellate, to twice branched, the axis to 16 cm. long, puberulent, lowest internode 0.5–3 cm. long; bracts soon deciduous, not seen; pedicels 0.4–1.2(–1.8) cm. long, puberulent. Flower (?)hermaphroditic; tepals 8 (rarely 7, 10, or 12), the two outer ovate to orbicular, 2–4(–5) by 2–3.5(–4.5) mm., ± puberulent on back, the inner ones ovate to obovate, 4–8 by 3.5–6 mm., or in flowers with 12 tepals, inner four sometimes only 3.5 by 1.2 mm., sometimes puberulent toward base; stamens (100 to) 140 to 320, the filaments 2.5–4 mm. long, connate for up to 0.5 mm., the anthers ± elliptic and 0.4–1 mm. long, or oblong and to 1.7 mm. long, retuse (rounded) at apex; ovary 1.2–2.5 mm. long, the style 2–3 mm. long, the stigma peltate, 0.7–1.2 mm. across, 2- or 3-lobed. Fruit ovoid to subobovoid, 2.4–3.4 by 1.8–2.3 cm., ± acute to beaked at apex, drying dark brownish, smooth to finely wrinkled or substrate; outer layer not detaching cleanly from stone, 1.5–3 mm. across, compact; stone obovoid to ellipsoid, 1.9–2.6 by 1.5–1.8 cm., rounded at apex, the walls 0.4–0.7 mm. across, smooth, unmarked; spongy layer thin.

DISTRIBUTION. India (Western Ghats and northeastern India) to Thailand and southwestern China (MAP 4).

SELECTED SPECIMENS SEEN. **India.** MYSORE: Coorg, *Dehra Dun Herb. no.* 33622 (A), 33627 (C), 33628 (NSW); Anamallays, *Beddome 418* (BM). TAMIL NADU: Kariem Shola (Top Slip) near Coimbatore, 1000 m., *Kostermans 25231* (L). WEST BENGAL: Kurseong, 1219 m., *Gamble 1624A* (K); Chunbali, 914 m., *Gamble 605A* (K); Siuhe Hills, 610 m., *Gamble 7569* (K); Bereith, Teesta, 305 m., *Gamble 1644A* (K); Mungpoo, *Prain's collector s.n.*, May 1900 (G, GH, P); Terai, *Clarke 28014* (K); above Tendhara, *Cave s.n.*, 23 May 1912 (E); Anwee, 610–1524 m., *Hooker & Thompson 2385* (K); Peque & Sikkim, up to 914 m., *Beddome 417* (BM); Khalumpong Div., 1067 m., *Gamble 10004* (K). ASSAM: near Nokrek, Garo Hills, 1219 m., *Koelz 24573* (L); Khasia, 610–1524 m., *Hooker & Thompson s.n.* (BM, C, FL, G, GH, K, L, M, P, US, W); Hmuntha, Lushai Hills, 1524 m., *Chand 4390* (L); Rungtong, 914 m., *Clarke 14690A* (K), *14690B* (BM). **Bangladesh:** Chittagong, Pharsha, *Gamble 6689A* (K); Sitapahar, *Cowan 11* (E). **Burma:** SE. Shan States, Keng Tung territory, between Pang Hoi Hpi and Peng Sai, 1341 m., *Rock 2205* (A, US, W); Sedashegus, *Mrs. Muller s.n.*, Feb. 1858 (E); Amherst Distr., Mikhalein Chaung, Dawna Range, 610 m., *Lace 4759* (E, K); Pu Bia, 1700 m., *Kerr 21009* (BM, P). **China.** YUNNAN: Meng-soong, Dah-meng-lung, Che-li Hsien, 1800 m., *C. W. Wang*

FIGURE 11. Hairs (from terminal bud, unless otherwise stated). a, *Calophyllum* sp. 9 (*bb 5467*). b, c, *C. symingtonianum* (*SFN 32904*). d–k, *C. polyanthum*: d, e, *Rock 2205*, from axillary bud; f–h, *Griffith 879*; i, *Poilane 10212*; j, *DD 33623*, from inflorescence; k, *Winit 1375*. l, *C. tomentosum* (*Kostermans 25008*). m–o, *C. walkeri*: m, o, *Kostermans 25100*; n, *CP 1170*. p, q, *C. trapezifolium*: p, *Kostermans 24138*, in life more adpressed; q, *Kostermans 24414*, very common hair type. Scale = 60 μm.





MAP 4. Distribution of *Calophyllum polyanthum* (circles), *C. dryobalanoides* (squares), and *C. dongnaiense* (star) in India-Southeast Asia.

78356 (A); Lan Tsang Hsien, 1800 m., *C. W. Wang* 76468 (A). **Vietnam:** Quang Tri, Dent du Tigre, 800–1000 m., *Poillane* 10242 (?) (K, P, SING); Ba Na, près de Tourane, 1200–1500 m., *Poillane* 29222 (?) (A, P). **Laos:** Pu Bra, 1700 m., *Kerr* 21009 (K). **Thailand:** Kao Kradang, Udawn, 450 m., *Kerr* 8752 (E, K, L, P); Me Chem, *Kerr* 2691 (K); Doi Pah Kao, *Kerr* 2608 (K); Chiangmai, Doi Kā, *Winit* 1375 (K), Doi Nang Kā, *Put* 3785 (BM, K, L), Doi Chiengdao, 100 m., *Smitinand et al.* 7787 (BKF); Phitsanulok, foothill of Puh Mieng mountain, 1300 m., *Larsen et al.* 938 (AAU); Loei, Phu Kradueng National Park, 1250 m., *Smitinand* 11780 (BKF); Van Samong, Pakadong, Lowi, *anon.* 706 (BKF 12385) (BKF); Kaolong, Nakorn Sri Tamara, *anon.* 624 (BKF 10145) (BKF); Nakorn Sri Thamrad, Kiriwong, *anon.* 1662 (BKF 31492) (BKF); Peninsula, Trang, Chawng, 200 m., *Smitinand* 4106 (BKF).

ECOLOGY. Tree of sometimes considerable size; usually in colline or lower montane rainforest, (200–)400–1800 m. alt. Flowering January to July (in Peninsular India apparently in January and February (Talbot, *loc. cit.*, as *C. tomentosum*) or March and April (Bourdillon, *loc. cit.*); flower scented. Fruiting March, June, July, September, and November (India); late January (Burma); March, April, July, September, and November (Thailand); and April (Laos). Fruits of Western Ghats specimens reported (e.g., Bourdillon, *loc. cit.*, as *C. tomentosum*) to be bright yellow or dark purple.

GERMINATION AND YOUNG PLANT. The radicle probably breaks through the stone to one side of the base. The seedling has three pairs of leaves separated by well-developed internodes; the lowest pair of leaves may either persist or drop off well before the others (*Gamble* 7569, *Clarke* 15130A).

LOCAL NAMES AND USES. In southwestern India *Calophyllum polyanthum* is the well-known poon spar or sirpoon tree. Wood of this tree furnished the poon spars used for masts, spars, and other parts of ships, and good trunks were much valued, as much as 2000 rupees being paid for single trunks in the nineteenth century. The wood has also been used for bridge building, general construction, and furniture making.

Calophyllum polyanthum can be recognized by its moderate-sized leaf blades that are markedly attenuate at the base, have a midrib that narrows gradually above the base, and are the same color on both surfaces, often drying greenish brown. The terminal inflorescence has numerous flowers; the flowers themselves usually have eight tepals, the outermost pair of which is markedly smaller than the rest. The fruit dries smooth or finely wrinkled, with a compact outer layer 1.5-3 mm. thick, and stone walls 0.4-0.7 mm. thick. The epithet *polyanthum* refers to the inflorescences, which have numerous flowers.

Calophyllum polyanthum is apparently related to *C. thorelii* and *C. touranense* (both from Vietnam, the former also found in Thailand), and perhaps also to *C. blancoi* (centered in the Philippine Islands). The differences between these species are listed in TABLE 5.

The specimens cited above from Vietnam are included in *Calophyllum polyanthum* only with some hesitation; they had previously been identified as *C. balansae*. The specimens are either in bud or just past flowering; they have rather small (lower limits of measurements given) leaf blades that are more or less cuneate at the base. Specimens collected by Kostermans near Coimbatore have leaf blades with strongly undulate margins and dense (upper limits of measurements given) venation. The leaf blades are somewhat more coriaceous than those of the other specimens, including the other specimens cited from Peninsular India, and the fruits are beaked.

The typification of *Calophyllum amoenum* is discussed under *C. calaba*. The type specimens of *C. smilesianum* and *C. smilesianum* var. *lutea* cannot be distinguished morphologically from the other specimens of *C. polyanthum*. However, the type specimen of *C. williamsianum*, Kerr 5038, differs somewhat from the other specimens in having large terminal buds and leaf blades (upper limits of measurements given), and robust inflorescences, the flowers tending to be congregated toward the ends of the inflorescence branches. The midrib on the upper surface of the lamina is rather abruptly narrowed at the base. However, in general details of venation, terminal bud, indumentum, and flower (except the rather long (1.4-1.7 mm.) anthers), Kerr 5038 agrees with the other specimens of *C. polyanthum* and so is included here. The outer pair of tepals are very much smaller than the inner ones, as is characteristic of *C. polyanthum*. Kerr (*loc. cit.*) considered both *C. williamsianum* and *C. smilesianum* to be close to *C. polyanthum*.

Calophyllum elatum is reduced to synonymy under *C. polyanthum* without much hesitation, although there seems to be some confusion over fruit color (see above). The specimens cited agree well with the illustration of *C. elatum* in Beddome (1869, *pl. 2*), except that the indumentum on the tepals is less prominent than in the illustration. They differ from specimens collected in

northeastern India only in their somewhat longer petioles and pedicels, but there is no absolute difference even in these characters. Maheshwari (*loc. cit.*) lectotypified *C. elatum*.

There are other specimens of *Calophyllum* from the Western Ghats and vicinity (e.g., *Bourdillon 1505*, at Kew) that seem to be neither *C. polyanthum* nor *C. tomentosum*, with which *C. elatum* has been confused. *Calophyllum tomentosum* itself has much more steeply ascending venation than *C. polyanthum*, its tomentose indumentum is conspicuous, and its inflorescence is axillary. *Bourdillon 1505* and the other specimens approach *C. tomentosum* in the first and last characters, while in the second they are close to *C. polyanthum*; their leaf blades are less than 9 by 3.9 cm.

5. *Calophyllum touranense* Gagnep. ex P. F. Stevens, sp. nov.

FIGURE 8, b-d.

C. touranense Gagnep. in Humbert, Fl. Gén. Indo-Chine Suppl. 1: 271. 1943; Phạm & Nguyễn, Cây-Cổ Miền Nam Việt-Nam, 179. *bang 62bis* C. 1960; Phạm, Cây-Cổ Miền Nam Việt-Nam. ed. 2. 2: 302. *fig.* 1970. *Nomen invalidum*.

C. balansae auct., non Pitard; Gagnep. in Humbert, Fl. Gén. Indo-Chine Suppl. 1: 271. 1943, *pro parte*.

A speciebus aliis *Calophylli* in foliis mediocris venulis lateralibus prominentibus 6 ad 10 (ad 14) per 5 mm., et fructu in siccitate reticulo crebero minute elevato interdum striato, strato exteriore crasso (circa 3-5.5 mm. in transverso), differt.

Tree 7-20 meters tall; trunk and bark unknown; latex yellow.

Twigs slightly flattened, 0.8-2.3 mm. across, \pm 4- or 6-angled, drying black, puberulent when young; axillary innovations without basal scars; internodes 0.5-3.5(-4.5) cm. long; uppermost pair of axillary buds rounded, 1-1.5 mm. long, erect; terminal bud plump, ca. 5 mm. long, with short, brown to grayish indumentum (hairs, FIGURE 9, o-r), underdeveloped internode to 3.5 mm. long. Petiole 0.7-2.5 cm. long, \pm strongly concave above, convex below, glabrous at maturity; lamina elliptic to ovate, (3.3-)4.2-7.2 by (1.4-)2.2-4.6 cm., acuminate at apex, cuneate to narrowly attenuate at base, slightly undulate and not recurved or slightly so at margin, coriaceous, drying bay to olivaceous above and sepia below, glabrous at maturity, the midrib above gradually narrowed from base, flat to slightly elevated, 0.1-0.3 mm. wide at midpoint, below narrowly raised, \pm angled, the venation apparent below and usually above, raised, 6 to 10 (to 14) veins/5 mm., angle of divergence 60-75°. Inflorescences terminal and from adjacent foliate axils, with numerous flowers, branched, the axis ca. 5 cm. long, puberulent when young, basal internode ca. 1.3 cm. long; bracts narrowly ovate, to 4 mm. long, caducous; pedicel (2-)3-5.5 mm. long, puberulent, in fruit 1-1.5 cm. by 2-3 mm. thick. Flower (?) hermaphroditic; tepals 9 to 13, the outer pair suborbicular, 3-3.7 by 3-4 mm., the next pair suborbicular, 4-6 by 4.5-7 mm., the inner ones more or less elliptic, 8-9.5 by 4-7 mm., in inner whorl to 10.5 by 4.5 mm.; stamens

ca. 400, the filaments to 4 mm. long, the anthers suboblong, 0.6–1 mm. long, \pm rounded at apex; ovary ca. 1.5 mm. long, the style ca. 3 mm. long, the stigma not peltate, ca. 0.5 mm. across. Fruit ellipsoid to obovoid, 2–3.7 by 1.2–2.3 cm., rounded to acute at apex, drying brown to blackish, finely and closely reticulate to striate; outer layer adhering to stone, 3–5.5 cm. thick, compact; stone ovoid-ellipsoid, 1.3–2.6 by 0.7–2 cm., rounded at apex, the walls (0.3–)0.6–1.1 mm. thick, smooth, not marked; spongy layer thin.

TYPE: Indochina [Vietnam], Annam, Hoi Mit, 40 km. N. of Tourane, 10 July 1927, J. & M. S. Clemens 4162 (holotype, A; isotypes, K, NY, P).

DISTRIBUTION. Thailand and Vietnam (MAP 3).

ADDITIONAL SPECIMENS SEEN. **Vietnam:** Col des Nuages, près de Tourane, 450 m., *Poilane* 7956 (K, P, US); Ba Na, près de Tourane, 1100 m., *Poilane* 7179 (A, K, L, P), 300 m., *Poilane* 7341 (P), 200–300 m., *Poilane* 29303 (A, P); sommet du Nui Bach Ma, sud de Hue, 1400–1500 m., *Poilane* 27748 (L, P), 1400–1500 m., *Poilane* 27759 (BM, P, US), *Poilane* 29973 (A, P). **Thailand:** Nakhon Ratchasima, Khao Yai Natl. Park, Khao Kieo, 1200 m., *Beusekom & Charoenpol* 1724 (A).

ECOLOGY. Rocky or stony ground, 200–1500 m. alt. Flowering in April; fruiting July to October (almost ripe fruit brownish green).

LOCAL USE. The wood is used in house construction (Hue, Vietnam).

Calophyllum touranense can be distinguished from other species in the genus by its elliptic to ovate leaf blades that have prominent, rather distant venation, its terminal inflorescence, its flowers with 9 to 13 tepals, the outer pair being notably smaller than the rest, and its rather large fruit with a thick outer layer that dries minutely wrinkled. The type specimen was collected at Tourane (now Da-nang), hence the specific epithet.

Calophyllum touranense is possibly close to *C. polyanthum*, the two having similar inflorescences, and flowers in which the outermost pair of tepals is much smaller than the others. *Calophyllum polyanthum* differs most obviously in having closer venation and fruit with both the outer layer and the wall of the stone thinner (see TABLE 5). A variant of *C. polyanthum* and *C. touranense* both grow near Ba Na, Da-nang. *Calophyllum touranense* has been confused with *C. balansae*; for the differences between the two, see *C. balansae*.

Specimens of *Calophyllum touranense* from Hue are very similar to those from around Da-nang, although the fruit of the former tends to dry blackish, rather than brown, and to be somewhat smaller. The description of the flowers is taken from *Poilane* 29973, from Hue. A specimen in very young bud from near Da-nang (*Poilane* 7179) had 9 to 11 tepals, but the flowers were too young to confirm the size differences between the successive pairs and whorls of tepals so marked in *Poilane* 29973. The specimen cited from Thailand is similar to those from Vietnam. It differs slightly, however, in having less apparent venation on the upper surface of the lamina and a stone with a somewhat thinner wall. Other specimens from the same locality have fruits

with an outer layer ca. 2 mm. thick and leaves with as few as four veins/5 mm. *Calophyllum* is reported to be the dominant tree in parts of the Khao Yai National Park, and further collections from those areas are much needed.

Gagnepain's description of *Calophyllum touranense* is invalid, since it is in French.

6. *Calophyllum balansae* Pitard in Lecomte, Fl. Gén. Indo-Chine I(4): 320. 1910; Phạm, Cây-Cỏ Miền Nam Việt-Nam. ed. 2. 2: 302. 1970, *pro parte*. TYPE: Tonkin [Vietnam], Ke-so, 6 May 1886, *Balansa* 4346 (lectotype, ♀).

Small tree; bark unknown.

Twigs slightly flattened, 1.5–2.5 mm. across, obscurely 4-angled, drying brown, sparsely puberulent when young; axillary innovations lacking basal scars; internodes 0.4–3.3 cm. long; uppermost pair of axillary buds and terminal bud unknown (hairs, FIGURE 9, n). Petiole 3.5–8.5(–13) mm. long, ± deeply concave above, convex below, glabrous; lamina obovate to subelliptic, 3–7 cm. long, 1.5–4.3 cm. across, bluntly subacuminate to obtuse (rarely rounded) at apex, cuneate at base, somewhat undulate and recurved at margin, subcoriaceous, drying amber to brick color above and amber to sepia below, glabrous, the midrib above narrowed gradually from already narrow base, somewhat depressed at first, soon becoming ± level, 0.2–0.4 mm. wide at midpoint, ultimately raised, below raised, striate, the venation above and below apparent, raised, 6 to 10 veins/5 mm., angle of divergence 60–70°. Inflorescences terminal and from adjacent foliate axils, with numerous flowers, sometimes flabellate, branched, branches 5-flowered, to 3.7 cm. long, the axis to 15 cm. long, ± puberulent near base (glabrous above), lowest internode 1.5–4 cm. long; lower bracts foliaceous, subsistent, persistently puberulent on and near midrib below, upper bracts not seen; pedicels (0.5–)1–2 cm. long, glabrous or puberulent. Flower (?) hermaphroditic; tepals 8 to 12, glabrous or almost so, the outer two suborbicular, 3.5–6 by 4–5.5 mm., the next pair orbicular to broadly ovate, 6–7.5 by 5.5–6.5 mm., the inner ones obovate, 8–10 by 3–6 mm.; stamens 195 to 265, the filaments to 6 mm. long, the anthers elliptic to oblong, 0.5–0.9 mm. long, ± retuse at apex; ovary 1.3–2 mm. long, the style 3–7 mm. long, the stigma subpeltate, ca. 0.5 mm. across. Fruit ellipsoid, 2–2.2 by 1.55–1.75 cm., ± sharply pointed at apex, drying brown, with shallow, sharp, rather dense wrinkles; outer layer detaching ± cleanly from stone, ca. 1 mm. thick, compact; stone ellipsoid, ca. 1.6 by 1.3 cm., apiculate, the walls 0.3–0.5 mm. thick but somewhat thicker at base, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Vietnam (MAP 3).

ADDITIONAL SPECIMENS SEEN. **Vietnam:** Hao Nho, in monte Crucis, *Bon* 781 (♀); in monte Lan Mat, *Bon* 2115 (♀), *Bon* 2074 (♀).

ECOLOGY. Probably in colline or lower montane forest in Vietnam; reported on calcareous rocks (*Balansa* 4346). Flowering March to May; fruiting in October.

Calophyllum balansae can be recognized by its rather small leaf blades that are at most subacuminate at the apex and that characteristically dry almost concolorous, and by its copious terminal inflorescences. Its subspherical, pointed fruits dry wrinkled, the outer layer of the fruit being ca. 1 mm. thick; the stone wall is ca. 0.5 mm. thick. The epithet commemorates the collector, Benjamin Balansa.

The status and relationships of *Calophyllum balansae* are unclear; it is similar to *C. polyanthum* and its relatives (TABLE 5), but when it becomes better known its specific rank may not be maintainable. Its terminal buds are unknown, but the hairs on the axillary buds are similar to those of *C. polyanthum*, *C. touranense*, and *C. thorelii* (FIGURES 9, 11).

Gagnepain (1943) cited specimens here placed in *Calophyllum touranense* and *C. aff. polyanthum* under *C. balansae*. *Calophyllum touranense* is rather similar to *C. balansae* in general leaf type (although the blade is more coriaceous) and in inflorescence and flower, but in fruit the two differ. The fruit of *C. touranense* dries finely wrinkled, the outer layer is at least 3 mm. thick, and the stone wall is 0.6–1.1 mm. thick. The specimens of *C. aff. polyanthum* that were cited by Gagnepain as *C. touranense* have inflorescences with flowers in young bud. The flowers have eight tepals and a peltate stigma, and the leaf blades have 11 to 14 veins/5 mm.

Calophyllum balansae and *C. symingtonianum*, from Malaya, have similar fruits; the differences between these two taxa are discussed under the latter species.

Calophyllum balansae has been lectotypified by Balansa 4346 at Paris. This specimen is in flower and agrees well with the original description. Pitard (*loc. cit.*) noted that Balansa collected this specimen on "monte Lan Mat"; this seems to be an error. Pitard did not describe the fruits: "fruit inconnu, monosperme d'après Bon." However, there are fruits in a packet on the sheet of Bon 781 that appear to belong to the specimen.

7. *Calophyllum symingtonianum* M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 338. pl. 18. 1956, *pro majore parte*; Kochummen, Malayan Forest Rec. ed. 2. 17: 222. 1965; T. C. Whitmore, Tree Fl. Malaya 2: 192. 1973, *pro parte*. TYPE: Malaya, Pahang, Cameron Highlands, Boh Plantation, 4000 feet [1219 m.], 12 April 1937, SFN 32633 coll. Nur (holotype, SING; isotypes, A, K, KEP, L, MO, P, UC, US).

Tree 12–39 meters tall, d.b.h. to 95 cm.; trunk at least sometimes with low, thick spurs or small buttresses; outer bark gray-brown to yellowish, with boat-shaped fissures, or with loose, elongate scales and narrow, square-section fissures between scales; inner bark pink; latex clear and almost colorless, free-flowing to sticky, or yellow and clear to opaque.

Twigs flattened, 1–1.5 mm. across, (weakly) 4-angled when young, soon becoming \pm rounded, drying mid-brown to blackish, puberulent when young; axillary innovations lacking basal scars; internodes 1–3 cm. long; uppermost pair of axillary buds \pm pointed, to 1.5 mm. long, spreading; terminal bud plump, 3–7 mm. long, with grayish to brownish, subcrustaceous indumentum

(hairs, FIGURE 11, b, c), underdeveloped internode 1.5–3.5 mm. long. Petiole 0.6–1.4 cm. long, narrowly concave above, convex below, usually slender, blackish when dry, subsersistently puberulent or not; lamina ovate to subelliptic, 5–9 by 1.4–3 cm., gradually acuminate at apex, cuneate (acute) at base, \pm closely and narrowly undulate but not recurved or only slightly so at margin, coriaceous, drying umber above—often with grayish covering—and sepia below, glabrous, the midrib above gradually narrowed from base, \pm flat, surrounding lamina obscurely raised, 0.2–0.3 mm. wide at midpoint, below slightly raised, obscurely angled, the venation on both surfaces subobscure to apparent, slightly raised, (6 to) 8 to 11 veins/5 mm., angle of divergence 70–85°. Inflorescences terminal and from adjacent foliate axils, with scars of 11 to many flowers, sometimes with branches to 4 cm. long and with scars of up to 11 flowers, the axis 4–5 cm. long, puberulent, lowest internode 1.3–2.5 cm. long; bracts unknown; pedicels in fruit 0.6–1 cm. long, subsersistently puberulent. Flower unknown. Fruit ellipsoid to ovoid, 1.7–2 cm. long, 1.5–1.6 cm. across, \pm rounded at apex, sometimes with stipe to 2.5 mm. long, drying brown, with dense, shallow, sharp wrinkles, or \pm smooth; outer layer not detaching cleanly from stone, 0.5–0.8 mm. thick, \pm compact; stone ellipsoid, ca. 1.5 by 1.3 cm., rounded at apex, the walls ca. 0.4 mm. thick, smooth, unmarked; spongy layer unknown.

DISTRIBUTION. Malaya, possibly also Thailand (MAP 3).

SELECTED SPECIMENS SEEN. **Thailand:** Trang, Kachong, 150 m., 30 May 1943, *anon.* 183 (BKF). **Malaya.** KEDAH: G. Inas F.R., 975 m., *FRI 9346* (KEP); Langkawi Is., G. Raya F.R., 305 m., *KEP 71194* (KEP, SING). KELANTAN: G. Stong, 762 m., *FRI 12481* (A, K, KEP, L, SING). PAHANG: Cameron Highlands, Bow Plantation, 1219 m., *SFN 32904* (K, KEP, L, LAE, SING); Ringlet Valley, *KEP 12980* (KEP); Ulu Sungei Uri, *KEP 33748* (KEP).

ECOLOGY. Colline and lower montane forests, 150–1220 m. alt. (lower altitudes in northern part of range). Fruiting in April.

LOCAL USE. The tree has hard wood that is used for making houses.

Calophyllum symingtonianum is an imperfectly known species that can be characterized by its rather small and relatively long-acuminate leaf blades borne on slender petioles, and by its terminal inflorescences bearing medium-sized, wrinkled fruits; its flowers are unknown. The specific epithet commemorates C. F. Symington, the Malayan botanist.

Calophyllum symingtonianum appears to be related to *C. dryobalanoides*. For the differences between the two species, see *C. dryobalanoides*.

The specimen cited above from Thailand is sterile; its identification is not certain.

There has been much confusion in Malaya between sterile material of *Calophyllum symingtonianum*, *C. ferrugineum* var. *oblongifolium*, *C. calaba* var. *bracteatum*, and *C. soulattri*. Fertile material of these species can be distinguished without difficulty, since there are considerable differences in inflorescences and fruits. The dissimilarities between sterile specimens are given below in TABLE 6.

TABLE 6. Comparison between sterile specimens of *C. symingtonianum*, *C. ferrugineum* var. *oblongifolium*, *C. calaba* var. *bracteatum*, and *C. soulattri* in Malaya.

	<i>C. symingtonianum</i>	<i>C. ferrugineum</i> var. <i>oblongifolium</i>	<i>C. calaba</i> var. <i>bracteatum</i>	<i>C. soulattri</i>
TERMINAL BUD INDUMENTUM	Subcrustaceous	Tomentose	Subtomentose	Tomentose
TWIG THICKNESS (mm.)	1-1.5	1-2	1-2.3(-3)	2-4
LEAF BLADE				
LENGTH (cm.)	5-9	4-10(-11)	2.3-4.2(-12.6)	(8-)11-17
SHAPE	Ovate to elliptic	Elliptic, rarely oblong	± Elliptic	Ovate to elliptic
TEXTURE	Thinly coriaceous	Coriaceous	Thinly coriaceous	Thinly coriaceous
MARGIN	Undulate	Nearly always flat	Undulate	Undulate
VENATION DENSITY (veins/5 mm.)	(6 to) 8 to 11	(13 to) 15 to 21	(12 to) 18 to 24	11 to 16
VENATION APPARENTLY TWICE AS DENSE ABOVE AS BELOW	No	Yes	Occasionally	No

Henderson and Wyatt-Smith (*loc. cit.*) included some specimens from Perak in *Calophyllum symingtonianum*. However, these specimens have more regularly elliptic leaf blades and stouter petioles; the fruits are twice as large as those of the type specimen and have a stone wall ca. 1 mm. thick. These specimens are included here in *C. fraseri*. The size of the fruits of *C. symingtonianum* as here delimited is more in line with the size of the leaf blades (cf. Henderson & Wyatt-Smith, *loc. cit.*).

KEP 71194 (Langkawi Island) was included in *Calophyllum floribundum* (= *C. tetrapterum*) by Henderson and Wyatt-Smith (*op. cit.*, p. 333). However, small buttresses are mentioned in the field notes of this specimen, the petioles are slender, and the terminal bud is like that of *C. symingtonianum*, to which species this specimen should be referred.

8. *Calophyllum dryobalanoides* Pierre, Fl. Forest. Cochinch. I: pl. 106. 1885; Vesque in C. DC. Monogr. Phanerog. 8: 601. 1893; Pitard in Lecomte, Fl. Gén. Indo-Chine 1(4): 319. 1910; Gagnep. in Humbert, Fl. Gén. Indo-Chine Suppl. I: 274. 1943, *pro minore parte*; Pham & Nguyễn, Cây-Cỏ Miền Nam Việt-Nam, 179. 1960; Pham, Cây-Cỏ Miền Nam Việt-Nam. ed. 2. 2: 302. fig. 1970. Type: Cochinchina [Vietnam], in montibus Dinh ad Baria Gallicae, Oct. 1866, Pierre 83 (lectotype, ♀; isolecotypes, A, K, L, P, SING).

Tree 8-30 meters tall, d.b.h. to 45 cm.; trunk (?) without buttresses; outer bark red (*vide* Pierre), fissured.

Twigs slightly flattened, 1-1.3 mm. across, obscurely to strongly 4-angled, drying blackish, puberulent when young; axillary innovations lacking basal scars; internodes (0.5-)1-2 cm. long; uppermost pair of axillary buds ± pointed, ca. 1 mm. long, erect or slightly spreading; terminal bud plump to subconical, 2.3-4 mm. long, with short, grayish, subadpressed indumentum (hairs, FIGURE 9, l, m), underdeveloped internode to 1 mm. long. Petiole 0.5-1.3 cm. long, rather sharply concave above, convex below, slender, ca. 1 mm. across, glabrous at maturity; lamina ovate, 2.3-9.3 by 1.2-3.2(-4) cm., acuminate at apex, acute to cuneate at base, slightly undulate and somewhat recurved at margin or not, rather thinly coriaceous, drying olivaceous above (midrib sometimes reddish) and sabelline below, glabrous at maturity, the midrib above gradually narrowed from base, ± flat, surrounding blade raised, 0.2-0.35 mm. wide at midpoint, below narrow, slightly depressed or raised, striate, the venation on both surfaces ± apparent or not, slightly raised (impressed on upper surface), 4 to 8 veins/5 mm., angle of divergence 60-75°. Inflorescences terminal and from adjacent foliate axils, when terminal with 13 to numerous flowers (with 3-flowered branches ca. 8 mm. long), when axillary with 5 to 9 flowers, the axis 2-2.7 cm. long, puberulent, lowest internode 1-1.3 cm. long; bracts not known; pedicels in fruit 0.5-1.3 cm. long, puberulent. Flower (?) hermaphroditic; tepals 8, the outer pair suborbicular, 3-3.5 by 2.7-3.5 mm., the next pair broadly ovate, ca. 5 by 4.5 mm., the inner ones elliptic to obovate, ca. 6.5 by 3.3 mm.; stamens (? 70 to) 105 to 115, the filaments to 3.5 mm. long, the anthers oblong, 0.7-1 mm. long, subretuse

at apex; ovary ca. 1.7 mm. long, the style ca. 2 mm. long, the stigma peltate, ca. 0.9 mm. across, 3-radiate. Fruit spherical to broadly ovoid, 1.8-2.3 by 1.75-2.1 cm., rounded at apex, drying vinaceous-brown, finely and rather sharply wrinkled; outer layer detaching cleanly from stone or not, 2-2.5 mm. thick, compact; stone subspherical, to 1.9 by 1.7 cm., rounded at apex, the walls 0.4-0.6 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Vietnam, Cambodia, and eastern Thailand (MAP 4).

SELECTED SPECIMENS SEEN. **Vietnam:** montibus Dinh ad Baria Gallieae, *Pierre* 3647 (K, P); in monte Lapoo, *Pierre* 88 (K); Bienhoa, Nui Chua Chan, 750 m., *Poilane* 19445 (P). **Cambodia:** Kampot, cascade Pokpok Vil, 1000 m., *Martin* 1213 (P). **Thailand:** Krat, Baw Bai, 200 m., *Kerr* 9462 (?) (K, L).

ECOLOGY. Colline forest, 200-1000 m. alt. Flowering January, February, and June (flower scented); fruiting in October.

LOCAL USES. *Calophyllum dryobalanoides* is used for small articles, the bark is used for pails, baskets, and partitions (Vietnam: *Pierre*, *loc. cit.*). Katang yields a fragrant oil used in hair dressing (Cambodia).

Calophyllum dryobalanoides is a poorly known species recognizable by its rather short terminal bud, ovate leaves with relatively distant venation, often terminal inflorescences, and relatively large, spherical fruits. The epithet alludes to the leaves, which are rather like those of *Dryobalanops* Gaertner f. (Dipterocarpaceae).

Calophyllum balansae and *C. symingtonianum*, two additional rather poorly known species, may be related to *C. dryobalanoides*. *Calophyllum balansae* has obovate to subelliptic leaf blades with six to ten veins/5 mm., more robust (1.5-2 mm. across) twigs, more profuse inflorescences, and larger flowers. The fruits of the two species are similar, but the terminal buds of *C. balansae* are unknown. Compared with *C. dryobalanoides*, *C. symingtonianum* also has larger inflorescences, a longer (3-7 mm.) terminal bud, more densely veined ((6 to) 8 to 11 veins/5 mm.) leaves, and fruit with a thinner outer layer and stone. Flowers of *C. symingtonianum* are not yet known. The differences between the three species, especially those between *C. symingtonianum* and *C. dryobalanoides*, are not great, and further collections may change the rank of the taxa involved.

A sheet of *Pierre* 83 at Paris is designated the lectotype of *Calophyllum dryobalanoides*, since *Pierre* clearly based his description of the fruit on this specimen. *Pierre* (*loc. cit.*) also cited *Pierre* 22 and 3647, which are in flower or just past flowering; his notes are attached to the latter specimen. In vegetative characters all three specimens are similar.

9. *Calophyllum* sp.

FIGURE 8, e.

Tree 23-25 meters tall, d.b.h. ca. 50 cm.; trunk and bark unknown; latex yellow.

Twigs slightly flattened, 1.2-1.5 mm. across, rather weakly 4-angled, drying brown, sparsely puberulent when very young; axillary innovations lacking

basal scars; internodes 0.6–3 cm. long; uppermost pair of axillary buds rounded, less than 0.5 mm. long, spreading; terminal bud rather plump, 2–3 mm. long, with grayish to brown, subcrustaceous indumentum (hairs, FIGURE 11, a), underdeveloped internode to 3 mm. long. Petiole 5–9 mm. long, deeply concave above, convex below, glabrous; lamina elliptic to suboblong, 4.3–8.8 by 1.4–2.9 cm., acuminate at apex, narrowly cuneate (acute) at base, fairly closely but shallowly undulate and not recurved at margin, thinly coriaceous, drying brown or greenish brown above and buff below, glabrous or almost so even when young, the midrib above narrowing gradually from base, raised, 0.15–0.25 mm. wide at midpoint, below raised, angled toward apex, striate toward base, the venation apparent above, apparent to subobscure below, raised, (5 to) 8 to 12 veins/5 mm., angle of divergence 65–75°. Infructescences from foliate axils, with scars of ca. 7 flowers, unbranched, the axis ca. 1.2 cm. long, puberulent at least toward base, lowest internode 1.5–4 mm. long; bracts ovate, ca. 1.5 mm. long, deciduous; pedicels in fruit 0.8–1.4 cm. by 1.5 mm., glabrous. Flower unknown. Fruit subspherical, ca. 1.7 by 1.5 cm., ± apiculate, drying yellowish brown, closely but shallowly wrinkled; outer layer detaching ± cleanly from stone, ca. 1.3 mm. thick, compact; stone spherical, ca. 1.2 by 1.15 cm., rounded at apex, the walls 0.2–0.3 mm. thick, smooth, unmarked; spongy layer initially thick.

DISTRIBUTION. Sumatra (MAP 3).

SPECIMENS SEEN. **Sumatra and adjacent islands.** ATJEH: Eiland Bereas, bij Toaping, 200 m., *Koorders 10623* (?) (BO). BARAT: Painan, Loeboek Ganggo, 600 m., *bb 5467* (A, BO); Painan, Baroeng Baroeng Balantan, *SWK/I=1* coll. *Babak* (BO).

Calophyllum sp. 9 can be recognized by its slender twigs, short terminal bud, rather narrowly elliptic to suboblong leaf blades, axillary inflorescences, and relatively large, shallowly and closely wrinkled fruits with a well-developed, compact outer layer.

Although *Calophyllum* sp. 9 appears similar to *C. symingtonianum*, the latter species differs in such characters as its longer terminal bud and its terminal inflorescences.

Koorders 10623 is included here with some hesitation; it has rather distant venation (the measurements given in parentheses in the description above).

10. *Calophyllum dongnaiense* Pierre, Fl. Forest. Cochinch. 1: pl. 108. 1885; Vesque in C. DC. Monogr. Phanerog. 8: 601. 1893; Ptiard in Lecomte, Fl. Gén. Indo-Chine 1(4): 324. 1910; Gagnep. in Humbert, Fl. Gén. Indo-Chine Suppl. 1: 268. 1943, in *clavis*; Phạm & Nguyễn, Cây-Cỏ Miền Nam Việt-Nam, 179. 1960; Phạm, Cây-Cỏ Miền Nam Việt-Nam, ed. 2. 2: 300. fig. 1970. TYPE: [Vietnam], in montibus Chiao Chang ad septentr. prov. Bien Hoa, 26 March 1877, *Pierre 3644* (holotype, ♀).

Tree ca. 20 meters tall, d.b.h. to 50 cm.; outer bark yellowish.

Twigs slightly flattened, (1.5–)2.5–3.5 mm. across, subulate, drying brown,

tomentose when young; axillary innovations (?always) lacking basal scars; internodes 2-7 cm. long; uppermost pair of axillary buds unknown; terminal bud bluntly conical, ca. 5 mm. long, tomentose (hairs, FIGURE 10, h-j), underdeveloped internode lacking. Petiole 1-2.2(-2.9) cm. long, concave above, convex below, glabrous when mature; lamina elliptic to suboblong, 11-24.5 by 3-6.6 cm., acute at apex and base, more or less undulate and recurved at margin, thinly coriaceous, drying sepia above and sepia to umber below, transiently subtomentose on midrib below, the midrib above \pm gradually narrowed from base, raised, 0.2-0.3 mm. wide at midpoint, below raised, striate, the venation above and below apparent, raised, 6 to 10 veins/5 mm., angle of divergence 80-90°. Infructescences (?)terminal and from uppermost foliate axils, with 5 to 7 flowers, unbranched (?always), the axis 3.5-6 cm. long, \pm tomentose, lowest internode 0.7-3.5 cm. long; bracts unknown; pedicels 0.9-1.7 cm. long, glabrescent. Flower unknown. Submature fruit spherical, ca. 1.5 cm. long and across, drying pruinose-brown, deeply wrinkled; outer layer detaching \pm cleanly from stone, ca. 1 mm. thick, with some air spaces; stone crushed, the walls ca. 0.3 mm. thick, smooth; spongy layer unknown.

DISTRIBUTION. Vietnam (MAP 4); known only from the type.

ECOLOGY. Fruiting in March.

Calophyllum dongnaiense is a poorly known species recognizable by its subulate twigs that dry a shiny brown, rather large leaf blades with relatively distant and distinct venation, and probably terminal inflorescences. At least the twigs, terminal bud, and lower part of the inflorescence are tomentose when young. The epithet is derived from the locality of the type specimen: "entre l'affluent de Daoué et la montagne Bartroum, d'où sortirait le Son cai ou Dong nài" (Pierre, *loc. cit.*).

The type specimen of *Calophyllum dongnaiense*, Pierre 3644, consists of a single sheet. The submature fruits are broken, as is the terminal bud, and the type and position of the inflorescence are not clear. Although *Poilane* 32327, from Kontum, Vietnam, is similar in its twigs, tomentose indumentum, and leaves, it differs in a number of characters and hence is not included here. The lamina is more coriaceous, dries bicolored (cf. *C. thorelli* group "o"), and has more distinct venation; the petiole is flat, not channeled, above; the inflorescences are clearly axillary; the hairs have many elongated cells (in the type only the terminal few cells are much elongated; FIGURE 10, cf. i and j); and the lower surface of the lamina has tomentose indumentum (it is less conspicuous in the type).

Gagnepain (*loc. cit.*) keyed out *Calophyllum dongnaiense* because its flowers were in pairs, those of the other species being numerous and "en grappes" (larger, more complex inflorescences?). The type specimen of *C. dongnaiense* cannot be distinguished from other specimens of *Calophyllum* from the Vietnam/Cambodia region in this way.

11. *Calophyllum tomentosum* Wight, Ic. Pl. Indiae Orient. 1: pl. 110. 1839, Illus. Indian Bot. 1: 128. 1840; Walp. Repert. Bot. Syst. 1: 397. 1842;

Planchon & Triana, *Ann. Sci. Nat. Bot.* IV. 15: 269. 1862; Bedd. *Fl. Sylvat.* 3: xxii. 1871; T. Anderson in Hooker f. *Fl. Brit. India* 1: 274. 1874, *pro parte*; W. Ferguson, *Timber Trees Ceylon*, 23. 1881; Vesque, *Epharמושis* 2: *tt.* 4, 5. 1889, in C. DC. *Monogr. Phanerog.* 8: 552. 1893, *excl. syn.*; Trimen, *Handb. Fl. Ceylon* 1: 101. 1893; Lewis, *Descr. Catal. Ceylon*, 21. 1902; Worthington, *Ceylon Trees*, 35. 1959; Maheshwari, *Bull. Bot. Survey India* 2: 146. *pl.* 4. 1960. TYPE: Ceylon, *Col. Walker s.n.* (κ , herb. Wight. prop.).

C. spectabile auct., non Willd.; Choisy, *Mém. Soc. Phys. Hist. Nat. Genève* 12: 423. 1851, *pro parte*.

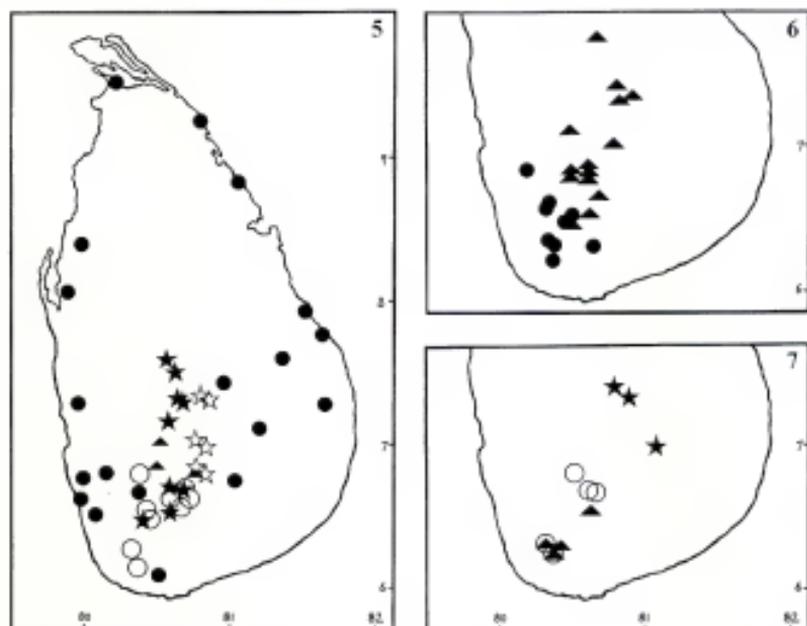
Tree 12–30 meters tall, d.b.h. to 100 cm.; trunk sometimes with small buttresses; outer bark very thick, red-brown with gray panels, to gray or yellowish, rather broadly and shallowly fissured, inner surface dull orange-straw; under bark reddish; inner bark red to red-brown; latex clear yellow, sticky. Branchlets subpendulous.

Twigs somewhat flattened, 1.7–2.5 cm. across, 4-angled, drying blackish, subsistently brown-tomentose; axillary innovations lacking basal scars; internodes 0.6–3 cm. long; uppermost pair of axillary buds rounded, to 1(–2.5) mm. long, subspreading; terminal bud plump, 5–10 mm. long, with short, brown, tomentose indumentum (hairs, FIGURE 11, 1), underdeveloped internode to 1(–3) mm. long. Petiole 0.9–2 cm. long, flat to concave above, convex below, subsistently tomentose, especially below; lamina ovate to (narrowly) elliptic, or subobovate, 6–12.8(–15) by 2–4.5(–6.2) cm., acute to acuminate at apex, narrowly cuneate to acute at base, undulate but not recurved at margin, coriaceous, drying sepia above and sabelline below, \pm tomentose over entire surface when young, indumentum persisting on and near midrib beneath (also on midrib above), the midrib above gradually narrowed from base, flat at first, becoming slightly raised, 0.2–0.5 mm. wide at midpoint, below raised, slightly striate, the venation above \pm apparent, raised, 5 to 11 (to 13) veins/5 mm., angle of divergence 45–65°. Inflorescences from foliate (rarely defoliate) axils, with 5 to numerous flowers (lower flowers flabellately arranged, or 5-flowered branches to 2 cm. long), the axis (0.7–)2–6 cm. long, \pm persistently tomentose, lowest internode (0.3–)1–3 cm. long; bracts ovate, 1.5–2.5 mm. long, deciduous; pedicels 0.6–2.3 cm. long, sparsely tomentose to tomentose. Flower (?) hermaphroditic; tepals 8 (rarely 4 or 10), the two outer ovate to suborbicular, 4–6 by 4–4.5 mm., the next pair obovate to elliptic, 7–9 by 4.5–6 mm., the inner ones elliptic to obovate, 6.5–11 by 2.5–5 mm.; stamens 80 to 190, the filaments to 3.5 mm. long, the anthers oblong, 0.8–2 mm. long, rounded to retuse at apex; ovary 1.5–2 mm. long, the style to 2.5 mm. long, the stigma peltate, 0.6–0.7 mm. across, slightly radiate. Fruit \pm spherical to ellipsoid, 1.8–2.3 by 1.6–2 cm., rounded at apex, drying brown, almost smooth or with broad, rounded wrinkles; outer layer adhering to stone, ca. 1 mm. thick, air spaces developing; stone spherical to ellipsoid, 1.5–1.7 by 1.3–1.5 cm., rounded at apex, the walls ca. 0.3 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Sri Lanka (MAP 5).

SELECTED SPECIMENS SEEN. Sri Lanka: Rakwana, 600 m., *Kostermans 25008* (A, E, K, L, US); Matele Distr., 200 m., *Kostermans 24495* (A, AAU, K, L, US); Sinharaja forest, Beverley, Deniyaya, 610 m., *Worthington 2611* (A, BM); Omeragalla Kurumejola 21 miles, 240 m., *Worthington 4029* (BM); Road Belihuloya-Balangoda, 300 m., *Kostermans 25015* (A, E, US); Halgale forest above Belihuloya, 700 m., *Kostermans 23620* (AAU, G, NY); upper road Rassagalla-Ratnapura, 800 m., *Kostermans 24646* (US); Uva Prov., Badulla Distr., Talpitigala, Uma Oya, 427 m., *Balakrishnan & Jayasuriya 848* (K, US); Kandy, *Moon 380* (BM); 18th Mile Kandy-Amaraipara Road, *Kostermans 24848* (G); Amparawa, near Gampola, 600 m., *Kostermans 25345* (K, L); Panilkande, 671 m., *Worthington 6623* (L); Peradeniya, *Jayaweera 1524* (cult.) (A). Java. BARAT: Bogor, cultivated (from Sri Lanka), Hort. Bog. VI C 125 (BO, NY, US).

ECOLOGY. Colline rainforest or sometimes intermediate forest, 200-800 (-1220) m. alt. Flowering March and June, reported November and April (Trimen, *loc. cit.*); fruiting March and June (fruit acidic).



MAPS 5-7. Distribution of *Calophyllum* in Sri Lanka. 5, *C. tomentosum* (solid stars), *C. walkeri* (open stars), *C. thwaitesii* (triangles), *C. bracteatum* (open circles), and *C. calaba* var. *calaba* (solid circles). 6, *C. trapezifolium* (triangles) and *C. calaba* var. *worthingtonii* (circles). 7, *C. cuneifolium* (stars), *C. vergens* (circles), and *C. moonii* (triangles).

GERMINATION AND YOUNG PLANT. The radicle breaks the stone wall to one side of the base. The seedling usually has two pairs of leaves separated by a short internode 2-4(-10) mm. long. Two of the fifteen seedlings seen had a longer (ca. 2 cm. long) internode. Subsequent internodes produced are longer, the terminal bud is functional, and the plant is erect. (Stevens 745, tree cultivated in Bogor.)

LOCAL USES. The wood is used in building. Oil ("kenna tel") that is extracted from the seeds is used for skin diseases.

Calophyllum tomentosum can be recognized by its rather narrowly elliptic lamina that has steeply ascending venation (the angle of divergence from the midrib is less than 65°) and subsistent, tomentose indumentum on the midrib below. The inflorescences are slender and axillary; the flowers usually have eight tepals, and the dried fruit is broadly wrinkled. The epithet *tomentosum* refers to the conspicuous tomentose indumentum of the plant.

Calophyllum tomentosum is not obviously close to other species of the genus.

Wight (1840, *loc. cit.*) mentioned that there were two varieties of *Calophyllum tomentosum*, one having oval leaves ending in a short, blunt acumen, and the other having long, rather narrow, lanceolate leaves tapering to a fine point at each end and very slightly undulate. The illustration given by Wight (1839, *loc. cit.*) is of this second form, which seems to be the common one. *Kostermans 24585* may be the first form; it has leaf blades up to 6.2 cm. wide that are somewhat more sharply acuminate than usual. However, it is not possible to recognize variants of *C. tomentosum* based on leaf shape.

Calophyllum tomentosum has been reported from India, but these reports seem to be incorrect (see *C. polyanthum*); I have not seen any material of the species from that country. Conversely, the reports of *C. elatum* (= *C. polyanthum*) from Sri Lanka (see Alston, 1931, for a summary) are probably incorrect, but I am not sure to which species they refer.

12. *Calophyllum walkeri* Wight, *Illus. Indian Bot.* 1: 128. *pl.* 45. 1840; Walp. *Rep. Bot. Syst.* 1: 397. 1842; Choisy, *Mém. Soc. Phys. Hist. Nat. Genève* 12: 423. 1851; Thwaites, *Enum. Pl. Zeyl.* 51. 1858; Planchon & Triana, *Ann. Sci. Nat. Bot.* IV. 15: 291. 1862; Bedd. *Fl. Sylvat.* 3: xxii. 1871; T. Anderson in Hooker f. *Fl. Brit. India* 1: 275. 1874; Vesque, *Epharosis* 2: t. 31. 1889; Trimen, *Handb. Fl. Ceylon* 1: 104. 1893; Vesque in C. DC. *Monogr. Phanerog.* 8: 584. 1893; Lewis, *Descr. Catal. Ceylon*, 22. 1902; Sastri *et al.* *Wealth India* 2: 30. 1950; Worthington, *Ceylon Trees*, 37. 1959. Type: Ceylon, *Col. Walker* (κ, herb. Wight. prop.).

Tree 4-7 meters tall, d.b.h. to 40 cm.; outer bark yellowish, cracked or fissured; inner bark brownish red or light red.

Twigs not flattened to slightly (rarely strongly) so, (1.5-)2-4 mm. across, ± 4 (rarely 2-)angled, drying dark brown to blackish, glabrous or sparsely puberulent when young; axillary innovations lacking basal scars; internodes

0.3-2(-3) cm. long; uppermost pair of axillary buds rounded, ca. 1 mm. long, spreading; terminal bud plump, (2.5-)3.5-6 mm. long, shortly brownish tomentose (hairs, FIGURE 11, m-o), underdeveloped internode to 2 mm. long. Petiole 3-7 mm. long, flat above, convex below, glabrescent; lamina obovate to cuneiform or trapeziform (rarely suborbicular or elliptic), (1.7-)2.1-4.6 by 1.1-4.3 cm., rounded to retuse (obtuse) at apex, cuneate to acute (rarely rounded) at base, slightly undulate or not and not recurved at margin, very coriaceous, drying olivaceous-honey above and sabelline to sepia below, subpersistently puberulent on midrib below or not, the midrib above gradually narrowed from base, \pm flat (rarely depressed at base), 0.25-0.5 mm. wide at midpoint, below raised, rounded to striate, the venation subobscure above, subobscure to subapparent below, 5 to 14 (to 17) veins/5 mm., angle of divergence 60-70°. Inflorescences from foliate axils, with 11 to 19 flowers, unbranched (with 3-flowered branches to 1 cm. long), the axis 3-7.2 cm. long, \pm puberulent at least when young, lowest internode 0.3-0.8(-2) cm. long; bracts obovate, sometimes foliaceous and to 2 cm. long, persistent; pedicels 1-2.5 cm. long, glabrous (rarely puberulent), (2-)2.5-5 mm. thick in fruit. Flower (?)hermaphroditic; tepals 10 to 15, the two outer usually broadly ovate to orbicular, 5-7 by 4-6 mm. (sometimes broadly triangular, ca. 1.5 by 2.5 mm.), the inner ones obovate to oblong, 6-8(-11) by 2.5-6.5 mm.; stamens 130 to 190, the filaments to 3.5 mm. long, the anthers oblong, ca. 1.3 mm. long, \pm retuse at apex; ovary 1.5-2 mm. long, the style 2-3 mm. long, the stigma peltate, 0.8-1 mm. across, 3-radiate. Fruit subspherical, 1.6-2.7 by 1.6-2.4 cm., subobtuse to rounded at apex, drying grayish brown, usually with broad, rounded wrinkles; outer layer detaching cleanly from stone or not, 1.2-2.5 mm. thick, compact or with air spaces developing; stone subspherical to ellipsoid, 1.6-2.2 by 1.4-1.7 cm., rounded to minutely pointed at apex, the walls 0.1-0.5 mm. thick, smooth, unmarked or obscurely 4-radiate; spongy layer thin.

DISTRIBUTION. Sri Lanka (MAP 5).

SELECTED SPECIMENS SEEN. Sri Lanka: Horton Plains, beside road to World's End, 2400 m., *Cramer & Tirvengadam 3951* (US); road from Horton Plains to Ohiya, *Nowicke & Jayasuriya 270* (F, K, US); Newera Ellia, 1829 m., *CP 1170, pro parte* (BM, BO, FI, G, GH, P, US, W); Corbet's Gap, 1219 m., *Worthington 3604* (BM); Madulkele, 1433 m., *Worthington 1957* (BM); Elk Plains near Ambawela, *Kostermans s.n.*, May 1969 (A, AAU, E); Ramboda area, above Protoaft Estate, 2000 m., *Kostermans 25100* (A, G, K, US).

ECOLOGY. Sometimes dwarfed upper montane forests and thickets, (1220-) 1600-2400 m. alt. Flowering February and May (perhaps only once every few years—Wight, *loc. cit.*); fruiting June and September (fruit dirty green, acid in taste).

Terminal galls ca. 1 cm. across and bilabiate at the apex occur at the ends of the twigs (*Worthington 1957, 3604*; neither specimen quite typical, see below).

LOCAL USES. The wood is used in construction and joinery; the oil from the seed is used for lighting.

Calophyllum walkeri can be recognized by its slightly flattened twigs that are almost square in cross section and have short internodes. The lamina is very coriaceous, usually rounded to retuse at the apex, and it has a midrib that is more or less flat on the upper surface and rounded or striate on the lower. The inflorescence has several flowers and usually a rather short lowermost internode; the flowers have at least ten tepals. The subspherical, broadly wrinkled fruit has a fairly thick outer layer and a thin-walled stone. The specific epithet commemorates Colonel G. W. Walker, who collected the type specimen.

There is some infraspecific variation in *Calophyllum walkeri*. The leaves of a few specimens are acute at the apex (e.g., *Worthington* 3604, 5474, 5484 (from Corbet's Gap), 1957 (from Madulkele); *Moon s.n.*); such specimens may be saplings or are perhaps wrongly identified. The bracts may be foliaceous and persistent (e.g., *Kostermans* 25087, 25100, where they are just like leaves), but they are normally smaller and deciduous. Wight, in his original description of *C. walkeri*, thought that it could be characterized by the very small outer pair of tepals; these outer tepals may also be more normal in size.

The circumscription of *Calophyllum walkeri* and the other small-leaved montane and submontane taxa in Sri Lanka and southern India has been quite troublesome, partly because some of the important early collections contain two taxa under the same number (see especially *C. trapezifolium* and *C. cuneifolium*). However, the taxa recognized may be distinguished by a number of characters (see TABLE 7). Although it is easy to be misled by lamina shape and size since the length: breadth ratio for all taxa involved decreases rather regularly with altitude, the species themselves having overlapping altitudinal ranges, careful examination of the terminal bud, twig, and midrib usually allow even sterile material to be identified. Differences in hair type within the complex are minor (FIGURES 11, 12). Vesque (1889, 1893) found latex canals in the tissue below the vascular bundle in *C. cuneifolium*, *C. trapezifolium*, *C. thwaitesii*, and *C. walkeri*. This is an uncommon character in the genus.

13. *Calophyllum thwaitesii* Planchon & Triana, *Ann. Sci. Nat. Bot.* IV. 15: 260. 1862, *pro parte* (α); Thwaites, *Enum. Pl. Zeyl.* 407. 1864, *pro parte*; Bedd. *Fl. Sylvat.* 3: xxii. 1871, *pro parte*; T. Anderson in Hooker f. *Fl. Brit. India* I: 275. 1874, *pro parte*; Trimen, *Handb. Fl. Ceylon* I: 102. 1893, *pro parte*; Vesque in C. DC. *Monogr. Phanerog.* 8: 556. 1893, *pro parte*. **TYPE:** Ceylon [Sri Lanka], Ambagamowa District, CP 3403, *pro parte* (holotype, ♀; isotypes, BM, BO, GH, K, NY, P, W).

C. decipiens auct., non Wight; Thwaites, *Enum. Pl. Zeyl.* 51. 1858, *pro parte* (α).

Tree; trunk and bark unknown.

Twigs slightly flattened, 1.7–3.5 mm. across, ± 4-ate, drying brown, puberulent when young; axillary innovations lacking basal scars; internodes

(0.5-)1-4 cm. long; uppermost pair of axillary buds rounded, less than 1 mm. long, suberect; terminal bud plump, 3-3.5 mm. long, with brown to grayish, subtomentose indumentum (hairs similar to those in FIGURE 12, e, g), underdeveloped internode not apparent. Petiole 2-6 mm. long, broadly concave above, convex below, puberulent below when young; lamina broadly obovate to elliptic or subtrapeziform, 3.6-8.6 by 3.1-6 cm., bluntly pointed to rounded or slightly retuse at apex, cuneate to rounded or shallowly cordate at base, not undulate but narrowly recurved at margin, coriaceous, drying chestnut to olivaceous above and umber to olivaceous below, often \pm nitid, brown-puberulent on midrib below when young, the midrib above narrowed rather gradually from base, \pm flat to raised, 0.2-0.5 mm. across at midpoint, below slightly raised, \pm striate (angled toward apex), the venation above apparent, raised, below subobscure, \pm flat (latex canals sometimes impressed above, less impressed below), (2 or) 3 to 6 (to 8) veins/5 mm., angle of divergence 50-60°. Inflorescences from foliate axils along stem, with 5 to 7 flowers, unbranched, the axis 3.2-13 cm. long, glabrous, lowest internode (1.2-)2-6 cm. long; bracts ovate to subelliptic, to 5 mm. long, subsistent; pedicels 1.4-3.5 cm. long, glabrous. Flower (?) hermaphroditic; tepals 8, the outer pair suborbicular, ca. 5 mm. long and across, the inner ones elliptic to obovate, to 7 by 3.5 mm.; stamens ca. 100, the filaments to 3 mm. long, the anthers suboblong, 0.7-1 mm. long, retuse at apex; ovary ca. 1.3 mm. long, the style unknown, the stigma peltate, ca. 1 mm. across. Fruit subspherical, ca. 2 cm. long and across, rounded at apex, drying vinaceous-brown, sharply wrinkled; outer layer detaching cleanly from stone, ca. 2 mm. thick, compact; stone subspherical, ca. 1.4 by 1.6 cm., rounded at apex, the walls ca. 0.25 mm. thick, smooth, unmarked; spongy layer at first thick.

DISTRIBUTION. Sri Lanka (MAP 5).

ADDITIONAL SPECIMENS SEEN. Sri Lanka: Horton Plains, 2100 m., *Hladik 1108* (A (frag.), ♀); Adam's Peak, *Moon s.n.* (FI); sine loco, *CP 1170, pro parte* (W).

ECOLOGY. Montane rain forest.

Calophyllum thwaitesii is a poorly known species that can be recognized by its short, plump, terminal bud; more or less flat veins and slightly raised midrib on the lower surface of the dried lamina; more or less impressed latex canals; and axillary inflorescences with the basal internode 1-6 cm. long. The epithet commemorates G. H. K. Thwaites's work on the plants of Sri Lanka; it was under his auspices that the CP (Ceylon Plants) series was collected.

Calophyllum thwaitesii is probably related to the group of species centered on *C. walkeri*; these species are compared in TABLE 7. *Calophyllum cuneifolium* has plump terminal buds and strongly four-angled twigs like those of *C. thwaitesii*, but its leaf blades are usually narrower and its midrib and venation are more prominent. *Bourdillon 179* (*C. austroindicum*, from India) has leaf blades shaped like those of *C. thwaitesii*, but it, too, differs in venation and midrib prominence. *Calophyllum austroindicum* also has larger, ovoid, beaked fruits.

TABLE 7. Characters distinguishing *Calophyllum walkeri* from related species in Sri Lanka and southern India.

	<i>C. austroindicum</i>	<i>C. canefolium</i>	<i>C. inaequalifolium</i>	<i>C. walkeri</i>	<i>C. thwaitesii</i>
TWIG SHAPE	Slightly to strongly flattened, ± strongly 4-angled	Slightly flattened, strongly 4-angled	Strongly flattened, 2- to 6-angled	Not (strongly) flattened, 4-angled	Slightly flattened, strongly 4-angled
TERMINAL INTERNODE OF INNOVATION	Often ca. 1/2 length of others	Often ca. 1/2 length of others	Ca. same length as others	Ca. same length as others	Ca. same length as others
TERMINAL BUD					
SHAPE	Plump	Plump	Plump to narrowly conical	Broadly plump	Plump
LENGTH (mm.)	2.8-3.5	1.5-3.5	(2.5-4-7(-10)	(2.8-3) 5-6	3-3.5
UPPERMOST PAIR OF AXIL-LARY BUDS	Inconspicuous, ± erect	Inconspicuous, ± spreading	Usually conspicuous, erect	Inconspicuous, ± spreading	Inconspicuous, ± spreading
LEAF BLADE					
APEX	Subciliate to retuse	(Rounded to) retuse	Acute to cuneate (rounded)	Rounded to retuse (subacute)	Bilobely cuneate to retuse
LENGTH : WIDTH RATIO	1.5-2.8	1.45-2.3	(1-1.75-2.6	1-1.6	1-2.25
MIDRIB ON LOWER SURFACE	Raised, rounded	Raised, rounded	Strongly raised, often angled	Raised, rounded	Slightly raised, rounded
VENATION					
DENSITY (veins/5 mm.)	5 to 10 (to 15)	3 to 7 (to 9)	10 to 19	5 to 14 (to 17)	(2 or) 3 to 6 (to 8)
PROMINENCE	Apparent	Apparent	At most subapparent	Usually subobscure	Subapparent above, subobscure below

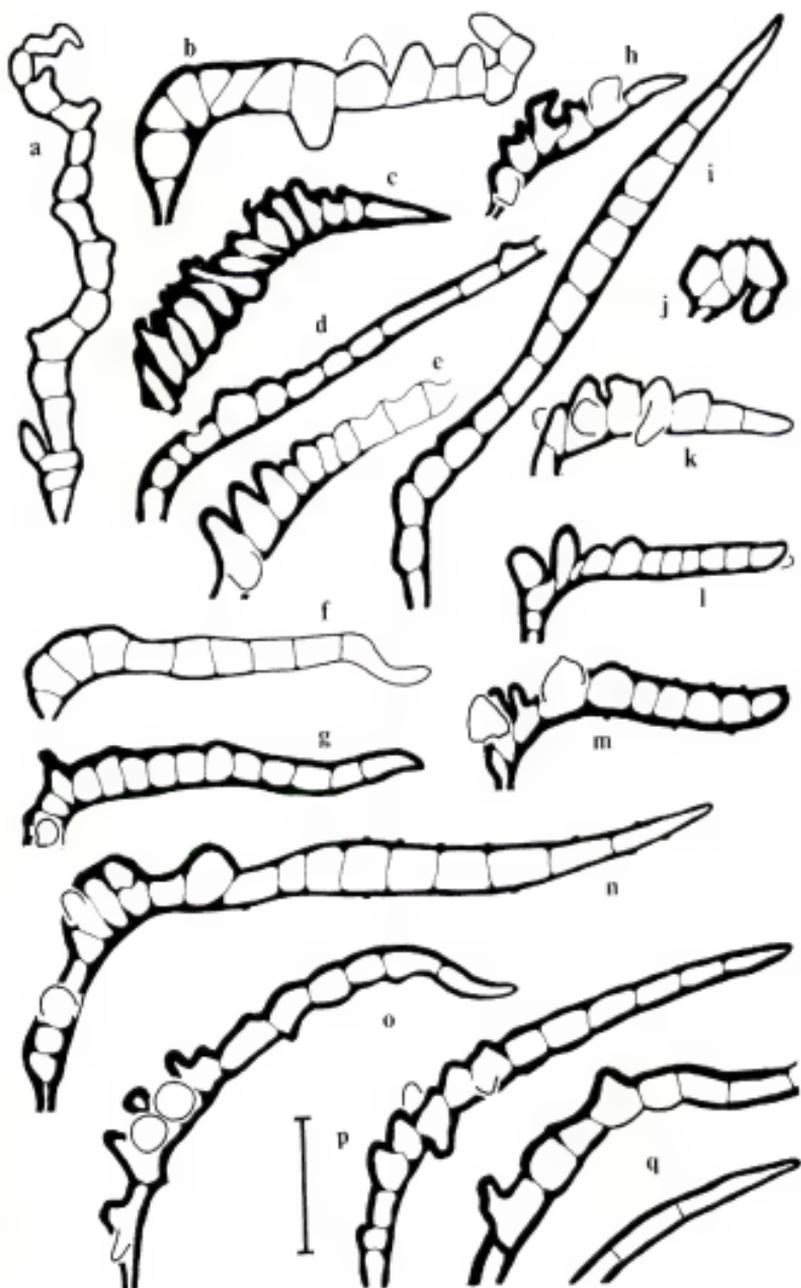
ANGLE OF DIVERGENCE	50-60(-65°)	(25-35-40°	(45-55-70°	60-70°	50-60°
INFLORESCENCE					
NUMBER OF FLOWERS	7 to 17	9 to 17	(3 to) 5 to 9	9 to 19	5 to 7
LOWEST INTERNODE LENGTH (cm.)	(0.4-1)-3	0.5-2.3	0.8-3.7	0.3-0.8(-2)	(1.2)-2-6
PEDICEL					
LENGTH (cm.)	(0.3-0.6-1.8	0.4-2.3	0.7-2.6(-3)	1-2.5	1.4-3.5
THICKNESS IN FRUIT (mm.)	Ca. 2	Ca. 2	1.5-2	(2-2.5-5	Ca. 2
FLOWER					
TEPAL NUMBER	8 (to 10)	8 to 11	8 to 11	10 to 15	8
FRUIT					
SHAPE	Ovoid	Subspherical	Ovoid (subspherical)	± Spherical	Subspherical
APEX	Beaked	At most shortly obtuse	Obtuse (rounded)	Rounded (very shortly pointed)	Rounded
SIZE (cm.)	3-3.3 × 1.7-2.3	1.8-2.3 × 1.6-2.2	1.8-2 × 1.7-1.9	1.6-2.7 × 1.7-2.4	Ca. 2 × 2
OUTER LAYER THICKNESS (mm.)	0.8-2	1.5-2.8	0.5-1	1.5-2.5	Ca. 2
STONE THICKNESS (mm.)	0.5-1.2	Ca. 0.4	0.4-0.5	0.1-0.5	Ca. 0.25

Although *Calophyllum thwaitesii* has been confused with *C. apetalum*, from India, the two species are not at all closely related. In *C. thwaitesii* the lamina is usually broader and with less dense, less apparent venation, the petiole more shallowly channeled, the anthers less than 1 mm. long, and the fruit much bigger and with a much thicker (ca. 2 mm., compared to ca. 0.5 mm.) outer layer. *Calophyllum vergens* (*C. thwaitesii* "β" of Planchon & Triana) differs most obviously from *C. thwaitesii* sensu stricto in its smaller leaf blades that are less coriaceous, cordate at the base, and with somewhat denser, more clearly raised venation, especially on the lower surface. The twigs are also somewhat thinner and are six- or sometimes two-angled.

Of the four collections of this species, *Hladik 1108* (sterile, collected from a small tree) has latex canals that are clearly impressed on the upper surface of the lamina, less so below; *CP 3403* (with flowers) has latex canals that are very slightly impressed on both surfaces; and *Moon s.n.* (sterile) is intermediate in this respect. In *Moon s.n.* the terminal pair of leaves seems to remain erect and enclose the terminal bud. The sheet of *CP 1170* at Vienna (with fruits, clearly belonging) has leaves like those of *CP 3403*, albeit a little smaller.

14. *Calophyllum trapezifolium* Thwaites, Enum. Pl. Zeyl. 51. 1858 ("trapezifolium"); Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 282. 1862; Bedd. Fl. Sylvat. 3: xxii. 1871; T. Anderson in Hooker f. Fl. Brit. India 1: 275. 1874; Vesque, Epharosis 2: t. 15. 1889; Trimen, Handb. Fl. Ceylon 1: 103. 1893; Vesque in C. DC. Monogr. Phanerog. 8: 563. 1893; Alston in Trimen, Handb. Fl. Ceylon (Suppl.) 6: 22. 1931; Worthington, Ceylon Trees, 36. 1959; Maheshwari, Bull. Bot. Survey India 2: 144. 1960, *pro parte*. TYPE: Ceylon [Sri Lanka], Hunasgiri District, 4000–5000 feet [1219–1524 m.], *CP 2446* (isotypes, BM, BO, FI, G, GH, K, NY, P, US, W).
- C. zeylanicum* Kosterm. Ceylon Jour. Sci. Bio. Sci. 12: 70. 1976. TYPE: Ceylon, Ratnapura Distr., Carney-Adam's Peak road, 200 m., 9 July 1973, *Subramanian s.n.* (holotype, L; isotypes, AAU, K).
- C. cuneifolium* Thwaites, Enum. Pl. Zeyl. 51. 1858, *pro parte*; Vesque, Epharosis 2: t. 10. 1889, *pro parte*, in C. DC. Monogr. Phanerog. 8: 557. 1893, *pro parte*.

FIGURE 12. Hairs (from terminal bud, unless otherwise mentioned). a, b, *Calophyllum austroindicum* (DD 20505): a, from peduncle. c, *C. apetalum* (Fernandes 977). d, *C. cuneifolium* (Kostermans 25056), hairs to 360 μm. long, terminal cells with thin walls. e, g, *C. vergens* (Kostermans 24469): e, to 240 μm. long. f, h–q, *C. calaba*. f, var. *bracteatum*, variant (Hasskarl 416). h, i, o, var. *bracteatum* (Kerr 17291). j, var. *bracteatum* variant (Lam 113), many hairs also like g. k, var. *worthingtonii* (Waas 1662). l, var. *bracteatum* (Stone & Kam 11712); m, n, *bracteatum* variant: m, *Wirawan 463*; n, *Kostermans 6307*. p, var. *calaba* (Kostermans 24406). q, var. *australianum* (*Dallachy s.n.*), base and apex of hair ca. 360 μm. long. Scale = 60 μm.



Tree 5-20 meters tall, d.b.h. to 80 cm.; trunk without buttresses; outer bark old gold to light brown, deeply to finely fissured (with knobby vertical lines); inner bark deep red to reddish; latex clear yellow to white.

Twigs strongly flattened, (1-)1.5-3 mm. across, 2- to 6-angled, drying dark brown to blackish, puberulent when young; axillary innovations lacking basal scars; internodes 0.5-6(-8) cm. long; uppermost pair of axillary buds \pm pointed, 1-5 mm. long, erect, conspicuous; terminal bud plump to narrowly conical, (2.5-)4-7(-10) mm. long, with grayish brown, puberulo-tomentose indumentum (hairs, FIGURE 11, p. q), underdeveloped internode to 3(-5) mm. long. Petiole 3.5-7 mm. long, \pm concave above, convex below, persistently puberulent below or not; lamina trapeziform or rhombiform to elliptic, ovate (rarely suborbicular), (1.8-)2.5-7(-10) by 0.9-4.3(-6) cm., acute to cuneate (rarely retuse) at apex, acute to cuneate (rarely rounded) at base, distantly undulate but slightly recurved at margin, coriaceous, drying olivaceous to greenish olivaceous-buff above and sabelline to olivaceous below, \pm persistently and subdensely puberulent on midrib below, the midrib above gradually to abruptly narrowed from base, flat to slightly raised (depressed at first), 0.3-0.6 mm. wide at midpoint, below raised, striate to angled, the venation prominulous to obscure above and below, 10 to 19 veins/5 mm., angle of divergence (45-)55-70°. Inflorescences from foliate axils near ends of twigs (rarely terminal), unbranched, with (3 to) 5 to 9 flowers (flabellately arranged), the axis 1.4-7 cm. long, \pm puberulent toward base, lowest internode 0.8-3.7 cm. long; bracts ovate, 2.5-4 mm. long, deciduous; pedicels 0.7-2.6(-3?) cm. long, glabrous. Flower (?)hermaphroditic; tepals 8 to 11, the outer pair ovate, 5-6 by 3.5-4.5 mm., the inner ones \pm obovate, 7-9.5 by 2.5-5.5 mm.; stamens (90 to) 140 to 325, the filaments to 5 mm. long, the anthers suboblong, 0.7-1(-1.7) mm. long, subrounded to retuse at apex; ovary ca. 2 mm. long, the style ca. 2 mm. long, the stigma peltate, ca. 0.9 mm. across, 3-radiate. Fruit broadly ovoid to subspherical, 1.8-2 by 1.7-1.9 cm., often obtuse (rounded) at apex, drying brown, sharply and closely wrinkled; outer layer detaching cleanly from stone or not, 0.5-1 mm. thick, compact or with small air spaces developing; stone subspherical, 1.3-1.6 by 1.2-1.5 cm., \pm rounded at apex, the walls 0.4-0.5 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Sri Lanka (MAP 6).

SELECTED SPECIMENS SEEN (for explanation of letters, see text). Sri Lanka: below Hunasgyriya, direction Mahangane, 800 m., *Kostermans 24414* (z) (A, K); Newera Ellia, *CP 1170, pro parte* (GH, NY, K, P, US); Madulkele, Knuckles, 900 m., *Kostermans 25074* (z) (A, AAU, E, K, US), *25083* (A, AAU, E, K, US); Warricyalla, Kandy, Hantam Range, 1067 m., *Worthington 2505* (A, BM); Kandy Distr., Dotulugala, 1463 m., *Waas 1041* (NY); E. of Madugoda, 778 m., *Jayasuriya 2120* (?) (L); Dolosbage, 838 m., *Worthington 1877* (BM); Jaffra, below 305 m., *de Silva 59* (NY); Aigburth Estate, Rakwana, 1067 m., *Worthington 2159* (BM); Rasgalle above Balangoda, 700 m., *Kostermans 23599* (A, K, L, US); Maskeliya Distr., Moray Estate, Fishing Hut, 1600 m., *Kostermans 24138* (A, AAU, E, US); Adam's Peak descent, 1524 m., *Balakrishnan 282* (US); Sinharaja, N. Ensalwatta, Matara Distr., *Sohmer & Waas 10451* (GH); N. of Pinnawala,

Adam's Peak Sanctuary, 1600 m., *Maxwell & Jayasuriya 915* (cf. z) (MO, NY, US); Sabaragamuwa Prov., Ratnapura Distr., Manikkawatta Forest, 1300 m., *Waas 1759* (GH), Hopewell Forest, 900 m., *Waas 1597* (GH); Double Cutting road, Laxapane to Maskaliya, 900 m., *Kostermans 24074* (US); near Gartmore Estate, *de Silva 32* (c, NY); Madamahanewera, 914-1219 m., *CP 2917, pro parte* (z) (BO, GH, MEL, P, W); Matale Distr., Matale Road N. of Nuala, Mile 35-36, *Meijer with Balasubramanian 677* (K); Corbet's Gap, *Meijer with Dassanayake 656* (US).

ECOLOGY. Locally common, lower montane forests, 600-1600 m. alt., (collected below 305 m.). Flowering February to June; fruiting June and July (fruit dirty green) (FIGURE 5, a, b).

Spherical galls ca. 1.5 cm. across are quite common (e.g., *CP 242, 2447, Kostermans 23599, 24074*). They terminate the stem and are bilabiate at the apex.

Calophyllum trapezifolium is a variable species that can nevertheless be fairly readily recognized by its strongly flattened twigs, rather narrow terminal bud usually with an erect and conspicuous pair of buds in the uppermost leaf axils, few-flowered inflorescence with a relatively long basal internode, and often ovoid, pointed fruits with an outer layer not more than 1 mm. thick. The leaves, although very variable in shape and size, are often acute to cuneate at the apex, and the midrib tends to be depressed toward the base on the upper surface and rather prominent and angled on the lower. The epithet *trapezifolium* comes from the trapeziform shape of the leaf blades.

Calophyllum trapezifolium is related to *C. walkeri* and other montane taxa; the characters distinguishing them are given in TABLE 7.

There is a group of specimens ("z" in the list above) that are barely distinguishable from *Calophyllum cuneifolium*; *C. zeylanicum* is based on specimens of this type. The terminal bud is short (2.5-4.5 mm.); the lamina is rather small, elliptic or sometimes obovate in shape, and more or less attenuate at the base; and there are 11 to 14 (rarely 7 to 17) veins/5 mm. diverging from the midrib at 45-55°. The anthers are relatively long for *C. trapezifolium* (1.2-1.7 cm), although the flowers themselves are rather small. *Calophyllum zeylanicum* was compared with *C. cuneifolium* (Kostermans, *loc. cit.*), and the characters by which it was distinguished from that species either tend toward (angle of divergence of venation, lamina shape) or are characteristic of (fruit shape) *C. trapezifolium*. In addition, *C. zeylanicum* has the strongly flattened twigs, the rather well-developed and erect pair of buds in the uppermost leaf axils, the terminal galls, the few-flowered inflorescence with a relatively long basal internode, and the fruits with a thin outer layer characteristic of *C. trapezifolium*. It is possible that further collections will show *C. zeylanicum* to be a taxon discrete enough to be recognized formally (probably subordinate to *C. trapezifolium*), but in view of the variation within the species, such recognition would be premature.

Balakrishnan 282 has the fruits, pedicels, twigs, and terminal buds of *Calophyllum trapezifolium*. Although its suborbicular leaf blades are superficially like those of *C. walkeri*, the midrib is strongly depressed toward the base on the upper surface of the blade and is angled below—characters

of *C. trapezifolium*. *Kostermans* 25083 is also superficially like *C. walkeri* in lamina shape, although there is considerable variation in this on a single shoot, but in all other characters (apart, perhaps, from the rounded apex of the fruit) it is like *C. trapezifolium*. *Kostermans* 25083 grows in the same area as *Kostermans* 25074, a paratype of *C. zeylanicum*. *Kostermans* 24515 and *Jayasuriya* 2120 are odd specimens; neither has obvious buds in the uppermost pair of leaf axils. In appearance the former specimen is somewhat similar to *C. calaba*, and the latter to *C. cuneifolium*.

Calophyllum trapezifolium has been distributed with other species under one number several times in the CP series. CP 2917, the type number of *C. cuneifolium* (q. v.), is mixed with *C. trapezifolium* "z"; CP 242, *C. calaba*, is mixed with the typical form of *C. trapezifolium*; and CP 1170, *C. walkeri*, is mixed with a specimen of *C. trapezifolium* that in lamina shape approaches *C. walkeri*.

15. *Calophyllum cuneifolium* Thwaites, Enum. Pl. Zeyl. 51. 1858, *pro parte*, *ibid.* 407. 1864; Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 289. 1862; Bedd. Fl. Sylvat. 3: 1871; T. Anderson in Hooker f. Fl. Brit. India 1: 275. 1874; Vesque, Epharמושis 2: t. 10. 1889, *pro parte*; Trimen, Handb. Fl. Ceylon 1: 103. 1893; Vesque in C. DC. Monogr. Phanerog. 8: 557. 1893, *pro minore parte*; Alston in Trimen, Handb. Fl. Ceylon (Suppl.) 6: 22. 1931; Worthington, Ceylon Trees, 30. 1959. TYPE: Ceylon [Sri Lanka], Madamahanevura, 3000-4000 feet [914-1219 m.], CP 2917, *pro parte* (isotypes, BM, FI, G, K, P, W).

Tree 18-35 meters tall, d.b.h. to 90 cm.; trunk without buttresses; outer bark yellowish, hard, deeply fissured, peeling in strips 3-5 cm. by ca. 5 mm. thick; inner bark reddish, inside finely ridged longitudinally.

Twigs not flattened, 1.5-2.8 mm. across, strongly 4-angled, drying dark brown, glabrous or sparsely puberulent when young; axillary innovations lacking basal scars; internodes 0.3-2.2 cm. long, terminal internode of innovation frequently $\frac{1}{2}$ (or less) length of others; uppermost pair of axillary buds rounded, less than 1 mm. long, spreading; terminal bud plump, 1.5-3.5 mm. long, with grayish brown, short, tomentose indumentum (hairs, FIGURE 12, d), underdeveloped internode absent. Petiole 0.4-1.2 cm. long, concave to flat above, convex below, glabrous; lamina cuneiform to obovate, (1.75-)2.8-5(-7.5) by (1.2-)1.6-2.5(-3.8) cm., retuse to rounded (rarely obtuse) at apex, narrowly cuneate (slightly rounded) at base, distantly undulate and slightly recurved at margin, coriaceous, drying hazel to greenish olivaceous above and sabelline to hazel below, soon glabrescent or sparsely subsersistently puberulent on midrib below, the midrib above gradually (rarely subabruptly) narrowed from base, level or slightly raised, 0.1-0.25 mm. wide at midpoint, below slightly raised, rounded, the venation \pm apparent above and below, raised, 3 to 7 (to 9) veins/5 mm., angle of divergence (25-)35-40°. Inflorescences from foliate axils along twigs (rarely terminal), with 9 to 17 flowers, unbranched, the axis 3.2-9 cm. long, strongly angled, rather sparsely puberulent toward base, lowest internode 0.5-2.3 cm. long; bracts ovate to

elliptic, 0.2-3 cm. long, subsistent when foliaceous; pedicels 0.4-2.3 cm. long, glabrous. Flower (?)hermaphroditic; tepals 8 to 11, sometimes glabrous, the outer pair broadly ovate, ca. 6 by 5 mm., the inner ones elliptic to obovate (rarely outer two ovate to suborbicular), 6-8.5 mm. by 4-5(-6) mm.; stamens 160 to 220, the filaments 2.5-4 mm. long, the anthers suboblong, 0.9-1.6 mm. long, rounded to retuse at apex; ovary 2-2.5 mm. long, the style ca. 2 mm. long, the stigma peltate, 0.8-1 mm. across, 2- to 4-radiate. Fruit subspherical, 1.8-2.3 by 1.6-2.2 cm., bluntly pointed to rounded at apex, drying brownish, rather strongly and closely wrinkled; outer layer adhering to stone, 1.5-2.8 mm. thick, compact; stone subspherical, 1.4-1.6 by 1.35-1.5 cm., rounded at apex, the walls ca. 0.4 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Sri Lanka (MAP 7).

SELECTED SPECIMENS SEEN. Sri Lanka: Kandy Distr., Knuckles, Madulkele, 800 m., *Kostermans 25056* (A, AAU, E, K, L, US); Tonacombe Namanakulla, 1435 m., *Worthington 5464* (BM); Corbet's Gap, Rangalla, 1158 m., *Worthington 5047* (BM); Badulla Distr., Madawelagama, at 6th Mile Post, Pine Nursery, 610 m., *Balakrishnan & Jayasuriya 819* (K, NY, US), Passera-Badulla, Talpitiyakala, 1000 m., *Kostermans 24437* (A).

ECOLOGY. Locally common, montane forest, sometimes in exposed, wind-swept conditions, 600-1800 m. alt. Flowering June and August; fruiting in June (fruit green).

Calophyllum cuneifolium can be recognized by its short terminal bud; strongly 4-angled twigs; obovate to cuneiform leaf blades with at most slightly raised midribs and clear, distant, steeply ascending venation; many-flowered inflorescences; and spherical fruits with a well-developed outer layer. The specific epithet alludes to the cuneiform shape of the leaf blades characteristic of this species.

Calophyllum cuneifolium is apparently related to *C. walkeri*. For the differences between these and other small-leaved species growing in the mountains of Sri Lanka, see TABLE 7.

Worthington 5413 has a persistently bracteate, terminal inflorescence; *Worthington 5464*, from the same area, has axillary inflorescences with deciduous bracts. The bases of the leaf blades in both specimens are more or less rounded, while those of other specimens, including *Balakrishnan & Jayasuriya 819* (also with persistent bracts), are narrowly cuneate.

CP 2917, the number of the type collection of *Calophyllum cuneifolium*, seems to be a mixed collection. The original description of *C. cuneifolium* reads "foliis parvis, cuneate spatulatis, obtuse brevi-acuminatis vel retusis, coriaceis." Some shoots of *CP 2917* have elliptic leaf blades that are more or less acute at the apex; others have cuneate-spatulate leaf blades that are retuse (cf. description above; the two types of leaves are illustrated in Vesque, 1889, *loc. cit.*). The venation density of the elliptic leaf blades is higher, and specimens with such leaves also have internodes all of similar length, a narrow terminal bud, and erect buds in the uppermost leaf axils.

Duplicates of *CP 2917* that have elliptic leaf blades are referred to *C. trapezifolium*.

16. *Calophyllum austroindicum* Kosterm. ex P. F. Stevens, sp. nov.

FIGURE 8, g-i.

C. trapezifolium auct., non Thwaites; Bourdillon, Forest Trees Travancore, 28. 1908; Brandis, Indian Trees, 54. 1907; Rama Rao, Fl. Pl. Travancore, 32. 1914; Gamble, Fl. Pres. Madras 1: 76. 1915; Maheshwari, Bull. Bot. Survey India 2: 144. 1960, *pro parte*; Somasundaran, Handb. Trees Shrubs So. States, 54. 1963.

A speciebus aliis *Calophylli* in gemma terminali parva (2.8-3.5 mm. longa), internodiis innovationis plus minusve eadem longitudine (vel internodio terminali breviori quam aliis), et fructu rostrato parietibus putaminis 0.5-1.2 mm. crassis, differt.

Tree (10-)25-30 meters tall, d.b.h. to 100 cm.; probably lacking buttresses; outer bark pale brown to yellowish; inner bark reddish; latex clear.

Twigs slightly to strongly flattened, 1.3-2(-3) mm. across, \pm 4-angled to subulate, drying dark brown, glabrous (rarely transiently brown-tomentose); axillary innovations lacking basal scars; internodes 0.5-3(-3.5) cm. long (terminal internode notably shorter than others); uppermost pair of axillary buds rounded, ca. 1 mm. long, erect; terminal bud plump, 2.8-3.5 mm. long, with brownish gray, subtomentose to tomentose indumentum (hairs, FIGURE 12, a, b), underdeveloped internode absent. Petiole (3-)5-8 mm. long, shallowly concave above, convex below, almost glabrous; lamina elliptic or trapeziform to obovate, 2.9-7 by 1.2-3.5 cm., subacuminate to rounded (rarely retuse) at apex, narrowly cuneate to acute (rarely rounded) at base, slightly undulate and barely recurved at margin, coriaceous, drying olivaceous, sepia, citrine, or brown-vinaceous above and olivaceous, sepia, or olivaceous-citrine below, more or less glabrous at maturity, the midrib above narrowing gradually from base, flat to slightly elevated, center sulcate at least near base, 0.15-0.35 mm. wide at midpoint, below raised, rounded to striate, the venation subobscure to subapparent on both surfaces, raised (below rarely impressed), 5 to 10 (to 15) veins/5 mm., angle of divergence 40-65°. Inflorescences axillary, with 7 to 17 flowers (3-flowered branches to 1.5 cm. long, or lower flowers flabellately arranged), the axis 1.3-7.7 cm. long, glabrous or sparsely farinose-puberulent toward base, lowest internode (0.4-)1-4 cm. long; bracts unknown; pedicels (0.3-)0.6-1.8 cm. long, glabrous. Flower (?)hermaphroditic; tepals 8 to 10, the outer pair suborbicular, 3.7-5 by 3.5-6 mm., the next pair broadly elliptic, ca. 6 by 4 mm., the inner ones elliptic or oblong to obovate, 4.5-8 by 1.7-4 mm.; stamens 100 to 125, the filaments to 2.5 mm. long, the anthers subelliptic to oblong, 0.7-1.3 mm. long, retuse (rarely subacute) at apices; ovary 1.5-1.8 mm. long, the style 1.5-2 mm. long, the stigma peltate, 0.7-1 mm. across, 3-radiate. Fruit ovoid, 3-3.3 by 1.7-2.3 cm., rostrate at apex, drying dark brown-vinaceous, more or less corrugated; outer layer adhering to stone, 0.7-2 mm. thick, compact; stone ellipsoid, 2.4-2.7 by 1.5-1.6 cm., obtuse at apex, the walls 0.5-1.2 mm. thick, smooth, not marked; spongy layer probably becoming thin.

TYPE: India, S. Tamilnadu, Turunneveli Distr., E. slopes Western Ghats, Walaigur cardamon estate, 1100 m., 16 July 1976, *Kostermans 26264* (holotype, L).

DISTRIBUTION. Southwestern India (MAP 8).

ADDITIONAL SPECIMENS SEEN. **India.** MYSORE: Narimale, Ghat Forests, Coorg, *Tireman s.n.* (Dehra Dun herb. no. 20505) (A). KERALA: TRAVANCORE, Udambansholoy, 1524 m., *Meebold 892/13085* (CAL); Quilon, *Bourdillon 179* (CAL); road Thakadi to Munar, 1500 m., *Kostermans 26139* (L). TAMILNADU: Silent Valley, Nilgiris, 610 m., *Beddome 13* (K), 423 (BM).

ECOLOGY. Large tree, montane ghat forests, 610–1525 m. alt. Flowering March (November and December—*Bourdillon, loc. cit.*); submature fruits June and December (ripe fruit purple—*Bourdillon, loc. cit.*).

LOCAL USE. The tree yields good timber.

Calophyllum austroindicum can be recognized by its small terminal buds; its rather short internodes all approximately the same length (or the terminal one smaller than the others); its fairly small leaves with often rather distant venation; and its beaked fruit with an obtusely pointed, somewhat thick-walled stone. The epithet *austroindicum* was coined because plants referable to this species have been found only in southern India.

Calophyllum austroindicum is perhaps related to the *C. walkeri* complex, from Sri Lanka, but it differs from all members of the complex in its beaked fruits that have a rather thick-walled stone (see also TABLE 7).

Calophyllum austroindicum seems to be a rather variable species. *Bourdillon 179* has anthers with acute apices and leaves superficially like those of *C. thwaitesii*. *Kostermans 26139* has leaves that dry olivaceous on the upper surface and young twigs with tomentose indumentum; *Kostermans 26264* has leaves that dry brown-vinaceous on the upper surface, and even the very young twigs are glabrous or almost so. However, the specimens have similar fruits, which are like those of *Meebold 892/13085*, the only other fruiting specimen seen. *Bourdillon (loc. cit.)* mentioned that the fruits were purple, which is rather unusual; the field notes of the two specimens collected by *Kostermans* mention green fruits, although in neither case is the fruit ripe.

17. *Calophyllum vergens* P. F. Stevens, sp. nov.

FIGURE 8, f.

C. thwaitesii Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 260. 1862, *pro parte* (β); Thwaites, Enum. Pl. Zeyl. 407. 1864, *pro parte*; Bedd. Fl. Sylvat. 3: 1871, *pro parte*; T. Anderson in Hooker f. Fl. Brit. India 1: 275. 1874, *pro parte*; Vesque, Epharmosis 2: t. 8. 1889; Trimen, Handb. Fl. Ceylon 1: 102. 1893, *pro parte*; Vesque in C. DC. Monogr. Phanerog. 8: 556. 1893, *pro parte*; Worthington, Ceylon Trees, 34. 1959.

C. decipiens auct., non Wight; Thwaites, Enum. Pl. Zeyl. 51. 1858, *pro parte* (β).

A speciebus aliis Calophylli in gemma terminalis breve 2.5–3.5 mm. longa, lamina parva minore quam 6.5 cm. longa apice rotundata vel leviter retusa

basi vadose cordata, inflorescenti internodio infimo plus quam 1.3 cm. longo, flore cum 8 tepalis, et fructu ovoideo circa 2.4 cm. longo, differt.

Tree ca. 30 meters tall, d.b.h. ca. 40 cm.; outer bark pinkish, pale brown, or yellowish, fissured, loose strips 3-4 cm. wide; inner bark reddish brown, ca. 10 mm. thick.

Twigs slightly flattened, 1.5-3 mm. across, (almost 2-) 4- or 6-angled, sometimes with transverse line at node, drying brown, glabrous or brown farinose-puberulent at first; axillary innovations lacking basal scars; internodes (1-)2-5 cm. long; uppermost pair of axillary buds \pm pointed, to 2.5 mm. long, erect to \pm spreading; terminal bud plump, 2.5-3.5 mm. long, with subadpressed, chestnut brown to gray-brown indumentum (hairs, FIGURE 12, e, g), underdeveloped internode to 1 mm. long. Petiole 2-3.5 mm. long, concave above, convex to angled below, glabrous; lamina broadly ovate or obovate to suborbicular, 1.2-6.3 by 2.1-5.8 cm., rounded (slightly retuse) at apex, shallowly cordate at base, slightly undulate but barely recurved at margin, thinly coriaceous, drying sepia above and cinnamon below, transiently farinose-puberulent on midrib below, the midrib above abruptly narrowed at base, depressed at first, becoming slightly raised, 0.15-0.5 mm. wide at midpoint, below raised, rounded to substrate, the venation above and below \pm apparent, raised, 5 to 9 (to 11) veins/5 mm., angle of divergence 50-60°. Inflorescences from uppermost foliate axils (rarely terminal), with 3 to 5 flowers, unbranched, the axis 1.3-4 cm. long, sparsely farinose-puberulent, lowest internode at least 1.3 cm. long; bracts in terminal inflorescences foliaceous, to 2.7 cm. long, otherwise unknown; pedicels 0.7-2.5 cm. long, glabrous. Flower (?)hermaphroditic; tepals 8, sometimes glabrous, the outer pair elliptic to ovate, 4.5-6 by 2.5-3.8 mm., the inner ones \pm obovate, 5-7.5 by 3-6 mm.; stamens 65 to 75, the filaments to 3 mm. long, slightly connate at base, the anthers oblong, 0.9-1.2 mm. long, rounded at apex; ovary ca. 1.8 mm. long, the style ca. 2.5 mm. long, the stigma peltate, ca. 0.7 mm. across, 3-radiate. Fruit ovoid, ca. 2.4 by 1.8 cm., acute at apex, drying wrinkled; outer layer detaching cleanly from stone, ca. 2 mm. thick, compact; stone subovoid, ca. 1.6 by 1.4 cm., obscurely pointed at apex, the walls ca. 0.25 mm. thick, smooth, unmarked; spongy layer initially thick.

TYPE. Ceylon [Sri Lanka, Hinidoon Corle, 305-610 m.], CP 3403, *pro parte* (holotype, BM; isotypes, BO, FI, G, K, P, W).

DISTRIBUTION. Sri Lanka (MAP 7).

ADDITIONAL SPECIMENS SEEN. **Sri Lanka:** Tumbagoda, road Tamanawette-Massenna, above Balangoda, Adam's Peak jungle, 900 m., *Kostermans* 24469 (A, L), 24474 (L); above road, Rasnagalle-Ratnapura, ca. 700 m., *Kostermans* 24645 (L); Adam's Peak jungle, upper part of Moray Estate near Fishing Hut, 1600 m., *Kostermans* 24469A (L); Panil Kanda Forest, below Hayes Est., 671 m., *Worthington* 6624 (L); Kanneliya F.R., *Meijer* 1037 (US); Kanneliya Forest near Hiniduma, low alt., *Kostermans* 25526 (L); Hiniduma F.R., low alt., *Kostermans* 24723 (L); Hinidumkande (Haycock), near Hiniduma, 500 m., *Kostermans* 25368 (L), 25668 (L).

ECOLOGY. Lowland to colline rainforest, to 900 (rarely to 1600) m. alt.

Calophyllum vergens can be readily recognized by its short terminal bud; small, suborbicular to broadly ovate leaf blades that are little longer than broad and cordate at the base; clear venation; axillary inflorescence with the basal internode at least 1.5 cm. long; and medium-sized, ovoid fruit. The epithet *vergens* (from *vergo*, "to incline," "to tend") was chosen because of the superficial similarities between this taxon and *C. clemensorum*, from Malesia (see below).

Calophyllum vergens is still a rather puzzling taxon. There are considerable, although perhaps not unexpected, differences in shape and size between leaves of adult plants and those of young plants and saplings, those of the latter being elliptic-lingulate, up to 16 by 3.7 cm., and cordate to rounded at the base. There are transverse lines across the nodes of shoots of young plants, as well as most older plants, but these do not seem to occur on the type. Only a single fruit is known (from *Kostermans 24474*); this is detached from the specimen, and the field notes remark "fruit dry."

Planchon and Triana described two morphs of *Calophyllum thwaitesii*, α and β . *Calophyllum thwaitesii* α , *C. thwaitesii* sensu stricto, is clearly a member of the *C. walkeri* complex, while *C. vergens* is a more slender plant, and although probably also a member of this complex, it is perhaps the most easily recognizable species. *Calophyllum vergens* is superficially very similar to *C. clemensorum*, from northeastern Borneo, but the latter has scars at the bases of the axillary inflorescences and fruits about 1 cm. long.

18. *Calophyllum apetalum* Willd. Ges. Naturf. Fr. Berlin Mag. 5: 79. 1811, *pro parte*; Sprengel, Syst. Veg. ed. 16. 2: 571. 1825, *pro parte*; Sastri *et al.* Wealth India 2: 17. 1950; Maheshwari, Bull. Bot. Survey India 2: 143. 1960; Somasundaram, Handb. Trees Shrubs So. States, 54. 1963; Troup, Silv. Indian Trees. ed. 2. 1: 223. 1975; Gandhi in Saldanha & Nicolson, Fl. Hassan Distr. 124. fig. 26C. 1976; *C. spurium* Choisy, Mém. Soc. Phys. Hist. Nat. Paris 1: 229. 1823, in DC. Prodr. 1: 563. 1824; G. Don, Gen. Syst. 1: 623. 1831; Wight & Arnott, Prodr. Fl. Penin. Indiae Orient. 1: 103. 1834, *pro parte*; Graham, Catal. Pl. Bombay, 27. 1839; Walp. Rep. Bot. Syst. 1: 397. 1842, *pro parte*; Dalzell & Gibson, Bombay Fl. 32. 1861 ("*C. speurium*"); Drury, Handb. Indian Fl. 1: 143. 1864, *nomen superfluum*; *C. decipiens* Wight, Ic. Pl. Indiae Orient. 1: pl. 10. 1839, Illus. Indian Bot. 1: 128. 1840; Choisy, Descr. Guttif. Inde, 42. 1849, Mém. Soc. Phys. Hist. Nat. Genève 12: 422. 1851, *pro parte*; Gamble, Fl. Pres. Madras 1: 76. 1915, *nomen superfluum*; *C. wightianum* Wall. ex Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 256. 1862; Wall. Catal. 4847. 1831, *nomen*; Bedd. Fl. Sylvat. 1: pl. 90. 1871, *ibid.* 3: xxii. 1871; T. Anderson in Hooker f. Fl. Brit. India 1: 274. 1874; Lisboa, Gaz. Bombay Pres. 25: 214. 1886; Vesque, Epharמושis 2: t. 20. 1889, in C. DC. Monogr. Phanerog. 8: 569. 1893; Cameron, Forest Trees Mysore Coorg, 17. 1894; Talbot, Syst. List Trees Bombay Pres. 16. 1894; Woodrow, Jour. Bombay

Nat. Hist. Soc. II: 126. 1897; Dalgado, Fl. Goa Savant. 15. 1898; Cooke, Fl. Pres. Bombay I: 81. 1901; Talbot, Trees Bombay Pres. ed. 2. 30. 1902; Brandis, Indian Trees, 54. 1907; Bourdillon, Forest Trees Travancore, 28. 1908; Talbot, Forest Fl. Bombay I: 101. fig. 63. 1909; Rama Rao, Fl. Pl. Travancore, 32. 1911, *nomen superfluum*. TYPE: India, Quilon, *Wallich dist. 4847* (neotype, CAL, B.V.; isoneotypes, G, K).

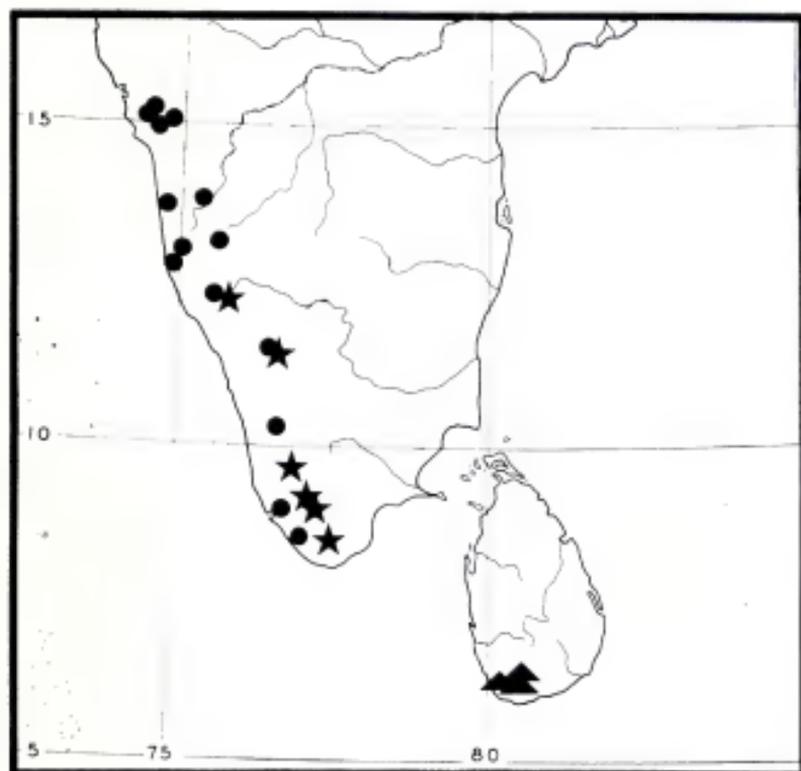
C. calaboides G. Don, Gen. Syst. I: 622. 1831. TYPE: described from India.
C. calaba L. Sp. Pl. 2: 514. 1753, *pro minore parte*; Burman, Fl. Indica, 120. 1768, *pro parte*; Lam. Encycl. M th. Bot. I: 553. 1783.

Tree 8–30 meters tall, d.b.h. to 80 cm.; trunk apparently unbuttressed; outer bark yellowish, strongly fissured; latex white, sticky (*Kostermans 26073*); wood pale reddish white to reddish brown with darker streaks and a characteristic odor (*vide Maheshwari, loc. cit.*).

Twigs slightly flattened, 1.8–3(–4) mm. across, strongly 4-angled to subalate, drying yellowish to dark brown, glabrous or sparsely farinose when young; axillary innovations lacking basal scars; internodes 0.5–2 cm. long; uppermost pair of axillary buds rounded, ca. 0.5 mm. long, \pm spreading, inconspicuous, terminal bud plump, 3–6.5 mm. long, with subfurfuraceous to short-tomentose, gray to brown indumentum (hairs, FIGURE 12, c), underdeveloped internode absent (–1 mm. long). Petiole 3–5 mm. long, deeply concave above, convex below, glabrous or almost so; lamina obovate to elliptic, 4–8.5(–10.5) by 2–4.5 cm., rounded to retuse at apex, subtruncate to rounded (rarely acute to cuneate) at base, usually abruptly narrowed at very base, not undulate and only slightly recurved at margin, coriaceous, drying sepia to hazel above and sepia to sabelline below, glabrous or sparsely and transiently farinose on midrib below, the midrib above abruptly narrowed at base, raised, center strongly sulcate near base, 0.3–0.6 mm. wide at midpoint, below raised, striate, the venation \pm apparent above and below, raised, 5 to 9 veins/5 mm., angle of divergence 50–65°. Inflorescences from foliate (rarely defoliate) axils, with 5 to 13 flowers, unbranched, the axis 1.7–7 cm. long, usually sparsely subfarinose, especially toward base (rarely subglabrous), lowest internode (0.5–)1–2.2 cm. long; bracts ovate, ca. 4 mm. long, soon deciduous; pedicels 0.9–1.5(–2.7) cm. long, glabrous. Flower (?)hermaphroditic; tepals usually 4 (rarely 3, 6, 8, or 9), the outer pair broadly ovate to suborbicular, 3.5–6 by 3.3–5.5 mm., the inner ones elliptic to obovate, 6–9 by 3.5–5 mm.; stamens 40 to 85, the filaments to 5 mm. long, free or almost so, the anthers oblong, 1.3–2.5 mm. long, rounded (mucronulate) at apex; ovary ca. 1.5 mm. long, the style ca. 3.5 mm. long, the stigma peltate, 1–1.5 mm. across, ca. 3-radiate. Fruit ovoid to ellipsoid, 0.9–1.5 by 7–9 mm., apiculate or not, drying grayish brown, smooth; outer layer adhering to stone, ca. 1 mm. thick, large air spaces developing; stone ovoid to ellipsoid, 0.75–1.3 by 5–7 mm., rounded to subobtuse at apex, the walls less than 0.1 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. India, Western Ghats (MAP 8).

SELECTED SPECIMENS SEEN. **India.** MAHARASTRA: Concan, *Stocks & Law s.n.* (BM, FL, G, GH, K, P, U, W). MYSORE: N. Kanara, Yellapor, *Talbot 381* (E); Nilkund, *Talbot 245* (E); Shimoga Distr., Hulical, Varshi Stream, *BSI Western Circle 86333* (K); Barakana, Agumbe, *BSI Western Circle 83277* (BM); Castle Rock, Kalmuli Jungle, *Fernandes 470* (A); Hassan Distr., Kempuhole ford, *HFP 927* (K, US); Londa, *Fernandes 977* (A); Dandeli, left bank of Kali R., *Fernandes 1088* (A); Madamhole, Coorg Distr., *BSI Western Circle 86783* (E); Kakethodu, Coorg, *Dehra Dun herb. no. 19148* (A); S. Kanara, *Beddome 421* (BM); monte Dschamalabad prope urbem Mangalore, *Hohenacker 322* (BM, C, G, FL, K, M, P, U, US, W); Bababoodun Hills, Malabar, *Law s.n.* (K). KERALA: S. Kerala, road Poonmudi to Trivandrum, 600 m., *Kostermans 26073* (L); Anamallays, 610 m., *Beddome 420* (BM), *Beddome s.n.* (K, NY); Travancore, Malagatta, *Bourdillon 1566* (K); Quilon, *Wight s.n.* (E). TAMILNADU: Madras State, *Wight s.n.* (K); Kalu Nuddie, *Ritchie 1649* (E, K).



MAP 8. Distribution of *Calophyllum apetalum* (circles), *C. austroindicum* (stars), and *C. cordato-oblongum* (triangles) in India and Sri Lanka.

ECOLOGY. Locally abundant, riverine forests, to 610 m. alt. Flowering October to March, after rains, especially November and December; fruiting March to May (reported December to January—e.g., Bourdillon, *loc. cit.*, as *C. wightianum*) (fruit becoming red with age).

The edges of the leaf blades are sometimes converted into hollow, winged or lipped galls (e.g., *Stocks & Law s.n.*; see also Talbot, 1909, *loc. cit.*, as *C. wightianum*).

LOCAL USES. The wood is strong and is used both in the construction of boats and oil mills and in general building. An oil with a characteristic smell and a bitter taste can be extracted from the seeds; with refinement the bitterness is lost. The oil is composed of the glycerides of stearic, palmitic, oleic, and probably linoleic acids. The fruit is edible (Sastri *et al.*, *loc. cit.*).

Calophyllum apetalum is a distinctive species recognizable by its lamina, which is usually less than 9 cm. long, more or less retuse at the apex, and often rather abruptly narrowed at the very base, and by its strongly four-angled stems. It has small flowers, and the outer layer of the fruit becomes disorganized by the development of large air spaces. There is considerable variation in the shape of the lamina and the fruit, but there are intermediates between the extremes. The epithet *apetalum* refers to the fact that the flower usually has only four tepals; these were called sepals by earlier workers.

Calophyllum spurium, *C. decipiens*, and *C. wightianum* are all illegitimate (superfluous) names, since reference is made to the earlier-published name, *C. apetalum*. Much of the confusion over the correct name for this taxon, which engendered the superfluous names, was due to overestimating the significance of tepal number variation and misinterpreting the nature of the tepals present. Thinking that the sepals were absent, Choisy started the confusion by calling the four tepals "petals"; he renamed *C. apetalum*, *C. spurium*. Further details of the nomenclature and synonymy of *C. apetalum* are given in Stevens (1980b); Maheshwari (*loc. cit.*) neotypified *C. apetalum*.

The meager original description of *Calophyllum calaboides* (Don, *loc. cit.*) suggests that this name is a synonym of *C. apetalum*.

19. *Calophyllum calaba* L. Sp. Pl. 732. 1753. SYNTYPES: Ceylon [Sri Lanka], *Hermann* 1: 65, 2: 42, 52, 3: 3 (NM).

Tree (rarely shrub), (0.5-)3-40(-49) meters tall, d.b.h. to 158 cm.; trunk usually without buttresses or spurs (rarely with steep, blunt buttresses to 4.5 meters tall (*SFN* 20865)); outer bark yellowish brown to yellowish, with rather distant, large, shallow, boat-shaped fissures, sometimes pustular, becoming more deeply fissured and scaling with age, inner surface blackish brown to dull yellowish brown; under bark dark red; inner bark thick, (pale) dark red; latex usually yellow, clear, sticky (rarely opaque, white or brownish); sapwood brown to whitish; heartwood reddish to dark brown.

Twigs flattened or strongly flattened, 1-2.5(-3.2) mm. across, 4- (2- or 6-)angled or rounded, drying dark to pale brown or yellowish, \pm persistently farinose to tomentose; axillary innovations lacking basal scars; internodes

0.5-4.5(-8.5) cm. long; uppermost pair of axillary buds \pm rounded, (0.3-)1-5 mm. long, erect, usually conspicuous; terminal bud plump to conical, (1.5-)3-11 mm. long, with grayish subcrustaceous to brown-tomentose indumentum (hairs, FIGURES 12, f, h-q; 13, a-d), underdeveloped internode to 2 mm. long. Petiole (0.2-)0.35-2 cm. long, shallowly to deeply concave above, convex below, soon glabrescent; lamina elliptic to ovate (rarely subobovate to oblong or cuneiform), (1.5-)3-13 by (0.7-)2-4.7(-5.5) cm., subacuminate to retuse at apex, acute to cuneate or cordate at base, slightly undulate and barely recurved at margin, coriaceous, drying brown-vinaceous or olivaceous to sepia above and dark brick or honey-sabelline to sepia below, transiently farinose to subsersistently short-tomentose on or near midrib below (also above), the midrib above usually narrowing gradually (quickly) from base, \pm raised to flat, center sulcate at least at first, (0.1-)0.15-0.4 mm. wide at midpoint, sometimes disappearing ca. 5 mm. short of apex, below raised, striate to angled, the venation \pm apparent above and below, raised (latex canals on upper surface also sometimes raised), (8 to) 10 to 20 (to 28) veins/5 mm., angle of divergence (50-)60-75°. Inflorescences from foliate axils along stem, with (3 to) 5 to 15 flowers, unbranched or with 3-flowered branches to 1.3 cm. long, the axis (0.1-)0.25-3.4 cm. long, puberulent to short-tomentose near base or along entire length, lowest internode 0.5-12 mm. long; bracts broadly elliptic to ovate, 2-5 mm. long, deciduous; pedicels 0.4-2(-2.8) cm. long, glabrous to puberulent, markedly incrassate in fruit or not. Flower (?)hermaphroditic; tepals 4 (rarely 6), rarely glabrous, the outer pair broadly elliptic to ovate, 3-4.5 by 2.5-4.5 mm., sometimes puberulent on back, especially toward base, the inner ones obovate to elliptic or oblong, 3.7-7.5 by 2-5.2 mm., rarely puberulent in strip down back; stamens 20 to 95, the filaments 2-3.5 mm. long, the anthers oblong, 0.4-1.5 mm. long, retuse to mucronulate at apex (rarely hastate, acute at apex); ovary 0.8-1.5 mm. long, the style 1.5-3.5 mm. long, the stigma peltate-infundibular, 0.4-1 mm. across, sometimes 3- or 4-radiate. Fruit spherical to ovoid or ellipsoid, 0.6-1.6 by 0.6-1.1 cm., minutely apiculate or not, drying \pm vinaceous-brown, pruinose or not, broadly wrinkled when young, smooth when ripe; outer layer not detaching cleanly from stone, 0.3-1 mm. thick, air spaces developing, especially under skin; stone spherical to ovoid or ellipsoid, 0.5-1.15 by 0.5-0.8 cm., rounded at apex, the walls 0.15-0.3(-0.5) mm. thick, somewhat thicker at base, smooth, unmarked; spongy layer thin.

Key to the Varieties of *Calophyllum calaba*

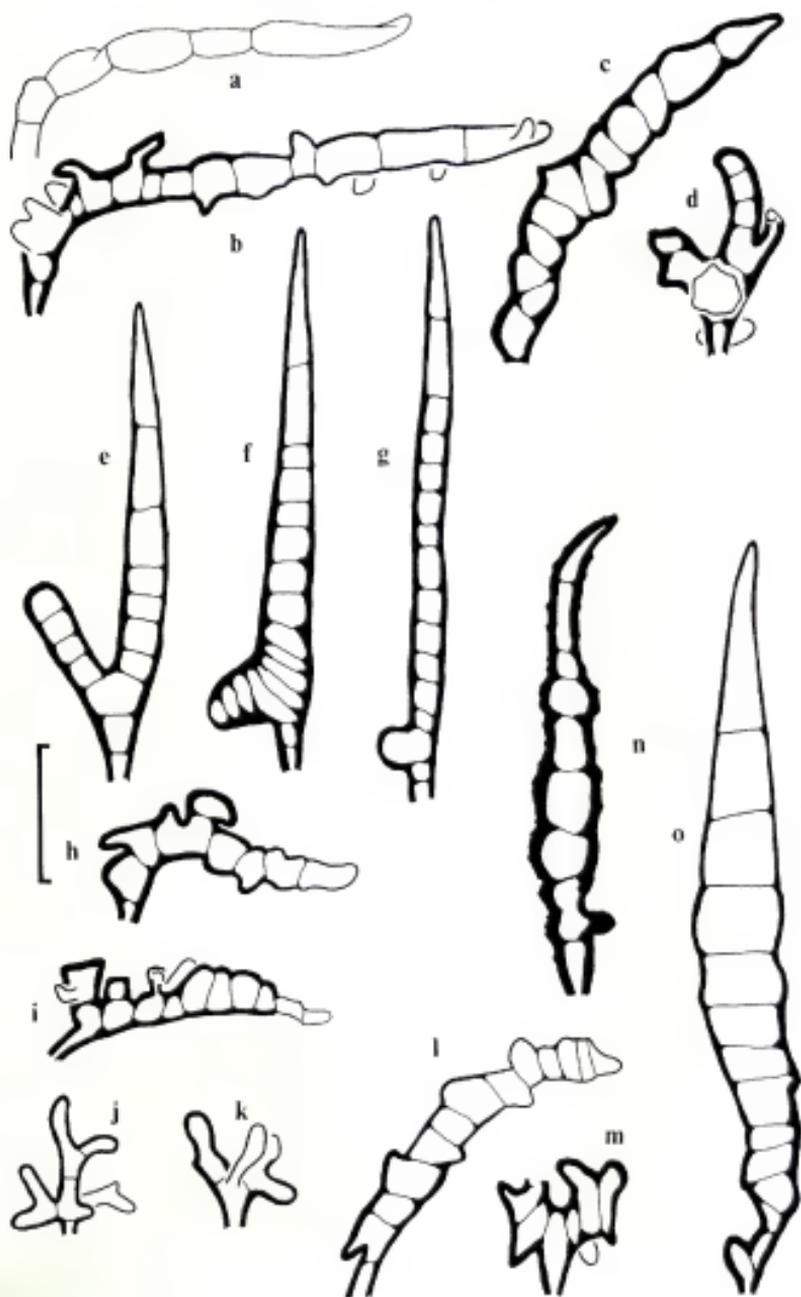
1. Lamina usually ovate, retuse to subacute at apex; indumentum usually short-tomentose; inflorescence often branched, indumentum restricted to base of axis; fruit ellipsoid. 19a. var. *calaba*.
1. Lamina variable in shape, usually acute to subacuminate at apex; indumentum rarely short-tomentose; inflorescence very rarely branched, indumentum usually along length of axis; fruit usually spherical.
2. Lamina very coriaceous, usually cuneiform to suborbicular; terminal bud plump. 19d. var. *cuneatum*.

2. Lamina coriaceous, rarely cuneiform or suborbicular; terminal bud conical to plump.
3. Lamina elliptic, usually with fewer than 12 veins/5 mm.
 4. Uppermost pair of axillary buds ca. $\frac{1}{3}$ length of terminal bud; angle of divergence of venation 50–65°; outer layer of fruit less than 0.3 mm. thick; stone with wall less than 0.2 mm. thick. 19b. var. *worthingtonii*.
 4. Uppermost pair of axillary buds ca. $\frac{1}{4}$ length of terminal bud; angle of divergence of venation 60–70°; outer layer of fruit 0.5–1 mm. thick; stone with wall 0.2–0.4 mm. thick. 19f. var. *australianum*.
3. Lamina usually other than elliptic, if elliptic then with more than 12 veins/5 mm.
 5. Lamina strongly cordate at base, with more than 12 veins/5 mm.; terminal bud subtomentose. 19e. var. *E*.
 5. Lamina very rarely cordate at base, if cordate then with fewer than 12 veins/5 mm. and terminal bud other than subtomentose. 19c. var. *bracteatum*.

19a. *Calophyllum calaba* L. var. *calaba*

- C. calaba* L.; Burman f. Fl. Indica, 120. 1768, *pro parte* Zeyl.; Moon, Catal. Pl. Ceylon, 41. 1824; Alston in Trimen, Handb. Fl. Ceylon (Suppl.) 6: 22. 1931; Oostr. Blumea Suppl. 1: 196. 1937.
- C. burmannii* Wight, Ic. Pl. Indiae Orient. 1: pl. 108. 1839, Illus. Indian Bot. 1: 129. 1840; Walp. Rep. Bot. Syst. 1: 397. 1842; Thwaites, Enum. Pl. Zeyl. 52. 1858; Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 261. 1862; Bedd. Fl. Sylv. 3: xxii. 1871; T. Anderson in Hooker f. Fl. Brit. India 1: 272. 1874; W. Ferg. Timber Trees Ceylon, 12. 1881; Trimen, Jour. Linn. Soc. London 24: 143. 1888; Vesque, Epharמוש 2: *tt.* 21, 22. 1889; Trimen, Handb. Fl. Ceylon 1: 99. 1893; Vesque in C. DC. Monogr. Phanerog. 8: 571. 1893; Lewis, Descr. Catal. Ceylon, 20. 1902; Worthington, Ceylon Trees, 35. 1959; *C. retusum* Wall. ex Choisy, Descr. Guttif. Inde, 41. 1849, Mém. Soc. Phys. Hist. Nat. Genève 12: 421. 1851. *Nomen superfluum*. TYPE: Ceylon, *Col. Walker s.n.* (x, herb. Wight. prop.).
- C. burmannii* Wight β [var.] *parvifolium* Wight, Ic. Pl. Indiae Orient. 1: pl. 107. 1839, Illus. Indian Bot. 1: 129. 1840; Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 261. 1862. TYPE: Ceylon, [*Macrae*] 140 (BM, K (herb. Wight. prop.)).
- C. inophyllum* auct., non L.; Lam. Encycl. Méth. Bot. 1: 553. 1783, *pro parte*.
- C. apetalum* Willd. Ges. Natürl. Fr. Berlin Mag. 5: 79. 1811, *pro parte*; Sprengel, Syst. Veg. ed. 16. 2: 571. 1825.

FIGURE 13. Hairs (from terminal bud). a–d, *C. calaba*: a, var. *E* (*Eyma* 3346); b, d, var. *cuneatum* (*SFN* 32594); c, var. *bracteatum* (*SAN* 53447). e–g, *C. bracteatum*: e, f, *Meijer* 878; g, *Kostermans* 23334. h, *C. pervillei* (*Perville* 229). i, *C. verticillatum* (*7929 SF*). j, k, *C. drouhardii* (*Forsyth-Major* 241). l, *C. chapelieri* (herb. *d'Aleizette s.n.*). m, *C. milvum* (*Baron* 4433). n, *C. robustum* (*NGF* 2077). o, *C. rigidum* (*Teysmann, HB* 642). Scale = 60 μ m.



Tree (1-)6.5-15(-25) meters tall, d.b.h. to 90 cm.; outer bark yellowish to dark gray, rough, deeply fissured; latex sparse, clear or semitransparent, yellow.

Twigs strongly flattened, when older drying dark brown, tomentose to sparsely pubescent; internodes 1-4.5(-7) cm. long; terminal bud conical, 5-7 mm. long, with tomentose to adpressed indumentum, uppermost pair of axillary buds about 1/2 its length. Lamina ovate (obovate, elliptic, or trapeziform), (3-)3.9-8.4 by (2-)2.5-4.2 cm., retuse to subacute at apex, broadly cuneate to subacute at base, coriaceous, (7 to) 10 to 14 (to 16) veins/5 mm., angle of divergence 60-75°. Inflorescences with 5 to 13 flowers, frequently branched, the axis 0.25-3.4 cm. long, tomentose on lowest internode (immediately above), lowest internode 2-9(-12) mm. long; pedicels 0.7-2(-2.8) cm. long, rarely incrassate in fruit. Outer tepals glabrous dorsally. Fruit ellipsoid (rarely subspherical).

DISTRIBUTION. Sri Lanka (MAP 5).

SELECTED SPECIMENS SEEN. Sri Lanka: top Diyuluma Falls, *Waas* 489 (US); S. of Mulliattivu, NE. Coast, *Fosberg with Balakrishnan* 53487 (K, US); Uva Prov., Monaragala Distr., Bibile, Baderenkende, 400 m., *Kostermans* 24406 (A, L, US); Bibile, Alutnawara Road side, 237 m., *Worthington* 2975 (BM); "Talawa," Lunnagalla 28/27 Culvert, 620 m., *Worthington* 2964 (A, BM, W); Amparai Distr., Divulana, Nuwaragala F.R., *Jayasuriya* 2084 (K, L); Devulane, Mile 18 Amparai-Kandy Road, *Kostermans* 24843 (A); Labugama reservoir E., 120 m., *Worthington* 3484 (BM), Panadura, 2-4 m., *Comanor* 1002 (A, E, K, MO, US); Ratnapoora, CP 242 (BM, BO, FI, G, GH, K, NY, P, W); W. of Kuchchaveli (N. of Trincomalee), "low" alt., *Kostermans* 24818 (G, L); Wilpattu Natl. Park, Kuruttu Pandi Villu, *Mueller-Dombois & Balakrishnan* 68091007 (A, K, NY); Caltura, *Macrae* 140 (BM, K); Kalutura Distr., Welipenna, Hallawakellae, *Balakrishnan* 1168 (K); Batticaloa Distr., 21 km. NE. of Maha Oya, *Stone* 11175 (KL, US); Batticaloa, "low" alt., *Jayasuriya* 2104 (L); 2 km. W. of Kalkudah, "low" alt., *Jayasuriya et al.* 690 (L, US); NW. Prov. Puttalam Distr., Lihiriyagama, Kalu Mookalana, *Sumithraarachchi* 431 (SY); Kodikamam, *Jayasuriya* 284 (K).

ECOLOGY. Dry or intermediate zone forest, 2-400(-620) m. alt. Often near coast, sometimes on sand dunes; thick bark fire resistant, so plant can grow in grassland; may sprout from cut stumps. *Fosberg with Balakrishnan* 53486 collected in swampy woods. Flowering January to June (flower scented); fruiting January, March, May, June, August, September (fruit green at first, then yellow, finally orange, with pleasant, acid taste).

LOCAL USES. The wood is used for bullock cart poles, spars, and axe handles, and in building. The fruit is sometimes eaten.

19b. *Calophyllum calaba* L. var. *worthingtonii* P. F. Stevens, var. nov.

C. pulcherrimum auct., non Wall. ex Choisy; Trimen, Jour. Bot. London 27: 161. 1889, Handb. Fl. Ceylon I: 100. 1893; Alston in Trimen, Handb. Fl. Ceylon (Suppl.) 6: 22. 1931; Worthington, Ceylon Trees, 32. 1959.

A varietatibus aliis *Calophylli calaba* in ramulis vetuste in siccitate flavescenti-brunneis, gemmis terminalibus indumento appresso praeditis, lamina elliptica raro obovata nervis lateralibus (8-)9-12(-15) per 5 mm. sub angulo 50-65° e costa abeuntibus, et pedicellis in fructu haud incrassatis, differt.

Tree 10-25 meters tall, d.b.h. to 25 cm.; outer bark yellowish, sometimes pustular or scaly, thin; latex not known.

Twigs strongly flattened, when old drying yellowish brown, at first with adpressed indumentum; internodes (0.5-)1.5-4(-5) cm. long; terminal bud narrowly conical, 3-5.5 mm. long, with adpressed indumentum, uppermost pair of axillary buds about 1/3 its length. Lamina elliptic (rarely obovate), 3.5-9 by 1.6-3.9 cm., rounded to acute at apex, cuneate at base, coriaceous, the veins (8 or) 9 to 12 (to 15)/5 mm., angle of divergence 50-60°. Inflorescences with 3 to 5 flowers, unbranched, the axis 0.8-1.2 cm. long, puberulent at base, lowest internode 2-3.5 mm. long; pedicels 7-13 mm. long, (?)glabrous, not thickened in fruit. Tepals glabrous dorsally. Fruit subspherical.

TYPE: Ceylon [Sri Lanka], Ratnapura District, Moropitiya, Mahane-Makulana Forest, ca. 600 m., 1 May 1973, *Kostermans 24691* (holotype, α ; isotypes, ι , US).

DISTRIBUTION. Southwestern Sri Lanka (MAP 6).

ADDITIONAL SPECIMENS SEEN. **Sri Lanka:** Pasdun Korale, Hewesse, *Trimen s.n.*, March 1887 (κ), Mandagale Nukelana, Hewesse, *anon.*, March 1887 (ι); Kegalla Distr., Dickhena, 400 m., *Waas 1662* (GH); Ratnapura Distr., Mahane-Makulana Forest, 600 m., *Kostermans 24699* (α , σ , US); Moropitiya, "low" alt., *Kostermans 24688* (σ , ι , US), *24689* (ι), 100 m., *24659* (ι), Kelinkande, near Moropitiya, 200 m., *Balasubramanian s.n.*, 1973 (ι); Hinidumakale (Haycock), near Hiniduma, 500 m., *Kostermans 25370* (κ , ι); Deniyaya, 50 M.P., Diyadawa Forest, 427 m., *Worthington 2915* (BM); Lower Deniyaya, 150 m., *Worthington 2224* (BM); Labugama Reservoir E., 129 m., *Worthington 3482* (BM); Kanneliya Road from Udeyama State Park, 45 m., *Worthington 5267* (?) (BM); Singaradja F.R., *Meijer 525* (US); So. Prov., Naniketa Ela, 45 m., *Worthington 4137* (BM, NSW); Kurunegala Distr., E. slope of Doluwakanda, 525 m., *Jayasuriya & Balasubramanian 538* (κ , US); Galle Distr., Kanneliya F.R., *Meijer 971* (US); Weerakande, 800 m., *Kostermans 25604* (α , ι); Godekanda (E. of Hiniduma), 150 m., *Jayasuriya et al. 795* (ι , US); sine loco, *CP 242, pro parte* (NY).

ECOLOGY. Slender tree of wet or sometimes rather dry rain forest, sometimes streamsides, 40-800 m. alt. Flowering in March; fruiting April, May, July, September (fruit yellow-orange, with sweet-acid taste).

The varietal epithet commemorates T. B. Worthington, who has collected extensively in Sri Lanka.

19c. *Calophyllum calaba* L. var. *bracteatum* (Wight) P. F. Stevens, comb. nov.

C. burmannii Wight var. *bracteatum* Wight, *Illus. Indian Bot.* 1: 129. 1840 ("var. *bractiatum*"); *C. amoenum* Wall. ex Choisy forma γ Planchon

- & Triana, Ann. Sci. Nat. Bot. IV. 15: 263. 1862, *pro parte*. SYNTYPES: Burma, Tenasserim, *Griffith 439* (κ); Tenasserim or Mergui, *Griffith 595* (κ).
- C. amoenum* Wall. ex Choisy β [var.] *obtusifolium* Choisy, Descr. Guttif. Indé, 42. 1849, Mém. Soc. Phys. Hist. Nat. Genève 12: 422. 1851, *pro majore parte*, in Zoll. Syst. Verzeich. 2: 149. 1854, Pl. Javan. 9. 1858; *C. amoenum* forma β Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 263. 1862. TYPE: Burma, Tavay, 24 Aug. 1827, *Wallich dist. 4849B* coll. Gomez (holotype, σ; isotypes, σ, κ).
- C. retusum* Wall. ex Choisy β [var.] *parvifolium* Choisy, Descr. Guttif. Indé, 41. 1849, Mém. Soc. Phys. Hist. Nat. Genève 12: 421. 1851; *C. amoenum* Wall. ex Choisy forma γ Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 263. 1862, *pro parte*. TYPE: Burma, Moalmyre, 3 March 1827, *Wallich dist. 4849A* (holotype, σ; isotypes, σ, κ).
- C. pulcherrimum* Wall. ex Choisy β [var.] *obtusum* Choisy in Zoll. Syst. Verzeich. 2: 149. 1854, Pl. Javan. 9. 1858. TYPE: Java, ex montosis Seribu, *Zollinger 1566* (?holotype, ρ).
- C. saigonense* Pierre, Fl. Forest. Cochinch. 1: *pl. 105*. 1885; Vesque in C. DC. Monogr. Phanerog. 8: 602. 1893; Pitard in Lecomte, Fl. Gén. Indo-Chine 1(4): 318. 1910; Craib in Schmidt, Bot. Tidsskr. 32: 328. 1915; Lecomte, Bois Indo-Chine, 124. 1925; Craib, Fl. Siam. Enum. 1: 121. 1931; Gagnep. in Humbert, Fl. Gén. Indo-Chine Suppl. 1: 274. 1943; Pham & Nguyễn, Cây-Cỏ Miền Nam Việt-Nam, 179. *bang 62bis E*. 1960; Pham, Cây-Cỏ Miền Nam Việt-Nam. ed. 2. 2: 303. *fig.* 1970; H. Keng, Gard. Bull. Singapore 28: 245. 1976. TYPE: Cochinchine, Beucar, ad flumen Saigon, Dec. 1869, *Pierre 3649* (lectotype, ρ; isolectotypes, κ, ρ).
- C. curtisii* Ridley, Jour. Asiatic Soc. Bengal, II. 59: 176. 1890; Curtis, Jour. Straits Branch Roy. Asiatic Soc. 25: 78. 1894; Ridley, Fl. Malay Penin. 1: 185. 1922; M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 321. 1956; Kochummen, Malayan Forest Rec. ed. 2. 17: 221. 1965; T. C. Whitmore, Tree Fl. Malaya 2: 177. 1973; Corner, Gard. Bull. Singapore Suppl. 1: 104. 1978. TYPE: Malaya, Penang, Government Hill, 500 feet [150 m.], Dec. 1855, *Curtis 523* (isotypes, BM, BO, K).
- C. harmandii* Pitard in Lecomte, Fl. Gén. Indo-Chine 1(4): 318. 1910. TYPE: Laos, Bassin de Attopée, *Harmand 1219* (holotype, ρ).
- C. amoenum* Wall. ex Choisy, Descr. Guttif. Indé, 41. 1849, Mém. Soc. Phys. Hist. Nat. Genève 12: 421. 1851, *quoad spec. cit.*; Wall. Catal. 4849. 1831, *nomen*; Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 263. 1862; Kurz, Jour. Asiatic Soc. Bengal, II. 43: 88. 1874, Forest Fl. Brit. Burma 1: 95. 1877; Theobald, Burma 2: 636. 1883; King, Jour. Asiatic Soc. Bengal, II. 59: 176. 1890; Vesque in C. DC. Monogr. Phanerog. 8: 576. 1893, *pro parte*; Gamble, Pl. Andaman Is. 6. 1903; Brandis, Indian Trees, 55. 1907; Koord.-Schum. Syst. Verzeich. 2: 39. 1910; Parkinson, Forest Fl. Andaman Is. 1: 87. 1922; Craib, Fl. Siam. Enum. 1: 121. 1931; Heyne, Nutt. Pl. Indonesië. ed. 3. 1: 1081. 1950; Maheshwari, Bull. Bot. Survey India 2: 142. *pl. 1*. 1960.
- C. hasskarlii* Teijsm. & Binn. ex Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 273. 1862, *pro parte*.
- C. teysmannii* Zoll. ex Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 275. 1862, *quoad descr. et spec. cit.*, non Miq.; Vesque, Epharmosis

- 2: *tt.* 25, 26. 1889, in C. DC. Monogr. Phanerog. 8: 579. 1893, *pro parte*; Koord. & Valeton, Bijd. Booms. Java 9: 381. 1903; Koord.-Schum. Syst. Verzeich. I(Fam. 187): 6. 1912; Koord. Exkursionsfl. Java 2: 617. 1912.
- C. retusum* auct., non Wall. ex Choisy; T. Anderson in Hooker f. Fl. Brit. India 1: 272. 1874, *pro syn.*; Vesque in C. DC. Monogr. Phanerog. 8: 578. 1893, *pro parte*.
- C. wallichianum* auct., non Planchon & Triana; Vesque in C. DC. Monogr. Phanerog. 8: 559. 1893, *quoad Falconer 761*.
- C. kunstleri* auct., non King; Curtis, Jour. Straits Branch Roy. Asiatic Soc. 25: 78. 1894; Ridley, Jour. Straits Branch Roy. Asiatic Soc. 59: 74. 1911; Foxworthy, Malayan Forest Rec. 2: fig. 1928; M. R. Henderson, Gard. Bull. Straits Settl. 4: 224. 1928; Maheshwari, Bull. Bot. Survey India 2: 141. 1960, *pro parte*.
- C. medium* Zoll. ex Vesque in C. DC. Monogr. Phanerog. 8: 579. 1893, *in synon. Nomen*.

Tree (0.5-)3-40(-49) meters tall, d.b.h. to 158 cm.; outer bark usually yellowish, strongly fissured; latex clear (cloudy) yellow, or almost white.

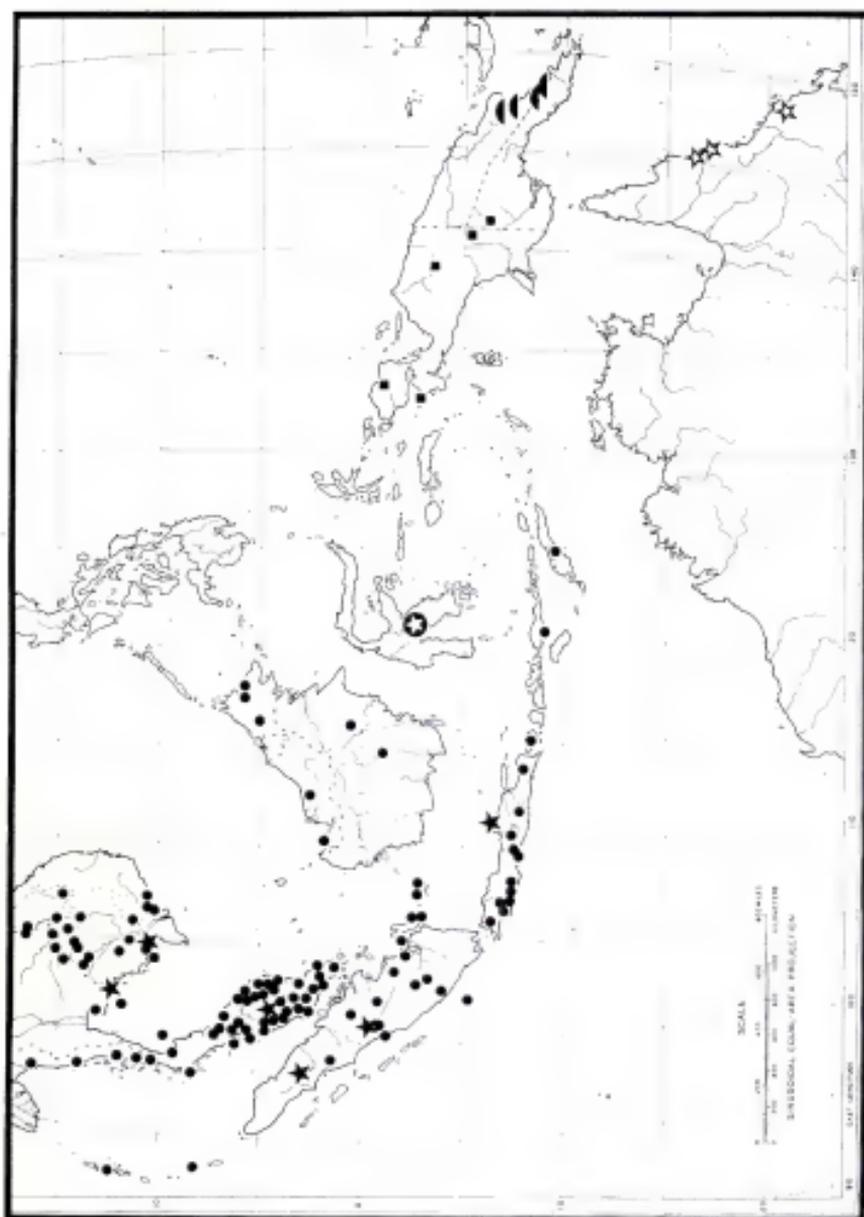
Twigs flattened, drying brown to yellowish, \pm transiently farinose to subtomtose; internodes 0.5-3(-4) cm. long; terminal bud plump to conical, (2.5-)6-11 mm. long, with subcrustaceous to subtomtose indumentum, uppermost pair of axillary buds $\frac{1}{3}$ - $\frac{1}{2}$ its length. Lamina elliptic to ovate (rarely obovate), (1.5-)4.2-13 by (0.7-)1.9-4.7(-5.5) cm., obtuse to subacuminate (rarely rounded) at apex, acute to rounded at base, coriaceous, with 12 to 20 (to 28) veins/5 mm., angle of divergence (50-)60-70(-75) $^\circ$. Inflorescences with 5 to 7 (to 12) flowers, unbranched, the axis (0.2-)0.5-1.5(-2) cm. long, puberulent, especially near base, lowest internode 1-3 mm. long; pedicels 4-11 mm. long, puberulent, incrassate in fruit or not. Outer pair of tepals \pm puberulent dorsally. Fruit \pm spherical.

DISTRIBUTION. Vietnam to Borneo, perhaps also the Sunda Islands and Timor (MAP 9).

SELECTED SPECIMENS SEEN (for explanation of letters, see discussion). **Burma:** Tenasserim Div., Tavoy Subdistr., $\frac{1}{8}$ km. S. of Paungdaw, 549 m., Keenan *et al.* 719 (E); Mayin-Uge, Tenasserim R., 0 m., Parkinson 2001 (K); Kalonta, Tavoy Range, 150 m., Sukoe 10806 (NSW); Moulmein, Falconer 761 (E, W, G, K, M, P); Mergui, Bokpyin, Parker 2764 (A, K), Yangwa Klong, Parker 2722 (A, K). **Vietnam:** montibus Dinh, ad Baria Galliae, Pierre 3643 (W, K, P); Saigon, Botanic Garden, Hlêt 625 (P); Ti Tinh, Tay Ninh, Pierre 86 (K), Cay Cong, Pierre 86 (K), Suôda, Muller 64 (A, W, P), Beaucoit, Pierre 3649 (K, P), Thu Byh, Muller 964 (P); Chudaumot, Chon Canh F.R., Chevalier 30005 (P); Lagi, SE. reserve de Cay Sangh, Evrard 2278 (P), Bin Thoan, Magnein 13 (P); Bien Hoa, Chevalier 36844 (P). **Cambodia:** Pnomh Penh, Béjaud 459 (A, P); Phu Quoc, sinus Siamica, Pierre 3649 (P); ad montem Pra, prov. Samrong Tong, Pierre 779 (A, W, K, P); Siêm réap, Reorp. Bassac, Pierre 779 (K); entre Samlong et Anlong Veng, pres Massif Dangrek, Poilane 13868 (K, P, US); Benteay Srei, J. E. Vidal 4838 (P); Kamput, Pierre 3649 (P); montibus Chiang Kinnig in prov. Pran, Pierre 3643 (P); Prov. de Kompong Chnang, Kralanh F.R., Chevalier 30037 (P), Pny Ong Ep, Chevalier 36899 (P); entre Aulong Veng et Sleik Krei, Poilane 14092 (P, US); Diêm Riép, Angkor Thom,

Banteng Drei, *Smitinand & Abbe 6356* (κ); Kah Kong, près de Thar Bang, 400 m., *Martin 1505* (φ). Laos: Savanna Khet, entre Lang à xinh xa ne et L. xoan, *Poilane 13685* (φ); km. 20 route de Savanna Khet à Quang Tri, *Poilane 11733* (BISH, φ, SING); near Kp. Sralas on W. bank of Mekong R. at Isle of Khong (Veal Tg. Tabeng, 40 km. WSW.), *Wharton 88* (NY); bassin de Sè-Moun, *Harmand 263* (φ); Sedone, environs de Paksè, *J. E. Vidal 4479* (φ). Thailand: Ubon Rachatani, Lam Dom Noi, 120 m., *Smitinand & Turbang 10504* (BKF); Yala, *Put 3670* (A, BM, C, K, P); Lam Lieng, Ranawng, less than 50 m., *Kerr 11733* (A, BM, C, K, P); Bang Son, Chumpawn, 20 m., *Kerr 11318* (A, C, K, P); Kaw Tao, 200 m., *Kerr 16065* (A, BM, C, K, P); Eastern, Si Sa Ket, *Phengkklai 900* (C, E, P); Surat, Kaw, Pa-ngan, *Put 1155* (BM, K), Wang Hin, *Saman 5* (P); Kao Katakam, 600 m., *Kerr 18419* (κ); Kapah-Janjaw, *SFN 2063* (BM, K, SING); Nah Prov., Sriracha Forest, 24 m., *Collins 804* (BM, K, US); Chaizaburi, Nawng Kai, 200 m., *Kerr 8526* (E, κ); Nong Yai boo, *Collins 645* (κ); Boi Et, 90 m., *Wanaraly 62* (κ); Surin, Sangka, 200 m., *Kerr 8271* (C, K, P); Tola, Salut, 50 m., *Kerr 13853* (κ, P); Krat, Kao Saming, *Put 566* (κ); Surat, Chaiya, n.f. Bandon, 10 m., *Seidenfaden 2576* (C, SING); Koh Chang, Klong Son, 266 m., *Schmidt 668* (C, κ); Phangnga, Ko Kho Khao, *Sangkachand (1185)* (BKF), between Thai Miang and Thung Maphrao, 30 m., *Smitinand 4157* (BKF); Phatthalung, Pak Phayum, *Siwanna s.n.*, 20 Oct. 1938 (BKF). Andaman and Nicobar Islands. ANDAMAN ISLANDS: sine loco, *King's collectors 378* (A, P). NICOBAR ISLANDS: Nancowry Harbour, *Kamphövener 2250* (?sapling) (C). Malaya. PERLIS: Bukit Bintang F.R., *KEP 69266* (KEP). KEDAH: Ulu Muda F.R., 305 m., *FRI 6757* (A, K, KEP, SAR, SING); Enggang F.R., 60 m., *KEP 73833* (KEP); Kedah Peak, 1036 m., *KEP 79295* (KEP); Perangin F.R., *KEP 20687* (KEP); Kubang Pasu, Mile 7¼ Jalan Kodiang, *KEP 73654* (KEP); Kuah, *KEP 32913* (KEP); Lankawi, Country Club, *van Balgooy 2316* (L); Bukit Sawak F.R., 15 m. *KEP 73614* (κ, KEP); G. Raya F.R., 90 m., *KEP 66415* (KEP); Tampoi F.R., *KEP 71168* (KEP); K. Nerang, Bukit Perah, 150 m., *KEP 67877* (KEP); Bukit Tangga F.R., *KEP 79256*, pro parte (KEP). PINANG: Ayer Hitam Dam Reserve, *Hardial & Samsuri 202* (A, C, LAE, SAR, SING); Batu Fereng, *Curtis 1425* (BM, K, SING); Muku Head, *Curtis 1425* (κ, SING); Pantai Acheh F.R., *KEP 66354* (KEP, SING). PERAK: near Ulu Kerling, 120–180 m., *King's collector 8597* (BM, G, K, UC); G. Tempurong, Kampar, 305 m., *FRI 5851* (KEP); Thaiping, 120–180 m., *King's collector 8497* (BM, FL, K); Ijok F.R., 45 m., *KEP 68170* (KEP); Larut, 610–914 m., *King's collector 5446* (E, FL, K, U, US); Dindings, Bruas F.R., 30 m., *KEP 69423* (κ, KEP); Parit F.R., *KEP 34263* (KEP); Batang Padang, Behran F.R., 45 m., *KEP 61807* (KEP); Kerian, Pondok Tanjong F.R., 15 m., *KEP 68201* (KEP, SING); Kinta, Tualang F.R., 15 m., *KEP 63271* (KEP); Sungei Palai, Bukit Bujang Malaka, 542 m., *KEP 54732* (KEP). SELANGOR: F.R.1. Kepong, *KEP 71971* (A, BO, K, SING, US); Sungei Buloh F.R., *KEP 13341* (KEP); Ulu Gombak F.R., 762 m., *KEP 79102* (A, BO, K, NY, SAN, SAR, SING); Weld Hill F.R., *KEP 1831* (KEP, SING); Ulu Langat F.R., 270 m., *FRI 15132* (KEP); Rantau Pajang F.R., *KEP 32324* (KEP); Kajang, Bangi F.R., *KEP 23666* (KEP); Klang, Bukit Cheraka, *KEP 38176* (KEP); Kerling, *KEP 32515* (KEP). NEGERI SEMBILAN: Port Dickson, Sungei Menyala F.R., 0

MAP 9. Distribution of *Calophyllum calaba* var. *bracteatum* (circles), *C. calaba* var. *cuneatum* (solid stars), *C. calaba* var. *E* (open star in circle), *C. calaba* var. *australianum* (open stars), *C. brassii* (squares), and *C. robustum* (half-circles) in Southeast Asia–Australia.



m., *KEP 64582* (KEP, SING); Seremban, Cape Rachado, 45 m., *KEP 71467* (KEP); Kuala Pilah, Serting F.R., *KEP 62953* (KEP, SING); Senaling Inas F.R., *KEP 42820* (KEP); Senawang F.R., *KEP 1980* (KEP, SING). MALACCA: Ayer Panas F.R., 45 m., *KEP 64163* (KEP); Bukit Shingei, *Alvins s.n.*, 29 March 1866 (SING). KELANTAN: Bukit Tapah Petri, *KEP 32750* (KEP); Ulu Kelantan, Bertam, 45 m., *KEP 65172* (KEP); Temangan, Kota Bahru, *SFN 33506* (KEP); Kemahang F.R., 21 m., *KEP 93587* (KEP); Ulu Sat, 120 m., *KEP 105445* (KEP); Semarak State Land, Pasir Puteh, 6 m., *KEP 68551* (KEP, SING); Sungei Anak Ketil, S. of G. Rabong, 270 m., *FRI 20700* (KEP, SAN). TRENGGANU: Pulau Laut Tengah, *KEP 30691* (KEP); Ulu Dungan near Sg. Behir, 270 m., *FRI 9367* (KEP); Bukit Bauk F.R., *FRI 16877* (KEP); Kemaman, Bukit Kajang, 150 m., *Corner s.n.*, 15 Nov. 1935 (SING); Jemka F.R., 45 m., *KEP 94722* (K, KEP); Bukit Besi, Mile 6 Jalan Talang, 60 m., *KEP 53365* (KEP); Sungei Kerbet, ca. 3 km. below K. Petang, 402 m., *FRI 20346* (KEP); Padang Kandis, road to Kampong Temila, Besut, *SFN 40346* (BO, E, K, SING). PAHANG: Balok F.R., *FRI 3794* (A, K, KEP, SAN, SING); Taman Negara near Kuala Kenyam, Jeram Belau, 305 m., *FRI 20149* (KEP); Pamah, Bukit Sulai, 60 m., *FRI 9159* (KEP); Temerloh, Kemasul F.R., *KEP 10652* (K, KEP); Rompin [Aur F.R.], *KEP 15463* (SING); Klou F.R., *KEP 92314* (KEP); Kuala Lipis dist., 150 m., *KEP 1266* (KEP, SING). JOHORE: Sungei Kayu, *SFN 32324* (A, K, KEP, SING); Kluang F.R., 60 m., *KEP 72702* (KEP); Renggam F.R., 45 m., *KEP 71273* (KEP); Jemaluang F.R., 33 m., *KEP 69967* (KEP); Ma Okil F.R., *KEP 71279* (KEP); Soga F.R., *KEP 79633* (KEP); Banang F.R., *KEP 79533* (KEP); Sungei Kahang, *KEP 5870* (K, KEP); Panchor, Tg. Sarat Range, *KEP 62819* (KEP). **Singapore:** Garden Jungle, *SFN 39444* (KEP, SING). **Sumatra and adjacent islands.** RIAU: Koeantan, Poelau Kedondong, 100 m., *bb 24798* (BO, L); sud de Peranap, chantiers de Semelinang, R. Kuantan Indragiri, *Normand 613* (P); Upper Riau, Pakanbaru, Tenajan R., 30 m., *Soepadmo 137* (A, BO, C, E, LAE, NY, SING). DJAMBI: Djambi, Ma. Pidjoean, 89 m., *bb 12837* (BO). SELATAN: Banjoeasin, Koeboestrecken, 15 m., *Grashoff 805* (BO, L); Rawas, *Dumas 1539* (BO, L); Lematang Ilir, Semangoes, 100 m., *bb 32255* (BO, L); weg van Boea2 naar de zuidkust, 100 m., *Lütjeharms 4707* (A, BISH, BO, G, K, NY, P, SING, US); Lebong, bij ds. Sekandau, Air Lemaoc, 700 m., *bb 2289* (BO, L). BARAT: Sididjoengdjoeng, Poedak, 290 m., *bb 5528* (BO), Moera, 596 m., *bb 6056* (BO), Padang Lawas, *bb 6627* (BO), Taratak Baroe, 600 m., *bb 5801* (BO); Painan, Baroeng Baroeng Belanti, 400 m., *bb 3994* (BO). UTARA: Angkola en Sipirok, Panobasan, 500 m., *bb 26121* (BO, L, SING). BANGKA: Lobok Besar, 30 m., *bb 34058* (A, P, SING); Bukung, 60 m., *bb 34144* (L); Muntok, Majang, *bb 7590* (BO); Kepo, 10 m., *bb 10677* (BO); Rendik, 20 m., *bb 11567* (BO); Perlang, 5 m., *bb 11634* (BO); Toboali, *bb 1940* (BO). BELITUNG: Tandjong Pandan, 100 m., *bb 11836* (BO); Mangar, *Teysmann s.n.* (BO). **Borneo.** SARAWAK. 1st Division: Mt. Santubong, 210 m., *Chew 1345* (A, AAU, L, SAR, SING, UC). SABAH. Keningau: Sook-Tulid forest, 90 m., *SAN 49660* (SAN). LABUK AND SUGUT: Japanese Trail near mile 80, *SAN 53447* (A, SAN). SANDAKAN: Oil Palm Research Station, Mile 32, Sungei Manjang, 30 m., *Stevens et al. 365* (A); Leila F.R., 30 m., *Stevens et al. 347* (A). KALIMANTAN. TIMUR: Central Kutei, Belajan R. near Long Bleh, *Kostermans 10406* (BO, CANB, K, L, SING). Tengah: Doesson, G. Prarawin, *Korthals s.n.* (young plant) (L). JAVA. BARAT: Bantam, Tjinahoeck, G. Karang Poelasari, 1050 m., *Koorders 2829* (BO); Preanger, 200 m., *van Steenis 5076* (A) (BO), *Warburg s.n.*, anno 1886-1887 (A) (E); Garoer, Pangentjongan, *Koorders 26480* (BO); G. Gede, 1300 m., *Kramer 161* (BO); Soekaboemi, Palaboeanratoe, *Koorders 2883* (BO);

Tjiandjoer, Takoka, *Koorders 11966* (80); G. Mandalagiri, *Lam 113a* (a) (80, L); Tjampaka near Tjidadap, Tjiharoem, G. Karang, 1000-1300 m., *Buwalda 3620* (a) (80, L); in montosis Nengotziembangan, *anon.* (a) (L); Passier Toegoe, *Hasskarl 416* (a) (L); Baya, *Hasskarl 499* (a) (L); Pasir Batoe Lawang, 500-600 m., *Backer 9046* (a) (80); Mt. Seribu, *Zollinger 124* (r). TENGAH: Banjoemas, Tjilatjap, Noesakambangan, *Koorders 34105* (80); Semarang, Ambarawa, Telomojo, G. Andong, 120 m., *Koorders 27784* (80, G); Banjarnegara, Pringombo, *Koorders 33931* (80); G. Muria, Mt. Argodjembangan, 700-1400 m., *Kostermans 6307* (A, 80, SING). TIMUR: Madioen, Ponorogo, G. Wilis Ngebel, 1375 m., *Koorders 2894* (80); Besoeki, Sitoebondo, Pantjoer-Idzen, 1000 m., *Koorders 14474* (80). LESSER SUNDA ISLANDS. BALI: N. of Tabanan, Mt. Batukaru, 1300 m., *Wirawan 463* (A, 80, L). FLORES: Lemo, Golo Ponto, 1500 m., *Schmutz 2977* (L). TIMOR: sine loco, *Teysmann s.n.* (80).

ECOLOGY. Common in lowland to colline mixed dipterocarp rain forest or evergreen forest, to 1400 m. alt. (in Java 700-1400 m. alt.). In Sabah sometimes on acid, sandy soil. Flowering (Vietnam to Sumatra) October to February (once in July in Cambodia and N. Malaya); flower scented. Fruiting December to May (once in July in Vietnam and Malaya); fruit pale yellowish green (Malaya), pale chestnut (Cambodia: *Martin 1505*), or turning purple-black when ripe (Malaya: *FRI 20700*). In Java and Bali flowering May, June, and November; fruiting July and August.

GERMINATION AND YOUNG PLANT. The radicle probably breaks through the stone near the base. The seedling has one pair of leaves (rarely two?). The first internode is 4-12 mm. long, and subsequent ones become gradually longer. The seedling leaf blades are 1.6-3.4 cm. by (4.5-)5.5-7.5 mm., and the next pair of leaves is similar in size. Subsequently produced leaves are narrower, and the young plant has narrowly ovate to elliptic leaf blades up to 20 by 1.75 cm. The terminal bud is functional, and the young plant is erect. (Data on seedlings from *Stevens et al. 365A* (Sabah); young plants similar throughout Borneo).

LOCAL USES. In Cambodia the wood is used for implement handles; the latex is used for shampoo (*Martin 1505*). The fruit is edible. In Thailand the wood is used for bows, furniture, and houses. In Malesia the wood is used for construction, and the latex is used as a fish poison in fresh water. On Bangka the latex is apparently used to cure(?) ulcers (*bb 33144*).

The epithet *bracteatum* alludes to the prominent bracts on the type specimen.

19d. *Calophyllum calaba* L. var. *cuneatum* (Symington ex M. R. Henderson & Wyatt-Smith) P. F. Stevens, comb. et stat. nov.

C. cuneatum Symington ex M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 339, pl. 19, 1956; Wyatt-Smith, Malayan Forest Rec. 17: 113, 1952, *nomen*; Kochummen, Malayan Forest Rec. ed. 2, 17: 217, 1965; T. C. Whitmore, Tree Fl. Malaya 2: 177, 1973. TYPE: Malaya, Pahang, Cameron Highlands, 14 May 1936, *SFN 31232* coll. *Holtum* (holotype, SING; isotypes, A, K, LAE, SING).

C. saigonense Pierre var. *nanum* Gagnep. in Humbert, Fl. Gén. Indo-Chine Suppl. 1: 274. 1943, *pro majore parte. Nomen invalidum.*

C. ?pulcherrimum auct., non Wall. ex Choisy; Henderson, Jour. Malay Branch Roy. Asiatic Soc. 5: 243. 1927.

Tree (3-)15-30 meters tall, d.b.h. to 30 cm.; latex brown (*Kostermans 6285*) or white (*SFN 18002*).

Twigs strongly flattened, drying brown to yellowish, subpersistently farinose to puberulent; internodes 0.5-3.5(-4.5) mm. long; terminal bud plump, (1.5-) 2.5-7.5 mm. long, with subcrustaceous to puberulent indumentum, the uppermost pair of axillary buds ca. 1/3 its length. Lamina elliptic, cuneiform, or suborbicular, 3-8 by (0.7-)1.4-4.5(-5.5) cm., acute to rounded at apex, acute to subcordate at base, very coriaceous, with (9 to) 11 to 17 veins/5 mm., angle of divergence 50-75°. Inflorescences with 3 to 11 flowers; unbranched; the axis 0.5-1.5 cm. long, puberulent, lowest internode 1-3 mm. long; pedicels 0.25-1.5 cm. long, puberulent, incrassate in fruit or not. Outer tepals puberulent dorsally. Fruit spherical.

DISTRIBUTION. Cambodia to Java, scattered (MAP 9).

SELECTED SPECIMENS SEEN. **Cambodia:** Bokor, montagne de l'Éléphant, 900 m., *Poilane 22977* (P); Mt. Cam Chay, val d'Émeraude, 1000 m., *Tixier 2812* (KLU); Poporkville and vicinity, 1000 m., *Stone 9282* (KLU). **Thailand:** Kao Sabap, Chantabun, 500 m., *Kerr 17793* (A, BM, C, K, P). **Malaya.** PAHANG: Cameron Highlands, 1219 m., *SFN 32594* (A, K, KEP, SING, US), near Tanah Rata, 1463 m., *SFN 18002* (KEP, SING); Mentigi F.R., *Kep 30957* (KEP). **Sumatra.** BARAT: Fort v. d. Kapellen, Soengei Talang, 1000 m., *bb 6473* (BO). UTARA: Karoland, res. Siboeatan, 1400 m., *bb 2770* (A, BO, K, SING); Toba, Pokir, *Lörzing 14422* (BO). **Java.** TENGAH: G. Muria, Tjollo, N. of Kudus, 1500 m., *Kostermans 6285* (A, BO, K, SING).

ECOLOGY. Colline or lower montane rainforest, sometimes dwarfed and windswept (Cambodia), (500-)900-1500 m. alt. Flowering November (Cambodia) and March (Sumatra). Fruiting December, and March to May; fruit orange (*Martin 821*) or green, turning black (*Stone 9282*), both from Cambodia.

The epithet *cuneatum* alludes to the lamina shape of the type specimen.

19e. *Calophyllum calaba* L. var. **E**

Shrub ca. 3 meters tall or small tree; latex unknown.

Twigs flattened, 1.5-2.5 mm. across, drying brown, transiently puberulent; internodes 1.5-6.5 cm. long; terminal bud conical, 2-4.5 mm. long, puberulotomentose, uppermost pair of axillary buds about 1/2 its length. Lamina (broadly) ovate, 2.4-8 by 1.5-4.3 cm., subacute to acuminate at apex, ± cordate at base, coriaceous, with 12 to 16 veins/5 mm., angle of divergence 60-70°. Inflorescences with 3 to 9 flowers, unbranched, the axis 1-5(-9) mm. long, subtomentose at least at base, lowest internode 0.5-2.5 mm. long; pedicels 6-10 mm. long, glabrous, not incrassate in fruit. Outer tepals sometimes sparsely puberulent toward base. Fruit ovoid.

DISTRIBUTION. Sulawesi (MAP 9).

SPECIMENS SEEN. **Celebes.** SULAWESI: Malili, 0 m., *Kjellberg 2099* (BO); Lake Matano, near Noeha, 383 m., *Eyma 3346* (A, BO, K, L, U).

ECOLOGY. Shrubbery near beach of lake, 383 m. alt., also at sea level. Flowering in August (tepals ("corolla leaves") with red base, pedicels pink); fruiting in August (fruit blue-black).

19f. *Calophyllum calaba* L. var. *australianum* (F. Mueller ex Vesque) P. F. Stevens, comb. et stat. nov.

C. australianum F. Mueller ex Vesque, *Epharosis* 2: *tt.* 22, 23. 1889, in *C. DC. Monogr. Phanerog.* 8: 574. 1893; F. M. Bailey, *Comp. Catal. Queensland Pl.* 54. 1913. TYPE: Australia [Queensland], Rockingham's Bay, *Dallachy s.n.* (holotype, *v.*)

C. tomentosum auct., non Wight; F. Mueller, *Frag. Phytogr. Austral.* 9(80): 174. 1875; F. M. Bailey, *Synopsis Queensland Fl.* 28. 1883, *Queensland Fl.* 1: 104. 1899, *Queensland Wood*, 17. 1899.

Tree to 20 meters tall, d.b.h. to 30 cm.; outer bark yellowish, fissured, somewhat flaky or tessellated; latex clear, sticky (B. P. M. Hyland, pers. comm.).

Twigs strongly flattened, when older drying brown, transiently puberulent; terminal bud rather plump, 3.5–7 mm. long, with subtomentose indumentum, uppermost pair of axillary buds less than 1/3 its length. Lamina elliptic (rarely suboblong), (3.7–)6–13 by (0.9–)2–3.9 cm., ± cuneate at apex, acute at base, coriaceous, with (6 to) 8 to 12 veins/5 mm., angle of divergence 60–70°. Inflorescences with scars of 5 to 11 flowers, unbranched, the axis 0.4–2.8 cm. long, persistently puberulent near base, lowest internode (0.5–)2–6(–8) mm. long; pedicels 7–12 mm. long, in fruit glabrous, not incrassate. Flower unknown. Fruit ellipsoid.

DISTRIBUTION. Australia, northeastern Queensland (MAP 9).

SELECTED SPECIMENS SEEN. **Australia.** QUEENSLAND: Finch Hatton Gorge, Mackay, *Scanlan s.n.*, 23 Dec. 1964 (BRI); Copperlode Falls dam site, 9.6 km. S. of Cairns, *Gittins 2210* (BRI, NSW); SFR [State Forest Reserve] 143, Little Mossman logging area, 275 m., *Hyland 6757* (LAE); Coast Range, Rockingham's Bay, *Dallachy s.n.*, MEL 44332 (MEL).

ECOLOGY. Rain forest. Fruiting October and February.

The epithet *australianum* was given to this taxon because it was the first species of *Calophyllum* believed to be restricted to Australia.

Calophyllum calaba can be recognized by its usually rather strongly flattened twigs and its medium-sized leaf blades that dry a characteristic olivaceous-sepia color on the upper surface and have fine and usually dense venation. The flowers have four (rarely six) tepals and less than 100 stamens. The spherical-ellipsoid fruits are small and less than 1.6 cm. long; the usually rather thin outer layer of the fruit often becomes disorganized by air spaces, and the

stone has thin walls. The epithet *calaba* is a Carib Indian name for the local form of *C. brasiliense* (see below).

The circumscription and subdivision of *Calophyllum calaba* have given me much trouble. Although *C. calaba* var. *calaba* and var. *bracteatum* differ in numerous, albeit mostly rather minor, characters, they are in part linked by *Calophyllum calaba* var. *worthingtonii* (see 1 below) and the specimens from the Sunda Islands provisionally referred to *C. calaba* var. *bracteatum* (see 3 below); unfortunately the variation of these latter groups is not well understood. The varieties can be recognized by the characters given in the key, but it is clear that the infraspecific classification adopted is liable to be modified.

Sterile specimens of *Calophyllum calaba* var. *bracteatum* from Malaya have been confused with other taxa; see TABLE 6.

There has been considerable nomenclatural and taxonomic confusion over *Calophyllum calaba* and its synonyms, and this is discussed below in some detail.

Circumscription of *Calophyllum calaba*

Planchon and Triana (1862, p. 264) thought that *Calophyllum burmannii* (= *C. calaba* var. *calaba*) was very close to *C. amoenum* (= *C. calaba* var. *bracteatum*), and they distinguished between the two mainly on fruit shape: *C. burmannii* had ovoid fruits, while those of *C. amoenum* were spherical. Vesque (1893, p. 575) thought that *C. australianum* (= *C. calaba* var. *australianum*) was no more than a large-leaved variant of *C. burmannii*, the two agreeing in indumentum and anatomy, but since he did not know the flowers of the latter, he maintained the two. His confusion over *C. amoenum* (see below) probably caused him to overlook the similarity between it and *C. burmannii*.

Calophyllum calaba var. *calaba* has distinctive, moniliform hairs, as noted by Vesque (1893); similar, albeit shorter, hairs occur on *C. calaba* var. *bracteatum*, as in *Hardial & Samsuri 202* (Malaya) and *SAN 53447* (Sabah). However, indumentum variation in *C. calaba* from Sri Lanka is greater than Vesque thought, the hairs of *C. calaba* var. *worthingtonii* having irregular cells in their basal half; there is also considerable variation in specimens from Southeast Asia-Malesia (FIGURES 12, 13). The Javanese specimens provisionally included in *C. calaba* var. *bracteatum* (see 3 below) have hairs with prominent protrusions near the base and thinner cell walls; they are often light colored, rather than brown as in the other specimens. The hairs of *C. calaba* var. *E* consist entirely of large, thin-walled cells (see also below). There are no important anatomical differences in transverse sections of the lamina of specimens from Sri Lanka, from Vietnam to Borneo, and according to Vesque (1893), from Australia. Specimens from the Sunda Islands lack clearly defined latex canals in the lamina (see also Vesque, 1889, 1893, under *C. teysmannii*) but are otherwise similar. There may be considerable variation in fruit color, but few of the observations made so far are reliable. Other variation discussed below is mostly in size and texture of parts and in distribution of indumentum.

Intraspecific Variation in *Calophyllum calaba*

The variation in *Calophyllum calaba* is discussed below under seven headings: 1, specimens from Sri Lanka; 2, the small-leaved Bornean specimens; 3, the specimens collected from the Sunda Islands; 4, Australian specimens; 5, high-altitude specimens with coriaceous leaves; 6, the specimens from the Celebes; and 7, other variation.

1. *Calophyllum calaba* vars. *calaba* and *worthingtonii* are similar in basic leaf type, flower, and fruit, but can be separated by the characters noted above. The differences in bark type, color of the dried twig, and indumentum may be connected with the different habitats of the two taxa. *Calophyllum calaba* var. *calaba*, with fissured bark and often well-developed indumentum, grows in drier places than does *C. calaba* var. *worthingtonii*, which has smooth bark and indumentum that is less well developed. At Labugama Reservoir the two taxa may grow fairly near one another (*Worthington 3484*, var. *calaba*, collected "from a stump"; *Worthington 3482*, var. *worthingtonii*, collected "in a cleared space originally forest"). The indumentum of *Worthington 3484* perhaps approaches that of var. *worthingtonii*. *Kostermans (1976)* thought that plants here placed in *C. calaba* var. *worthingtonii* were the young stage of var. *calaba*, but the situation is not that simple.

It should be noted that in leaf shape, unbranched inflorescence, and indumentum, *Calophyllum calaba* var. *worthingtonii* approaches var. *bracteatum*.

On a sheet of *CP 242 (Calophyllum calaba* var. *calaba*) at Paris there are single flowers in the axils of foliage leaves; these flowers are twice the size of flowers on a normal inflorescence and are borne on pedicels ca. 2 cm. long. The pedicels of *Kostermans 24406* (also var. *calaba*) have become notably incrassate in fruit (cf. var. *bracteatum*), but this specimen is otherwise unremarkable.

2. The specimens from Borneo cited above all have strongly flattened twigs that dry a yellowish color, well-developed, short-tomentose indumentum, and small leaves with petioles 2-5 mm. long and blades (1.5-)2.1-6(-8.2) by 1.1-2.2(-2.7) cm. that are often retuse at the apex; there are 17 to 24 (to 28) veins/5 mm. *Chew 1345* has rather old flowers; *Kostermans 10406* is just past flowering; the other specimens are sterile. Bark characters of trees seen in Sarawak and Sabah are similar to those of Malayan trees and also agree with the description given by Henderson and Wyatt-Smith (*loc. cit.*) for *Calophyllum curtisii*. Specimens with flowers and ripe fruits are needed; however, rotting fruits found under the tree from which *Stevens et al. 365* was taken were apparently similar to fruits of the Malayan specimens, the stone measuring ca. 5 mm. long and across with walls less than 0.2 mm. thick.

3. Although about 50 numbers of the *Calophyllum calaba* complex have been collected from Java to Timor, most are sterile; I do not understand the variation in the area. There is a small group of specimens (denoted by "a" under *C. calaba* var. *bracteatum*, not incorporated into the description) from West Java in which the twigs are only slightly flattened and are sharply

four-angled, the lamina is strongly undulate at the margin, and the veins are relatively distant (only 5 to 9 (to 10)/5 mm.). The base of the lamina is variable in shape and is sometimes subcordate (see 6 below); hence some specimens have been identified as *C. venulosum*! In inflorescence, flower, and fruit there is good agreement with *C. calaba* var. *bracteatum*, and Hasskarl 499 has hairs similar to those typical of *C. calaba*, although with somewhat thinner cell walls.

Of the other specimens from the area, *Teysmann s.n.* (Timor) has branched inflorescences, as have some cultivated specimens from Java in Beccari's herbarium (at FI); the inflorescence axis is often glabrous toward the apex, the pedicels are long (0.7-1.6 cm., to 2 cm. in fruit), often glabrous, and not strongly angled, and the stone wall is 0.15-0.5 mm. thick. The lamina has nine to fifteen veins/5 mm.

Where these specimens differ from *Calophyllum calaba* var. *bracteatum* in inflorescence and flower they approach var. *calaba*. The venation density and fruit with a rather thick outer layer are similar to those of var. *australianum*. Specimens with a more coriaceous lamina approach the Javanese specimens of *C. calaba* var. *cuneatum*.

4. *Calophyllum australianum* is a poorly known taxon from Queensland; I have not seen flowers from this area. However, specimens of *C. australianum* are similar to those of *C. calaba* var. *bracteatum* in facies and fruit, so *C. australianum* is reduced to varietal rank under *C. calaba*, albeit with some hesitation. *Calophyllum calaba* var. *australianum* has fewer than ten veins/5 mm., more or less elliptic leaf blades, and ellipsoid fruits with an outer layer that is relatively thick at maturity and with relatively thick-walled stones. In venation density, leaves of Javanese specimens of *C. calaba* are more or less intermediate between those of vars. *australianum* and *bracteatum*.

5. *Calophyllum calaba* var. *cuneatum* is basically a high-altitude form of the species, and as might be expected, it has more coriaceous leaf blades. The leaf blades of the specimens cited from Cambodia are often rounded at both the apex and the base, while the specimens from Java and Sumatra have rather plump terminal buds and subdepressed midribs. The latex of *C. calaba* var. *cuneatum* is reported as being white or brown; that of *C. calaba* var. *bracteatum* is nearly always clear yellow.

Further collections may show that *Calophyllum calaba* var. *cuneatum* cannot be maintained. If it is assumed that specimens of *C. cuneatum* from Malaya come from under 3000 feet in altitude, they key out as *C. curtisii* (= *C. calaba* var. *bracteatum*) in Henderson and Wyatt-Smith (*op. cit.*). These authors thought that *C. cuneatum* was close to *C. fraseri*; the type specimen of the latter species also has flowers with four tepals. However, whatever the status of that specimen, most of the material placed in *C. fraseri* belongs to a taxon quite unrelated to *C. calaba* (see also the discussion after *C. fraseri*).

The manuscript name "*Calophyllum karoense* Beum." has been used for this taxon (*bb 2770*, see Henderson & Wyatt-Smith, *loc. cit.*).

6. *Calophyllum calaba* var. *E* at first sight looks very different from the other material placed in the species. It has a cordate lamina that is rather undulate at the margin, long internodes, congested inflorescences, and hairs with unthickened cell walls (FIGURE 13, a). However, it seems to approach *C. calaba* from the Sunda Islands, and until more collections are made from this area, it seems premature to describe it formally. Its fruits are reported to be blue-black when ripe, an unusual color for this species.

7. *Helfer 881* (Burma) has strange, almost hastate anthers, but it is otherwise unremarkable.

Nomenclature and Synonymy

Three species were mentioned in the protologue of *Calophyllum calaba*: one from the West Indies (*C. brasiliense* sensu lato, *C. antillanum* sensu stricto); one from Sri Lanka (*C. calaba* sensu stricto); and one from India (*C. apetalum*). A detailed discussion of the nomenclature of these three names has been given elsewhere (Stevens, 1980b); *C. calaba* is to be typified on the element from Sri Lanka.

Identity of *Calophyllum amoenum*

The name *Calophyllum amoenum* has been used sporadically for plants here included in *Calophyllum calaba* var. *bracteatum*, but this is incorrect even if this taxon is maintained at the specific level. Choisy's description of *C. amoenum*, given below, is very muddled, and although Planchon and Triana (1862a) satisfactorily disentangled the taxa involved, their nomenclature unfortunately cannot be followed.

"*C. amoenum* (Wall! cat.) foliis elliptico-lanceolatis acutis, floribus racemosis racemis luxuriantibus divaricatis, petalis 4 post inflorescentiam reflexis minimis. (Wall. cat! no 4849. A. Moalmyre. C. Amherst. 1731. Amherst.) V. quoque ex Griffith in H. Boiss. Folia saepe acutissima et aliquandò semipedalia."

Planchon and Triana (*loc. cit.*, p. 279) noted that there was a specimen of *Calophyllum polyanthum* collected by Griffith, but without number or locality, in Boissier's herbarium at Geneva; Choisy had labeled this specimen *C. amoenum*. Choisy's description of the inflorescence and of the probably eight-lobed flowers (the 4 "petals" plus, presumably, 4 sepals) of *C. amoenum* agree with Griffith's specimen rather than with the Wallich specimens cited by Choisy. The reference to the petals being small and reflexed might better fit specimens of *C. amoenum* as it has often been interpreted, since the four small tepals become reflexed. However, *Wallich dist. 4949C* (c), the specimen on which part of Choisy's description of *C. amoenum* may be based, lacks flowers. Choisy's citation of *Wallich dist. 4849A* and *4849C* under *C. amoenum* is probably due to confusion between these specimens at Geneva. A label of *Wallich dist. 4849A* is attached to an original label of *4849C*, through which the stem of a specimen of the latter number is inserted. Choisy's description of the leaves fits both Wallich's and Griffith's

specimens. *Calophyllum amoenum* is typified by the only unambiguous part of the description (that of the inflorescence), and hence on the unlocalized specimen collected by Griffith; *C. amoenum* so typified is reduced to synonymy under *C. polyanthum*.

If the taxon previously called *Calophyllum amoenum* is recognized as a distinct species, it must be called *C. saigonense* Pierre.

Additional nomenclature and synonymy

The specimen of *Calophyllum burmannii* var. *parvifolium* from Wight's herbarium now at Kew bears the number "140." (At the British Museum there is a probable duplicate of this specimen. It was collected by Macrae and is also numbered 140.) [Macrae] 140 has more oval blades, tomentose twigs, and more richly flowered inflorescences than is usual in *C. calaba* var. *calaba*. The venation is dense (14 to 19 veins/5 mm.), and the specimen is superficially rather different from others. Wight (1840, *loc. cit.*) noted that *C. burmannii* var. *parvifolium* had an inflorescence with more numerous flowers and shorter pedicels than *C. burmannii* sensu stricto, and that the leaves were smaller and more decidedly oval; the twigs were described as being tomentose. However, the variety is not worth maintaining.

Calophyllum burmannii var. *bracteatum* was based on Griffith 439 and 595, purportedly from Malacca (Malaya). Although Wight designated his varieties of *C. burmannii* merely by Greek letters, from his discussion it is clear that he considered them to be varieties. Wight spelled the varietal epithet "bractiatum," which was changed by Planchon and Triana (1862a) to "brachiatum." However, since Wight specifically referred to the bracts of his variety and made no mention of any branching, the epithet should be spelled "bracteatum." The specimen of Griffith 439 at Kew has prominent bracts; the locality of the specimen is given as Tenasserim (in Burma). The specimen of Griffith 595 is in fruit; the locality of one of the two sheets is given as "Mt. Merpu," and that of the other as "Tenasserim."

The type specimens of *Calophyllum amoenum* var. *obtusifolium*, *C. retusum* var. *parvifolium*, and *C. saigonense* are all clearly referable to *C. calaba* var. *bracteatum*. Choisy (1851, *op. cit.*) apparently did not give any rank to the taxa that he designated by Greek letters. However, in a numerical list of Wallich's specimens at the end of his paper (p. 437), he noted under Wallich 4849 "les échantillons marqués de la lettre β [*Calophyllum amoenum* β *obtusifolium*] constituent une variété assez distincte." It seems reasonable to consider the taxa that Choisy designated by Greek letters to be varieties. This argument can be applied to the infraspecific epithet of *C. pulcherrimum* Wall. ex Choisy β *obtusum* Choisy since Choisy recognized varieties elsewhere in the same publication (see also Article 35.3 of the Leningrad Code).

The type of *Calophyllum retusum* var. *parvifolium* is Wallich *dist.* 4849A. Choisy (*loc. cit.*) cited the type as Wallich 1731, from Moalmyre; this is Wallich's original number—and the epithet *parvifolium* Wallich's original name—for the plant.

Choisy cited Wallich *dist.* 4849B, the type of *Calophyllum amoenum* var. *obtusifolium*, as "Wall. cat! no. 4849. B [Wallich's final catalogue number]

Tavay. (W. Gomez). Id. pl. Birm. no. 1731 [an earlier number for the same specimen; W. Gomez was the collector of the plant] et 153. Tavay [the field number of the specimen]."

At the British Museum and Paris there are possible isotypes of *Calophyllum australianum* collected by Dallachy from Rockingham's Bay. Dallachy collected these specimens on September 13, 1867, October 3 and 4 [1867], and February 22, 1868. Since it is unclear from which collections the Paris and London duplicates came, isotypes of *C. australianum* cannot be designated.

A specimen of *Pierre 3649* at Paris, collected at "Beucar, ad Saigon," is designated the lectotype of *Calophyllum saigonense*. This is the only collection that Pierre made near Saigon, and it agrees well with the protologue. Pierre's handwritten notes are attached to a sheet of *Pierre 779* at Paris.

Calophyllum harmandii was separated from *C. saigonense* in a key by Pitard (*loc. cit.*) on inflorescence size; *C. harmandii* was supposed to have an inflorescence with fewer than five flowers, while that of *C. saigonense* had five or more. Gagnepain (1943) considered *C. harmandii* to be an insufficiently known species and did not include it in his key. However, the type specimen of *C. harmandii* has infructescences with seven or more scars and is indistinguishable from *C. saigonense*.

Henderson and Wyatt-Smith, in their description of *Calophyllum curtisii* (*loc. cit.*), noted that *Wallich 4849A* belonged to the same taxon as their species, and so it is not surprising that *C. curtisii* is here reduced to synonymy under *C. calaba* var. *bracteatum*. They ascribed an "umbelliform" inflorescence to *C. curtisii*, but as is characteristic of *C. calaba* var. *bracteatum*, each pair of flowers is separated by an internode, the internodes separating the pairs of the flowers on the end of the inflorescence tending to be longer than the lower ones.

Planchon and Triana (1862a) appear to have been somewhat confused over the taxon that they called *Calophyllum teysmannii*. The description that they gave and the specimens that they cited are referable to *C. calaba* var. *bracteatum*, but *C. teysmannii* is a superfluous name for *C. dasypodum*. This is discussed further under *C. dasypodum*.

20. *Calophyllum bracteatum* Thwaites, Enum. Pl. Zeyl. 51. 1858; Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 280. 1862; Bedd. Fl. Sylv. 3: xxii. 1871; T. Anderson in Hooker f. Fl. Brit. India I: 274. 1874; Vesque, Epharosis 2: tt. 5, 6. 1889; Trimen, Handb. Fl. Ceylon I: 102. 1893; Vesque in C. DC. Monogr. Phanerog. 8: 554. 1893; Lewis, Descr. Catal. Ceylon, 22. 1902; Alston in Trimen, Handb. Fl. Ceylon (Suppl.) 6: 21. 1931; Worthington, Ceylon Trees, 28. 1959. TYPE: Ceylon [Sri Lanka], Saffragam district, Caraila Corle, March 1863, CP 2674 (isotypes, BM, BO, G, GH, FI, K, P, W).

C. acuminatum auct., non Lam.; Moon, Catal. Pl. Ceylon, 41. 1824.

Tree 20-30 meters tall, d.b.h. to 113 cm.; trunk without buttresses; outer bark pinkish red-brown to yellowish, smooth, or very thin and with deep fissures, panels white and wide, with close-set lenticels (Worthington, *loc.*

cit.); inner bark deep red; latex white, resinlike, sparse. Branches pendulous.

Twigs slightly flattened, 1.5–2 mm. across, strongly 4-angled, drying dark brown, subsersistently brown-tomentose; axillary innovations lacking basal scars; internodes to 4 cm. long at beginning of innovation, as short as 3 mm. at end; uppermost pair of axillary buds rounded, to 1 mm. long, erect; terminal bud plump, 6–8(–9.5) mm. long, brown-tomentose (hairs, FIGURE 13, e–g), underdeveloped internode not apparent. Leaves at beginning of innovation: petiole 4.5–9 mm. long, concave above, convex below, soon glabrescent; lamina ovate to elliptic, 6.5–19 by 2.4–6(–8) cm., acuminate at apex, acute to broadly cuneate or subtruncate at base, undulate and slightly recurved at margin, thinly coriaceous, drying umber to dull olivaceous above and olivaceous to sabelline below, often shiny, \pm persistently subtomentose on midrib (sometimes on surface as well), the midrib above rather quickly narrowed at base, slightly depressed at first, becoming \pm raised, 0.2–0.7 mm. wide at midpoint, below raised, slightly striate, the venation above and below subapparent, raised, 8 to 13 veins/5 mm., angle of divergence 60–70°. Leaves at end of innovation: petiole as short as 1.5 mm.; lamina linear to narrowly obovate, 2–5.5 by 0.2–1 cm., often subsersistently short brown-tomentose above and below. Inflorescences from foliate axils toward ends of twigs, with 1 to 7 flowers, unbranched, the axis 0.3–3.6 cm. long, puberulo-tomentose, lowest internode 0.3–0.9(–2) cm. long; bracts elliptic to ovate, 2–5 by 1–2.5 mm., subsistent; pedicels 3–8 mm. long, to 1.7 cm. long in fruit, pubescent, slender. Flower (?)hermaphroditic; tepals 4 or 8, the outer pair ovate to obovate, 5–6 by 3–3.5 mm., cucullate or not, thin, short-tomentose on back, the inner ones obovate to narrowly elliptic, 4–6 by 1.7–3.5 mm.; stamens 80 to 90, the filaments to 2.7 mm. long, the anthers elliptic, 0.4–0.7 mm. long, rounded to retuse at apex; ovary 1–1.2 mm. long, the style 1.8–2.7 mm. long, the stigma subpelate, ca. 0.5 mm. across, slightly radiate. Fruit ellipsoid, 1.5–1.8 by ca. 1 cm., minutely apiculate or not, drying brown, smooth; outer layer not detaching cleanly from stone, ca. 0.4 mm. thick, with large air spaces developing; stone ellipsoid to obovoid, 1–1.65 by 0.65–0.9 cm., rounded to obtuse at apex, the walls ca. 0.2 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Southwestern Sri Lanka (MAP 5).

SELECTED SPECIMENS SEEN. **Sri Lanka:** Southern Prov., Nelliwa, Galle Distr., Kalubowitayan Kanda, *Tirvengadam & Cramer 258* (P, US); Ratnapura Distr., Sinharaja Forest, SE. of Weddagala, *Meijer 878* (A, US); Kurulugala Kanda base, *Wass 405* (K, NY, US); Kuruwita, N. of Ratnapura, 500 m., *Kostermans 23334* (A, AAU, G); Madampe, 180 m., *Worthington 2133B* (BM); Springwood Estate, Rakwana 88/6, *Worthington 2649* (A, BM); Knehija Forest, Udiyama S.P., 60 m., *Worthington 5261* (BM); Nakiyodeniya, 75 m., *Worthington 5254* (BM); Tumbagoda, upper road Balangoda, Rassagala, 800 m., *Kostermans 24464* (E, K, L), above Balangoda, 600 m., *Kostermans 24461A* (L); Moropitya F.R., near base camp 10 km. S. of main road, *Meijer 459* (US).

ECOLOGY. Rainforest, often in river valleys, 50–915 m. alt. Flowering January to March and July; fruiting February and April to July (fruit white (*Kostermans 23334*)).

LOCAL NAME AND USES. "Walu-keena" (Sinhalese). The wood is used for buildings, masts, and plywood.

Calophyllum bracteatum is a very distinctive species easily recognized by the conspicuous alternation in leaf size and shape along the stem. Leaves produced early in the flush are large and are separated by well-developed internodes, while those produced toward the end are much smaller and narrower and are separated by short internodes. The slender inflorescence axis with its subsistent bracts is also a distinctive feature (the name *bracteatum* refers to these rather persistent bracts).

Calophyllum bracteatum is perhaps related to *C. calaba*, which dries a similar color and has rather similar fruits; its hairs strikingly resemble those of *C. cordato-oblongum*, an otherwise very different species.

21. *Calophyllum soulattri* Burman f. Fl. Indica, 121. 1768; F. Mueller, Jour. Roy. Soc. New S. Wales 24: 174. 1890, Bot. Centralbl. 44(1): 29. 1891; Merr. Interp. Rumph. Herb. Amboin. 371. 1917, Philip. Jour. Sci. 19: 366. 1921, Enum. Philip. Fl. Pl. 3: 81. 1923; Holthuis, Blumea 5: 214. 1942; Heyne, Nutt. Pl. Indonesië. ed. 3. 1: 1085. 1950; Sastri et al. Wealth India 2: 20. 1950, *pro parte*; M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 319. 1956; Maheshwari, Bull. Bot. Survey India 2: 142. 1960; Backer & Bakh. f. Fl. Java 1: 386. 1963; T. C. Whitmore, Guide Forests Brit. Solomon Is. 77. 1966; I. H. Burkill, Dict. Econ. Prod. Malay Penin. ed. 2. 1: 416. 1966; T. C. Whitmore, Gard. Bull. Singapore 22: 15. 1967; Meijer, Bot. Bull. Herb. Forest Dept. Sabah 7: 16. 1967; Phạm, Cây-Cỏ Miền Nam Việt-Nam. ed. 2. 2: 300. *fig.* 1970; Foreman, Check List Vasc. Pl. Bougainville, 42. 1971; T. C. Whitmore, Tree Fl. Malaya 2: 192. 1973; Hartley et al. Lloydia 36: 276. 1973; P. F. Stevens, Austral. Jour. Bot. 22: 399. 1974, Jour. Arnold Arb. 57: 175. 1976; H. Keng, Gard. Bull. Singapore 28: 245. 1976; Corner, Gard. Bull. Singapore Suppl. 1: 105. 1978; Perry, Med. Pl. E. SE. Asia, 174. 1980; *C. suriga* Buch.-Ham. ex Carey in Roxb. Fl. Indica. ed. 2. 2: 608. 1832; Roxb. Hortus Bengal. 93. 1814; G. Don, Gen. Syst. 1: 623. 1831, *nomen*; Wight, Illus. Indian Bot. 1: 129. 1840; Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 292. 1862[?]; T. Anderson in Hooker f. Fl. Brit. India 1: 276. 1874; Vesque in C. DC. Monogr. Phanerog. 8: 609. 1893, *nomen superfluum*. TYPE: Java, *Burman s.n.* (G).

Apoterium sulatri Blume, Bijl. Fl. Nederl. Indië 5: 218. 1825. TYPE: Java, *Blume s.n.* (lectotype, L, herb. Lugd. Bat. 903, 343-183).

C. tetrapetalum Roxb. ex G. Don, Gen. Syst. 1: 622. 1831, Hortus Bengal. 93. 1814, *nomen*; Carey in Roxb. Fl. Indica. ed. 2. 2: 608. 1832; Wight, Illus. Indian Bot. 129. 1840. TYPE: "stove plant, native of the East Indies" (n.v.).

C. hirtellum Miq. Pl. Jungh. 201. 1854, Fl. Indiae Batavae I(2): 511. 1859. TYPE: Java, Tjanjor, *Junghuhn s.n.* (holotype, L; isotypes, P, U).

C. cymosum Miq. Fl. Indiae Batavae, Suppl. 1(3): 497. 1861; F. Mueller in Walp. Ann. Syst. Bot. 7: 357. 1868. TYPE: Sumatra occidentalis,

- Paja-Kombo, *Teysmann*, *HB* 653 (lectotype, u; isolectotypes, BO, K, L, MEL).
- C. diepenhorstii* Miq. *Fl. Indiae Batavae*, Suppl. I(3): 497. 1861; F. Mueller in Walp. *Ann. Syst. Bot.* 7: 357. 1868; Vesque in C. DC. *Monogr. Phanerog.* 8: 605. 1893; *C. spectabile* Willd. var. *diepenhorstii* (Miq.) Boerl. *Catal. Pl. Phanerog. Horto Bot. Bogor.* 2: 81. 1901. TYPE: Sumatra, in prov. Priaman, *Diepenhorst*, *HB* 2236 (holotype, u; isotypes, BO, L, MEL).
- C. lanceolatum* Warb. *Bot. Jahrb.* 13: 381. 1891, non Blume, 1825, nec Teijsm. & Binn. 1853; *C. warburgii* Engler in Engler & Prantl. *Nat. Pflanzenfam.* 3(6): 222. 1893, *nomen novum*; Lauterb. *Nova Guinea Bot.* 8: 843. 1912, *Bot. Jahrb.* 58: 13. 1922; A. C. Smith, *Jour. Arnold Arb.* 22: 345. 1941, *pro majore parte*. TYPE: Kei Inseln, anno 1889, *Warburg 20048* (isotypes, A, LAE (frag.), US).
- C. spectabile* Willd. var. *ceramicum* Boerl. *Catal. Pl. Phanerog. Horto Bot. Bogor.* 2: 80. 1901. TYPE: Cult. hort. Bogor. (semina ex Ceram) sub numero *VI C 46* (holotype, BO; isotypes, BO, US).
- C. spectabile* Willd. var. *miquelii* Boerl. *ibid.* 81. TYPE: Cult. hort. Bogor. sub numero *VI C 137* (holotype, BO; isotypes, BO).
- C. kiong* Lauterb. & K. Schum. in K. Schum. & Lauterb. *Fl. Deutschen Schutzgeb. Südsee*, 450. 1901; Lauterb. *Bot. Jahrb.* 58: 11. 1922; O. Schwarz, *Repert. Sp. Nov.* 24: 89. 1927. SYNTYPES: Deutsch Neu Guinea [Papua New Guinea, Morobe Province], Sattelberg, Nuselang, 850 m., 8 Dec. 1893; *Kärnbach 74* (frag., WRSL); bei Laleca, 300 m., 12 April 1889, *Hellwig 657* (WRSL); Sattelberg, 2 Dec. 1898 & 10 Jan. 1899, *Bammler 6* (WRSL).
- C. hibbardii* Elmer, *Leafl. Philip. Bot.* 2: 503. 1908. TYPE: Philippine Islands, Negros Island, prov. Negros Oriental, Cuernos Mountains, Dumaguete, 3500 feet [1067 m.], April 1908, *Elmer 9837* (isotypes, A, BM, BO, E, F, FI, G, K, L, LY, MO, NY, US, W).
- C. lancifolium* Elmer, *Leafl. Philip. Bot.* 7: 2683. 1915 ("C. lancifolia"); Merr. *Enum. Philip. Fl. Pl.* 3: 80. 1923. TYPE: Philippine Islands, Mindanao, Agusan Province, Cabadbaran (Mt. Urdaneta), 1000 feet [305 m.], July 1912, *Elmer 13266* (lectotype, A; isolectotypes, BM, BO, E, F, FI, G, GH, K, L, MO, NY, U, UC, US, W).
- C. zschokkei* Elmer, *Leafl. Philip. Bot.* 7: 2686. 1915; Merr. *Enum. Philip. Fl. Pl.* 3: 81. 1923. TYPE: Philippine Islands, Sibuyan Island, Magallanes (Mt. Giting-Giting), Paula River, 750 feet [225 m.], March 1910, *Elmer 12129* (lectotype, GH; isolectotypes, A, BM, BO, E, F, FI, G, K, LY, MO, NY, P, W).
- C. versteegii* Lauterb. *Bot. Jahrb.* 58: 12. 1922. TYPE: Süd Neu Guinea, Noord Fluss, Nepenthes-Hügel, 25 Sept. 1907, *Versteeg 1748* (isotypes, BO, K, L, U).
- C. cholobtaches* Lauterb. *ibid.* 59: 20. 1924, *pro majore parte*. TYPE: Palau Inseln, Korrör, 10-100 m., 13 Feb. 1914, *Ledermann 14251* (lectotype, WRSL).
- C. solomonense* A. C. Smith, *Jour. Arnold Arb.* 22: 346. 1941, *paratypo excepto*; Whitmore, *Guide Forests Brit. Solomon Is.* 78. 1966, *pro parte*, *Gard. Bull. Singapore* 22: 9. 1967, *pro parte*; P. F. Stevens, *Austral. Jour. Bot.* 22: 398. 1974, *pro parte*. TYPE: Solomon Islands, Guadalcanal, Ma-Massa, Konga, 500 m., 8 Feb. 1931, *Kajewski 2469* (holotype, A; isotypes, BM, BO, BRI, G, L, P, SING).

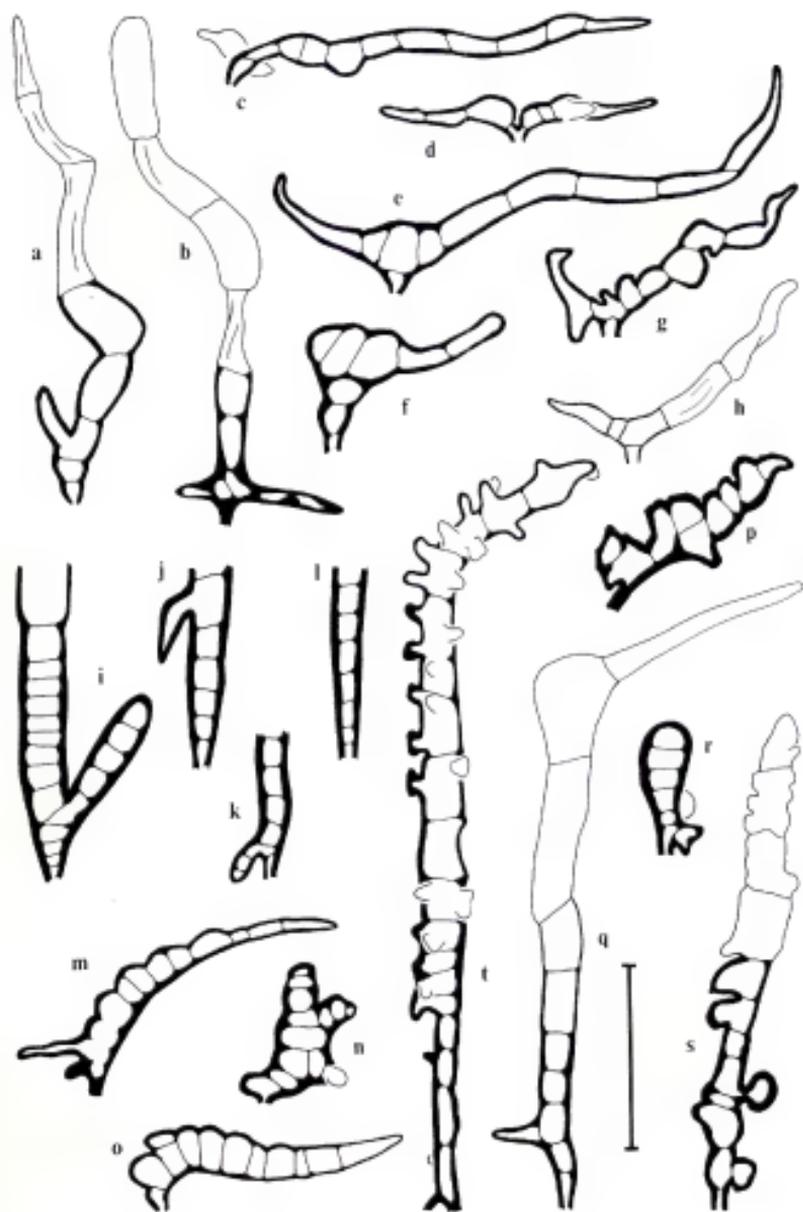
- C. paludosum* C. T. White, Jour. Arnold Arb. 31: 98. 1950; T. C. Whitmore, Guide Forests Brit. Solomon Is. 77. 1966, Gard. Bull. Singapore 22: 14. 1967. TYPE: Solomon Islands, New Georgia, Bupara River, 16 Oct. 1945, BSIP 192 coll. Walker & White (holotype, BRI; isotypes, A, CANB, K, LAE, MEL).
- C. spectabile* auct., non Willd.; Choisy in DC. Prodr. 1: 562. 1824; G. Don, Gen. Syst. 1: 622. 1831, *pro parte*; Moritz, Syst. Verzeich. Zoll. Java, 25. 1845-46; Choisy, Descr. Guttif. Inde, 43. 1849, Mém. Soc. Phys. Hist. Nat. Genève 12: 423. 1851, *pro parte*, in Zoll. Syst. Verzeich. 2: 149. 1854, Pl. Javan. 10. 1858; Miq. Fl. Indiae Batavae 1(2): 511. 1859; Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 266. 1862, *pro parte*; T. Anderson in Hooker f. Fl. Brit. India 1: 271. 1874, *pro parte*; Kurz, Jour. Asiatic Soc. Bengal, II. 43: 88. 1874, *ibid.* 45: 119. 1876, Forest Fl. Burma 1: 94. 1877; Naves in Blanco, Fl. Filip. ed. 3. t. 241. 1879; Fernand.-Vill. Novis. App. 17. 1880; Theobald, Burma 2: 636. 1883; Pierre, Fl. Forest. Cochinch. 1: pl. 107. 1885; Vidal, Rev. Vasc. Pl. Filip. 54. 1886; Vesque, Epharמושis 2: tt. 26, 27. 1889; King, Jour. Asiatic Soc. Bengal, II. 59: 175. 1890; Vesque in C. DC. Monogr. Phanerog. 8: 583. 1893; Drake in Grandid. Hist. Nat. Polit. Madagascar 35: pl. 356. 1896; Gamble, Pl. Andaman Is. 6. 1903; Koord. & Valetton, Meded. s'Lands Plant. 61(Bijd. Booms. Java 9): 386. 1903; Merr. Philip Is. Bur. Gov. Lab. Publ. 27: 20. 1905; Brandis, Indian Trees, 55. 1907; Pitard in Lecomte, Fl. Gén. Indo-Chine 1(4): 323. 1910; Koord.-Schum. Syst. Verzeich. 1(Fam. 187): 5. 1912; Koord. Exkursionsfl. Java 2: 617. 1912; Koord.-Schum. Syst. Verzeich. 3(1): 87. 1914; Ridley, Fl. Malay Penin. 1: 185. 1922, *pro parte*; C. E. Parkinson, Forest Fl. Andaman Is. 1: 87. 1922; Gagnep. in Humbert, Fl. Gén. Indo-Chine, Suppl. 1: 274. 1943; H. Perr. Mém. Mus. Nat. Hist. Nat. Paris, n.s. 24: 77. 1948, in Humbert, Fl. Madagascar Comores, Fam. 136: 5. 1951, *pro parte*; Pham & Nguyễn, Cây-Cỏ Miền Nam Việt-Nam, 179. 1960.
- C. apetalum* auct., non Willd.; Blanco, Fl. Filip. ed. 2. 429. 1845, *ibid.* ed. 3. 2: 415. 1879, *excl. descr. fr.*
- C. acuminatum* auct., non Lam.; Hassk. Abh. Naturf. Ges. Halle 9: 184. 1866.
- C. wallichianum* auct., non Planchon & Triana; Kurz, Jour. Asiatic Soc. Bengal, II. 45: 119. 1876; Theobald, Burma 2: 637. 1883; Maheshwari, Bull. Bot. Survey India 2: 146. 1960, *pro parte*.
- C. pulcherrimum* auct., non Wall. ex Choisy; Fernand.-Vill. Nov. App. 17. 1880.
- C. burmannii* auct., non Wight; Lauterb. Nova Guinea Bot. 8: 309. 1910.
- C. kunstleri* auct., non King; Merr. Philip. Jour. Sci. C. 7: 307. 1912, Sp. Blanc. 267. 1918, Bibl. Enum. Bornean Pl. 393. 1921, Enum. Philip. Fl. Pl. 3: 79. 1923.
- ?*C. odoratissimum* Norona, Verh. Batav. Genootsch. 5(4): 12. 1790. *Nomen.*
- C. oblongum* Koord. ex Koord.-Schum. Syst. Verzeich. (Fl. N. O. Celebes) 3: 87. 1914, Fl. N. O. Celebes, Suppl. 2: pl. 89. 1922. *Nomen.*
- C. treubii* Koord. ex Koord.-Schum. Syst. Verzeich. (Fl. N. O. Celebes) 3: 87. 1914, Fl. N. O. Celebes, Suppl. 2: pl. 88. 1922. *Nomen.*
- C. celebicum* Koord. (*pro majore parte*), *C. minahassae* Koord., et *C. wigmannii* Koord. ex. Koord.-Schum. Syst. Verzeich. (Fl. N. O. Celebes) 3: 87, 88. 1914. *Nomina.*

- C. sorsogonense* Elmer ex Merr. Enum. Philip. Fl. Pl. 3: 81. 1923, in synonym. sub *C. zschokkei*, nomen; Elmer, Leaflet. Philip. Bot. 10: 3744. 1939. *Nomen invalidum*.
- C. inophyllum* auct., non L.; Holthuis, Blumea 5: 214. 1942.
- Calophyllum* sp. Walker, Forests Brit. Solomon Is. Prot. 124. 1948.
- C. canum* auct., non Hooker f.; Keith, N. Borneo Forest Rec. ed. 2. 2: 313. 1952, *pro parte*.
- C. lowii* auct., non Hooker f.; J. Anderson, Trees Peat Swamp Sarawak, pl. 26b. 1973.

Tree 4.5–26 meters tall (rarely shrub), d.b.h. to 70 cm.; trunk very rarely buttressed, spurred, or with small knee roots to 7 cm. tall; outer bark usually yellowish to pale brown, with distant, shallow, boat-shaped fissures, often slightly flaky and scaly, not hoop marked, inner surface straw colored to sulfur or bright yellow; under bark reddish; inner bark dark to pale red; latex usually white and fluid (yellowish brown to yellow, especially in Solomon Islands).

Twigs rather strongly flattened, (1–)1.5–4.5(–5.5) mm. across, 4-angled (rounded, or 2- or 6-angled), with obscure horizontal line at node, drying brown (yellowish), subglabrous to persistently tomentose; axillary innovations lacking basal scars; internodes (0.5–)1.5–10 cm. long; uppermost pair of axillary buds pointed, (0.5–)2–5 mm. long, erect (rarely \pm spreading, or inconspicuous); terminal bud conical, 0.4–2 cm. long, with short, grayish- to brown-adpressed to brown-tomentose indumentum (hairs, FIGURE 14, a–m), underdeveloped internode lacking (–2 mm. long). Petiole (0.15–)0.6–2.7 cm. long, broadly (rarely deeply) concave above, convex below, glabrous to subsersistently tomentose; lamina ovate to elliptic or suboblong (rarely subobovate), (3.5–) 6.5–29(–36) by (1.5–)2.4–10.2 cm., acute to acuminate (rarely rounded or truncate and apiculate) at apex, acute to cuneate (rarely rounded to shallowly cordate) at base, usually closely undulate and slightly recurved at margin, coriaceous, drying amber to olivaceous-buff above and sepia to sabelline-olivaceous below, glabrous to subsersistently tomentose on midrib above and below (rarely entire lower surface initially tomentose), the midrib above usually narrowing rather quickly (gradually) near base, \pm broadly depressed at base or not, raised (very rarely surrounding leaf also raised), 0.15–0.4(–0.6) mm. wide at midpoint, below raised, striate to subangled or rounded, the venation on both surfaces subobscure to apparent, finely raised, (6 to) 12 to 18 (to 21) veins/5 mm., angle of divergence (60–)65–80°. Inflorescences from foliate axils, with (3 to) 7 to 21 flowers, usually flabellate, branched,

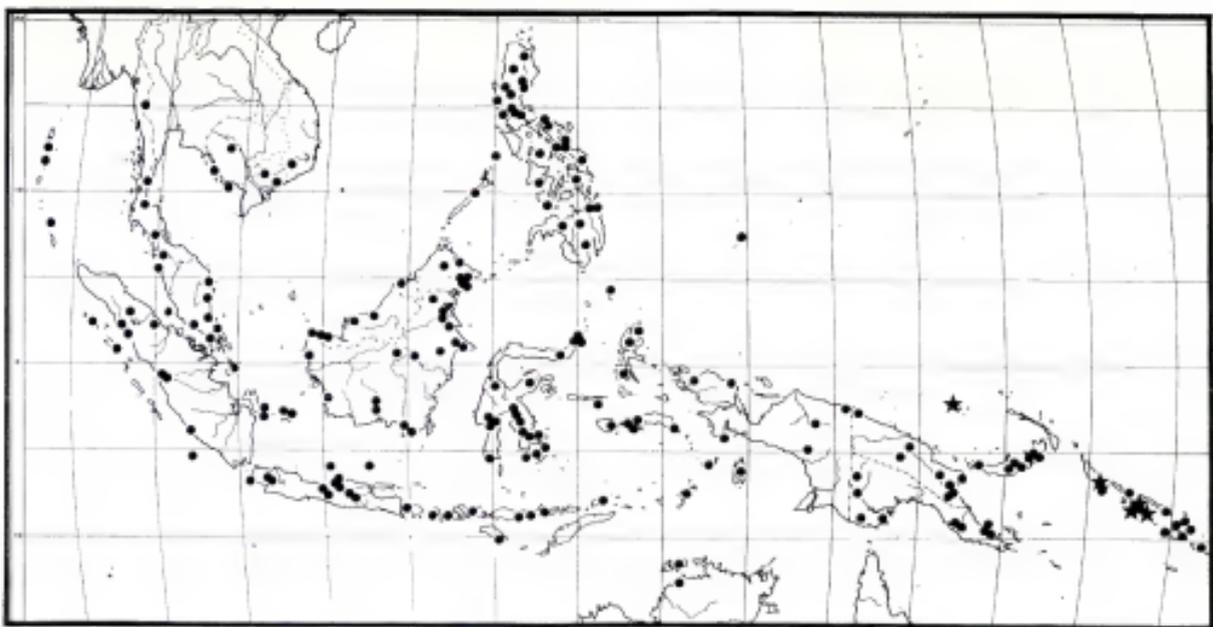
FIGURE 14. Hairs (from terminal bud, unless otherwise indicated). a–m, *Calophyllum soulattri*: a, LAE 52389; b, Sinclair 10866; c, BS 38937; d, BS 38967; e, Kuswata & Soepadmo 232; f, Brass 2469; g, h, NGF 15542; i–l, *Cel./V-318* (hairs to 840 μ m. long, individual cells to 230 μ m. long), j–l, from stem; m, *Kostermans & Soegeng 237*, much variation on this specimen. n–s, *C. rigidum*: n, SFN 30873; o, S 13704; p, *Teysmann, HB 642*; q, *Teysmann, HB 11379*; r, *FRI 8109*; s, *Hallier 2138*. t, *C. moonii* (*Kostermans 24670*), apical cells sometimes thin walled. Scale = 120 μ m.



branches with up to 5 flowers and to 2.7 cm. long, the axis to 0.3-3.5 cm. long, puberulent to tomentose at base, often glabrous toward top, lowest internode to 0.5(-1.7) cm. long; bracts ovate, to 6 mm. long, tomentose on lower surface, deciduous; pedicels 0.6-2.8(-3.2 in fruit) cm. long, glabrous (rarely tomentose), usually slender. Flower (?) hermaphroditic; tepals 4, the outer pair ovate, 4.5-6 by 3-5 mm., rarely tomentose on back, the inner pair \pm obovate, 5-9 by 3.2-5 mm.; stamens 40 to 140, the filaments to 4 mm. long, the anthers oblong, 0.7-2.5(-3) mm. long, rounded to retuse at apex; ovary 1-2 mm. long, the style 1.5-2.5 mm. long, the stigma peltate, 0.4-0.7 mm. across, 3- (rarely 4-) radiate. Fruit \pm spherical, 0.9-1.6(-2.2) by 0.9-1.5(-1.8) cm., often apiculate, drying blackish, pruinose, smooth (rarely wrinkled); outer layer detaching cleanly from stone, (1-)1.5-3.5 mm. thick, compact, air spaces sometimes developing under skin; stone subspherical, 0.7-1.1(-1.5) by 0.65-1(-1.3) mm., rounded at apex, the walls 0.2-0.4(-0.8) mm. thick, smooth, unmarked, basal plug sometimes present; spongy layer thin.

DISTRIBUTION. Vietnam to Australia (Northern Territory), the Solomon Islands, and Palau Island; more or less naturalized on the Mascarenes (MAP 10).

SELECTED SPECIMENS SEEN (for explanation of letters, see discussion). **Vietnam:** Haut Donai, stat. agric. de Blao, 800 m., *Poilane* 22402 (BO, K, P); Baochang ad Bienhoa, *Pierre* 1797 (K, P); montibus Dinh ad Baria Gallia, *Pierre* 1797 (K, P); ad Caybê in Galliae Austria, *Pierre* 435 (A, BM, BO, MO, NY, P, SING, US); Bienhoa, Trang Bom, *Poilane* 23613 (B, K, P). **Cambodia:** Phu Quoc, *Pierre* 3646 (P); Phom Kohay, Pursat, *Muller* 635 (P); Koh Kong, Kirirom, *Dy Phon* 2012 (P). **Thailand:** Tripagodas, ca. 40 km. N. of Wangka, 280 m., *Bloembergen* 536 (A, BO, BRI, K, P, SING); Bangsak, Trang, under 50 m., *Kerr* 19035 (A, BM, C, K); Bang Son, *Put* 1562 (BM, K); Suradhanee, Prasong, Hue Din Sua, *Boonchu* s.n., 18 Oct. 1933 (BKF). **Andaman and Nicobar Islands.** MIDDLE ANDAMAN: Amit-la-ted [Claudius Range], *Parkinson* 1173 (A); Middle Strait, *Kurz* s.n., *pro parte* (K); Dhany Khari, *King's collector* s.n., 31 Oct. 1894 (A); Port Mount, *King's collector* s.n., 19 Oct. 1894 (A, P); Ani Khet, *King's collector* s.n., 13 June 1891 (E). SOUTH ANDAMAN: Port Blair, *Parkinson* 696 (A). CAMORTA: sine loco, *Kurz* s.n., Feb. 1875 (K). **Malaya.** PERLIS: State Land Bukit Keterin, 15 m., *KEP* 73912 (KEP). KEDAH: Bukit Tunga F.R., *KEP* 79256, *pro parte* (KEP). PINANG: sine loco, *Wallich* dist. 4841D (BM, G, K). NEGRİ SEMBILAN: Pasoh F.R., *anon.* s.n., 9 July 1974 (KEP). MALACCA: in a garden, *Maingay* 1063 (*Kew* dist. 167) (K). KELANTAN: Kemalrang F.R., T. Meserh, *KEP* 84795 (KEP). PAHANG: Kuantan, *KEP* 15748 (SING); Endau, *KEP* 29640 (SING). JOHORE: Sungei Gembut, *SFN* 36806 (A, K, KEP, LAE, SING); Sungei Tuenseh, *Corner* s.n., 10 June 1934 (KEP, SING); Jason Bay, *Sinclair* 10866 (A, B, E, FI, G, K, NY, P, SING); Kuala Sedili, *Kadim & Noor* 247 (A, BO, K, LAE, SING); Pulau Pisang, *Wyatt-Smith* s.n., 18 Nov. 1954 (KEP); Pulau Yu, 40 m., *Allen* s.n., 30 July 1955 (SING). MALACCA STRAITS: Pulau Jarak, *KEP* 71009 (KEP, SING). **Sumatra and adjacent islands.** RIAU: Lingga, Semarang, 20 m., *Binnemeijer* 7540 (BO, L); Asahan, Boerach Batoe, 30 m., *Yates* 2106 (BO, K, L, MICH, NY); T [ebing] Tinggi, 5 m., *Bruinier* 160 (BO). SELATAN: Benkoelen Is., Malakoni, 20 m., *bb* 19720 (A, BO); Enggano, Boea-Boea, 100 m., *Lütjeharms* 3882 (A, BISH, BO, K, NY, P, SING, US). BARAT: near Pajakumbuh, Haran Canyon, 150 m., *Meijer*



MAP 10. Distribution of *Calophyllum soulattri* (stars, collections with stones that have basal plugs; circles, all other collections) in Southeast Asia-Australia.

5394 (L, SING), Tjiakar, 500 m., *Meijer 4765* (CANB, K, L, SING), base of Mt. Sago, Kampong Padang Panjang, 600 m., *Meijer 5648* (L); Priaman, *Diepenhorst, HB 2359* (BO, L, U). UTARA: Padang Si Dimpoean, Padang Lawas, Sosopan, Aek Si Olip, *Toroës 5447* (A, G, K, NY); Is. Morsala, Silabua, 5 m., *Kostermans' collector 16*, anno 1951 (A, BO, K, L, SING); Sibolga, Baroës, Koboen (M. Tapoës), 0 m., *bb 31028* (A, BO, L, NY, SING); Zuid Nias, Hili Batoe, 10 m., *bb 5754* (BO). ATJEH: Karolanden, Lao Pengoeloe, *bb 12514* (BO), Lao Soeloe, 200-300 m., *bb 9287* (BO); Labeohan Batoe, Bila, Goenoeng Panjaboengan, *Toroës 4357* (A, NY, US), Pasar Baroe, *bb 8890* (BO), Goenting Sago, *bb 7725* (BO); Simaloer Is., Tapah (Defajan), *Achmad 1691* (BO, L). BANGKA: Lobok Besar, Perlang near Kabu, 50 m., *bb 34191* (A, K, SING); Rias, 10 m., *bb 15396* (BO, L); Gadoeng, 20 m., *bb 10567* (BO). BELITUNG: Tandjong Pandan, Air Malih, 30 m., *bb 9185* (BO); Mangar, *Teysmann s.n.* (BO). **Borneo and adjacent islands.** SARAWAK. 1st Division: Kuching, *S 21597* (K, L, SAR, SING); Lundu, *S 9558* (K, L, SAR, SING); Semengoh F.R., 30 m., *Stevens et al. 285* (A); Mattang, *Beccari P. B. 1299* (F); Telok Paku, Bako N [atl.] P [ark], *S 14751* (A, K, SAN, SAR, SING). 3rd Division: Batang Lassa, *S 33634* (f) (KEP, SAN, SAR). 4th Division: Batang Bintulu, 0 m., *S 12098* (K, L, SAN, SAR, SING). BRUNEI. Andalau F.R., 60 m., *Ashton s.n.*, July 1959 (SAR); Sungei Samit (Belait), *KEP 30429* (K, KEP). SABAH. Ranau: Mile 9, Telupid-Ranau road, *SAN 73828* (K, L, SAN). Sandakan: Ulu Dusun F.R., 5 m., *Stevens et al. 350* (f) (A). Kinabatangan (Lamag): Bintang Mas Karamuak, 21 m., *SAN 81641* (A). Lahad Datu: Matrid, *A 2493* (K, KEP, L, SING); Silam, 90 m., *SAN 47680* (K, L, SAN, SAR, SING); Pulau Sakar, 12 m., *SAN 25363* (K, KEP, L, SAN, SAR, SING); Kelumpang F.R., Mostyn Lor Malang, 30 m., *SAN 40883* (K, L, SAN, SING); Tembaran Is., 30 m., *KEP 80511* (KEP); Kunak, 15 m., *SAN 68098* (K, L, SAN); Madai F.R., 90 m., *SAN 46117* (K, L, SAN). Semporna: Semporna, near Agr. Station, *SAN 26321* (?f) (BO, K, KEP, L, SAN, SAR, SING). KALIMANTAN. Timur: Salimbatoe, Sungei Roemah, 25 m., *bb 11237* (f) (BO); Mara, 150 m., *bb 10833* (f) (BO); Mt. Ilas Bungaan, 400 m., *Kostermans 13937* (f) (BO, K, KEP, L, LAE, NY, SING); Tandjong Redeb, Kelai R. near Long Lanuk, 10 m., *Kostermans 21129* (f) (BO, CANB, G, K, L); Tundjung Plateau, near Djohan Asa, 100 m., *Kostermans 12623A* (BO, CANB, K, KEP, L, SING); Tidoengsche Landen, Malinau (Kabiran), 10 m., *bb 17855* (A, BO); Bloe-oe, *Jaheri 1489* (BO); W. Koetei, Mendom (Sei Atan, Klindjan), 100 m., *bb 29268* (f) (BO, L, MO); Boven Makaham, Laham, 40 m., *bb 20607* (A, BO); E. Koetei, G. Tepian Lobang, on Menubar, NE. of Sangkulirang, 200 m., *Kostermans 6034* (f) (A, BO, K, SING). Selatan: G. Pamatton, *Korthals s.n.* (L); Doesson, *Korthals s.n.* (L); Martapoera, Manoekapan, *Labohm 2071* (BO), Djoengoer, 350 m., *bb 10413* (BO); Afd. Pleihari, Kampong Kintap, *bb 2154* (BO, L), Bentok Darat, 300 m., *bb 10723* (BO); Sungei Alang, 200 m., *bb 14199* (BO). Tengah: Sampit, Samrang, 30 m., *bb 10540* (BO), Koeling, 10 m., *bb 9858* (f) (BO); Afd. Beneden Dyak., Sei Kladan (Kahajan), *bb 2097* (BO, L). Barat: Moera Kojong, 10 m., *bb 7479* (BO); Palo, 5 m., *Becking 35* (BO); Mempewa, Toho, 25 m., *bb 6326* (\pm f) (BO). **Philippine Islands.** PALAWAN: Binohan Mt., near Puerto Princesa, *Ebalo 395* (A, NY, UC). CALAMIAN: Busuango Is., Malbato, *Marche B305* (P). MINDORO: Mt. Yagaw, 500 m., *PNH 19091* (L, PNH). LUZON. Mountain: Bontoc subprov., *Vanoverbergh 1888* (?h) (P), *3280* (?h) (F). Cagayan: sine loco, *FB 22061* (US). Nueva Vizcaya: Caraballo Mt., *Loher 13636* (M, US). Pangasinan: sine loco, *FB 8298* (NY). Nueva Ecija: sine loco, *FB 22182* (BM, BO, P, US). Aurora: Baler, Principe, *Merrill 1049* (K, NY, US). Bulacan: Angat, *Species Blancoanae 336* (A, BM, BO,

F, GH, K, MO, NY, P, US, W). ZAMBALS: sine loco, *FB 5841* (?c) (LY). RIZAL: Montalban, *Loher 12299* (h) (A, M, UC); Manila, San Mateo, *Vidal 976* (FI, K). BATAAN: Lamao R., Mt. Mariveles, *FB 1812* (K, NY, US). LAGUNA: Famy, Minayotan, 500 m., *PNH 39376* (= *Lagrimas s.n.*, 23 March 1959) (c) (A, L, PNH, SAN, SING); San Antonio, *FB 13197* (BM, BO, K, LY, P, US). QUEZON: Mt. Binuang, *BS 28632* (h) (A, BO, K, P, US); Lucban, 1000 m., *Elmer 7525* (s) (A, BO, E, F, FI, G, K, L, LY). CAMARINES NORTE: sine loco, *FB 30616* (NY). CAMARINES SUR: Sipaco, *FB 30331* (SING). ALBAY: Monito, *FB 27383* (c) (A); Bataan Is., *BS 80689* (K, MICH, NY). SORSOGON: Cumadcad R., 150 m., *PNH 9776* (c) (A, PNH); Irosin (Mt. Bulusan), *Elmer 17385* (s) (A, BISH, BM, BO, C, F, FI, G, GH, K, MO, NY, P, U, UC, US). CATANDUANES: sine loco, *BS 30293* (A, US). SIBUYAN ISLAND: Capiz, Magellanes (Mt. Giting Giting), 310 m., *Elmer 12293* (BISH, BM, BO, E, F, FI, G, K, MO, NY, W). TICAO ISLAND: sine loco, *FB 1085* (K, NY, US). SAMAR: sine loco, *BS 17493* (BM, K, US). LEYTE: sine loco, *Wenzel 1613* (A, BM, F, G, MO, NY). NEGROS: Negros Oriental, Dumaguete, Cuernos Mts., 1067 m., *Elmer 9837* (h) (A, BM, E, FI, G, K, LY, MO, US, W). PANAY: Guimaras Is., *FB 317* (NY, US). MINDANAO. SURIGAO: sine loco, *FB 25074* (A, K, US). AGUSAN: Cabadbaran (Mt. Urdaneta), 610 m., *Elmer 13989* (A, BISH, BM, C, E, F, FI, G, GH, K, LY, M, NY, P, U, W). LANAOS: Lake Lanao, Camp Keithley, *Clemens s.n.*, Feb. 1907 (G), June, 1907 (K). Bukidnon: Mt. Candoon, *BS 38937* (h) (A, K, P, US); Mt. Dumalucpihan, *BS 38967* (A, P, US); Kimantri Plain, Malaybalay, *FB 30279* (B, BO, P, US). DAVAO DEL SUR: Santa Cruz, *Williams 2770* (A, NY, US). **JAVA and adjacent islands.** BARAT: Buitenzorg, Tjikeumeuh, 250 m., *Bakhuisenf. 3563* (BO, L, U); Pakantjilan, *Bakhuisenf. 276* (U); SE. van Depok, Tjilong, *Backer 31212* (BO); Bodjong Eyot., 200 m., *Bakhuisenf. 6351* (BO, L); Tjitjadas, SE. of Batavia, 15 m., *Lanjouw 8* (A, BO, K); Kampong Baru, 200 m., *Schiffner 2245* (A, BO, K); Kampong Nangrang, 250 m., *Schiffner 2244* (BO, L); Tjamplong, *Kuhl & van Hasselt s.n.* (L); Udjong Kulon Nature Reserve, Mt. Pajung, 300 m., *Kostermans s.n.*, 17 Dec. 1960 (A, BO, L, SING); Tjiluluran-Sangiang Sirah, 100-300 m., *Wirawan 344* (f) (BO, K, L, SING). TENGAH: Djokjakarta, Sleman, Kalioerang, 1000 m., *Ja 2569* (BO, L); Karel bij Karangmodjo, *Boerrigter 855* (BO); Semarang, *Koorders 2873* (BO, C); Kedoengdjati (Djambosschen), *Koorders 25403* (BO); Djapara, Soemanding, *Ja 1837* (BO); Kedoe, Weetoetoe, W. van Kedjadar, 500 m., *Plokhheim s.n.*, 9 Nov. 1921 (BO). TIMUR: montis Ngebell, prope Pondrongo, *Waitz s.n.* (L); Kediri, G. Pandan, *Thorenaar 204* (BO). KARIMOENDIAWA: Tandjong Gelam, *Karta 305* (BO). BAWEAN ISLAND: G. Besar, 400 m., *Buwalda 3192* (= *Ja 4234*) (f) (A, BO, L). **Lesser Sunda Islands.** BALI: Mt. Sangiang, 500 m., *Kostermans s.n.*, 7 July 1958 (f) (L). LOMBOK: Mambalan, 600 m., *bb 21396* (A, BO). SUMBA: Loka-Winggor, *Teymann, HB 8826* (BO); Djagamango, 975 m., *bb 5400* (BO). SUMBAWA: Mt. Batulanteh, 500-600 m., *Kostermans 18611* (f) (BO, G, L, P), 19076 (A, BO, C, CANB, G, LAE, NY, P, SING); Matemaga, 650 m., *bb 14050* (BO); Kawowo, 700 m., *bb 12024* (BO). FLORES: Ngada, Keo, 1400 m., *bb 21428* (BO, L); S. part Mt. Ndebi, 400 m., *Kostermans s.n.*, April 1965 (f) (L); Werang (Kempo), 350 m., bis Berg Beliling, 1600 m., *Schmutz 2018* (?f) (L); Denge to Wai Rebo, 900 m., *Schmutz 3537* (f) (L); Nunang, 900 m., *Schmutz 663* (?f) (L); Ngada, Nderoe, 800 m., *bb 11399* (BO); Maoemere, G. Egon, 1703 m., *bb 6897* (BO). SOLOR: Belodoea, 750 m., *bb 15975* (BO). WETAR: Kali, N. v. Ilwaki, 700 m., *bb 27200* (?f) (BO, K, L, SING). **Celebes.** TALAUD: Karakelang, G. Duata, 200 m., *Lam 2925* (A, BO, K), G. Piapi, 400 m., *Lam 3263* (BO, K). SULAWESI: Manado, Amoeang, Loban Kolai, 250 m., *bb 17133* (A, BO); Paloe, Ngilalaki,

1250 m., *bb* 28259 (BO), Banggai, Pongian, 100 m., *bb* 31876 (r) (BO); Minahassa, Kajoewatoe, 200 m., *Koorders* 17292 (BO, P), bij Tondano, 900 m., *Koorders* 17302 (BO, P), Pinamorongangeberge, 500 m., *Koorders* 17301 (BO, P); Boleäng Mongondow, Rangagon, 250 m., *bb* 32482 (BO); B. Boalemo, Popaja, 250 m., *bb* 15698 (BO); Mamasa, Pena, 1500 m., *bb* 33066 (?) (BO, L); Enrekeng, Rantalemo, 1100 m., *bb* 29191 (BO, SING); Todjamboe, 700 m., *Kjellberg* 2946 (BO); Liasa, 300 m., *Kjellberg* 2263 (BO); Kosali-Porema, 500 m., *Kjellberg* 2615 (BO); Djenepono, Lembaja, 1650 m., *bb* 8576 (BO); Malili, *Kjellberg* 2033 (r) (BO), nabij La Rona, *bb* 2370 (BO), Boschafd. Bataemati, 600 m., *bb* 23570 (BO), B. Takale Kadjoe, 1500 m., *bb* 24074 (?) (BO, L), Oesoe, *Cel.* III/63 (r) (BO), Kawata, 200 m., *Cel.* V/318 (r) (A, BO); Sungei Tolewou, *Musser et al.* 528 (A); Sungei Sadaunta, *Musser et al.* S-19a (A); Wavotobi, 100 m., *Kjellberg* 864 (BO); Lepo-Lepo, presso Kandari, *Beccari s.n.* (Fl, herb. Becc. 1138); Mengkoka, Kolaka, 0-100 m., *Elbert* 3229 (r) (A, BISH, BO, CANB, FI, G, SING, US), KABAENA: Balo, Eempuhu, *Elbert* 3305 (r) (BO), MUNA: Onsoeme, 100 m., *bb* 21773 (r) (A, BO), BUTUNG: Bone, Bonteriloe, 1100 m., *bb* 29018 (BO), *Moluccas*. SANANA: Molboefa, 200 m., *bb* 29819 (BO, L, SING); Soelabesi, *Hulstijn & Atje* 410 (BO, L), HALMAHERA: Taso, G. Sembilan, 300 m., *Pleyte* 266 (A, BO, K, SING), MOROTAI: G. Sabatas, 180 m., *Lam* 3567 (A, K), BATJAN: sine loco, *de Vries* (?95) (L), BURU: Kak Toea, 800 m., *bb* 22831 (L, MO); Wai Geren Olon, 800 m., *bb* 21506 (BO, L), AMBON: Waai, Mt. Salahatu, 200 m., *Kuswata & Soepadmo* 255 (A, BO, K, LAE, P, SING); Benteng, *Rant* 533 (BO); Amboina, *Pl. Rumph. Amboin.* 482 (BO, F, K, L, MO, P, SING, US); Hitoe Messen, 150 m., *Pl. Rumph. Amboin.* 481 (BM, BO, GH, K, NY, P, US); Latoera, *Boerlage* 415 (BO), SERAM: Kairatu, Gemba, 0-5 m., *Kuswata & Soepadmo* 110 (A, BO, L, NY, P, SING), Waiselang, 150 m., *Kuswata & Soepadmo* 232 (A, BO, CANB, K, P, SING); Roembatoe, 800 m., *bb* 23035 (BO); W. of Piroe, 1-100 m., *Rutten* 1645 (BO, K, L); Porong Mountains, Makina, 1000-1200 m., *Rutten* 2246 (A, BO); Wae Kali, 100-200 m., *Kornassi* 1017 (BO, K, L); Kiandarat, 60 m., *bb* 25839 (BO), **Papua**—see Stevens (1974). Also, KAI ISLANDS: Keteil a Tual, *Beccari s.n.* (Fl, herb. Becc. 1139-1141), TANIMBAR ISLANDS: Makatian, 30 m., *bb* 24403 (A, BO); P. Jamdena, Weri Ranarmoje, *Buwalda* 4676 (A, BO, K, SING); near resthouse between Kp. Ingei and Otember, *Buwalda* 4216 (A, BO, K), ARU ISLANDS: P. Kobroor, Dosinamala, *Buwalda* 5093 (A, BO, K), IRIAN BARAT: Geelvink Bay: Japen, Seroei, *bb* 30629 (A, SING), PAPUA NEW GUINEA: Manus: Derimbat, 50 m., *LAE* 52459 (A, LAE, K); Kaguli Ridge, 30 m., *LAE* 52940 (LAE); Mt. Dremsel, 600 m., *LAE* 59153 (LAE), **Australia**. NORTHERN TERRITORY: Melville Island, *Dunlop* 3435 (DNA, CANB); Port Darwin, *anon.*, anno 1890 (BRI), **Caroline Islands**. PALAU: Urukthapel, *Dutton* 80 (US).

ECOLOGY. Small tree of lowland or colline rainforest, rarely dominant in canopy (Great Nicobar Island); to 1700 m. alt. Prefers well-drained habitats but sometimes in swamp forest, where it develops small knee roots (Malaya—Corner, *loc. cit.*; Sabah—pers. obs.). In Sabah, Papua New Guinea, and the Solomon Islands (Santa Isabel), also over ultramafic rock. Also in secondary forest. Flowering throughout year, but in Java mostly September to December. (In Cambodia flowering in October, fruiting December to March—*Dy Phon* 2012). Entire inflorescence white (except yellow anthers and reddish stigma); flower scented. Ripe fruit purplish black.

Galls—conical protuberances ca. 1 mm. tall—occur just in from the edge

of the lamina on *Pleyte 266* (from the Moluccas). Similar galls on a specimen from Sumba Island were caused by gall midges (Docters van Leeuwen-Reijnvaan & Docters van Leeuwen, 1941).

GERMINATION. The radicle breaks the stone to one side of the base, and the seedling has two pairs of leaves usually separated by a very short internode, although in *Stevens et al. 285A* the internode is up to 1 cm. long. Subsequent internodes are ca. 1 cm. long; their length is not affected by the light or nutrient status of the plant. The terminal bud is functional, and growth is erect. Eventually internodes more than 5 cm. long are produced (*Stevens, 1974, loc. cit.*; *Stevens et al. 285A, 358, 916*). Burger's account (1970) of the germination does not agree with this.

On Manus Island, and probably also on Bougainville and the Solomon Islands (Papuaasia), the radicle pushes out a well-developed basal plug 5-7 mm. across during germination. The seedling has two pairs of leaves separated by a very short internode; the first internode is up to 5 cm. long (*LAE 52458, 52459; NGBF 1219*).

LOCAL USES. Although the wood of *Calophyllum soulattri* is not very durable, it is used for masts and spars and in house construction throughout its range. In Bangka "getah malang-malang" is used to poison dogs. The bast, "babakan slatri," is given to horses in Djakarta once a month to keep them in good condition. An infusion of the root is rubbed on to alleviate rheumatic pain. Oil from the seeds is used like that of *C. inophyllum* (q. v.); the sourish fruits can be eaten, but if eaten in excess they cause severe stomachache and diarrhea (Heyne, *loc. cit.*). In the Caroline Islands fresh bark from the shoot is used as medicine for women who have just given birth (Lauterbach, as *C. cholobtaches*). On the Huon Peninsula (Papua New Guinea) the leaves are reported to make a durable thatch (*Clemens 184*).

Although a variable species, *Calophyllum soulattri* is usually readily recognizable by the well-developed uppermost pair of axillary buds that are nearly always tightly adpressed to the terminal bud, and by the somewhat thinly coriaceous lamina that is rather closely undulate at the margin and that often dries a characteristic olivaceous-buff on the upper surface, the venation being fine. The inflorescence, which nearly always has lateral branches half the length of the main axis or longer, is also distinctive. The fruits are usually subspherical and dry blackish and smooth; the outer layer is well developed and compact, and the stone wall is thin. The hairs show little variation; they typically have a single basal branch. The epithet *soulattri* is derived from a Javanese local name for the plant.

Calophyllum soulattri has been confused with *C. kunstleri* (= *C. rigidum*). However, the venation on the dry lamina of *C. kunstleri* is apparently twice as dense on the upper surface as on the lower, the inflorescence is unbranched (the flowers tend to be arranged in pseudowhirls), and the fruit usually dries brown and wrinkled. In Malaya, sterile material of *C. soulattri* and *C. symingtonianum* has been confused; for differences between these species, see TABLE 6.

Variation within *Calophyllum soulattri*

The greatest variation within *Calophyllum soulattri* is in the Philippines-Celebes-Moluccas area. Although some of this variation is rather trivial (in such characters as indumentum, leaf texture, and midrib type—this perhaps rather surprisingly) and is neither correlated with other characters nor always constant within a collection, field work in this area may lead to some modification of the limits of *C. soulattri*. More important variation occurs in the fruit (e.g., the larger-fruited specimens from the Tanimbar Islands). The rather remarkable variation in germination, seedlings, and fruits in *C. soulattri* from the easternmost part of Papuaia (see below) may eventually lead to the plants there being given formal recognition.

In the area from Java and eastern Borneo to the Moluccas and the Aru Islands, there are a number of specimens with strongly flattened twigs that are rounded at the edges (specimens "f" in the list above). Such specimens also tend to have a thicker lamina that dries a browner color than is usual; the indumentum is often, but not always, poorly developed; and the pedicels are strongly incrassate in fruit. In specimens of this type from the Lesser Sunda Islands, the submature fruits are about 1.5 cm. long and dry brown and wrinkled; in Borneo (e.g., *Kostermans 6034*, Kalimantan) the fruits dry brown and smooth, with the stone walls about 0.7 mm. thick—thicker than is usual in *C. soulattri*. *Kuswata & Soepadmo 253* (Ambon), which also has flattened twigs, has a chartaceous lamina and stones with walls only about 0.4 mm. thick.

In a number of specimens from Sulawesi ("r" in the list), the midrib on the upper surface of the lamina is surrounded by raised blade. However, such specimens are not otherwise unusual.

Fruiting specimens from the Tanimbar Islands (e.g., *Kuswata & Soepadmo 110*) have fruits up to 2.3 by 1.8 cm. that dry blackish and wrinkled; the stone walls are about 1 mm. thick. Such specimens have not been incorporated in the description and are included here *fructe de mieux*; they possibly approach *Calophyllum leleanii*. Two specimens from Sulawesi (*bb 24074, 33066*) have large, ellipsoid fruits 2–3.3 cm. long with ellipsoid stones that are pointed at the apex and have walls ca. 1.5 mm. thick. Specimens collected by Kurz from the Nicobar Islands also have rather large fruits; in this case the wall of the stone is ca. 0.8 mm. thick, and the specimens are more typical.

Specimens similar to those from Papuaia that have well-developed tomentose indumentum on the vegetative parts and on at least the lower part of the inflorescence axis (see Stevens, 1974a, *loc. cit.*) occur elsewhere in the range of the species. However, there are intermediates between such specimens and those with inconspicuous indumentum, and it is unwise to recognize taxa based on indumentum characteristics.

Calophyllum spectabile var. *ceramicum* was described from a robust specimen with leaf blades up to 27 by 10.2 cm.; such specimens (e.g., *Pleyte 266*) are quite common in the Moluccas. Similar specimens have also been collected in central Sulawesi, where the local people consider that the plants belong to a species distinct from the small-leaved form (compare *Musser*

et al. 528, the large-leaved form, with *Musser et al.* 507, the smaller-leaved form). However, it seems premature to recognize a taxon based on these large-leaved specimens.

Elmer based his invalidly published name, *Calophyllum sorsogonense*, on a plant that has the inflorescence, flower, and fruit characters of *C. soulattri*, but has a lamina that is shallowly cordate at the base and dries a rather dark, dull brownish gray, and a petiole that is short (specimens "s" in the list, from the Philippine Islands); at first sight this is a very distinctive form. However, the leaves of some specimens from Sulawesi have well-developed petioles and blades that are more or less acute at the base and more or less truncate at the apex, being finally mucronate; in characters like indumentum and color of the dried leaf, they are similar to *C. sorsogonense*. Such specimens (e.g., *Koorders 17300*, to which the name *C. oblongum* *Koorders* has been given) also approach some from Java (e.g., *Koorders 28105*). Sterile specimens recently collected in Sulawesi (e.g., *Musser et al. 1044*) also have cordate leaf bases, but are otherwise quite different.

The type specimen of *Calophyllum hibbardii* (*Elmer 9837*) has leaf blades that dry a rather dark brown color; although the lateral branches of the inflorescence are long, the inflorescence is not flabellate, and its lowest internode is up to 1.7 cm. long. (The isotype of *C. hibbardii* at Lyons has a terminal inflorescence.) The pedicels in young fruit are up to 3.2 cm. long, and the fruits are immature—when mature, they might be rather large for *C. soulattri*. *Calophyllum hibbardii* is a fairly distinct variant of *C. soulattri*, but it cannot be recognized formally (specimens matching the type of *C. hibbardii* are denoted by "h" in the above list; they are known only from the Philippine Islands).

Other specimens from the Philippine Islands ("c" in the list) have coriaceous leaf blades with relatively distant venation, but they are otherwise like *Calophyllum soulattri*.

Stevens (1974a, *loc. cit.*) cited *NGBF 1089A* (from Manus Island, Papua New Guinea; consisting only of fruits) as *Calophyllum pseudovitiense* (= *C. neo-ebudicum*), albeit with some hesitation: the stones have basal plugs (as in *C. pseudovitiense*) but were picked up underneath a tree of *C. soulattri*. Further collections from Manus Island by D. B. Foreman clearly show that such fruits come from a tree that in vegetative and floral characters agrees with *C. soulattri*. However, the relatively thick-walled stones have basal plugs that are pushed out during germination, and the young plant has long internodes from the very beginning; in all young plants seen of *C. soulattri* *sensu stricto* (in Sarawak, Sabah, various places on the Papua New Guinea mainland, and New Britain), the internodes are initially short. Similar fruits occur probably on Bougainville (*NGBF 1219*) and certainly on the Solomon Islands (New Georgia group: *BSIP 192, 1249, 2812, 5953, 6144, 11597, 15808*); they may be up to 2.5 cm. long. The only other specimen of *C. soulattri* *sensu lato* with mature fruit seen from the Solomon Islands (Choiseul: *BSIP 17507*) had stones with a discolored area ca. 2.5 mm. across at the base, as in "normal" *C. soulattri*, but no plug. Latex of specimens from the Solomon Islands is frequently reported as being yellow(ish) in color, sometimes clear

(e.g., *BSIP 192*), but not always (*BSIP 3833* and *2388* apparently had white latex). *NGBF 1219*, taken from the tree under which the stones with basal plugs were collected on Manus, had white latex. *Calophyllum soulattri* on the mainland of Papua New Guinea sometimes has yellow latex (e.g., *Hartley 11906*), although it is usually white. Fruits of both types turn blackish purple when ripe. Clearly much careful field work is needed to understand this variation; it should be remembered that *C. paludosum* C. T. White was described from a specimen (*BSIP 192*) that has stones with a basal plug.

Synonymy and Nomenclature

In the following discussion, reasons are given for the reduction of several species to synonymy under *Calophyllum soulattri*, and a number of names are lectotypified. Further details of the synonymy of *C. lanceolatum* and names based on specimens collected in Papuasia are given in Stevens (1974a).

Calophyllum soulattri was described from material originating from Java. At Geneva there are three specimens of this species originally in Burman's herbarium and subsequently in that of Delessert; two are annotated "*soulattri*" (by different hands, one apparently by Burman).

Merrill (1917, *loc. cit.*) was correct in his equation of *Bintangor montana* Rumphius (*Herb. Amboin.* 2: 216, t. 72, 1741) and *B. montana secunda* Rumphius (*ibid.*, p. 217) with *Calophyllum soulattri*: Rumphius mentioned the characteristically drying leaves. *Bintangor montana secunda* was described as having leaf blades "bifid" at the apex; specimens of *C. soulattri* with retuse apices are uncommon, even in Sulawesi.

Apoaterium sulatri is lectotypified on a specimen apparently annotated by Blume held at Leiden (*herb. Lugd. Bat.* 903, 343-183).

The original publication of *Calophyllum tetrapetalum* must be ascribed to G. Don, not Roxburgh. Don described *C. tetrapetalum* from a stove plant, and the description fits *C. soulattri*: "leaves ovate or oblong lanceolate, obtusely acuminate. Racemes axillary, short, corymbose, 2-3 together. . . . Native of the East Indies." I have not seen authentic material of *C. tetrapetalum* Roxb. ex G. Don. Roxburgh's description (1832, *loc. cit.*) of a plant with very finely serrulate leaves is at first glance that of a different species (or genus!). However, a Roxburgh specimen from the East Indies at the British Museum, although annotated *C. tetrapetalum*, is clearly *C. soulattri*; because of the way that the specimen was pressed, the rather closely undulate leaf margin appears to be serrulate.

The name *Calophyllum suriga* is a superfluous name for *C. soulattri*, since the latter is cited as a synonym in the protologue. Whether or not the species described by Carey (in Roxburgh, 1832, *loc. cit.*) is to be assigned to *C. soulattri* is another matter (see also Planchon & Triana, *loc. cit.*). The description reads rather like that of *Mammea longifolia* (Wight) Planchon & Triana;¹³ for instance, the flowers are said to be borne below the leaves.

¹³ Kostermans (1961) used the name *Mammea suriga* (Buch.-Ham. ex Roxburgh) Kosterm. for this species.

I have not seen material which could be assigned to the original *C. suriga*.

Calophyllum hirtellum, *C. cymosum*, and *C. diepenhorstii* have all previously been reduced to synonymy under *C. soulattri* or *C. spectabile*; they are based on specimens representing a common form of the species. *Calophyllum cymosum* was based on two specimens, one collected by Junghuhn from northern Sumatra, the other collected by Teysmann from western Sumatra; a sheet of the latter at Utrecht is designated the lectotype. Boerlage (*loc. cit.*) described two varieties of *Calophyllum spectabile* (= *C. soulattri* as now interpreted) and reduced *C. diepenhorstii* to a variety of that species, but none of these varieties can be maintained. The type specimen of *C. spectabile* var. *miquelii* is unremarkable.

A few more details of the synonymy of some Papuan names can now be given. I have seen syntypes (or fragments of them) of *Calophyllum kiong*, and it is clear that Whitmore was correct in reducing this to synonymy under *C. soulattri* (Whitmore, 1967, *loc. cit.*). The name "kiong," used 75 years ago in the Finschhafen area and taken by Lauterbach and Schumann for the epithet of their *C. kiong*, is still used there for this plant. The reduction of *C. versteegii* to *C. soulattri* is not yet definite. The inflorescences of the isotypes may have a short axis to 2 mm. long, but the inflorescence is neither flabellate nor branched. The leaf blades dry a dark, rich, shining brown above. These are rather unusual characters for *C. soulattri*. Details of the typification of *C. solomonense* are discussed under *C. leleanii*.

Calophyllum lancifolium was described from Philippine material with very narrow leaf blades. However, there are intermediates between it and broader-leaved specimens (e.g., Williams 2770 and FB 24736). The specimen of Elmer 13266 at the Arnold Arboretum is designated the lectotype of *C. lancifolium*. *Calophyllum zschokkel*, also from the Philippines, was described from specimens having rather small leaves and lacking well-developed indumentum; they link the larger-leaved specimens from the Philippine Islands with two particularly small-leaved specimens, BS 38967 (Mindanao) and BS 30293 (Luzon). The sheet of Elmer 12129 at the Gray Herbarium is made the lectotype of *C. zschokkel*.

Vanoverbergh 1888, determined by Merrill as *Calophyllum vanoverberghii* and collected from the type locality of that species, matches the type of *C. hibbardii* (see above) fairly well. *Calophyllum vanoverberghii* was described as having an oblong, very coriaceous leaf blade that dried the same color on both surfaces, while the duplicates seen of *Vanoverbergh 1888* have an ovate, subchartaceous leaf blade that has not dried concolorous. Although the description of the inflorescence of *C. vanoverberghii* suggests that it is similar to that of *C. soulattri*, I hesitate to reduce *C. vanoverberghii* to synonymy under *C. soulattri* without seeing type material.

Of the five specimens cited in the original description of *Calophyllum cholobtachae*, fragments of three (*Ledermann 14251*, *Raymondus 128* and *334*) have been seen; *Raymondus 29* and *293A* have not. *Ledermann 14251* was the only fertile specimen (*Lauterbach, loc. cit.*), and the fragment of this number at Wrocklaw (designated the lectotype) has the branched inflorescence and almost chartaceous, rather greenish-drying lamina characteristic

of *C. soulattri*. Lauterbach compared *C. cholobtaches* to *C. klong* (also = *C. soulattri*) but noted that the former had less dense and more steeply ascending venation. These differences are of no significance. The leaves seen of *Raymondus* 128 and 334 both have only 6 to 8 veins/5 mm.—very distant for *C. soulattri*. However, only the former specimen is probably to be referred to *C. soulattri*, while the latter is *C. pelewense* (q. v.).

Early authors almost without exception used the name *Calophyllum spectabile* Willd. for *C. soulattri*. *Calophyllum spectabile* was described from Mascarene material and is a synonym of *C. tacamahaca* (for more details see Stevens, 1976, *loc. cit.*).

22. *Calophyllum brassii* A. C. Smith, *Jour. Arnold Arb.* **22**: 352. 1941; P. F. Stevens, *Austral. Jour. Bot.* **22**: 359. 1974. TYPE: Netherlands New Guinea [Irian Jaya], Idenburg River, 4 km. SW. of Bernhard Camp, 850 m., 7 March 1939, *Brass & Versteegh 13122* (holotype, α ; isotypes, BO, BRI, L).

Tree 20–30 meters tall, d.b.h. to 68 cm.; trunk without spurs or buttresses; outer bark yellowish brown to dark brown, with few to many shallow fissures, inner surface brown–orange and orange mottled; under bark brown–red and dark red mottled; inner bark reddish; latex white, rather curdy, slightly sticky (also reported to be light yellow or brownish).

Twigs (strongly) flattened, 2.5–6 mm. across, \pm 2-, 4-, or 6-angled, with obscure raised horizontal lines at node, drying brown (yellowish), \pm persistently subfarinose to short-tomentose; axillary innovations lacking basal scars; internodes 0.5–6(–8) cm. long; uppermost pair of axillary buds \pm pointed, 2.5–7 mm. long, erect; terminal bud subconical, 0.5–1.4 cm. long, with brownish gray, short-tomentose to (?) subcrustaceous indumentum, the hairs unthickened except at base, often with short, basal branches, the underdeveloped internode to 1.5 mm. long. Petiole 1–6(–8) mm. long, broadly concave above, convex to angled below, subsersistently tomentose or subglabrous; lamina elliptic to oblong, (3–)6–17 by (1.9–)4–6 cm., rounded to shallowly retuse or apiculate at apex, (narrowly to) broadly rounded or cordate at base, usually only slightly undulate and strongly recurved at margin, (thickly) coriaceous, drying brick or cinnamon to greenish olivaceous above and near sabelline below, subsersistently puberulent to short-tomentose on midrib below (also above), the midrib above usually narrowing fairly quickly near base, raised, 0.25–0.6 mm. wide at midpoint, below strongly raised, usually angled, the venation subobscure (rarely subapparent) above and below, depressed to raised above, raised below, 10 to 16 veins/5 mm., angle of divergence 65–80°. Inflorescences from foliate axils, with numerous flowers, flabellate, branched, branches to 1.3 cm. long and with 5 flowers, the axis 1.2–5 cm. long, \pm tomentose, especially at nodes and toward base, lowest internode 1.5–4.5 mm. long, upper internodes to 1.7 cm. long; bracts suboblong to semiorbicular, to 3 mm. long, deciduous; pedicels (0.5–)0.7–2 cm. long, glabrous. Flower (?) hermaphroditic; tepals 4 (rarely 5), the outer pair lingulate, 3.8–4.5 by 1.7–2 mm., the inner pair elliptic to obovate, 4–4.7 by 2.1–2.7 mm.; stamens 65

to 105, the filaments to 2.3 mm. long, the anthers subelliptic, 0.4–0.7 mm. long, retuse at apex; ovary 0.6–0.9 mm. long, the style 1.2–1.7 mm. long, the stigma peltate-infundibular, 0.3–0.5 mm. across, not radiate. Submature fruit broadly ovoid, ca. 1.4 by 1.3 cm., apiculate, drying brown, deeply wrinkled; outer layer not detaching cleanly from stone, 0.7–1.5 mm. thick, compact; stone ovoid, 1–1.1 by 0.8–1 cm., apiculate, the walls less than 0.2 mm. thick, smooth, unmarked; spongy layer initially thick.

DISTRIBUTION. Western portion of the New Guinea mainland (MAP 9).

ADDITIONAL SPECIMENS SEEN. **Papuasias.** IRIAN JAYA. Vogelkop: N. slopes of upper Aifat Valley, between Senopi and Aifatfekaan, W. of Kebar Valley, 920 m., *BW 12843* (L, LAE), 870 m., *BW 12848* (L, LAE). Fakfak: Tavoei [Onin Peninsula], *bb 22317* (probable) (A, BO, L, LAE, SING). Digul: 5 km. NE. from junction Iwoer R. and E. Digul, Sub. Div. Moejoe, 400 m., *BW 8530* (L). PAPUA NEW GUINEA. Western: Kiunga, 20 m., *Stevens et al. 838* (A).

ECOLOGY. Primary colline (often with *Agathis* Salisb.) or sometimes lowland rainforest, (20–)400–920 m. alt. Flowering and fruiting in March; ripe fruit blackish.

Stevens et al. 838 has subspherical, eventually crateriform galls in rows along the midrib of the lower surface of the lamina, or sometimes just in from the margin.

GERMINATION AND YOUNG PLANT. The radicle breaks the stone wall to one side of the base. The seedling has two pairs of leaves separated by an internode less than 5 mm. long. Subsequent internodes are less than 1.5 cm. long. The terminal bud is functional, and the plant is erect. Only after the plant is some 30 cm. tall are internodes of ca. 3 cm. long or more produced (pers. obs.).

Calophyllum brassii can be recognized by its strongly flattened twigs and its very coriaceous leaves, which are usually broadly rounded to cordate at the base, strongly recurved at the margin, and with rather dense venation. The branched inflorescence has a short basal internode and numerous flowers with four tepals. The epithet commemorates L. J. Brass, one of the greatest botanical collectors in New Guinea.

A few fruits occur on *Stevens et al. 838*; all lack an embryo. They are spherical, about 7.5 mm. long and across, with the outer layer about 1.8 mm. thick, and the obovoid stone about 5.5 by 3.2 mm. across and strongly apiculate (all measurements from fluid-preserved material). The wrinkled fruits of *Brass & Versteegh 13122* are still immature, but it is interesting to see that there, too, the stone is apiculate; it is probable that mature fruits, when dried, will be almost smooth.

Calophyllum brassii is close to *C. soulattri* (Smith, *loc. cit.*; Stevens, *loc. cit.*). However, the leaf blades of *C. soulattri* are rarely so coriaceous or cordate at the base, the inflorescences have fewer flowers, and the stone is not apiculate.

BW 12843 and *12848* (from the Vogelkop) differ from the other specimens

of this species in their yellowish-drying twigs and their relatively thinner leaves. *Stevens et al. 838* tends to have short internodes, and like the specimens from the Vogelkop, its indumentum is subtomentose. Although this specimen was found at much lower altitudes than the others, it should be noted that at Kiunga genera and species commonly found at higher elevations grow at less than 30 meters altitude. In addition to *Calophyllum brassii*, *Dimorphanthera* F. Mueller (two species), *Vaccinium* L., *Lithocarpus* Bl., and *Podocarpus* L'Hér. ex Pers. all grow in the same area.

BW 8530 is superficially similar to the form of *Calophyllum goniocarpum* that grows at Kiunga, since it has the most narrowly rounded leaf bases of the specimens included in *C. brassii* (cf. also *bb 22317*). *Calophyllum brassii* and *C. goniocarpum* are not at all closely related and differ in inflorescence (much longer axis with short branches (if any) in *C. goniocarpum*) and fruit (angled, much larger, thicker-walled stone in *C. goniocarpum*). The uppermost pair of axillary buds is erect and usually well developed in *C. brassii*, and suberect and inconspicuous in *C. goniocarpum*; this difference helps to distinguish sterile material of the two taxa.

23. *Calophyllum rigidum* Miq. Fl. Indiae Batavae, Suppl. 1(3): 497. 1861; F. Mueller in Walp. Ann. Syst. Bot. 7: 357. 1868; Vesque in C. DC. Monogr. Phanerog. 8: 606. 1893; H. Keng, Gard. Bull. Singapore 28: 255. 1976. TYPE: Sumatra, ad littoram Siboga, *Teysmann, HB 642* (holotype, u; isotypes, BO, K, L, MEL, P, W).

Calophyllum kunstleri King, Jour. Asiatic Soc. Bengal, II. 59: 174. 1890; Ridley, Fl. Malay Penin. 1: 182. 1922, *pro parte*; I. H. Burkill & M. R. Henderson, Gard. Bull. Straits Settl. 3: 347. 1925; M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 320. 1956; Maheshwari, Bull. Bot. Survey India 2: 141. 1960, *pro parte*; I. H. Burkill, Dict. Econ. Prod. Malay Penin. ed. 2. 1: 416. 1966, *pro parte*; T. C. Whitmore, Tree Fl. Malaya 2: 187. 1973; Corner, Gard. Bull. Singapore Suppl. 1: 104. 1978. SYNTYPES: Malaya, Perak, Larut, 300 feet [90 m.], Dec. 1883, *King's collector [Kunstler] 5328* (A, BO, FI, G, K, SING, US), 100 feet [30 m.], Dec. 1883, *5374* (G, K, SING, UC, US), 100 feet [30 m.], Jan. 1884, *5459* (FI, P).

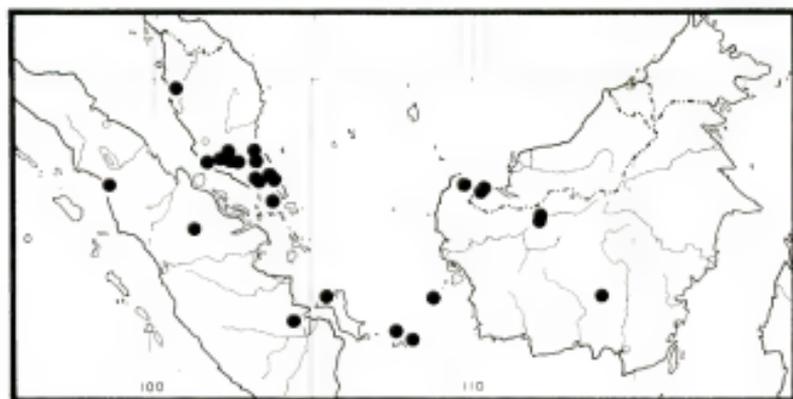
Tree 6-24(-36) meters tall, d.b.h. to 45 cm.; trunk without buttresses, "loop roots" sometimes present in plants from swamps; outer bark gray-brown to dark brown, shallowly fissured or with vertical lines of lenticels, often hoopmarked, inner surface blackish; under bark dark red; inner bark red; latex clear yellow and fluid or sticky, opaque yellow and not very sticky, or yellowish brown. Branches often pendulous, at least in Malaya.

Twigs slightly to strongly flattened, (0.9-)1.2-3.5 mm. across, \pm 4-angled, soon becoming rounded, usually drying blackish (mid-brown), subsersistently puberulous to short-tomentose; axillary innovations lacking basal scars; internodes (1.3-)2-4(-6.5) cm. long; uppermost pair of axillary buds subacute, to 4 mm. long, suberect, plump and very conspicuous just before flowering; terminal bud plump to narrowly conical, (3-)4.5-10(-13) mm. long, with usually castaneous, short, tomentose indumentum (hairs, FIGURES 13, o; 14, n-s),

underdeveloped internode to 2.5(-6) mm. long. Petiole 0.6-1.5(-2.3) cm. long, concave to \pm flat above and convex (rarely subangled) below, subsersistently puberulo-tomentose; lamina ovate (subelliptic to suboblong), (4-)6.7-17.5 by (1-)2.2-5.6 cm., gradually (short-)acuminate at apex with acumen to 1.7 cm. long, (rarely retuse (Sarawak)), cuneate or attenuate (rarely rounded) at base, not undulate or barely so and not recurved at margin, coriaceous, drying bay to umber and usually shiny above, umber and \pm shiny below, \pm persistently puberulent to subtomentose on midrib below (also above), the midrib above gradually narrowed from base, level or slightly raised, \pm strongly sulcate, 0.2-0.4(-0.7) mm. wide at midpoint, below usually strongly raised, rounded or slightly striate, the venation subobscure to apparent above, latex canals and veins often equally clear especially in older leaves, apparent below, latex canals less prominent than veins, raised, (7 to) 10 to 17 veins/5 mm., angle of divergence 40-70(-80) $^{\circ}$. Inflorescences from foliate axils along twig, with 3 to 11 flowers, usually unbranched (rarely with 3-flowered branches to 3 mm. long), the axis 0.2-2.5 cm. long, short-tomentose toward base, lowest internode 1-5 mm. long, flowers often congested (with 2 pseudo-whorls of 4 and 5, or 4 and 3, flowers); bracts ovate, 2-6.5 by 1-2.5 mm., short-tomentose below, subsistent; pedicels 0.5-2.7 cm. long, slender, glabrous, to 1.2 mm. thick in fruit. Flower (?)hermaphroditic; tepals 4, the outer two ovate, 4-5.5 by 3-4 mm., the inner two elliptic to obovate, 5-9 by 2.3-3.5 mm.; stamens ca. 75, the filaments to ca. 4.5 mm. long, the anthers elliptic-oblong, 0.5-0.8 mm. long, retuse at apex; ovary 1.5-2.5 mm. long, the style 2.8-4.3 mm. long, the stigma peltate, ca. 0.5 mm. across. Fruit spherical, 1.2-1.6 cm. long and across, minutely apiculate, when young usually ovoid and sharply pointed at apex, drying brown, broadly wrinkled; outer layer eventually detaching cleanly from stone, 1-2.5 mm. thick, compact; stone ellipsoid to subspherical, 1.1-1.4 by 1-1.25 cm., rounded at apex, the walls 0.15-0.5 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Southern Malay Peninsula to western Borneo, scattered; excluding Java (MAP 11).

SELECTED SPECIMENS SEEN. **Malaya.** PERAK: Larut, 90 m., *King's collector* 5328 (A, BO, FI, G, K, SING). MALACCA: Bukit Sedanan, *Derry* 119 (BM, SING); Ayer Panas, *Derry* 151 (SING). NEGRİ SEMBILAN: Seremban, Cape Rachado F.R., 45 m., *KEP* 71466 (KEP); Port Dickson, P[asir] Panjang F.R., *KEP* 66506 (KEP); Senaling Inas F.R., *SFN* 1753 [= *KEP* 628 fide Henderson & Wyatt-Smith, *loc. cit.*] (SING); Tampin F.R., S. slope of G. Tampin, 540 m., *FRI* 14233 (K, KEP, SAN, SING); G. Angsi, Pedas, 457 m., *FRI* 14586 (K, KEP, SAR, SING); Kuala Pilah, Serting, *KEP* 62876 (KEP). PAHANG: Ulu Sungai Anak Endau, 180 m., *FRI* 8109 (atypical) (A, KEP, SAR, SING); Tasek Bera State Land, *KEP* 35850 (KEP); Rompin, *KEP* 6538 (SING). JOHORE: Mawai, Sungei Tementang, *SFN* 34719 (A, B, K, KEP, LAE, P, SING); G. Panti E., *Jumali & Kuswata* 218 (BO); Kota Tinggi, *Ridley* 4185 (K, SING); Kluang F.R., 225 m., *KEP* 76289 (KEP); Renggam F.R., 90 m., *KEP* 71264 (KEP); Ulu Sedili, G. Sumalayang, 610 m., *FRI* 14104 (atypical) (A, K, KEP, SAN, SING). **Singapore:** Jurong Road, 17th mile, *Baker* 5732 (G, NSW); Bukit Mandai, *Ridley* 1955 (SING). **Sumatra.** RIAU: Upper Riau, Pakanbaru, Tenajan R., *Soepadmo* 40 (B, BO, C, E, L, SING). SELATAN: Banjoerasin en Koeboestrecken, Bajoeng Lintjir, 15 m., 148



MAP 11. Distribution of *Calophyllum rigidum* in Malasia.

T I P 15 (BO, L). UTARA: Siboga, *Teysmann, HB 642* (BO, K, L, MEL, P, U, W). BANGKA: Djebus, *Teysmann s.n.* (BO). BELITUNG: Tandjong Pandan, 30 m., *bb 10244* (BO); Mangar, *Teysmann s.n.* (BO). BORNEO and adjacent islands. SARAWAK. 1st Division: Bako Natl. Park, 75 m., *S 16203* (?) (A, K, SAN, SAR); Lundu, G. Pueh, 457 m., *S 13704* (A, BO, K, SAN, SAR, SING); G. Matang, 305 m., *Stevens et al. 250* (?) (A); Semengoh Arboretum, 30 m., *Stevens et al. 139* (A); Semengoh F.R., *Stevens et al. 288* (?) (A). KALIMANTAN. Tengah: Beneden Dajak, Kapoeas, Moeroei, Danau Rawah, 1 m., *bb 2602* (L). Barat: Karimata Archipelago, *Teysmann, HB 11379* (BO, FI, K, L); Soengai Kenepai, *Hallier 2138* (A, BO, K, P); Smitau, P. Madjang, 30 m., *bb 7677* (BO).

ECOLOGY. Well-drained mixed dipterocarp forest (throughout its range), swamps (Malaya, Sumatra), and sub-kerangas vegetation (Sarawak); 0-610 m. alt. Flowering December and February (Malaya), June (Sumatra); fruiting March to May, August (fruit whitish (*KEP 35850*)).

GERMINATION AND YOUNG PLANT. The radicle probably breaks through the stone to one side of the base. The seedling appears to have two pairs of leaves separated by an internode 0.5-2.7 cm. long (*148 T I P 15*). Each later-produced internode is successively longer. The terminal bud is functional, but the young plant is arched, with the leaves being held in one plane; the stem only later straightens. (Young plants seen in both Malaya and Sarawak: *Stevens et al. 53, 247.*)

LOCAL USES. *Calophyllum rigidum* is used in ship building and for general construction (Malacca).

Calophyllum rigidum can be readily distinguished from other species of the genus by its rather coriaceous lamina, which is usually gradually acuminate at the apex and which often dries a dark, bay brown. The venation density on the upper surface of the lamina is often apparently twice that on the lower (due to the latex canals as well as the veins being raised on the former),

and the midrib on the lower surface is very prominent, yellowish, and rounded. As King noted in his description of *C. kunstleri*, "the nervation is closer than in any other species that I have seen, and the surfaces of the leaves have a peculiarly lustrous sheen." The terminal buds usually have a very dark brown tomentum, and the axillary buds are often plump, conspicuous, and clearly supra-axillary. The inflorescence is congested (see below), the flowers have four tepals, and the wrinkled fruits have a compact, relatively thick outer layer. The epithet *rigidum* refers to the leaf blades, which are usually thick and rigid when dry.

The inflorescence of *Calophyllum rigidum* is commonly described as being subumbellate, but it is unlike the subumbellate inflorescence of *C. soulattri*. The inflorescences of *C. soulattri* are usually flabellate and branched; those of *C. rigidum* are never flabellate and are only rarely branched. In some specimens up to seven flowers from three nodes may arise together on a condensed axis (e.g., King's collector 5328, Malaya), while in others four flowers from two nodes may arise together and be separated from the terminal triad, or triad plus one or two pairs, by an internode ca. 1 cm. long (e.g., SFN 30877 and Ridley 4185, Malaya; Soepadmo 40, Sumatra). In specimens such as Teysmann, HB 642 (Sumatra) and Hallier 2138 (Kalimantan), the inflorescences commonly have a subbasal group of four flowers and a terminal group of five flowers.

The variation in leaf—especially in *Calophyllum rigidum*—is rather great. The type specimen has leaf blades somewhat more coriaceous than those of other specimens, although with similar details of midrib and venation. Its twigs dry brown, while those of the other specimens usually dry blackish. Most of the specimens collected from Malacca and Negri Sembilan (Malaya) are at first sight very different from the others, having slender twigs (less than 1.3 mm. across), small leaves (less than 8 by 2.2 cm.), and flowers usually in pairs on the inflorescences and separated by well-developed internodes. In Derry 151 the lowest internode is almost absent. However, in other details these specimens are not unusual.

FRI 8109 and 12304 (Malaya) have more or less elliptic leaf blades with rather obscure venation, but in details of infructescence and fruit they agree well with the other specimens. Some specimens from around Kuching, Sarawak (e.g., Stevens et al. 240, S 13704), have leaf blades that are retuse at the apex. In other vegetative characters they agree fairly well with the other specimens, although the terminal bud is not such a dark brown. Their fruits and arched seedlings are also typical of the species; their flowers are unknown. Stevens et al. 288 (Sarawak, sterile) is a perplexing specimen; it is rather robust and has something of the facies of *Calophyllum castaneum*, but its indumentum is quite different, since the hairs do not have the enlarged, birefringent apical cells characteristic of that species.

The hairs of *Calophyllum rigidum* are rather variable, although the variation is less than might be expected (FIGURES 13, O; 14, n-s). There is frequently a basal branch, often made up of only a single cell. The cells, at least at the base, have notably thick and rather rough walls, and the hairs are often entirely composed of such cells. If the apical cells are thin walled, they

lack the brown contents found in the thick-walled ones. The hairs are erect or curved; if curved, the curvature is either notably abrupt and at the middle or near the apex of the hair, or more gradual and from near the base.

24. *Calophyllum robustum* P. F. Stevens, Austral. Jour. Bot. 22: 392. 1974.

TYPE: Papua, Northern District, Dobodura Plain, Samboga River area, 100 feet [30 m.], 13 March 1945, NGF 2077 coll. Cavanaugh & Fryar (holotype, LAE; isotypes, A, BRI, CANB, E, K, L).

Tree 18–30 meters tall, d.b.h. to 65 cm.; trunk (?) without buttresses; outer bark yellowish at first, becoming gray to brown, deeply fissured; under bark pink; inner bark brown; latex milky or clear yellow; sapwood yellowish red, extremely hard, merging to red heartwood. Crown spreading, smaller branches and leaves ± pendulous.

Twigs flattened, 3.5–5 mm. across, 4-angled and with a ± prominent raised line decurrent from middle of petiole, sometimes with obscure horizontal raised lines at nodes, drying dark brown to blackish, subpersistently farinose-puberulent; axillary innovations lacking basal scars; internodes 1.5–6 cm. long; uppermost pair of axillary buds ± pointed, 1–4(–12) mm. long, spreading; terminal bud narrowly conical, 1.6–3.3 cm. long, with brown, subcrustose to puberulent indumentum (hairs, FIGURE 13, n, also moruloid), underdeveloped internode 4–7 mm. long. Petiole 1.3–2.3 cm. long, deeply concave above, convex to angled below, drying blackish, glabrous to persistently puberulent; lamina oblong to elliptic, 13–31 by 5–8.5 cm., abruptly acuminate at apex, rounded to shortly acute at base, rather closely undulate and narrowly recurved at margin, coriaceous, drying gray-olivaceous above and sabelline below, subpersistently farinose-puberulent on midrib below, the midrib above narrowing gradually from base, raised, center sulcate, 0.4–0.6 mm. wide at midpoint, below strongly raised, angled, the venation subapparent above, apparent below, raised, 13 to 16 veins/5 mm., angle of divergence 70–80°. Infructescences from foliate axils, with scars of 5 to 7 flowers, unbranched, the axis 0.4–1.1 cm. long, with farinose to puberulent indumentum at least near base, lowest internode 4–8 mm. long; bracts unknown; pedicels 1.2–1.5 cm. by 2.5–3 mm., glabrous. Flower unknown. Fruit spherical to ovoid-ellipsoid, 2.5–3 by 1.8–2.3 cm., acute to subrounded at apex, drying brown, densely and shallowly wrinkled; outer layer not detaching cleanly from stone, 1.2–2.6 mm. across, compact, strong; stone ca. 2.5 by 1.7 cm., obtusely pointed at apex, the walls less than 0.1 mm. thick, smooth, (?)unmarked; spongy layer thin.

DISTRIBUTION. Eastern New Guinea (MAP 9).

SPECIMENS SEEN. **Papua:** see Stevens, *loc. cit.*

ECOLOGY. Well or poorly drained lowland rainforest, 30–180 m. alt. Fruiting March and November.

GERMINATION. The radicle probably breaks through the stone to one side of the base. The seedling has two pairs of pseudovercillate leaves. Subse-

quently produced internodes are long, but the stem is arched at first, becoming erect only some 30 cm. or more behind the apex. The terminal bud is functional. (Based on two seedlings only; see also Stevens, *loc. cit.*)

Calophyllum robustum can be recognized by its long, narrowly conical terminal bud, and by its densely veined, more or less oblong leaf blades 13–31 cm. long that have a strongly angled midrib on the lower surface and that dry an olivaceous color on the upper surface. The wrinkled fruits have a tough outer layer and appear to have a very thin-walled stone. (The 1.5 mm. thick stone mentioned earlier (Stevens, *op. cit.*, p. 394) may refer to this tough outer layer, but more collections are needed to confirm fruit structure.) The epithet *robustum* refers to the large leaves and terminal buds and the thick stems of this species.

25. *Calophyllum moonii* Wight, Ic. Pl. Indiae Orient. 1: pl. 111. 1839, illus. Indian Bot. 1: 129. 1840; Walp. Rep. Bot. Syst. 1: 397. 1842; Thwaites, Enum. Pl. Zeyl. 52. 1858; Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 269. 1862; Bedd. Fl. Sylv. 3: xxii. 1871. TYPE: Ceylon [Sri Lanka], eastern Korle, *Moon s.n.* (n.v.). FIGURE 15, i.

C. spectabile auct., non Willd.; T. Anderson in Hooker f. Fl. Brit. India 1: 271. 1874, *pro parte*; Trimen, Handb. Fl. Ceylon 1: 99. 1893; Vesque in C. DC. Monogr. Phanerog. 8: 583. 1893, *pro parte*; Lewis, Descr. Catal. Ceylon, 20. 1902.

C. soulattri auct., non Burman f.; Alston in Trimen, Handb. Fl. Ceylon Suppl. 6: 22. 1931; Sastri *et al.* Wealth India 2: 20. 1950, *pro parte*; Worthington, Ceylon Trees, 32. 1959.

Tree 20–30 meters tall, d.b.h. to 35 cm.; no buttresses; outer bark yellowish, thin and smooth, or very dark brown and smooth, or dark yellow-gray, thick, and with wide panels (Worthington, *loc. cit.*), sometimes deeply fissured; inner bark dark red; latex clear (*Kostermans 24658*).

Twigs flattened, 3–5 mm. across, \pm 4-angled, drying blackish, with brown, puberulent to tomentose indumentum, soon glabrescent or not; axillary innovations lacking basal scars; internodes (1–)3–12 cm. long; uppermost pair of axillary buds \pm pointed, 2–12 mm. long, spreading to suberect, very obvious; terminal bud plump, 1.2–2 cm. long, with brown, tomentose indumentum (hairs, FIGURE 14, t), underdeveloped internode to 2 mm. long. Petiole 1–1.8 cm. long, concave above, convex below, sometimes persistently puberulent below; lamina ovate to suboblong or elliptic, (7–)9–16(–20.5) by (3.7–)5–6.5 cm., rounded to retuse (acute) at apex, broadly rounded to acute at base, distantly undulate and slightly or not recurved at margin, coriaceous, drying hazel above and sabelline below, soon glabrescent or persistently puberulent tomentose on midrib below, the midrib above narrowing quickly near base, raised, 0.3–0.5 mm. wide at midpoint, below strongly raised, angled toward apex and striate toward base, the venation subapparent above and apparent below, raised, 8 to 13 (to 16) veins/5 mm., angle of divergence 70–85°. Inflorescences from foliate axils toward ends of twigs, with 5 to 11 flowers, flabellate, unbranched, the axis 1–3.5 cm. long, \pm tomentose at base, lowest

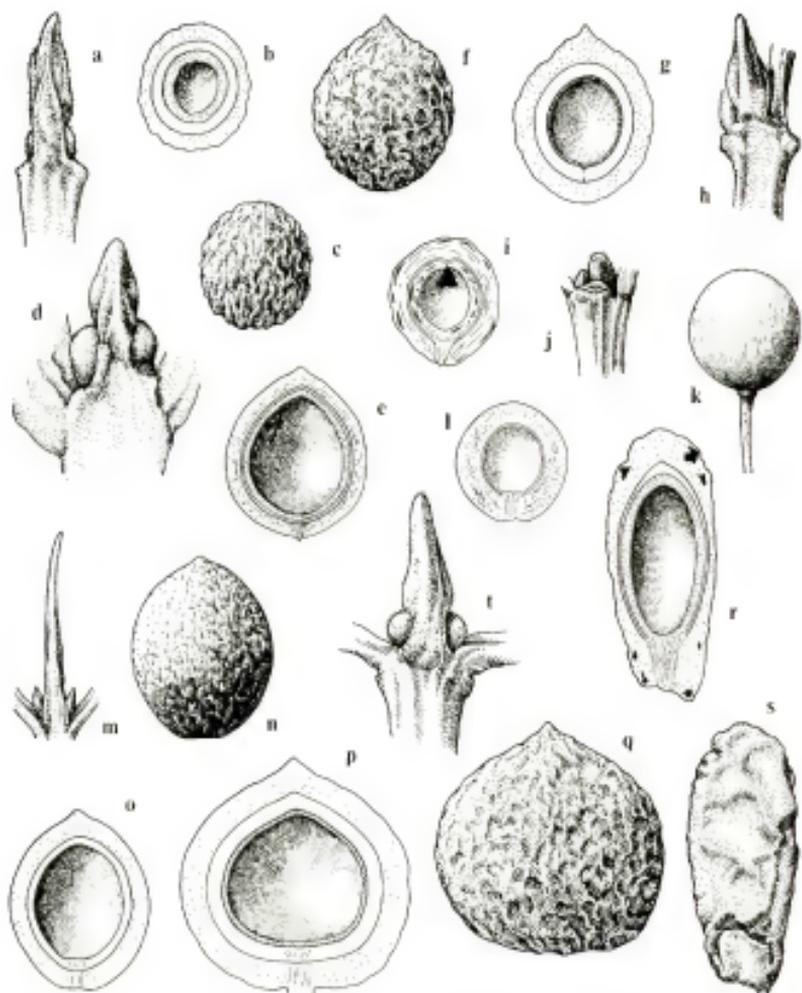


FIGURE 15. a-c, *Calophyllum milvum* (28423 SF). a, bud, $\times 3$. b, c, fruit, $\times 0.75$: b, transverse section; c, from outside. d, e, *C. humbertii* (23728 SF): d, terminal bud, $\times 6$; e, fruit, $\times 1$. f-h, *C. lingulatum* (4800 RN). f, g, fruit, $\times 1$: f, from outside; g, longitudinal section. h, terminal bud, $\times 3$. i, *C. moonii* (Kostermans 24670), $\times 1$, arrow at indented stone apex. j-l, *C. verticillatum* (7929 SF). j, terminal bud, $\times 3$. k, l, fruit, $\times 1$: k, from outside; l, longitudinal section. m-o, *C. paniculatum*. m, terminal bud (1297 RN), $\times 1$. n, o, fruit (11078 SF), $\times 1$: n, from outside; o, longitudinal section. p, q, *C. aff. paniculatum* 1 (23120 SF), fruit, $\times 1$: p, longitudinal section; q, from outside. r, s, *C. aff. paniculatum* 2 (22855 SF), fruit, $\times 1$: r, longitudinal section; s, from outside. t, *C. vernicosum* (de Cary 14522), terminal bud, $\times 6$.

internode 0.3–2 cm. long; bracts ovate, ca. 3 mm. long, deciduous; pedicels (0.3–)0.6–1.8 cm. long, glabrous, in fruit to 3 mm. thick. Flower known only in late bud, (?)hermaphroditic; tepals (?)4 or 6 to 8, the outer pair ca. 6 by 5.5 mm., the inner ones 6–7.5 by 2.5–4.5 mm.; stamens 75 to 110, the filaments to 3 mm. long, the anthers oblong, 1–1.5 mm. long, retuse at apex; ovary ca. 2 mm. long, the style ca. 2.5 mm. long, the stigma peltate, ca. 1.2 mm. across, 2-radiate. Fruit ovoid to ellipsoid, 1.8–2.5 by 1.6–1.9 cm., apiculate or not, sometimes with fibrous stipe to 3.5 mm. long, drying cinnamon, smooth or shallowly and broadly wrinkled; outer layer not detaching cleanly from stone, ca. 1 mm. thick, notably fibrous, air spaces developing; stone subellipsoid, 1.1–1.4 by 0.9–1.2 cm., shallowly retuse at apex, the walls ca. 0.2 mm. across, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Southwestern Sri Lanka (MAP 7).

SELECTED SPECIMENS SEEN. **Sri Lanka:** Kalutara Distr., Hallawakellae forest, Welipenna, *Balakrishnan 1178* (K, US); Kuttapitiya Jungle, Pelmadulle, 4 m., *Worthington 6437* (?) (L); Ratnapura Distr., Moropitiya logging area, *Kostermans 24670* (A, E, K, L, US); Athweltota near Moropitiya, *Jayasuriya 904* (AAU, K); Mahane-Makalane hill forest, near Moropitiya, 400 m., *Kostermans 24701* (L); Kalawana–Moropitiya road, close to culvert 29/3, 100 m., *Cramer 4159* (US); Hiniduma F.R., *Kostermans 24704* (?) (L, US), Hinidumkande (Heycock), near Hiniduma, 500 m., *Kostermans 25502* (K, L); Heycock Forest, sea level, *Cramer 3084* (?) (US); Kunneliya Forest S. P., 60 m., *Worthington 5262* (BM, F); Naunkilla ela, Kaneliya F.R., 30 m., *Worthington 3678* (BM); sine loco, *CP 3402, pro parte* (K, US).

ECOLOGY. Lowland rainforest, to 500 m. alt. Fruiting April to June; fruit green, acid.

GERMINATION AND YOUNG PLANT. The radicle probably breaks the stone near the base. The seedling has a single pair of leaves. Subsequent pairs of leaves (which are produced singly) are separated by internodes of 0.7–1.3 cm. The terminal bud is functional, and the plant is probably erect. (*Kostermans 25560*, four plants.)

Calophyllum moonii is a distinctive species recognizable by its long terminal bud and conspicuous, often spreading, uppermost pair of axillary buds; its large, coriaceous leaf blades that are often rounded to retuse (at most acute) at the apex; and its few-flowered, flabellate but unbranched inflorescences. The fruits have a fibrous outer layer and a thin-walled stone that is shallowly retuse at the apex. The epithet commemorates F. Moon.

There is some variation in the apex of the lamina in *Calophyllum moonii*. Wight (1839, *loc. cit.*) illustrated a specimen with rather narrowly elliptical leaf blades that are acute at the apex and base, but many specimens have broader, subovate leaf blades that are more or less retuse at the apex and rounded at the base. I thought at first that there were two species involved, but there is no difference in characters such as terminal bud, indumentum, and fruit in specimens differing in leaf apex. Wight's illustration shows the flower as having four tepals; in the flowers dissected I have found six to eight.

The specimens from Hiniduma and Kuttapitiya Jungle are sterile; they are included here with some hesitation.

The retuse apex of the stone of *Calophyllum moonii* is rather remarkable. It was noticed in all fruiting specimens examined.

There is little similarity between *Calophyllum moonii* and *C. soulattri* (or *C. spectabile* auct., non Willd.), with which it has been confused; Kostermans (1976) noted that the two were distinct. Although the inflorescences of *C. moonii* are flabellate, they are unbranched (vs. practically always branched in *C. soulattri*). In *C. soulattri* the uppermost pair of axillary buds is characteristically closely adpressed to the terminal bud, the lamina is thinner and dries closely undulate, the fruit dries blackish and has a compact outer layer that practically lacks fibers, and the stone is rounded at the apex. The relationships of *C. moonii* are obscure, but the hairs are similar to those of *C. tomentosum* (cf. FIGURES 14, t, and 11, l).

26. *Calophyllum milvum* P. F. Stevens, sp. nov.

FIGURE 15, a-c.

C. parviflorum auct., non Baker f.; Drake in Grandid. Hist. Phys. Nat. Polit. Madagascar 35: pl. 357. 1894; Lecomte, Madagascar Bois Forêt d'Analamazaotra, 102. pl. 39. 1922; H. Perr. Mém. Mus. Nat. Hist. Nat. Paris, n.s. 24: 78. 1948, in Humbert, Fl. Madagascar Comores, Fam. 136: 8. 1951.

A speciebus aliis *Calophylli* in internodio infimo innovationis circa duplo longiore quam aliis, foliis parvis coriaceis basibus cuneatis vel in petiolis decurrentibus et nervis lateralibus subobscuris, floribus cum 8 tepalis (duobus exterioribus interdum subpersistentibus), et parietibus fructus 1.2-2 mm. crassis, differt.

Tree 12-20 meters tall, d.b.h. to 60 cm.; trunk without buttresses; outer bark gray, brown, or whitish, fissured; inner bark yellowish or red; latex yellow or blackish (Lecomte, *loc. cit.*).

Twigs somewhat flattened, 1.8-3(-3.5) mm. across, 4-angled or rounded, drying dark brown to blackish, puberulent when young; axillary innovations lacking basal scars; lowest internode of an axillary innovation (1.8-)2.8-5.5 cm. long, others 0.5-3 cm. long; uppermost pair of axillary buds rounded, to 1.2 mm. long, suberect; terminal bud plump, (3.5-)5-8.5 mm. long, with compact, grayish to brown indumentum (hairs, FIGURE 13, m), underdeveloped internode to 2(-6) mm. long. Petiole 0.3-1.1 cm. long, shallowly concave above and convex below, glabrescent; lamina elliptic to obovate (rarely subcuneiform), (1.8-)2.3-7 by (1.1-)2-4.2 cm., rounded to retuse at apex, cuneate to decurrent at base, slightly undulate and narrowly recurved at margin, very coriaceous, drying amber to sabelline on both surfaces, ± transiently puberulent on midrib below, the midrib above gradually narrowed from base, at least margins raised, 0.2-0.6 mm. wide at midpoint, below raised, striate, the venation obscure on both surfaces, slightly raised to flat, 9 to 15 veins/5 mm., angle of divergence 55-65°. Inflorescences from foliate axils, with 7 to 11 flowers, unbranched, the axis 3-6 cm. long, puberulent, especially toward base, lowest internode 1-4 cm. long; bracts ovate, ca.

3 mm. long, deciduous; pedicels 0.5–1.3 cm. long, \pm glabrous. Flower (?)hermaphroditic; tepals 8 (rarely 7), the outer pair broadly ovate, 6–7.5 by 6–6.5 mm., sometimes persisting in fruit, the inner ones \pm obovate, 7.5–12 by 3–8 mm.; stamens 115 to 180 (to 255), the filaments to 4.5 mm. long, the anthers oblong, 1–2.1 mm. long, \pm retuse at apex; ovary 2–2.5 mm. long, the style 3–3.5 mm. long, the stigma peltate, 1–1.4 mm. across, 3- or 4-radiate. Fruit spherical to ovoid, 1.8–2.7 by 1.5–2.1 cm., rounded to acute at apex, drying brown, broadly and shallowly wrinkled, perhaps smooth when young; outer layer probably not detaching cleanly from stone, 1.5–3.5 mm. thick, compact; stone subspherical to ovoid, 1.4–1.8 by 1.2–1.65 cm., obtuse (rounded) at apex, the walls 1.3–2 mm. thick, smooth, unmarked; spongy layer thin.

TYPE: Madagascar [Moramanga], forêt d'Analamazaotra, 800 m., Perrier de la Bâthie 5328 (holotype, ν ; isotypes, σ , κ).

DISTRIBUTION. Central Madagascar (MAP 12).

SELECTED SPECIMENS SEEN. Madagascar: Ambatondrazaka, Manakambahiny-est, Nonokambo, 26556 SF (ν), Manaka, 6901 RN (ν); Ambodipaiso, Toby-Ambodipaiso, 900 m., 26663 SF (ν); massif de l'Andringitra, forêt d'Ambodipaiso, Manakanbahiny, 1200 m., Cours 2333 (ν); Perinet, Analamazaotra, 25673–25677 SF (all ν); Bevetraka, 21266 SF (ν), 21267 SF (ν); Sahahamy, 2530 SF (ν), Ambotrafanga, 27-B-R-172 SF (ν); Manjakandriana, Antiahambavy, 15879 SF (ν); Ambatondrazaka, Manaka[na] Est, 6901 RN (ν); Fianarantsoa, Fandrandava, Sambalahy, 13531 SF (ν); Ajozorobé, Tsaralahy, Fenéol 15 (ν); Anosibe, ouest du village d'Antandava (P.K. 45 de la route Moromanga–Anosibe), 28423 SF (ν), Ankazomanitra, 26809 SF (ν); sine loco [?E. Imerina], Baron 2235 (ν , κ pro parte, ν), 2244 (ν , κ , ν), 2662 (κ), 4433 (ν , κ , μ , ν), 7045 (κ).

ECOLOGY. Locally common in colline/lower montane, mossy, and dry forest, sometimes on summits, 800–1200(–1500) m. alt. Flowering December and January. Fruiting November to January; fleshy fruit eaten by lemurs and potomacheres, the former rejecting and the latter ingesting the seeds (?stones: Perrier de la Bâthie, 1948, *loc. cit.*). (Perrier de la Bâthie (1951, *loc. cit.*) recorded flowering in January and February, fruiting from February to June.)

GERMINATION. The seeds apparently do not germinate unless they are surrounded by the pericarp (Perrier de la Bâthie, 1948, *loc. cit.*).

LOCAL USES. The wood is used in carpentry and construction.

Calophyllum milvum is a typical montane species of the genus, having small, rather thickly coriaceous leaf blades with obscure venation, shoots with short internodes, and inflorescences with relatively long axes and large flowers. However, the lowest internode of the innovation, which is clearly about twice as long as the upper internodes, and the thick-walled stone immediately distinguish it from other species, including *C. parviflorum*, with which it has been confused. The epithet *milvum* alludes to the characteristic, almost kitelike lateral shoots.

The specimen 29179 *SF* (Massif d'Anorimbato, à l'ouest d'Ambaravarana (Tsiroanomandidy)) is from a locality to the west of the others cited, and it may be related to *Calophyllum milvum*. However, the lamina has much clearer venation and is broadly revolute at the margin. The specimen was in flower when collected in May; flowering in *C. milvum* seems to be restricted to December and January. Other specimens with lateral shoots like those of *C. milvum* but with clear venation are discussed under *C. pervillei*.

27. *Calophyllum lingulatum* P. F. Stevens, sp. nov. FIGURE 15, f-h.

A speciebus aliis Calophylli quibus laminis cordatis habent in inflorescentiis axillaribus haud ramosis, floribus cum 8 tepalis, et fructibus apicibus acutis putaminibus parietibus crassis haud signatis vel angulatis, differt.

Tree; trunk and bark not known.

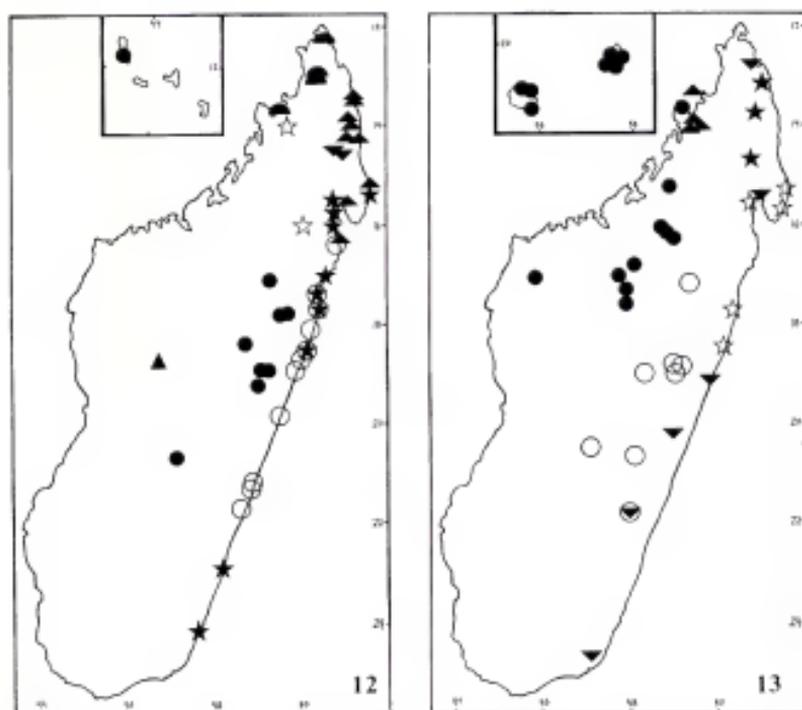
Twigs slightly flattened, 1.7-2 mm. across, strongly 4-angled when young, drying dark brown, ± glabrous; axillary innovations lacking basal scars; lowest internode of axillary innovation 2.2-3.5 cm. long, others 1-2 cm. long; uppermost pair of axillary buds rounded, less than 1 mm. long, suberect; terminal bud plump, 3-4.5 mm. long, with brown, subcrustaceous-puberulous indumentum, underdeveloped internode absent. Petiole 1-1.5 mm. long, obscure; lamina ovate or lingulate to oblong, 4.7-8.2(-12.5) by 2.2-4.5 cm., rounded to obtuse at apex, cordate at base, strongly undulate and slightly recurved at margin, coriaceous, drying shiny and amber on both surfaces, subfarinose on midrib below, the midrib above abruptly narrowed near base, soon becoming raised, 0.2-0.4 mm. wide at midpoint, below raised, angled toward apex and striate toward base, the venation subapparent on both surfaces, slightly raised, 7 to 10 veins/5 mm., angle of divergence 60-70°. Inflorescences from foliate axils on ends of twigs, with 5 to 9 flowers, unbranched, the axes 1.9-5 cm. long, farinose-puberulent toward base, lowest internode 1.3-2.5 cm. long; bracts elliptic, ca. 3 mm. long, deciduous; pedicels 0.35-1.4 cm. long, sparsely farinose. Flower (?) hermaphroditic; tepals 8, the outer pair ovate, 5.5-7.5 by 4.5-6 mm., the inner ones elliptic to obovate, 8.5-11 by 2.4-5 mm.; stamens 85 to 100, the filaments to 4.5 mm. long, the anthers oblong, 1.2-1.6 mm. long, slightly retuse at apex; ovary 1.5-2.5 mm. long, the style ca. 3 mm. long, the stigma peltate, ca. 1 mm. across, 3-radiate. Fruit ovoid, ca. 2.4 by 1.9 cm., acute at apex, drying brown, densely and shallowly wrinkled; outer layer not detaching cleanly from stone, 2.5-3 mm. thick, compact; stone ellipsoid, ca. 1.65 by 1.4 mm., rounded at apex, the walls 1-1.7 mm. thick, smooth, unmarked; spongy layer thin.

TYPE: Madagascar, Ambanja, Marovato, 18 Nov. 1952, 4500 *RN* coll. *Sajy* (holotype, ♀; isotype, ♀).

DISTRIBUTION. Northern Madagascar (MAP 12).

ADDITIONAL SPECIMEN SEEN. **Madagascar:** Mandritsara, Antsirabe, Antsiatriaba, 3-R-388 *SF* (♀).

ECOLOGY. Flowering and fruiting in November.



MAPS 12, 13. 12, distribution of *Calophyllum milvum* (solid circles), *C. milvum* var. (long, erect triangle), *C. lingulatum* (empty stars), *C. vernicosum* (half-circles), *C. fibrosum* (erect triangles), *C. humbertii* (inverted triangles), *C. verticillatum* (solid stars), and *C. chapelieri* (empty circles; overlapping distribution with *C. verticillatum*, stars in circles) in Madagascar. Inset: *C. comorense* (Comores Islands). 13, distribution of *C. recedens* (solid circles), *C. paniculatum* (erect triangles), *C. aff. paniculatum* 1 (solid stars), *C. aff. paniculatum* 2 (empty stars), *C. aff. paniculatum* 3 (inverted triangles), and *C. drouhardii* (empty circles) in Madagascar. Inset: *C. tacamahaca* (Mascarenes).

LOCAL USES. The wood is used in construction and for joinery.

Calophyllum lingulatum can be recognized by its cordate-based lamina, axillary inflorescences, flowers with eight tepals, and fruits with rather thick-walled stones that are neither marked nor angled. The epithet refers to the rather tongue-like shape of the leaves.

Calophyllum lingulatum is perhaps related to *C. milvum*, which has similar inflorescences, flowers, and fruits. Both species apparently also have axillary innovations with the basal internode much longer than the others, although this must be confirmed for *C. lingulatum*. There are, however, numerous

vegetative differences between the two. The terminal bud of *C. lingulatum* is shorter, and the lamina is thinner and cordate at the base. The midrib on the upper surface of the lamina is sharply raised; the venation is more distant and is easily visible, rather than subobscure.

Although 3-R-388 SF is sterile, it is almost certainly *Calophyllum lingulatum*. The measurement of lamina length in parentheses in the description is taken from this specimen.

28. *Calophyllum humbertii* P. F. Stevens, sp. nov.

FIGURE 15, d, e.

A *Calophyllum* milvo, quo aliter similis est, in gemma terminali 2-3 mm. longa (in *C. milvo* (3.5-)5-8.5 mm. longa), folia basi obtusa vel rotundata (cuneata vel decurrenti), inflorescentia bracteis foliaceis subpersistentibus praedita (parvioribus, haud persistentibus), et putamine parietibus circa 0.2 mm. crasso (1.3-2 mm. crasso), differt.

Small tree; trunk and bark not known.

Twigs slightly flattened, 1.7-2 mm. across, slightly 4-angled, drying blackish, glabrous; axillary innovations lacking basal scars; first internode of an axillary innovation 2-4.5 cm. long, others 1-3 cm. long; uppermost pair of axillary buds rounded, ca. 0.7 mm. long, erect; terminal bud plump, 2-3 mm. long, brown-puberulent, underdeveloped internode to 0.8 mm. long. Petiole 2-3 mm. long, broadly concave above and convex below, glabrous; lamina obovate to suborbicular, 1.9-3.9 by 1.2-2.9 cm., rounded or slightly retuse at apex, obtuse to rounded at base, not undulate but slightly recurved at margin, coriaceous, drying umber to fulvous on both surfaces, glabrous at maturity or persistently subpuberulent on midrib below, the midrib above gradually narrowed from base, slightly depressed to flat, 0.3-0.5 mm. wide at midpoint, often disappearing ca. 3 mm. below apex, below raised, \pm rounded, the venation obscure on both surfaces, \pm flat, 8 to 11 veins/5 mm., angle of divergence 45-60°. Inflorescences from foliate axils, with 7 to 9 flowers, unbranched, the axis 3.2-4.5 cm. long, glabrous or sparsely subfarinose toward base, lowest internode 1-2.5 cm. long; bracts leafy, cuneiform, to 2.7 by 2.9 cm., subsistent; pedicels 0.6-1.1 cm. long, glabrous. Flower (?) hermaphroditic; tepals 8 (rarely 9), the outer pair ovate, 4.5-5.5 by ca. 3.5 mm., the inner ones obovate to elliptic, 7-8 by 3-6.5 mm.; stamens 100 to 115, the filaments to 3 mm. long, the anthers oblong, 1-1.4 mm. long, retuse at apex; ovary ca. 1.5 mm. long, the style ca. 2 mm. long, the stigma peltate, 1.3-1.5 mm. across, \pm 3-radiate. Fruit broadly ovoid, ca. 2.3 by 1.8 cm., obtuse at apex, drying brown, sublongitudinally wrinkled; outer layer detaching cleanly from stone, ca. 2 mm. thick, compact; stone broadly ovoid, ca. 1.7 by 1.4 cm., rounded at apex, the walls ca. 0.2 mm. thick, smooth, unmarked; spongy layer thin.

TYPE: Madagascar, sommêt oriental du massif de Marojejy (nord-est), à l'ouest de la haute Manantenina, affluent de la Lokoho, 1850-2137 m., anno 1949, *Humbert & Cours* 23728 (holotype, ♀; isotypes, ♀).

DISTRIBUTION. Northern Madagascar (MAP 12).

ADDITIONAL SPECIMENS SEEN. **Madagascar:** massif de Marojejy, à l'ouest de la haute Manantenina, 1500-1700 m., *Humbert 22592* (♀); vallée de la Lokoho (nord-est), mont Beondroka, au nord de Maroambihy, 1000-1450 m., *Humbert 23516* (♀).

ECOLOGY. Small tree, montane (sometimes ericoid) forest, 1000-2137 m. alt. Flowering and fruiting in March.

Calophyllum humbertii can be recognized by its short terminal bud; axillary innovations in which the first-produced internode is much longer than subsequent ones; small, broad leaf blades; and fruits, which have a relatively thick, compact outer layer and a thin-walled stone. The epithet commemorates the noted French botanist, H. Humbert.

The facies of *Calophyllum humbertii* is somewhat similar to that of *C. milvum*; in both the axillary shoots have basal internodes that are much longer than the others. However, the shorter terminal bud, broadly obovate to suborbicular lamina, subpersistent and foliaceous bracts, and thin-walled stone of *C. humbertii* immediately distinguish it from *C. milvum*.

Two specimens of *Calophyllum humbertii* (*Humbert & Cours 23728* and *Humbert 22592*) have fruits. Those of the former are more or less mature, while those of the latter are clearly immature; in neither is the stone wall well developed.

29. *Calophyllum laxiflorum* Drake, Bull. Soc. Linn. Paris 2: 1220. 1896; H. Perr. Mém. Mus. Nat. Hist. Nat. Paris, n.s. 24: 79. 1948, *pro parte*, in Humbert, Fl. Madagascar Comores, Fam. 136: 12. fig. 2, 6-8. 1951, *pro parte*. TYPE: Madagascar, sine loco, *Chapeller s.n.* (holotype, ♀; isotype, ♀).

C. sorapa Drake in Grandid. Hist. Phys. Nat. Polit. Madagascar 35: pl. 358, 2. 1896.

(?)Tree; trunk and bark not known.

Twigs rather strongly flattened, 1.7-2.4 mm. across, strongly 4-angled, drying blackish, glabrous when mature, axillary innovations lacking basal scars; internodes (0.2-)0.5-5 cm. long; uppermost pair of axillary buds rounded, less than 0.5 mm. long, inconspicuous; terminal bud plump, 1.7-2.4 mm. long, with short, grayish indumentum. Petiole 2-3.5 mm. long, broadly and shallowly concave above, convex below, glabrous; lamina obovate, 2.7-4.8 by 1.4-2.4 cm., acute at apex, cuneate or ± rounded at base, slightly recurved but barely undulate at margin, coriaceous, drying dark brown and nitid above, dark brown below, glabrous when mature, the midrib above rather abruptly narrowing at or near base, slightly raised, 0.15-0.25 mm. wide at midpoint, below raised, not very conspicuous, obscurely angled, the venation above ± apparent, slightly raised, below subobscure, not raised, 4 to 7 veins/5 mm., angle of divergence 20-40°. Inflorescences from foliate axils, with 5 to 9 flowers, unbranched, the axis 4.5-6 cm. long, glabrous, lowest internode ca. 2.5 cm. long; bracts unknown; pedicels 1.1-1.9 cm. long, glabrous. Flower and fruit unknown (ovary ca. 2 mm. long).

DISTRIBUTION. KNOWN only from the type collection, made in (?eastern) Madagascar.

Calophyllum laxiflorum is a poorly known species that can be recognized by its short terminal bud, its obovate leaf blades that dry dark, shiny brown and have steeply ascending venation, and its long, few-flowered inflorescence axis with a long basal internode. The epithet *laxiflorum* alludes to the inflorescence, in which the flowers are separated by relatively long internodes.

Perrier de la Bâthie (1951, *loc. cit.*) included three species in *Calophyllum laxiflorum*: *C. laxiflorum* sensu stricto, *C. pervillei*, and *C. verticillatum* (the last described here as new). 28357 SF has leaves similar to those of the preceding species, but its fruits are quite different; there are yet other small-leaved specimens with more widely ascending venation. Since the taxonomic situation is so unclear, the two early names have been narrowly circumscribed. *Calophyllum verticillatum*, described below, is very different from the other small-leaved taxa with which it has been confused. Other small-leaved specimens are discussed after the treatment of *C. pervillei*.

Calophyllum laxiflorum is known only from the type specimen, which is just past flowering. The leaves differ from those of *C. pervillei* and 28357 SF in their steeply ascending venation (angle of divergence 20–40°, vs. at least 50° for the other species) and in the dark, shining, brown color of the dried lamina (with the midrib noticeably paler). The lowest flowers on the inflorescence axis of *C. laxiflorum* are borne ca. 2.5 cm. from the base. The lowest pedicel scar in infructescences of *C. pervillei* is less than 1 cm. from the base of the axis; the type specimen of *C. pervillei*, which is in very young bud, has inflorescences less than 7 mm. long. *Calophyllum laxiflorum* has more robust twigs than *C. pervillei*—1.7–2.4 mm. across, rather than 0.8–1.5 mm.

Although one sheet of *Chapelier s.n.* at Paris that was labeled *Calophyllum laxiflorum* is a fruiting specimen of *C. verticillatum*, it cannot serve as type for *C. laxiflorum*. Fruits are not mentioned in the protolog, and the specimen does not have the inflorescences described for *C. laxiflorum*. *Calophyllum verticillatum* can be immediately distinguished from *C. laxiflorum*, *C. pervillei*, and the other small-leaved specimens by the pseudovercillate arrangement of the leaves at the termination of each innovation.

The illustration of *Calophyllum sorapa* in Grandidier (*loc. cit.*) is clearly to be referred to *C. laxiflorum*; it is very similar to the type specimen of *C. laxiflorum*, except that tepals are illustrated. It is possible that the epithet *sorapa* is a misreading of the local name, "fouraha." Perrier de la Bâthie (1948, *loc. cit.*) thought that *C. sorapa* was to be equated with *C. pervillei*; later (1951, *op. cit.*) it was placed in synonymy under *C. chapelieri*, with *C. sorapa* and *C. chapelieri* typified by the same specimen. However, in leaf arrangement and inflorescence type the illustration of *C. sorapa* is very different from *C. chapelieri*, which is another species with pseudovercillate leaves at the end of each innovation.

Perrier de la Bâthie (1948, *loc. cit.*) was rather confused over the whole complex. He thought that Drake del Castillo separated *C. pervillei* from *C.*

laxiflorum by the umbelliform inflorescence of the former. Drake did not mention such inflorescences in his description of *C. pervillei*; he noted only that the inflorescences were cymose and shorter than the leaves. Perrier de la Bâthie may have been confused by the inclusion of specimens of *C. verticillatum* in *C. pervillei*.

30. **Calophyllum pervillei** Drake, Bull. Soc. Linn. Paris 2: 1220. 1896, in Grandid. Hist. Phys. Nat. Polit. Madagascar 35: pl. 358, 3. 1896.
TYPE: Madagascar, Ste. Marie, 23 April 1849, *Perville* 229 (holotype, *p*; isotypes, *k*, *p*).

C. laxiflorum auct., non Drake; H. Perr. Mém. Mus. Nat. Hist. Nat. Paris, n.s. 24: 79. 1948, *pro parte*, in Humbert, Fl. Madagascar Comores, Fam. 136: 12. 1951, *pro parte*.

Tree; trunk and bark not known.

Twigs flattened, 0.8–1.5 mm. across, strongly 4-angled, drying dark brown, glabrous when mature; axillary innovations lacking basal scars; basal internodes of innovation 1.5–4 cm. long, others (0.3–)0.5–3 cm. long; uppermost pair of axillary buds rounded, less than 0.5 mm. long, erect, inconspicuous; terminal bud rather narrowly conical, 1–2 mm. long, with short, grayish indumentum (hairs, FIGURE 13, h), underdeveloped internode absent. Petiole 1.5–2 mm. long, rather deeply concave above, convex below, glabrous; lamina obovate to subrhombiform or subelliptic, 0.9–6 by 0.5–2.4 cm., bluntly pointed to rounded at apex, narrowly cuneate to acute at base, slightly undulate or recurved at margin or slightly recurved at very base, coriaceous, drying sepia and nitid above, amber below, margin often discolored at base, glabrous, the midrib above gradually narrowed from base, raised, strongly sulcate, at least in basal part, 0.15–0.25 mm. wide at midpoint, disappearing ca. 2 mm. short of apex, below slightly raised, obscurely angled, the venation obscure to subapparent above, slightly raised, below usually subobscure, 7 to 11 veins/5 mm., angle of divergence 50–60(–65)°. Infructescences from foliate axils along stem, with scars of 5 to 9 flowers, unbranched, the axis ca. (?)2 cm. long, lower part brown-puberulent when young, lowest internode at most 6 mm. long; bracts ovate, ca. 2 mm. long; pedicels 4–8 mm. long, stout, to 1.8 mm. across. Flower unknown. Fruit spherical, 1.7–2.2 cm. long and across, obscurely pointed at apex or not, drying smooth, dark brown; outer layer detaching easily from stone when ripe, 2–2.5 mm. thick, compact; stone spherical, 1.3–1.8 cm. long and across, rounded at apex, the walls ca. 2 mm. thick, less than 1 mm. thick to one side of base, smooth, unmarked; spongy layer probably thin.

DISTRIBUTION. Madagascar.

SELECTED SPECIMENS SEEN. **Madagascar:** Farafangana, Efetz [Efatsy], Analazaha, 15384 SF (*p*); sine loco, *Bolvin s.n.* (*p*).

ECOLOGY. Fruiting in August.

Calophyllum pervillei is a poorly known taxon that can be characterized by its short terminal bud; strongly 4-angled twigs; small, obovate leaf blades with steeply ascending venation and a raised midrib disappearing just short of the apex; few-flowered, rather short inflorescence with a basal internode less than 6 mm. long; and thick-walled stone.

Calophyllum pervillei is perhaps related to *C. laxiflorum*; for the differences between the two, see the latter.

8773 SF, from the Col d'Ambatondradama, between Mahalevona and Sahafihitra, 700 m., may belong to *Calophyllum pervillei*, but the fruit is ovoid, ca. 2.2 by 1.5 cm., and sharply pointed at the apex; pedicels of this specimen are up to 2.3 cm. long. However, the fruits are quite immature, since the stone is very weak and the embryo is undeveloped, so the shape differences of the fruit may be unimportant.

Calophyllum aff. *pervillei*

There are a number of small-leaved collections of *Calophyllum* from Madagascar that cannot presently be assigned to species. Some of the variation shown by these specimens is described below.

28357 SF, from the Col du Maningotry, 300-600 m., is vegetatively almost identical to the specimens described as *C. pervillei*, but its ovoid fruits are ca. 4 by 2.4 cm., prominently beaked, and drying sharply and densely wrinkled. The outer layer of the fruit is 2-2.8 mm. thick, and the ovoid stone is ca. 2.7 by ca. 1.8 cm., with the walls 2.7 mm. thick.

There are three specimens that have the same fruit type, with the outer layer moderately thick (1.2-2.5 mm.) and compact; however, the stone walls are rather thin (0.2-0.9 mm.). Although the lamina varies considerably in size (2.2-6.4 by 1.2-3.4 cm.), variation in venation is less (7 to 11 veins/5 mm., angle of divergence 55-70°), and the terminal bud is always plump, being 3-4 mm. long. The inflorescence axes and pedicels are puberulent. The three specimens differ greatly in fruit size and shape: the fruit may be spherical or ovoid, 1.6-3.3 by 1.4-2.5 cm., and either beaked or rounded at the apex. The status of this group is uncertain. (Specimens: 28905 SF, Amborompotsy (à l'O. d'Ambatafinandrantana); 5217 SF, Ambositra, Itremo, Lamamy; 11563 SF, Mont Ambatomenaloha, à l'E. d'Itremo.)

The relatively small, spherical fruits of 11563 SF (above) are similar to those of 15037 SF (from Sarolamby, Marolambo), which, however, have very short internodes less than 1 cm. long, a terminal bud less than 2 mm. long, and a different facies.

There is a group of flowering specimens from around Ambohimirahavy, to the north of the localities of all the other specimens discussed above, which have the growth habit of *Calophyllum milvum*, the lowest internode of an innovation being much longer than the others, although they have a terminal bud 3-4 mm. long. Otherwise, in such characters as their clear venation and their prominently raised midrib, they at least superficially approach 15037 SF. (Specimens: 992 SF, Humbert 24890 and 25155.)

31. *Calophyllum drouhardii* H. Perr. Mém. Mus. Nat. Hist. Nat. Paris, n.s. 24: 79. 1948, in Humbert, Fl. Madagascar Comores, Fam. 136: 10. fig. 2, 1, 2. 1951. Type: Madagascar, forêt Orientale [Andrebo, E. Imerina], Perrier de la Bâthie 14635 comm. Drouhard (lectotype, ♀; isolectotype, ♀).

Tree 10–15 meters tall; trunk and bark not known.

Twigs slightly flattened, 0.7–1.5 mm. across, narrowly 4-alate, drying mid to dark brown, sparsely brown-farinoso; axillary innovations lacking basal scars; internodes 0.7–1.7(–2.5) cm. long; uppermost pair of axillary buds less than 1 mm. long, inconspicuous; terminal bud plump, 2.5–4 mm. long, brown-puberulent, underdeveloped internode inconspicuous. Petiole 2–5 mm. long, deeply concave above, convex below, fugaceously farinoso; lamina elliptic to subrhombiform or obovate, 0.9–3.7 by 0.5–2 cm., rounded to obtuse at apex, ± cuneate to acute at base, slightly recurved and not undulate at margin, coriaceous, drying near amber on both surfaces, often shiny above, sparsely and subpersistently farinoso especially on midrib below, the midrib above narrowing rather abruptly near base, slightly raised, 0.1–0.3 mm. wide at midpoint, below raised, slightly striate or rounded, the venation ± apparent on both surfaces, less so below than above, raised (impressed below), 13 to 19 veins/5 mm., angle of divergence 65–70°. Inflorescences from foliate axils along stem (rarely also terminal), with (?) 1 to 3 to 15 flowers, unbranched, the axis 0.7–6.5 cm. long, subglabrous or brown-farinoso, lowest internode 0.7–1.5 cm. long; bracts sometimes foliaceous and persistent at anthesis, to 10 by 7 mm.; pedicels 0.35–2 cm. long, glabrous or sparsely farinoso. Flower (?) hermaphroditic; tepals 8 or 9, the outer pair broadly ovate, 4.5–6 by 3.5–5 mm., the inner ones elliptic to obovate, 7.5–8 by 3–4 mm.; stamens 135 to 180, the filaments to 3.5 mm. long, connate for up to 0.5 mm., the anthers suboblong, 0.8–1.2 mm. long, retuse at apex; ovary 1.3–1.5 mm. long, the style ca. 4 mm. long, the stigma peltate, 0.7–0.8 mm. across, not lobed. Fruit ovoid, 2–2.4 by ca. 1.5 cm., acute at apex, drying brown, with shallow, ± longitudinal wrinkles; outer layer not detaching cleanly from stone, ca. 0.8 mm. thick, compact; stone ellipsoid, ca. 1.5 by 1.1 cm., rounded at apex, the walls ca. 0.3 mm. thick, smooth, (?) unmarked; spongy layer (?) thin.

DISTRIBUTION. Central Madagascar (MAP 13).

SELECTED SPECIMENS SEEN. Madagascar: Manerinerina sur le Tampoketsa, entre l'Ikopa et la Betsiboka, 1600 m., Perrier de la Bâthie 16740 (♀); Ambatondrazaka, E. Mambatositra, Manaka, 10561 RN (♀); Moramanga, Savoka, 900 m., 26776 SF (♀); Ambatovy, 28373 SF (♀); Autanditra, Perinet, 8338 SF (♀); à l'ouest d'Iremo (O. Betsileo), 1500–1700 m., Humbert 28355 (♀); près d'Ankalozza, Boiteau s.n. anno 1968 (♀); Ambohimombo forest, 1350–1440 m., Forsyth-Major 341 (BM, ♂); Fianarantsoa, Fandrandava, Ampamaherana, 13638 SF (♀); Sambalahy, 13530 SF (♀); Andramabovata, 13270 SF (♀), Tolongoina, Fort Carnot, 13538 SF (♀).

ECOLOGY. Colline or montane forest, 900-1700 m. alt. (*Morat 3258* taken from tree growing in area with podzol pan; base of tree under water ("sur curaise, pied dans l'eau")). Flowering mostly December to February, rarely March and October; fruiting November and January.

LOCAL USE. The wood is used in construction.

Calophyllum drouhardii can be recognized by its slender, narrowly 4-angled twigs, small leaf blades with dense venation and obtuse to retuse apices, and relatively very large, beaked fruit with a thin woody layer. The epithet commemorates E.-J. Drouhard, whose daughter married Perrier de la Bâthie.

A sheet of *Perrier de la Bâthie 14635* (collected by Drouhard) at Paris has been designated the lectotype of *Calophyllum drouhardii*. This specimen has some terminal inflorescences, and the venation on the underside of the lamina is subimpressed.

32. *Calophyllum paniculatum* P. F. Stevens, sp. nov.

FIGURE 15, m-o.

A speciebus aliis *Calophylli* in lamina magna (oblongo-)ovata in siccitate concava marginibus valde recurvatis venulis lateralibus subdensis, inflorescentiis axillaribus ramosis, et fructu plerumque ellipsoideo, differt.

Tree ca. 20 meters tall, d.b.h. to 50 cm.; trunk and bark not known.

Twigs slightly flattened, 3-4 mm. across, 4-angled, sometimes with 4 additional raised lines, drying dark brown to blackish, when young sparsely farinose; axillary innovations probably lacking basal scars; internodes 1-4 cm. long; uppermost pair of axillary buds subacute, 1.5-7.5 mm. long, spreading; terminal bud plump, 1.1-2.4 cm. long, with gray to brown, subrustaceous indumentum, underdeveloped internode 3-10(-14) mm. long. Petiole 1.7-2.4 cm. long, broadly and deeply concave above and convex below, glabrescent; lamina narrowly ovate to oblong, 9.5-30 by 3.3-7 cm., acute at apex, acute to attenuate at base, distantly undulate and recurved at margin, drying broadly convex, sepia or olivaceous above and sabelline to fulvous-umber below, glabrous at maturity, the midrib above generally quickly narrowed near base, at first only margins raised, 0.2-0.3 mm. wide at midpoint, becoming raised toward apex, below raised, striate, the venation subobscure to subapparent on both surfaces, raised, sometimes impressed above or flat below, 11 to 16 veins/5 mm., angle of divergence 75-80°. Inflorescences from foliate axils, with 15 to numerous flowers, usually with branches to 3 cm. long and with 5 flowers, the axis 4.5-14 cm. long, farinose toward base, lowest internode 1.8-4 cm. long; bracts not known; pedicels 1-2.5 cm. long, glabrous or sparsely farinose. Flower (?) hermaphroditic; tepals 8 (rarely 9), the outer pair broadly elliptic to ovate, 5-6.5 by 4.5-6 mm., the inner ones elliptic to obovate, 7.5-11 by 3.5-7 mm.; stamens 380 to 400, the filaments to 5 mm. long, the anthers oblong, 0.6-1.2(-1.4) mm. long, retuse at apex; ovary ca. 2 mm. long, the style ca. 3.5 mm. long, the stigma peltate, 0.8-1 mm. across, \pm 3-radiate. Fruit ellipsoid (rarely ovoid), 2.4-2.6(-4.2) by 1.9-2.2(-2.6) cm.; \pm acute at apex, drying vinaceous-brown,

irregularly striate; outer layer detaching cleanly (?always) from stone, 2-2.3(-3) mm. thick, compact; stone ellipsoid to ovoid-ellipsoid, 1.9-2.4(-3.5) by 1.6-1.75(-1.9) cm., rounded to obtuse at apex, the walls 0.8-0.9(-1.2) mm. thick, smooth, unmarked; spongy layer thin.

TYPE: Madagascar, Maromandra, Ambanja, 6 Oct. 1954, 11078 SF (holotype, ♀).

DISTRIBUTION. Northwestern Madagascar (MAP 13).

ADDITIONAL SPECIMENS SEEN. Madagascar: Nossi-Bé, 5518 RN (♀), 8278 RN (♀), Boivin s.n., March 1851 (♀); Ambanja, Ambodimanga (3 km. de Renavony), 1297 RN (♀); Andampy, 10673 SF (♀); Sambirano, Massif du Manongarivo, 500 m., 11484 SF (♀).

ECOLOGY. Light forests, to 500 m. alt., sometimes near sea. Flowering January, February, and June; fruiting in November.

LOCAL USE. The wood is used in carpentry.

Calophyllum paniculatum can be recognized by its long terminal bud; long, narrowly ovate lamina with rather sharply recurved margins; axillary and usually branched inflorescences; and usually ellipsoid fruits. The epithet *paniculatum* alludes to the axillary, branched inflorescences of this species, an unusual combination in the genus.

There are three specimens with fruits: 10673 SF, 11078 SF, and 11484 SF. 11484 SF is the only specimen with ripe fruits; they are very much larger than those of the other specimens (measurements in parentheses in the description above), although they are of the same type. The fruits of 10673 SF and 11078 SF have a well-developed woody layer, although the embryo is still small.

The specimen cited above collected by Boivin from Nossi-Bé was included in *Calophyllum spectabile* by Perrier de la Bâthie (1951).

A sterile specimen collected by Boivin from "forêt de Ravine-Tsara, Île Ste. Marie" is superficially like *Calophyllum paniculatum*, although it has more distant venation (only 9 veins/5 mm.).

There are a number of other specimens with large leaves, long terminal buds, axillary, sometimes branched inflorescences, flowers with usually more than eight tepals, and rather large fruits. The specimens may provisionally be called *Calophyllum* aff. *paniculatum*, but much careful field work is needed here, as with the other Madagascan species. They are discussed below.

Calophyllum aff. **paniculatum** 1

FIGURE 15, p. q.

Tree 25-40 meters tall, d.b.h. to 100 cm.; outer bark brown, slightly fissured; latex yellow.

Twigs 3.5-5 mm. across, with ca. 8 raised lines; terminal bud 1.4-2.5 cm. long. Petiole 1-2 cm. long; lamina elliptic to suboblong, (8.5-)10-13 by (3-)4-6.5 cm., shallowly retuse to obtuse at apex, (shortly) acute at base, strongly recurved at margin, entire lamina ± concave, the midrib above abruptly

narrowed at base, very narrow and obscured by lamina, the venation raised, 15 to 19 veins/5 mm., angle of divergence 70–80°. Inflorescence branched, with farinose indumentum; pedicels 0.5–1.6(–2) cm. long. Flower with (10 to) 12 to 14 tepals; stamens 185 to 325, the anthers oblong, 0.8–1.4 mm. long; stigma peltate, ca. 1.3 mm. across. Fruit spherical, ca. 3.2 cm. long and across, apiculate, drying brown, wrinkled; outer layer not detaching very cleanly from stone, 4.5–6.5 mm. thick, compact; stone spherical, 2.3–2.7 by 2.1–2.3 cm., apiculate, the walls ca. 2 mm. thick, smooth, unmarked, developed at base.

DISTRIBUTION. Northeastern Madagascar (MAP 13).

SPECIMENS SEEN. **Madagascar:** Massif de Marojejy, près du col de Doan-yanala, 800–1200 m., *Humbert 23120* (p); Massif de l'Anjanaharibe, haute Andramonta, bassin de la Lokoho, 700 m., *Humbert et al. 24526* (p); vallée de l'Andramonta, 917 *SF* (p); Andapa, Ampontsilahy, 14578 *SF* (p).

ECOLOGY. Large tree, 700–1200 m. alt. Flowering and fruiting in December (flower scented).

***Calophyllum* aff. *paniculatum* 2**

FIGURE 15, r, s.

Tree 15–20 meters tall; trunk and bark not known.

Twigs 2.5–3 mm. across, strongly 4-angled or with ca. 8 raised lines; terminal bud 8–10 mm. long. Petiole 0.8–1.1 cm. long; lamina oblong to subelliptic, 5–12 by 2.2–4.1 cm., rounded to retuse (rarely mucronate) at apex, acute to ± attenuate at base, broadly recurved at margin, entire lamina ± concave, the midrib above abruptly narrowed at base, ca. 0.25 mm. across at midpoint, the venation raised, 7 to 12 veins/5 mm., angle of divergence 70–80°. Inflorescences unbranched [rarely flabellate toward base], subglabrous [or densely subfarinose]; pedicels [0.6–]1.5–3 cm. long. Flower with [8 to 10 or] 12 to 14 tepals; stamens [250 to 305 or] 690 to 720, the anthers oblong, 1–1.3 mm. long; stigma peltate, [1–1.5 or] 2–3 mm. across. Fruit ellipsoid, 3–3.7 cm. long, ca. 1.5 cm. across, rounded at apex, drying brown, with broad, rounded wrinkles; outer layer not detaching cleanly from stone, 2–3 mm. thick, compact; stone ellipsoid, 2.5–2.7 by 1.2–1.3 cm., obtuse at apex, the walls ca. 1.2 mm. thick, smooth, unmarked, not developed at base.

DISTRIBUTION. Northeastern Madagascar (MAP 13).

SPECIMENS SEEN. **Madagascar:** Nantoraka, au sud de Maroantsetra, 22855 *SF* (p); Antalaha, Ambohitralana, 5290 *RN* (p); Ampanavoana, 7254 *RN* (p); Fénériver, Analalava, circa 4 km. ouest de Foulpointe, 20–50 m., 20158 *SF* (p); Tampolo, 15212 *SF* (p).

ECOLOGY. Sublittoral forest on sand (22855 *SF*), also on "montagne" (5290 *RN*). Flowering June and July; fruiting October and November.

Calophyllum aff. paniculatum 3

Tree ca. 12 meters tall, d.b.h. ca. 40 cm.; bark not known.

Twigs 3-3.5 mm. across, usually 4-angled to 4-subulate; terminal bud (0.7-)1.2-1.5 cm. long. Petiole 0.6-1.2 cm. long; lamina elliptic to oblong, 5.5-14 by 2.7-5.1 cm., retuse (rarely subacute) at apex, cuneate to attenuate at base, strongly to slightly recurved at margin (entire lamina \pm concave), the midrib above abruptly narrowed at base, 0.3-0.8 mm. wide at midpoint, the venation raised, (6 to) 12 to 15 veins/5 mm., angle of divergence 70-75°. Inflorescences branched or unbranched, puberulent; pedicels 0.7-2 cm. long. Flower with (?11 or) 12 to 15 tepals; stamens ca. 390, the anthers oblong, 0.6-1.1 mm. long; stigma peltate, ca. 0.7 mm. across. Fruit ellipsoid, 2.9-3.3 by 1.9-2.1 cm., \pm acute at apex, drying pruinose-brown to dark brown, \pm longitudinally wrinkled; outer layer not detaching cleanly from stone, 2.5-3.2 mm. thick, compact; stone ellipsoid, 2.1-2.4 by ca. 1.4 cm., obtuse at apex, the walls ca. 1 mm. thick, smooth, unmarked, developed at base.

DISTRIBUTION. Eastern Madagascar (MAP 13).

SPECIMENS SEEN. Madagascar: forêt d'Anche-Diego, 178-R-6 [SF] (small leaves) (p); Antanimenabaka, 26-R-202 [SF] (p); vallée de la Manampanihiny, environs d'Ampasimena, Humbert 20607bis (p); bassin de la Manampanihiny, mont Vohimano, au nord d'Ampasimena, 600-700 m., Humbert 20682bis (p); Antalaha, Ampanavoana, Vinanivao, 19183 SF (p); Maroantsetra, Farofandina, 15745 SF (p); Moramanga, forêt ouest d'Ampandroantraka, 16954 SF (p); Marolambo, Androrangavola, Sandranamby, 15036 SF (p); forêt Infanadiana, 13819 SF (?) (p), 14239 SF (?) (p); Fianarantsoa, Rindry, Fort Carnot, 7301 SF (p), 4804 SF (p); Fort Dauphin, Mahatalaky, forêt Lepourbe, 14545 SF (p); sine loco, anon. 279 (p).

ECOLOGY. Flowering September and December; fruiting June and September.

The specimens cited as *Calophyllum aff. paniculatum 1* are the most distinct group. They are characterized by robust twigs and terminal buds, branched, puberulent inflorescences, and spherical fruits with a thick outer layer and stone. The specimens collected by Humbert cited under *C. aff. paniculatum 3* are in some ways similar, but have thinner, 4-angled twigs and less dense venation (8 to 10 veins/5 mm.).

Calophyllum aff. paniculatum 2 is less robust than *C. aff. paniculatum 1*, and its leaves have only seven to twelve veins/5 mm. (vs. 15 to 19 veins/5 mm.). The inflorescence is generally less robust and is unbranched, but the flowers have more numerous stamens. The fruit of *C. aff. paniculatum 2* looks somewhat like a superannuated sausage and differs in numerous particulars from that of *C. aff. paniculatum 1* (FIGURE 15, p-s). The often subglabrous inflorescences and the large stigma of *C. aff. paniculatum 2* are also noteworthy. The terminal bud of *C. aff. paniculatum 2* is more or less enclosed in a pocket formed from the concave petioles and lower part of the midribs of the rather persistently erect terminal pair of leaves.

The specimens from Fénérive cited under *Calophyllum aff. paniculatum 2* may not belong there; both are in flower and differ from the other specimens

in the description above by the measurements enclosed in brackets.

Calophyllum aff. *paniculatum* 3 is not a cohesive taxon. Four of the specimens cited are in fruit; in all of these the stone lacks the fibrous base characteristic of *C. aff. paniculatum* 2. The fruits of 4804 SF and 15036 SF are rather sharply wrinkled and have a 2.5–3.2 mm. thick outer layer with obvious latex canals; the stone is obtuse at the apex. In 15745 SF the outer layer is only ca. 1 mm. thick, although the fruits are younger. The outer layer of the fruit of 19183 SF is ca. 2.5 mm. thick but lacks obvious latex canals. The last two specimens have a more or less flat-drying lamina, and the terminal bud is not enclosed by the erect terminal pair of leaves.

Possible Hybridization with *Calophyllum inophyllum*

19184 SF (♀; from Antalaha, Ampanavoana, Maraontoro; collected near a river on sandy, clayey soil) was possibly taken from a hybrid between a member of the *Calophyllum* aff. *paniculatum* complex and *C. inophyllum*. Although the specimen has the facies of *C. inophyllum*, the color of the dry leaf, its strongly recurved margin, more or less invisible midrib, and high venation density (10 to 14 veins/5 mm.) are atypical, as is the terminal bud, which is ca. 1 cm. long. The pedicels in fruit are up to 2.8 cm. long. The fruit is ovoid, ca. 2.6 by 1.9 cm., and beaked at the apex; the outer layer is 1.5 mm. thick; the stone has walls ca. 1.2 mm. thick and a basal plug. Apart from the absence of a thick, persistent, spongy layer, the fruit is very similar to that of *C. inophyllum*.

33. *Calophyllum chapelieri* Drake, Bull. Soc. Linn. Paris 2: 1220. 1896; Drake in Grandid. Hist. Phys. Nat. Polit. Madagascar 35: pl. 358, 1. 1896; H. Perr. Mém. Mus. Nat. Hist. Nat. Paris, n.s. 24: 79. 1948, in Humbert, Fl. Madagascar Comores, Fam. 136: 10, fig. 2, 4, 5. 1951. TYPE: Madagascar [environs de Tamatave], *Chapelier* s.n. (holotype, ♀).

Tree 3–15 meters tall, d.b.h. to 80 cm.; outer bark grayish.

Twigs flattened, 3–4(–5) mm. across, rounded or with 4 obscure raised lines, becoming striate, drying brownish black, glabrous when mature; axillary innovations lacking basal scars; internodes in lower part of innovation (2–)3–7.5 cm. long, penultimate internode 0.5–1.5(–2) cm. long, ultimate internode ca. 3 mm. long; uppermost pair of axillary buds very small and inconspicuous; terminal bud plump, 2–2.5 mm. long, with brown, ± crustose indumentum (hairs, FIGURE 13, l), underdeveloped internode absent. Petiole 2.2–4 cm. long, deeply concave above, convex below, glabrous; lamina obovate (rarely elliptic), 8.6–12.7 by 1.7–6.5 cm., rounded or slightly retuse at apex, narrowly acute at base, not undulate but strongly recurved at margin, coriaceous, drying umber above and cinnamon-sabelline below, glabrous when mature, the midrib above gradually narrowed from base, raised, strongly sulcate at first, 0.3–0.5 mm. wide at midpoint, below raised, angled toward apex, striate toward base, the venation ± apparent above, apparent below, raised, 4 to

7 veins/5 mm., angle of divergence 35–55°. Inflorescences from uppermost foliate axils (sometimes two together), with 7 to 11 flowers, unbranched, the axis 3–8 cm. long, glabrous, lowest internode 2–4.5 cm. long, the flowers tending to be in fours, with two pairs separated by a short internode, the groups of four separated by a longer internode; bracts ovate, to 3 mm. long, deciduous; pedicels 1–2.5 cm. long, glabrous. Flower (?) hermaphroditic; tepals 8 (rarely 9), the outer pair suborbicular, 7.5–9 by 7.5–8 mm., strongly concave, sometimes persisting in fruit, the inner ones elliptic to oblong, 9–14 mm. by 4.5–6.5 cm.; stamens 230 to 360, the filaments to 5 mm. long, the anthers oblong, (0.8–)1.3–2 mm. long, slightly retuse at apex; ovary ca. 1.5 mm. long, the style 3.5–4 mm. long, the stigma peltate, 1.5–1.8 mm. across, \pm 4-radiate. Fruit ellipsoid, ca. 1.8 by 1.5 cm., apiculate or not, drying grayish brown, rather broadly wrinkled; outer layer separating \pm cleanly from stone when ripe, 2–3.5 mm. thick, compact except for air spaces developing under skin; stone ellipsoid, 1.2–1.4 by 1–1.2 cm., apiculate or not, the walls 0.4–0.6 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Madagascar, the eastern coast (MAP 12).

SELECTED SPECIMENS SEEN. **Madagascar:** Mananara nord, Ant[an]ambe, 12864 SF (p); Fénérive, Amposina, Tanambao-Tampolo, Tampolo, 16101 SF (p); près de Brickaville, Perrier de la Bâthie 14077 (p); Ambila-Lemaitso, Antomanala, 8311 SF (p); Mahanoro, Tambola, 4901 SF (p); Ambilabe, Ambinany, 21530 SF (p); Mananjary, F. Marohita, 19538 SF (p); Pangalona, 9511 SF (p); Andranomany, 5628 SF (p); Faraony, Perrier de la Bâthie 11571 (p).

ECOLOGY. Sandy soil near coast, low elevations. Flowering January, September, November, and December; fruiting July, September, November, and December.

Prominent, elliptic, crateriform galls (projections ca. 3.5 by 3 by 2 mm.) sometimes occur on the lower side of the lamina, either irregularly distributed or in a row often near the margin (FIGURE 5, g).

LOCAL USES. The wood is used in construction, and oil is sometimes extracted from the seed.

Calophyllum chapelieri can be recognized by its moderate-sized leaves more or less grouped together at the end of an innovation, and its flowers, which are borne in fours along the inflorescences. The epithet commemorates L. A. Chapelier, a collector who died in Madagascar at the age of 23.

Calophyllum chapelieri is closely related to *C. verticillatum*; the differences separating the two species are discussed under the latter.

There are two collections from Ambila-Lemaitso (4929 SF (p), Boiteau 1127 (p)) that appear to be intermediate between *Calophyllum inophyllum* and *C. chapelieri*. Their leaf blades are thinner than those of *C. chapelieri* and are more acute at the apex, the midrib on the upper surface of the lamina is rather abruptly narrowed at the base, and the margin of the lamina is less strongly recurved. The internodes at the end of the innovation are longer, and the fruits (Boiteau 1127) have stone walls ca. 0.8 mm. thick

and a thin, but well-marked, spongy layer. In all these characters, apart from the leaf apex, these specimens approach *C. inophyllum*. However, they differ from that species in having rather narrow leaves that are loosely aggregated at the ends of the innovations and narrowly recurved at the margins, and in the fruits, which have only a thin spongy layer and apparently lack a basal plug.

A sterile specimen (*Geay 7582* (MO (s.n.), v), from Mananjary), cited as *Calophyllum spectabile* by Perrier de la Bâthie (1951, *op. cit.*), also has pseudoverticillate leaves. However, this specimen has a terminal bud up to 2.5 cm. long enclosed in a pocket formed by the concave petiole and the lower part of the midrib, and the lamina is ca. 25 by 5-7.5 cm. with a rounded to subcordate base.

34. *Calophyllum verticillatum* P. F. Stevens, sp. nov.

FIGURE 15, j-l.

C. laxiflorum auct., non Drake; H. Perr. in Humbert, Fl. Madagascar Comores, Fam. 136: 12, fig. 2, 6-8. 1951, *pro parte*.

A speciebus aliis *Calophylli* (*C. chapelieri* excepto) in paribus duobus vel tribus foliarum apice innovationis pseudoverticillatis dispositis et floribus inflorescentiarum necnon pseudoverticillatis dispositis differt, et a *C. chapelieri* in ramulis gracilioribus, foliis inflorescentiis floribusque minoribus, staminibus 120 ad 150 (non 230 ad 360), et parietibus putaminis 0.2-0.35 mm. crassis (non 0.4-0.6(-1) mm. crassis), differt.

Tree 10-20 meters tall, d.b.h. to 40 cm.; bark not known.

Twigs slightly flattened, 1-1.5 mm. across, 4-angled when young, soon becoming rounded, drying brown, glabrous; axillary innovations lacking basal scars; internodes 1-4 cm. long, terminal internode of innovation ca. 2 mm. long; uppermost pair of axillary buds very small and inconspicuous; terminal bud plump, 1.3-1.7 mm. long, with short, brown indumentum (hairs, FIGURE 13, i), underdeveloped internode absent. Petiole 0.3-1.5 cm. long, concave above and convex below, glabrous; lamina obovate, (2-)3-5.3(-8) by (0.45-)1-2.2(-3.1) cm., rounded to slightly retuse at apex, acute to cuneate at base, not undulate and not recurved to narrowly so at margin, coriaceous, drying fulvous-umber above and sabelline below, glabrous or transiently farinose on midrib below, the midrib above gradually narrowed from base, \pm raised, 0.2-0.35 mm. wide at midpoint, below slightly raised (margins sometimes slightly depressed), substrate, the venation apparent on both surfaces, raised, 5 to 7 veins/5 mm., angle of divergence 30-50°. Inflorescences from uppermost foliate axils, with 5 to 7 flowers, unbranched, the axis (0.5-)1.5-5.5(-7) cm. long, glabrous, the lowest internode (0.5-)1-3.5 cm. long, the next internode not developing, the uppermost, if present, well developed; bracts ovate, ca. 2.5 mm. long, soon deciduous; pedicels 0.7-2.7 cm. long, glabrous. Flower (?)hermaphroditic; tepals 8, the outer pair broadly ovate, 5.5-6.3 by 4-5.5 mm., strongly concave, the inner ones elliptic to suboblong, 7-10.2 by 2.6-5 mm.; stamens 120 to 150, the filaments to 4 mm. long, connate for up to 0.5 mm., the anthers oblong, 1.6-2.2 mm. long,

retuse at apex; ovary 1.8–2 mm. long, the style ca. 3.7 mm. long, the stigma peltate, 1.2–1.4 mm. across, \pm 3-lobed. Fruit ovoid to subspherical, 1.3–2 by 1.2–1.6 cm., mucronulate, drying pale brown, drying closely and sharply wrinkled when young, smooth when older; outer layer not detaching cleanly from stone, 2.5–3.3 mm. thick, compact apart from air spaces developing under skin; stone ellipsoid, 0.9–1.4 by 0.8–1.2 cm., rounded at apex, the walls 0.2–0.35 mm. thick, smooth, unmarked; spongy layer thin.

TYPE: Madagascar, Fénérive, Ampasina, Tampolo, 8 Jan. 1957, 16487 SF (holotype, ♀; isotypes, ♀).

DISTRIBUTION. Madagascar, the eastern coast (MAP 12).

ADDITIONAL SPECIMENS SEEN. **Madagascar:** Antalaha, Ambohitralanana, 8060 RN (♀), Vavasaha, 9109 RN (♀), 9125 RN (♀); Anfanavoana, Ajanazana, Laninhiny, 7490 SF (♀); Anandrovoa, S. de Rantabe, 8933 SF (♀); Maroantsetra, Ambodipaka, 12133 SF (♀); Soanierana Ivongo, 2456 SF (♀), Forêt Sahavolawena, 7929 SF (♀); Fénérive, Amposina, Tampolo, 3 m., 17702 SF (♀); Forêt de Mangalimaso, à l'ouest de Foulpointe, 22104 SF (♀); Ambila-Lemaitso, Tampila, 6476 SF (♀); Farafangana, Thorombe, Analazaha, 4833 SF (♀); vallée de la Manampanihy, aux environs d'Ampasimena, 20–100 m., Humberti 20607 (♀); sine loco, herb. du Petit-Thouars (♀), Chapelier s.n. (♀).

ECOLOGY. Lateritic or sandy soils, low altitudes. Flowering October, December, and January; fruiting July (fruit not quite mature), September to December.

Ellipsoid, crateriform galls ca. 2 by 1.5 mm. occur on the lower surface of the lamina on some specimens.

LOCAL USE. The wood is used in construction.

Calophyllum verticillatum and *C. chapelieri* are similar in their distinctive inflorescence type, with the flowers in pseudowhorls or at least close together, and in the arrangement of leaves at the ends of the twigs, and they have similar fruits and crateriform galls. However, *C. verticillatum* is consistently smaller in all its parts, its lamina has an at most slightly recurved margin, the arrangement of flowers in fours along the inflorescence axis is more regular, the thick sepals are rarely persistent around the base of the fruit, the stamens are only half as numerous, and the ovoid to subspherical fruit has a stone about half the thickness of that of *C. chapelieri*. (The almost whorled leaves and flowers of *C. verticillatum* suggested its specific epithet.) The distribution of *C. verticillatum* is somewhat more northerly than that of *C. chapelieri*, but it has also been collected to the south of the known range of *C. chapelieri*.

7490 SF, from Antalaha, is the only specimen more or less intermediate between the two species. It has larger leaves than is usual for *Calophyllum verticillatum* (the measurements in parentheses in the description above), ellipsoid fruit, and subsistent sepals. However, the facies and infructescence type are more those of *C. verticillatum*; *C. chapelieri* is not known from Antalaha.

The relationship between *Calophyllum verticillatum* and *C. chapelieri*, although undoubtedly close, needs to be investigated in the field; specific rank for the two taxa seems most appropriate at present.

35. *Calophyllum fibrosum* P. F. Stevens, sp. nov.

A speciebibus aliis *Calophylli* in lamina parva nervis lateralibus infra planis vel leviter impressis marginibusque costarum depressis, et in fructu strato exteriore fibris prominentibus subpersistentibus circa putaminem, differt.

Tree 6–30 meters tall, d.b.h. to 35 cm.; bark not known; latex yellow.

Twigs slightly flattened, 0.7–1.7 mm. across, strongly 4-angled, drying brown, glabrous; axillary innovations lacking basal scars; internodes 0.5–5 cm. long; uppermost pair of axillary buds rounded, ca. 0.7 mm. long, ± spreading; terminal bud plump, 1–1.5 mm. long, with short, brown hairs, underdeveloped internode to 1 mm. long. Petiole 0.3–1.5 cm. long, somewhat concave above and convex below, glabrous; lamina obovate to subelliptic, 2.9–5.8(–8.5) by 0.9–3.3(–4.5) cm., subacute to subretuse at apex and narrowly cuneate to acute at base, slightly undulate and strongly recurved at margin, coriaceous, drying brown to greenish brown and shiny above, paler brown and subpruinose below, glabrous at maturity, the midrib above narrowing gradually from base, raised, center ± sulcate, 0.1–0.25 mm. wide at midpoint, below slightly raised, margins depressed, angled, somewhat inconspicuous, the venation apparent above, raised, subobscure below, ± impressed, (4 to) 6 to 12 veins/5 mm., angle of divergence (55–)60–70°. Inflorescences from uppermost foliate axils (rarely from lower down), with 5 to 11 flowers, (flowers flabellately arranged), unbranched, the axis (0.5–)1–4.2 cm. long, glabrous or puberulent toward base, lowest internode (0.2–)0.5–1.8 cm. long; bracts not known; pedicels 0.7–1.5 cm. long, glabrous, slender, to 2.7 cm. by 1.5 mm. in fruit. Flower (?)hermaphroditic; tepals 8 (rarely 10), glabrous, the outer pair suborbicular to broadly ovate, 4.7–5.7 mm. long and across, the inner ones oblong to elliptic, 7.5–9 by 2–4 mm.; stamens 140 to 155, the filaments to 3.5 mm. long, the anthers oblong, 0.9–1.3 mm. long, slightly retuse at apex; ovary 1–1.4 mm. long, the style 3.5–3.7 mm. long, the stigma peltate, 0.7–1.2 mm. across, ± 3-radiate. Fruit ellipsoid, 1.6–2 by 1.3–1.6 cm. (rarely obovoid, ca. 2.3 by 1.25 cm.), rounded or mucronulate at apex, drying brown to pale brown, smooth; outer layer not detaching cleanly from stone, 3–4 mm. thick, subcompact, very fibrous; stone ± ellipsoid, 1.3–1.6 by 0.8–0.9 cm., ± obtuse at apex, the walls 0.4–0.9 mm. thick, smooth, unmarked, fibrous at base; spongy layer thin.

TYPE: Madagascar, Antalaha, Ambohitralanana, 16 Nov. 1956, 8594 RN coll. Ranzokiny (holotype, ♀; isotype, ♀).

DISTRIBUTION. Northeastern Madagascar (MAP 12).

ADDITIONAL SPECIMENS SEEN. Madagascar: Vohemar, Anahomana, 4218 SF (♀); Sambava, 8076 RN (♀), Antsahovy, Antongondriha, 859 SF (♀); entre Tsaratanana et Analamanara (route de Sambava et Vohemar, entre Nosiarina

et Antsirabe-N.), 27644 *SF* (♀); S. d'Analamanara (près de Tsaratanana), entre Sambava et Antsirabe-N., forêts entre la Bemarivo et la Mahanara, 27177 *SF* (♀); Antalaha, Ankorodomo, 7041 *RN* (♀); Maroantsetra, Andranofotsy, Farankaraina, 15526 *SF* (♀), 15710 *SF* (♀), 16357 *SF* (♀), 15 m., 17726 *SF* (♀); Mananara, Ambatomiloma 5802 *SF* (♀); côte est de Madagascar au Nème, *Chapelier s.n.* (♀).

ECOLOGY. Flowering March and December (flower scented); fruiting March, July, August, November, and December (outer layer of fruit quite pleasant to eat (859 *SF*)).

LOCAL USES. The wood is used in construction and canoe building.

Calophyllum fibrosum is a distinctive species, even when sterile, because of its small, usually obovate lamina. The venation on the lower surface is subobscure and often impressed, and the midrib is rather inconspicuous since it is raised and has depressed edges. Fibers of the outer layer of the fruit persist around the stone after the epicarp has fallen away, hence the specific epithet. Branching is profuse, and the terminal bud may not be functional.

36. *Calophyllum eputamen* P. F. Stevens, Jour. Arnold Arb. 57: 168. 1976.

TYPE: Mauritius, Pétrin, 600 m., 3 Dec. 1973, *Coode 4263* with *Guého & Badré* (holotype, x; isotype, x). **FIGURE 6, f, g.**

Tree 5-6 meters tall, d.b.h. to 30 cm.; trunk without buttresses; for details of bark see varieties.

Twigs not flattened or slightly so, 2.5-6.5 mm. across, 4-angled, drying brown to dark brown, glabrous; axillary innovations lacking basal scars, although often with pair of scars ca. 1 cm. from base; internodes 0.3-2.5 cm. long; uppermost pair of axillary buds unknown; terminal bud plump, 4.5-10 mm. long, with grayish, crustaceous indumentum (hairs, FIGURE 16, a, b), underdeveloped internode absent. Petiole 0.5-1.5 cm. long, broadly and shallowly concave above, convex below, glabrous; lamina elliptic to suborbicular or obovate (rarely ovate), 5.7-17.4 by (3.3-3.9-9.8 cm., obtusely pointed to retuse at apex, cuneate to acute at base, not undulate to distantly so, slightly recurved at margin, coriaceous, drying cinnamon to honey color above and below, glabrous when mature, the midrib above narrowed gradually from base, flat to slightly raised, striate, 0.9-3 mm. wide at midpoint, often disappearing ca. 5 mm. short of apex, below flat to raised, striate, the venation obscure to apparent above, apparent below, raised, 6 to 13 veins/5 mm., angle of divergence 60-75°. Inflorescences from foliate axils (very rarely terminal), with 9 to 17 flowers, unbranched, the axis 4.5-11 cm. long, glabrous, lowest internode 0.5-3 cm. long; bracts broadly ovate to suborbicular, 0.3-2 cm. long, subsistent, subfurfuraceous below; pedicels 0.9-3.4 cm. long, glabrous. Flower (?)hermaphroditic; tepals 8 to 12 (or 13), the outer pair suborbicular to broadly ovate, 6.5-10 by 5-9 mm., sometimes glabrous, the inner ones elliptic to obovate, 9-13 by (1.5-3.5-9 mm., innermost tepals much smaller than outer ones; stamens 270 to 410, the filaments to 7.5 mm. long, connate for up to 1 mm., the anthers oblong, 1.3-2 mm. long, ± truncate

at apex; ovary 2-2.7 mm. long, the style 4-5.5 mm. long, the stigma peltate, 1.2-1.7 mm. across, (2- to) 4-radiate. Fruit ellipsoid to ovoid, 2.4-4 by 2-2.5 cm., ± acute at apex, drying brown, finely wrinkled; the outer layer (?-)3-3.5 mm. thick, at apex and base to 7.5 mm. thick, compact; stone and spongy layer absent; embryo to 2.2 by 1.5 cm.

Key to the Varieties of *Calophyllum eputamen*

1. Terminal bud 4.5-7 mm. long; petiole 5-10 mm. long; lamina 5.7-10.5 cm. long. 36a. var. *eputamen*.
 1. Terminal bud 8-10 mm. long; petiole 8-15 mm. long; lamina (7-)9.5-17.5 cm. long. 36b. var. *grandis*.

36a. *Calophyllum eputamen* P. F. Stevens var. *eputamen*

Outer bark light red-brown, fissured; inner bark red, paler pinkish straw toward cambium; latex yellow, clear, sticky.

Twigs 2.5-5 mm. across; terminal bud 4.5-7 mm. long. Petiole 0.5-1 cm. long; lamina broadly obovate or elliptic to suborbicular (rarely ovate), 5.7-10.5 by 3.9-8 cm., rounded to retuse at apex, the midrib above 1.5-3 mm. across at midpoint, below flat to slightly raised, 6 to 11 veins/5 mm., angle of divergence 60-70°. Fruit to 4 by 2.4 cm.

DISTRIBUTION. Mauritius.

SPECIMENS SEEN. Mauritius: see Stevens, *loc. cit.*

ECOLOGY. Small tree of stunted forests and heathlands on very shallow soil, often in swampy and marshy places; 450-600 m. alt. Flowering January to March; fruiting August and December (fallen fruit brown or black).

Elliptic galls—outgrowths from the leaf—sometimes occur in a line 0.6-1.3 cm. in from the edge of the lamina and may distort the whole leaf (e.g., *Coope 3951*).

36b. *Calophyllum eputamen* P. F. Stevens var. *grandis* P. F. Stevens, Jour. Arnold Arb. 57: 169. 1976. TYPE: Mauritius, Bassin Blanc, 500 m., 6 Dec. 1973, *Coope 4290* with *Guêho & Lorence* (holotype, κ ; isotype, λ).

Outer bark yellow-gray, with vertical fissures 2.5-5 cm. apart when older, the inner surface yellow-brown; under bark red, creamy under cracks; inner bark salmon pink, almost white near cambium; latex yellow, clear, sticky.

Twigs 3.5-6.5 mm. across; terminal bud 8-10 mm. long. Petiole 0.5-1.5 mm. long; lamina elliptic or oval to obovate, (7-)9.5-17.4 by (3.3-)4.4-9.8 cm., subretuse to obtuse at apex, the midrib above 0.9-2 mm. wide at midpoint, below ± raised, 8 to 13 veins/5 mm., angle of divergence 65-75°. Fruit 2.4-3.5 by 2-2.5 cm.

DISTRIBUTION. Mauritius.

SPECIMENS SEEN. Mauritius: see Stevens, *loc. cit.*

ECOLOGY. Small tree, sometimes common in valleys or in forests on windswept ridges, 500-720 m. alt. Regeneration reported in disturbed valley forests (Coode 4290). Fruiting in December.

Calophyllum eputamen can be recognized by its medium-sized to large lamina with a broad, flat, striate midrib and rather distant venation, and its ovoid fruits that have a thick outer layer and lack a stony layer, at least at maturity. The specific epithet refers to the absence of a stony layer in the ripe fruit.

The differences between the two varieties recognized are mainly in the sizes of the parts. *Calophyllum eputamen* var. *eputamen* may grow in less well drained habitats than var. *grandis*, but this must be confirmed.

Calophyllum eputamen is probably related to *C. parviflorum*. For the differences between these species, see the latter.

37. *Calophyllum parviflorum* Bojer ex Baker, Fl. Mauritius, 16. 1877; P. F. Stevens, Jour. Arnold Arb. 57: 173. 1976; *C. tacamahaca* Willd. var. *parviflorum* (Bojer ex Baker) Vesque in C. DC. Monogr. Phanerog. 8: 548. 1893. Type: Mauritius, herb. Justice Blackburn (lectotype, κ).

Tree 1.5-5 meters tall; trunk without buttresses; outer bark yellow when young, becoming pink and gray with vertical, pustular, lenticellar lines, finally becoming fissured, the inner surface bright orange-brown to deep brown; under bark salmon to dark red-brown; inner bark pinkish brown; latex yellow, clear.

Twigs not flattened or slightly so, 1-3 mm. across, with 4 or 6 raised lines, drying brownish, sparsely subfarinose when young; axillary innovations lacking basal scars; internodes 0.2-1(-2.5) cm. long; uppermost pair of axillary buds rounded, to 1 mm. long, \pm spreading; terminal bud plump, 4-6 mm. long, with gray-brown, crustaceous indumentum (hairs, FIGURE 16, c-e), underdeveloped internode to 1 mm. long. Petiole 3-7 mm. long, broadly concave above, convex below, soon glabrescent; lamina elliptic to obovate, 2-5.5(-7.5) by 1.3-3.5(-4.8) cm., rounded to obtuse at apex, rounded to cuneate or subtruncate at base, not undulate to distantly so, slightly recurved at margin, coriaceous, drying \pm sabelline on both surfaces, soon glabrescent apart from sparse, farinose-puberulent indumentum on midrib below, the midrib above gradually narrowed from base, flat to somewhat depressed, 0.3-1 mm. across at midpoint, below raised, \pm angled toward apex, striate toward base, the venation above subobscure, below subapparent, raised, 8 to 15 veins/5 mm., angle of divergence ca. 60°. Inflorescences from foliate axils, with 5 to 11 flowers, unbranched, the axis 0.5-7.5 cm. long, \pm glabrous, lowest internode (0.3-1)-2.5 cm. long; bracts often foliaceous, ovate to obovate, 1.5-10 mm. long, caducous to subsistent; pedicels 4-17 mm. long, glabrous. Flower (?) hermaphroditic; tepals 8 to 12, sometimes glabrous, the outer pair suborbicular, 4.5-6 by 4-5.5 mm., the next two (when more than 8) ca. 5.5 by 3.5-4.3 mm., the inner ones \pm elliptic, 7-9.5 by 2.5-5 mm.; stamens 85 to 255 (to 320), the filaments to 3 mm. long, connate for up to 0.6 mm., the anthers suboblong, 0.6-1.3 mm. long, rounded to retuse

at apex; ovary 1.3–2.5 mm. long, the style 2–3.5 mm. long, the stigma peltate, 0.7–1.3 mm. across, 1- to 3-radiate. Fruit ellipsoid, ca. 2.5 by 1.2 cm., acute to beaked at apex, beak to 7 mm. long, drying brown, smooth; outer layer ca. 0.4 mm. thick, compact, hard; stone and spongy layers absent in mature fruit; seed ca. 1.5 by 1 cm.

DISTRIBUTION. Mauritius.

SPECIMENS SEEN. Mauritius: see Stevens, *loc. cit.*

ECOLOGY. Common in colline forests and shrubbery, sometimes in exposed conditions; 240–660 m. alt. Flowering February, March, and July to September; fruiting in September.

Calophyllum parviflorum is characterized by its rather small leaf blades, which are rounded to obtusely pointed at the apex and which have a flat to more or less depressed midrib on the upper surface, and by its ovoid fruits, which are sharply beaked to acute at the apex and which lack a woody layer when mature. The epithet refers to the flowers, which are small—at least when compared with those of the widespread *C. inophyllum*.

Calophyllum parviflorum is most closely related to *C. eputamen*. However, in the latter species the leaf blades are larger (5.7–10.5 cm. long); the midrib on the upper surface of the blade is depressed and (0.8–)1.5–3 mm. across at the midpoint; and the midrib on the lower surface of the lamina is usually little raised. The axis of the inflorescence is 4.5–11 cm. long, and the fruit is up to 4 by 2.4 cm., with the outer layer (?–)3–3.5 mm. thick. Two specimens, MAU 15475 and MAU 16670, are perhaps more or less intermediate between the two species.

There is relatively little infraspecific variation in *Calophyllum parviflorum*. The young fruit has a distinct, but very thin, woody layer, but this disappears by the time the fruit has ripened. Further variation in the fruit is detailed in Stevens, *loc. cit.* The sapling may have oval to oblong leaf blades up to 11.2 by 3.5 cm.

The lectotypification of *Calophyllum parviflorum* was discussed in Stevens, *loc. cit.*

Reports of *Calophyllum parviflorum* from Madagascar are referable to *C. milvum*. The two species do not seem to be closely related; *C. milvum* differs most obviously from *C. parviflorum* in its axillary innovations, which have long basal internodes, and in its fruits, which have thick-walled stones.

38. *Calophyllum inophyllum* L. Sp. Pl. 513. 1753; Burman f. Fl. Indica, 120. 1768; G. Forster, Fl. Ins. Austral. Prodr. 41. 1768; DC. Prodr. 1: 562. 1824; Blume, Bijdr. Nederl. Indië 5: 217. 1825; Blanco, Fl. Filip. 612. 1837; Wight, Ic. Pl. Indiae Orient. pl. 77. 1839; Miq. Fl. Indiae Batavae 1(2): 510. 1859; Thwaites, Enum. Pl. Zeyl. 51. 1858; Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 282. 1862; Bentham, Fl. Austral. 1: 183. 1863; T. Anderson in Hooker f. Fl. Brit. India 1: 273. 1874; F. Mueller, Descr. Notes Pap. Pl. 36. 1875; Hillebr. Fl. Hawaiian Is. 40. 1888; Vesque, Epharמוש 2: t. 1. 1889, in C. DC. Monogr.

Phanerog. 8: 544. 1893; Drake in Grandid. Hist. Phys. Nat. Polit. Madagascar 35: pl. 355. 1894; Brandis, Indian Trees, 54. fig. 43. 1907; Pitard in Lecomte, Fl. Gén. Indo-Chine 1(4): 324. 1910; K. Schum. & Lauterb. Fl. Deutschen Schutzgeb. Südsee, 499. 1911; Heckel, Ann. Mus. Colon. Marseille, sér. 2. 10: 262. pl. 25. 1912; Koord.-Schum. Syst. Verzeich. 1(Fam. 187): 4. 1912; Merr. Enum. Philip. Fl. Pl. 3: 79. 1923; Craib, Fl. Siam. Enum. 1: 120. 1931; Kanehira, Fl. Micronesica, 234. fig. 106. 1933; Merr. Trans. Am. Philos. Soc. 24(2): 269. 1935; Kanehira, Formosan Trees. rev. ed. 473. fig. 433. 1936; Sastri *et al.* Wealth India 2: 18. 1950; Heyne, Nutt. Pl. Indonesië. ed. 3. 1: 1083. 1950; Sarlin, Bois Forêt Nouv.-Caléd. 207. pl. 92. 1954; M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 314. pl. 1C. 1956; Robson in Exell & Wild, Fl. Zambes. 1: 394. t. 76. 1961; H.-L. Li, Woody Fl. Taiwan, 601. fig. 235. 1963; Backer & Bakh. f. Fl. Java 1: 386. 1965; T. C. Whitmore, Guide Forests Brit. Solomon Is. 77. 1966, Tree Fl. Malaya 2: 186. 1973; P. F. Stevens, Austral. Jour. Bot. 22: 374. 1974; A. C. Smith & Darwin, Jour. Arnold Arb. 55: 223. figs. 6-8. 1974; Troup, Silvic. Indian Trees, ed. 2. 1: 234. 1975; P. F. Stevens, Jour. Arnold Arb. 57: 170. 1976; Perry, Med. Pl. E. SE. Asia, 173. 1980. TYPE: Ceylon, *Hermann s.n.* (lectotype, BM, herb. *Hermann 2.82*).

Balsamaria inophyllum Lour. Fl. Cochinch. 2: 469. 1790. ed. Willd. 2: 574. 1793.

C. bintagor Roxb. Hortus Bengal. 41. 1814; G. Don, Gen. Syst. 1: 622. 1831; Roxb. Fl. Indica. ed. 2 (W. Carey, ed.). 2: 607. 1832. TYPE: based on Rumph. Herb. Amboin. 2: t. 71. 1741.

C. blumei Wight, Illus. Indian Bot. 1: 128. 1840 ("C. blumii"); Walp. Rep. Bot. Syst. 1: 397. 1842; *C. inophyllum* L. β [var.] *blumei* (Wight) Hassk. Pl. Jav. Rar. 276. 1848. TYPE: based on Bl. Bijdr. Nederl. Indië 5: 217. 1825.

C. inophyllum L. β [forma] *obovata* Miq. Pl. Jungh. 291. 1854. TYPE: Java, ad sinum maris Wijnkoopersbaai, [*Junghuhn s.n.*] (lectotype, L, sheet no. 903,343-103).

C. inophyllum L. γ [forma] *oblongata* Miq. Pl. Jungh. 291. 1854. TYPE: Java, sine loco, *Junghuhn s.n.* (lectotype, L, sheet no. 903,343-55).

C. wakamatsui Kanehira, Bot. Mag. Tokyo 48: 401. 1934, Jour. Dept. Agr. Kyushu Imp. Univ. 4: 371. 1935. TYPE: Palau, Amiriik, ca. 200 m., 1 Aug. 1933, *Kanehira 2343* (isotype, NY).

C. inophyllum L. var. *takamaka* Fosberg, Kew Bull. 29: 255. 1974. TYPE: Aldabra Atoll, South Island, Takamaka Grove, 9 Feb. 1968, *Fosberg 49272* (holotype, us; isotype, K).

C. tacamahaca auct., non Willd.; Montrouzier, Mém. Acad. Roy. Soc. Lyons Sci. Lett. 10: 188. 1860, Flora, n.s. 20: 345. 1862.

C. ovatifolium Norona, Verh. Batav. Genootsch. 5(4): 13. 1790. *Nomen*.

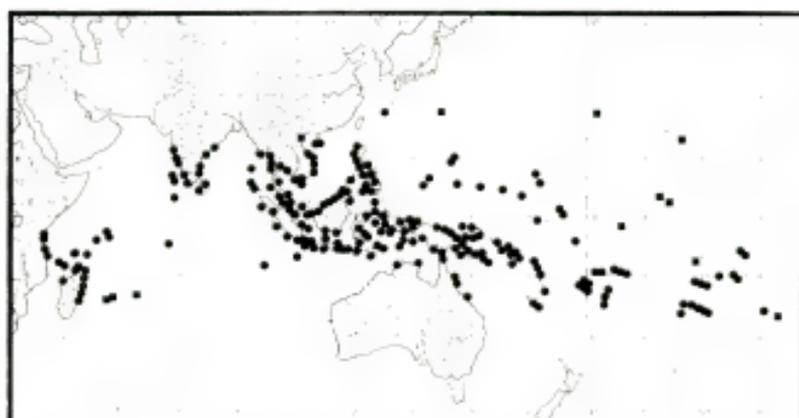
Tree 7-25(-35) meters tall, d.b.h. to 150 cm; trunk without buttresses, often twisted, not erect; outer bark brown to gray (blackish), often mottled, with discrete boat-shaped fissures becoming confluent vertically, inner surface

orange; under bark reddish; inner bark reddish; latex yellow, clear, very sticky.

Twigs slightly flattened, 3-5.5(-7) mm. across, 4-angled, sometimes with two additional raised lines, or rounded, drying brown to dark brown, glabrous; axillary innovations lacking basal scars; internodes (0.4-)1-3(-5) cm. long; uppermost pair of axillary buds rounded to pointed, ca. 1 mm. long, spreading; terminal bud plump, 4-9 mm. long, with grayish to brownish, puberulent to subcrustaceous indumentum (hairs, FIGURE 16, f-m), underdeveloped internode to 4 mm. long. Petiole 1-2.5(-3.2) cm. long, broadly concave above, convex to angled below, glabrous; lamina elliptic to ovate, obovate, or oblong, (5.5-)8-20(-23) by (3.4-)4.6-11.5 cm., rounded to retuse or subacute at apex, cuneate to rounded and finally decurrent at base, rather distantly undulate and slightly recurved at margin, coriaceous, drying olivaceous above to sabelline(-sepia) below, glabrous, the midrib above quickly narrowed at base or not, at first depressed, margins raised or not, 0.2-0.9 mm. wide at midpoint, becoming raised toward apex, below raised, angled (striate) toward base, the venation apparent on both surfaces, raised, 4 to 10 veins/5 mm., angle of divergence (60-)70-80°. Inflorescences from foliate axils, with 5 to 15 (to 31) flowers (rarely with flowers arranged flabellately), usually unbranched (sometimes with 3-flowered branches), the axis 2.5-15 cm. long, glabrous (minutely puberulent toward base), lowest internode (0.2-)0.5-2(-3.8) cm. long; bracts ovate, 3-4 mm. long, very soon deciduous; pedicels (1-)1.5-4.5 (-6.3) cm. long, glabrous. Flower (?)hermaphroditic; tepals 8 (rarely to 13), the outer pair ovate to suborbicular, 5.5-10 by 4.5-8 mm., the next pair subelliptic, 9-15 by (5-)7.5-10 mm., the inner ones obovate to elliptic or oblong, 9-16 by (3-)5-10 mm., rarely glabrous; stamens (175 to) 210 to 360 (to 440), the filaments (3-)5-7 mm. long, connate for up to 2 mm., the anthers oblong, 0.7-2 mm. long, rounded to retuse at apex; ovary 1.5-3.5 mm. long, the style (2.5-)4.5-9 mm. long, the stigma peltate, 0.7-2 mm. across, 3- to 5-radiate. Fruit spherical to obovoid, 2.5-5 by 2-4 cm., apiculate to rounded at apex, sometimes with stipe to 12 mm. long, drying grayish brown, sharply wrinkled; outer layer usually not detaching cleanly from stone, (0.5-)1-2(-3.6) mm. thick, compact; stone subspherical, (1.7-)2-3.9 by 1.9-3.4 cm., rounded (very rarely apiculate) at apex, the walls 0.7-1.2 mm. thick, smooth, unmarked, the basal plug 4-10 mm. across; spongy layer persistent even in mature fruit.

FIGURE 16. Hairs (from terminal bud). a, b, *Calophyllum eputamen* var. *grandis* (Coode et al. 4284). c-e, *C. parviflorum* (Coode et al. 4057). f-m, *C. inophyllum*: f, Degener & Ordóñez 13786; g, Parker 2156; h-k, Schmutz 1160 (k, from above); l, Bois 172 coll. Barreau; m, Sumithraachchi & Davidse 589. n, *C. recedens* (Hildebrandt 3324). o, *C. vernicosum* (Baron 6258). p, *C. tacamahaca* (Coode et al. 4174). q-cc, *C. wallichianum*. q-w, var. *incrassatum*: q, SFN 34911; r-u, Soepadmo 71; v, Stevens et al. 108; w, FRI 12646. x, y, var. *wallichianum* (Wallich dist. 4843). z, aa, var. *tahanense*: z, FRI 7256; aa, SFN 20601. bb, cc, var. *wallichianum* (FRI 5450). Scale = 60 μ m. (in o, scale = 30 μ m.).





MAP 14. Distribution of *Calophyllum inophyllum* (circles, probably native; squares, possibly introduced).

DISTRIBUTION. Eastern Africa to Taiwan, the Ryukyu and Line islands, and New Caledonia; often planted both within its range and in West Africa and the tropics of the New World (MAP 14).

SELECTED SPECIMENS SEEN. **Guinea:** Conakry, jardin du Gouvernement, *anon.* 15 (cult.) (κ). **Ivory Coast:** Abidjan, *Greeners* 695 (cult.) (g). **Ghana:** bay to the W. of Axim, *Morton* A2090 (cult.) (κ). **Camerouns:** shore of Kribi, *de Wilde* c.s. 2116A (cult.) (κ, mo). **Nigeria:** Ibadan, *FHI* 22476 (cult.) (κ). **Kenya:** Mombasa Distr., Shanzu Beach, *Greenway* 13093 (κ). **Tanzania:** Mafia Is., *Ferne* s.n., June 1873 (κ); Kisimania Mafia, Dundani, 6 m., *Greenway* 5327 (κ); Pemba, *Vaughan* 382 (BM); Panza Is., SW. of Pemba, *Greenway* 1401 (κ); Pagani, Chengene, Nwera, *Tanner* 2855 (κ). **Mozambique:** at S. of Muamizi Is., near Ponta Messangi, *Gomes e Sousa* 4458 (κ, w). **Madagascar:** Vohémar, Ampanafena, 10278 SF (p); Antalaha, Ambohitralanana, 6623 RN (p); Maroantsetra, Andramafotsy, Farankaraina, 3491 SF (p); Tampina, au S. de Tamatave, *de Cary* 17725 (p); Mananjary, *Geay* 8187 (p); Nossi-Vé, *Humboldt* 154 (BM, p, κ, w); Nossi-Bé, 4329 RN (p); presqu'île d'Ambato, *Perrier de la Bâthie* 5307 (p); Ambanja, Antafiabé, Nosy Faly, 10442 SF (p). **Mauritius.** Port Louis, *Ayres* s.n., Dec. 1860 (GH, κ). **Rodrigues:** sine loco, *Balfour* s.n. (BM, κ). **Réunion:** Ste. Marie, *Cadet* 5157 (κ). **Comores:** Johanna Is., *Hildebrandt* 1687 (BM, κ, p, w). **Aldabra:** South Is., *Renvoise* 1011 (B, κ). **Farquhar:** North Is., settlement, *Stoddart* 1384 (κ). **Seychelles:** Mahé, Mamelles, *Jeffrey & Zelia* 492 (BO, κ). **Chagos:** Diego Garcia Atoll, *Stoddart* 790 (κ, US). **Maldives:** Addu Atoll, *Sigee* 56 (κ, US); Malé Atoll, Kuda Bados Islet, 1 m., *Fosberg* 36887 (US). **Ceylon:** Panadura, 2-4 m., *Comanor* 1003 (GH, κ, US). **India.** MAHARASHTRA: Concan, *Stocks & Law* s.n. (BM, E, G, K, NY, P, W). MYSORE: Mangalore, *Meebold* 10264 (E). TAMILNADU: Tranquebar, *Didrichsen* 3866 (A, C); Madras, Marciam, *Thompson* s.n. (C, FI, K (sub 524), M, P). WEST BENGAL: Calcutta, *Kamphovener* 429 (C). **Burma:** Amherst, *Wallich* dist. 4841F (G, κ); Tenasserim, *Packman* 43 (BM). **Japan:** Okinawa Prefecture, Kinikami-Son, *Amano* 6060 (A, US); Yaeyama Gunto, Irimito Is., Sunai, *Walker*

& *Tawada* 6558 (A, US). Hainan: Yaichow, Nam Shan Ling, 60 m., *C. L. Tso* 23001 (A, B, E, K, P, US); Ching Mai Distr., Pak Shik Lang & vicinity, Ku Tung Village, *C. I. Lei* 1031 (B, BO, K, P, SING, US, W). Vietnam: secus flumen Saigon, 25-30 m., *Pierre* 3652 (A, AAU, C, K, MO, P, US, SING); Nhatrang, Hoa Cat, *Poilane* 4735 (P). Cambodia: Pnomh Penh, Khutung, *Béjard* 287 (P); Koh Kong, presqu'île Smach, *J. E. Vidal* 4984 (P). Laos: Luang Pralang, Dupuy 207 (P). Thailand. Koh Kadam, *Schmidt* 546 (C); Bangkok, less than 5 m., *Kerr* 4344 (K). Andaman and Nicobar Islands: Teressa Is., *King's collectors s.n.*, 26 Feb. 1894 (A); North Reef Is., *Prairie's collectors s.n.*, 24 Nov. 1903 (A). Malaya. KEDAH: Baling, *KEP* 32983 (A, K, KEP). PINANG: Batoo Phungie [Batu Ferenghi], *Curtis* 133 (K). PERAK: Taiping, bottom of Maxwell's Hill, 150 m., *FRI* 13601 (?cult.) (A, K, KEP, SING). SELANGOR: Kuala Lumpur, Public Gardens, *KEP* 4982 (cult.) (K, KEP, SING). NEGERI SEMBILAN: Cape Rachado area, sea level, *KLU* 13209 (AAU, KLU, MO). MALACCA: sine loco, *Maingay* 1064 (*Kew dist.* 164) (K). KELANTAN: Kuala Kelantan, near Kota Bahru, *Ridley s.n.*, 15 Feb. 1917 (K). PAHANG: Telok Berhala, Pulau Tioman, sea level, *SFN* 18530 (BO, KEP, SING, UC). JOHORE: Padang Mulud, SE. coast of Johore, *Shah & Shukor* 2466 (C, SING, UC). Singapore: Pulau Senang, 45 m., *Sidek bin Kiah* 67 (A, C, LAE, SING). Sumatra and adjacent islands. RIAU: Lingga, Pulau Singkep, 2 m., *bb* 2005 (BO, L); Berhala, 2-5 m., *Lörzing* 6926 (BO). SELATAN: Verlaten Eil., *Backer* 32087 (BO, K, L); Anak Krakatau, *Borssum-Waalke* 1080 (L); S. Enggano, Boea-Boea, 0 m., *Lütjeharms* 4205 (BO, F, K, P). BARAT: Is. of Sipora, *Boden Kloss (SFN)* 14763 (BM, BO, K, SING). ATJEH: Is. Beras, bij Benteng, *Koorders* 10621 (BO). BANGKA: Pulau Lepar, 50 m., *Bünneke* 2449 (BO, L). BELITUNG: sine loco, *van Rossum* 39 (BO). ANAMBAS AND NATAENA: Ranai, *van Steenis* 1321 (L). Borneo and adjacent islands. SARAWAK. 1st Division: Sematan, *Purseglove & Shah* 4621 (K, L, SAR, SING). 4th Division: Baram Distr., Miri, *Hose* 693 (BM, K, P, UC). 5th Division: Lawas, Tagai sawmill, 3 m., *S* 1793 (cult.) (BO, K, L, SAR, SING). BRUNEI: Jerudong beach, *BRUN* 5408 (A, KEP, L, SAR). SABAH. Kuala Penyu: Pulau Tiga, *SAN* 25816 (K, KEP, L, SAN, SAR, SING). Kota Kinabalu: Gaya Is. F.R., 1.5 m., *A* 331 (A, BO, CANB, K, KEP, SING). Kudat: Balembangan Is., sea level, *SAN* 25768 (K, L, SAN, SING). Sandakan: Elopura forest distr., 3 m., *A* 726 (A, BO, K, KEP, P, SING, US). Lahad Datu: Pulau Sakar, S. shore, sea level, *SAN* 21672 (SAN). Semporna: Malanta, *SAN* 1664 (A, BO, K, US). KALIMANTAN. Selatan: Pleihari, Sungei Taboenio, *Dachlan* 2392 (K). Tengah: Sampit, Kuala Pemboeang, Patoelat, *bb* 2159 (BO). Barat: Palo, sea level, *Becking* 63 (BO); Île Ste. Barbe [?Pulau Pedjantan], *Langlassé* 277 (O, P). Philippines. PALAWAN: Mangsi Is., *anon. s.n.* (US); Palawan Is., *BS* 1361 (A, BO, BM, G, P, SING). MINDORO: Lagondian, Puerta Galera, *Barlett* 13729 (A, MICH). LUZON. Ilocos Norte: Bangui, *BS* 27642 (P). La Union: sine loco, *BS* 21087 (GH). Isabela: sine loco, *FB* 29360 (UC). Nueva Ecija: sine loco, *FB* 8486 (SING). Pangasinan: San Carlos, *Gates* 8372 (MICH). Zambales: Botolan, *Merrill* 2929 (K, US). Bataan: Limay, *Species Blancoanae* 936 (A, BM, BO, K, MO, NY, P, US, W). QUEZON: Guinayangan, *BS* 20779 (A, BM, MO, SING, US). Camarines Sur: Pasacao, *Ahern* 22 (BO, K, NY, US). Albay: Batan Is., *FB* 28447 (A). CATANDUANES: sine loco, *FB* 28101 (BM, SING). MASBATE: sine loco, *FB* 1010 (K, NY, US). LEYTE: sine loco, *FB* 26215 (SING). BOHOL: sine loco, *BS* 1232 (BO, LY, NY, US). NEGROS: Negros Oriental, Dumaguete (Cuernos Mts.), *Elmer* 10130 (A, BISH, BM, BO, FL, G, K, LY, MO, NY, US, W). PANAY: Capiz, *FB* 24596 (MO). MINDANAO. Agusan: sine loco, *FB* 23668 (GH, US). Davao: Santa Cruz, *Williams* 2733 (A, K, NY, US). Cotabato: sine loco, *FB* 18259 (BO, LY). Lanao: sine loco, *FB* 20609

(A, UC). Zamboanga del Norte: Pasanan, sea level, *PNH 36270* (CANB). BASILAN: sine loco, *BS 16327* (BM, K, P, US). SULU ARCHIPELAGO. Jolo: Mt. Bayao, *PNH 36886* (BISH). **Java and adjacent islands.** BARAT: Pulau Panaiten (Prinseneiland), N. of mouth of Tjiharasahas, *Borssum-Waalkes 268* (A, BO, K, SING). TENGAH: Banjoemasin, Tjilatap, Noesakambangan, *Koorders 24109* (BO). TIMUR: Soerabaja, Daoen Laut (Eil. Bawean), *Ja 4206* (BO); Kangean Is., N. van Ardjasa, sea level, *Backer 26786* (BO, K, L). COCOS KEELING ISLAND: sine loco, *Guppy s.n.* (K). CHRISTMAS ISLAND: East. Terraces, 75 m., *Powell 57* (L). **Lesser Sunda Islands.** BALI: Banjie Poh, 32 km. W. van Singaradje, *Dillweijn & Demandt s.n.*, Oct. 1929 (L). LOMBOK: bij Laboehan Hadji, 2 m., *Bloembergen 3064* (A, BO, K). SOEMBAWA: Podja, 2 m., *Soejarto 85* (A, BO). FLORES: W. coast, near Nisar, 1-10 m., *Schmutz 1160* (L). SUMBA: Solo, Waloewiti, 10 m., *bb 15970* (BO, L). TIMOR: S. Belu, Kampong Natarain (Bolan), sea level, *Kooy 837* (L). WETAR: Massapoen, 2 m., *bb 27280* (L). KAI ISLANDS: Little Kei Is., *Moseley s.n.*, Sept. 1874 (BM, K). TANIMBAR ISLANDS: Makatian, 1 m., *bb 24401* (BO, L). **Celebes.** SULAWESI: Minahassa, Menado, *Koorders 17289* (BO, L). KABAENA: Balo, Eempuhu, *Elbert 3399* (A, BO, FI). BUTUNG: Paisir Kadjo, 0-100 m., *Elbert 2820* (A, BO, FI). SALAJAR: Saleijet, *Docters van Leeuwen 1848* (BO, U). **Moluccas.** TALIABU: Waloi, *Atjeh (exp. van Hulstijn) 128* (BO, L). SANANA: sine loco, *Atjeh (exp. van Hulstijn) 400* (BO, L). HALAMAHERA: Hokoe2 Kijé (Djalolo), 50 m., *Pleyte 131* (A, BO, K, SING). TERNATE: Monge, 35 m., *Bish 15* (A, BO, K, L, SING). OBI: WOOI, *bb 23833* (BO, L). BANDA: Neira, 2 m., *bb 13433* (BO). BURU: Namlea, *bb 24171* (BO, L). SERAM: Gaoer Serani, 1 m., *bb 25958* (BO, SING). AMBON: Ft. Nieuw Victoria, *Rant 725* (BO). **Papusia:** see Stevens, 1974, *loc. cit.* Also, IRIAN JAYA. ARU: Pulau Kobroór, Selibatatabata, *Buwalda 5246* (BO, K). **Australia.** QUEENSLAND: Rockingham Bay, *Dallachy s.n.* (BM, BO, FI, G, P). NORTHERN TERRITORY: Wessel Is., *Latz 3216* (CANB). **Pacific Islands.** BONIN ISLANDS: Hahajima, 0-500 m., *E. H. Wilson 8290* (cult.) (A, K, US). MARIANA ISLANDS: Guam, Pego R., *Nelson 261* (P); Rota Is., *Grether 4449* (US); Merizo and vicinity, *Fosberg 25394* (BISH, US). CAROLINE ISLANDS: Palau, sine loco, *Kanehira & Nisida 2767* (US); Yap, Colonia, 90 m., *Evans 301* (GH, NY, US); Ponape, *Ledermann 13889* (K); Ulithi Atoll, Fasserai Islet, *Fosberg 25454* (BISH, US); Truk, Natsushima (Dublon Is.), *Takamatsu 76* (BISH, US); Kusaie, Utua, *Takamatsu 370* (BISH, US); Mortlok Group, Lukunof Atoll, *D. Anderson 2174* (BISH, US). MARSHALL ISLANDS: Jaluit Atoll, Medyado Islet, *Fosberg 26788* (BISH, NY, P, US); Arno Atoll, Ine Islet, *D. Anderson 3613* (BISH, NY, US); Rongelap Atoll, Burok Is., *Taylor 46-1463* (old clearing) (A, G, NY, US); Jerno Is., *Fosberg 33871* (cult.) (BISH); Major Atoll, Majuto Is., *Fosberg 26945* (BISH). GILBERT ISLANDS: Tarawa, Tabonimata, *Adaire 36* (K, LAE). ELLICE ISLANDS: Nadumea Is., Haumaefa Village, *Chambers 68* (BISH). NAURU: Yarren, *Burges K5* (K). FIJI: Mamanuthas. Malolo Group: Ngalito Is., *Degener 32219* (E, NY). Viti Levu. Ovalau: Thawathi, *A. C. Smith 8101* (BO, GH, K, NY, P, US). Vanua Levu. Taveuni and Lakemba, *Seemann 48* (BM, G, GH, K, P). HORNE ISLANDS: Alofi, Mt. Vaisei, *Yen X58* (BO). WALLIS ISLANDS: Uvea, *Graeffe 33* (BM). TONGA: Tongatapu, Sopo, *Yuncker 15024* (BM, GH, U, US). NIUE: near Alofi, *Yuncker 9738* (A, K). SAMOA: Savaii, Matauta Bay, *Reinecke 506A* (BO, E, G); Swains Is., *Bryan 1354* (BISH). MARQUESAS: Noukahiva, *Batard 48* (P); Fautuhiva, Omoa, *F. B. H. Brown 930* (BISH); Hiva Oa, Atuona Village, 20 m., *Mumford & Adamson 445* (BISH). TUAOMOTU ARCHIPELAGO: Makatea, 100 m., *W. B. Jones 881* (BISH, BO); Anaa, Ole Pipi, 2 m., *St. John 14277* (cult.) (BISH); Ngake Tkume Atoll, *Doty & Newhouse 12326* (BISH). SOCIETY ISLANDS: Tahiti, Pare, Papeete, 3 m., *Grant 4322* (BO);

Tautira, Vaionifa, 0 m., *Grant 4003* (BISH, BO); Meetia, Fatia-po to Fareua, 100 m., *St. John 14223* (US); Mangariva, *Seurat s.n.*, 25 Nov. 1902 (P); Raiatea, Uturoa, 1 m., *Moore 122* (BISH, KLU, LAE); Moorea, Afareaitu Village, *H. M. Smith 139* (A, BISH, MO, NY); Tahaa, Haamene Bay, *Fosberg & Cooke 12140* (A, BISH, P). MANGAREVA ISLANDS: Aukena Is., Pt. Mata Kuiti, 3 m., *St. John 14650* (BISH); Taravai Is., 5 m., *St. John 14815* (BISH); Mangareva Is., Mt. Duff, 90 m., *St. John 14190* (BISH). TUBUAI ISLANDS: Rurutu, N. side of Mauo, 50 m., *St. John 16702* (BISH); Raivavae, Pic Rouge, 130 m., *St. John & Fosberg 15948* (BISH, US); Rimatara, Anapoto, 10 m., *St. John & Fosberg 16791* (BISH, US); Maria Is., 3 m., *Fosberg 12117* (BISH); Tapapatavai Is., 1 m., *St. John 16409* (BISH). COOK ISLANDS: Rarotonga, *Cheeseman 510* (K); Avatiu, *Wildner 917* (BISH); Aitutaki, *Stoddart 2262* (BISH, US). RENNEL ISLAND: sine loco, *Noona Dan Expedition 2886* (C). NEW HEBRIDES: Vanua Levu, Banks Group, *Kajewski 431* (A, P); Aneityum, Anelgauhut Bay, *Kajewski 783* (A, P, US). HAWAII: Molokai, near dock at Pulsoo, *Degener 8672* (G, K, MASS, MO, NY, US); Oahu, Waikiki, *Rock 2540* (GH); Lanai, *Remy 564* (GH, P); Midway Atoll, Sand Is., *Lamoureaux 2218* (US). PHOENIX ISLANDS: Canton Is., Paa Hotel Garden, *Luomala 18* (BISH). LINE ISLANDS: Flint Is., *St. John & Fosberg 17444* (cult.) (BISH); Fanning Is., copra station, 1 m., *Christophersen 15* (BISH); Palmyra Atoll, Papali Is., *Dawson 19863* (BISH). PITCAIRN ISLAND: Adamstown, *Fosberg 11261* (cult.) (BISH, US). NEW CALEDONIA: presq'île de Nouméa, *Balansa 1774* (P); Prony, *Franc 1706A* (G, K, P); Île d'Oro (Île des Pins), *Virot 1037* (P); coast between Balade and Amos, *McKee 4814* (E).

ECOLOGY. Often common by seashore, sometimes inland (especially on islands) on sandy soils, to 200 m. alt.; also on basaltic outcrops (Christmas Island; Ridley, 1930). Even in cultivation, trunk soon begins to lean; when near sea, main trunk may become prostrate and lean out over sea (lateral branches then more or less erect). Flowering probably throughout year; possibly two bursts of flowering on Madagascar (November to February—17 specimens; April to June—9 specimens; cf. Perrier de la Bâthie, *loc. cit.*, who mentioned flowering September to December). Volkens (1912) noted several bursts of flowering yearly in Java (Buitenzorg), with local synchronicity in flushing. Flower sweet scented. Fruiting throughout much of year; fruit grayish green. When outer layer of fruit has rotted away, fruit floats easily (up to 126 days according to Schimper; reference not seen) and is dispersed by sea currents, although how long seed remains viable not known (Ridley, 1930). Fruit eaten and dispersed by fruit bats (Troup, 1921; Ridley, 1930; van der Pijl, 1957). Immature fruit in Singapore eaten by squirrels (Burkill, *loc. cit.*).

Revolvate leaf-roll galls caused by the psyllid, *Leptynoptera sulphurea*, are known from much of Malesia. Somewhat curved, elongate excrescences on the underside of the lamina caused by a lepidopteran occur on Verlaten Island (Docters van Leeuwen-Reijnvaan & Docters van Leeuwen, 1926).

GERMINATION AND YOUNG PLANT. The radicle breaks the stone just to one side of the base and also pushes out the basal plug. The seedling has three or four pairs of leaves separated by well-developed internodes; the lowest pair of leaves (or, when four pairs altogether, the lowest two pairs) may be small (ca. 2 cm. long) and drop off early. Subsequently produced internodes

are longer, the terminal bud is functional, and the plant is erect. (Germination similar in plants from Malaya, Sarawak, the Philippines, New Guinea, and Australia; see also Stevens, 1974, *loc. cit.*; Lubbock, 1892, p. 234 & fig. 209.) The young seedling illustrated by Burger (1972, fig. 19A) is similar to those described above, but I have not seen the variation in phyllotaxy that he described from the somewhat older plant (see his fig. 19B); this variation is probably exceptional.

SELECTED LOCAL NAMES AND USES. "M'tondoo" and variants (Tanzania (Segeju, Zigua, Digo), Mozambique, the Comores); "foraha" (Madagascar); "takamaka" and variants (Seychelles, Mauritius, Aldabra; recorded by Perrier de la Bâthie (*loc. cit.*) as the name used in Madagascar, but probably an error); "takamaka de Madagascar" (Mauritius); "nagachampa," "punnaga" (Sanskrit); "punnai Pinnay" (Tamil); "vuma," "nonne" (Kanara); "ponnyet," "ph'ông" (Burma); "kating" (Siam); "cây mun" (Vietnam); "penaga laut," "penaga ayer," "pudek" (Malaya, Christmas Island); variants of "penaga" to Bali ("poenaga"), Sabah ("poenajoh," "punagao"), and Makassar ("poenago"); "njamplong" and variants (Java, Bali, southern Borneo); "bangkalan" and variants (eastern Sabah; common in Philippines; Celebes); "palo maria (de playa)" (Philippines, Mariana Islands); "dalo" (Kwara'ae, Solomons); "ndilo" (Fiji); "fifau" (Rotuma); "tsilo," "tilo" (Horn Islands); "liwej" and variants (Marshall Islands); "ragick" and variants (Caroline Islands); "fetau" and variants (Wallis, Ellice, Tonga, Niue, Samoa, Carolines); "tamanu" and variants (Bonin Islands, Nauru, Cook, Hawaii, Rarotonga, Tahiti, New Caledonia); "Alexandrian laurel" (formerly widely used, "a transferred and inappropriate name"—Burkill, *loc. cit.*).

Calophyllum inophyllum is a very useful plant. "To boil bark with water can be used as dye for fish net. Fruit produces oil called Bitter Oil used as oil for lighting purposes, fuel for automobile, airplane, and generating electricity. To mix with acid makes electric oil. It can also be used to make candle and medicine" (*Fung 20261*, from Hainan). Although some of these uses are apocryphal, most parts of the plants are important to local peoples throughout the range of the species.

The wood is moderately heavy and fairly strong and has a closely interlocked grain; it is especially durable under water. Canoes and small boats are frequently made of *Calophyllum inophyllum*, and it provides wood for ship building (mostly keels, knees, and pulley blocks). The wood is used in various other aspects of construction, as well as in making cart wheel hubs, food vessels, and bowls (the latter apparently mostly in the Pacific).

Oil can be extracted from the seeds by heating them either cut and with water or finely crushed. The oil contains resin; the purified oil contains approximately 49.7% oleic acid, 23.8% linoleic acid, 16.8% palmitic acid, and 9.7% stearic acid (see Sastri *et al.*, *loc. cit.*). It is used in soap making and is important as an illuminant. It is also used against rheumatism and skin infections when applied externally. Injected into the muscles, the refined oil relieves the pain in leprosy. In parts of Oceania the oil is used to anoint the body, as either a substitute for, or a pleasant-smelling additive

to, coconut oil. Mixed with the resin of *Vateria* Roxb. (Dipterocarpaceae), the oil is used for caulking boats (India).

Defatted protein from the seeds is of some nutritional value (Venkatesan & Rege, 1973).

The round stones are used as marbles.

The pounded bark may be used in cases of orchitis; the juice as a purgative; a decoction of the bark against indolent ulcers. The aromatic latex exuding from the bark is an emetic and a purgative, or it may be used as a scent (Tahiti); it has also been used as a dye and in the treatment of wounds. An infusion of the leaves is frequently used as an eye wash, but it has many other uses (e.g., against chicken-pox). The juice exuding from squeezed leaves has been used against hemorrhoids; the Cambodians inhale over leaves when they have headaches. *Calophyllum inophyllum* contains saponins, hydrocyanic acid, and also poisonous coumarin derivatives (Kawazu *et al.*, 1968), and is sometimes used as a fish poison. There are numerous other medicinal and quasi-medicinal uses of the plant (see especially Sastri *et al.*, *loc. cit.*; Heyne, *loc. cit.*; Burkill, *loc. cit.*; Perry, *loc. cit.*).

Calophyllum inophyllum is quite widely planted as an ornamental tree and is known as "Alexandrian laurel."

Calophyllum inophyllum is a distinctive species readily recognizable by its medium-sized to large, oval to elliptic leaf blades that are more or less rounded at the apex and have relatively distant and distinct venation; its large, long-pediceled flowers that nearly always have eight tepals; and its fruits, which dry grayish and sharply wrinkled. The only species of *Calophyllum* habitually found on sandy beaches, it is a characteristic species of such habitats in the Indian and western Pacific oceans. The epithet *inophyllum* means "fiber leaf" and refers to the closely set veins that are characteristic of the genus as a whole.

The major infraspecific variation in *Calophyllum inophyllum* is in fruit size. *Calophyllum inophyllum* var. *takamaka* was described from a small-fruited form from Aldabra Island (western Indian Ocean) with fruits less than 25 mm. across; fruits from the Pacific were supposed to be 27-40 mm. across (Fosberg, *loc. cit.*). All 19 fruiting specimens of *C. inophyllum* from Madagascar seen at Paris (except for a possibly incorrectly localized sheet in the Richard herbarium) have fruits less than 27 mm. across; the fruits of *C. inophyllum* in the Mascarenes may be similar in size (Stevens, 1976, *loc. cit.*), while those from the Seychelles are less than 3 cm. across. Although the fruits of specimens from Ceylon and India eastward are usually more than 3 cm. across, there are numerous exceptions with fruits that are ca. 25 mm. or less in diameter (e.g., Vietnam (*Pierre* 3652), Sabah (*S* 1644, *A* 726—the latter cited by Fosberg, *loc. cit.*), Ryukyu Islands (*Wilson* 8020), Hainan (*Lau* 5631), Java (*Koorders* 28793), and Timor (*Kooy* 837)). Thus, although it seems best not to recognize the small-fruited variant of *C. inophyllum* formally, it is nevertheless of considerable interest that this small-fruited form should be predominant in the western Indian Ocean, when it is less frequent elsewhere.

Throughout the range of *Calophyllum inophyllum*, some specimens may have more or less strongly stipitate dried fruits with the stipe up to 12 mm. long, and the fruit may also be subacute at the apex. In neither case is the variation clear-cut, nor is it correlated with other characters. A few specimens from the Moluccas (e.g., *Pleyte 131*) have a lamina that is suboblong and rather abruptly narrowed at the base, with the midrib on the upper surface also abruptly narrowed at the base. Although such specimens are very distinctive at first sight, all intermediates between them and more typical specimens occur.

Although *Calophyllum wakamatsui* is clearly referable to *C. inophyllum*, its status is unclear. Fruits of specimens of *C. wakamatsui* growing inland on the Caroline Islands have a remarkably thick (to 3 mm.) outer layer; the leaves are also more coriaceous than is usual. If this taxon is recognized as a variety, the name *C. inophyllum* var. *wakamatsui* Fosberg & Sachet (Smithson. Contr. Bot. 45: 12. 1980) is available.

The exact boundaries of the natural distribution of *Calophyllum inophyllum* are unclear. It was earlier suggested (Stevens, 1976, *loc. cit.*) that *C. inophyllum* might be introduced in the Mascarenes; both seedlings and regeneration occur there, and at least seedlings are found in places where introduction is more obvious, as at Abidjan, Ivory Coast. *Calophyllum inophyllum* seems to be native on the East African mainland (see Robins, 1976; Robson, *loc. cit.*). Hillebrand (*loc. cit.*) noted that *C. inophyllum* was planted in groves on Hawaii and was probably an early introduction; elsewhere in the Pacific it has been recorded as occurring in sacred groves (often cut down by the early missionaries). The wide distribution of *C. inophyllum* in the Pacific may in part have been caused by man—see MAP 14.

Nomenclature

Roxburgh's *Calophyllum bintagor* is based on the plant illustrated and described by Rumphius (Herb. Amboin. 2: 211. t. 71. 1741). This plant, *Bintagor maritima*, is clearly *C. inophyllum*, and Rumphius gave much interesting information about it.

Blume mentioned in his description of *Calophyllum inophyllum* that the flowers had twelve tepals (four sepals and eight tepals; Blume, *loc. cit.*). Wight thought that Blume's plant could not be the same as *C. inophyllum*, which usually has eight tepals, and so described *C. blumei*, basing it on Blume's description. Hasskarl (*loc. cit.*) reduced *C. blumei* to a variety of *C. inophyllum* (taxa that Hasskarl designated by lower-case Greek letters appear from his discussion to be varieties). Although *C. inophyllum* usually has eight tepals, an occasional flower has up to thirteen, and infraspecific taxa based on tepal number cannot be maintained.

Miquel described two forms of *Calophyllum inophyllum*, formae β *obovata* and γ *oblongata*. There are several sheets of *C. inophyllum* (*obovata*) at Leiden and Utrecht; sheet 903,343-104 at the former herbarium is designated the type of forma *obovata*. One shoot on this sheet has the leaves damaged and strongly retuse just to one side of the apex (perhaps leading to Miquel's mention of the apices being "perspicue emarginatis"); on a label both the

height of the tree ("40'") and the type locality are written. The plant was almost certainly collected by Junghuhn, although this is not mentioned on the sheet. I did not see any sheets of *C. inophyllum* γ (*oblongata*) from Utrecht; sheet no. 903,343-55 at Leiden is made the lectotype of this name. It agrees with the original description and was collected by Junghuhn.

Balsamaria inophyllum was correctly considered to be the same as *Calophyllum inophyllum* by Willdenow in his edition of Loureiro's *Flora Cochinchinensis*. There is a specimen labeled *Balsamaria inophyllum* in the British Museum collected by Loureiro from Cochinchina; it is *C. inophyllum*.

References to *Calophyllum inophyllum* in the literature are numerous; only a few are cited above. Anyone interested in a more complete summary of the literature should write to the author.

39. *Calophyllum tacamahaca* Willd. Sitzungsber. Ges. Naturf. Fr. Berlin Mag. 5: 79. 1811; Choisy, Mém. Soc. Hist. Nat. Paris 1: 228. 1823, in DC. Prodr. 1: 562. 1824, *pro parte*; Sprengel, Syst. Veg. ed. 16. 2: 571. 1825; Camb. Mém. Mus. Hist. Nat. Paris 16: pl. 17C. 1828; G. Don, Gen. Syst. 1: 622. 1831, *pro majore parte*; Bojer, Hortus Maurit. 52. 1837; Wight, Illus. India Bot. 1: 128. 1840; Choisy, Rev. Guttif. Inde, 43. 1849, Mém. Soc. Phys. Hist. Nat. Genève 12: 423. 1851, *pro parte*; Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 286. 1862; Vesque, Epharosis 2: t. 2. 1889, in DC. Monogr. Phanerog. 8: 547. 1893, *pro parte*; Cordemoy, Fl. Île Réunion, 333. 1895; P. F. Stevens, Jour. Arnold Arb. 57: 177. 1976. TYPE: Bourbon [Réunion], *du Petit-Thouars s.n.* (holotype, ν , herb. Willd. 10115).
- C. spectabile* Willd. Sitzungsber. Ges. Naturf. Fr. Berlin Mag. 5: 79. 1811; Choisy, Mém. Soc. Hist. Nat. Paris 1: 228. 1823, in DC. Prodr. 1: 562. 1824, *pro parte*; Sprengel, Syst. Veg. ed. 16. 2: 571. 1825; G. Don, Gen. Syst. 1: 622. 1831, *pro parte*; Bojer, Hortus Maurit. 52. 1837. TYPE: Île de France [Mauritius], *du Petit-Thouars s.n.* (holotype, ν , herb. Willd. 10116).
- C. lanceolatum* Blume, Bijl. Fl. Nederl. Indië 4: 217. 1825; Miq. Fl. Indiae Batavae 1(2): 511. 1859. TYPE: described from cultivated material originating from Mauritius.
- C. lanceolarium* Roxb. Fl. Indica. ed. 2 (W. Carey, ed.). 2: 608. 1832; Roxb. Hortus Bengal. 41. 1814; G. Don, Gen. Syst. 1: 623. 1831, *nomina*; Hooker & Arnott, Bot. Beechey Voy. 173. 1833; Wight, Illus. Indian Bot. 1: 129. 1840. TYPE: described from cultivated material originating from Mauritius (AM).
- C. inophyllum* auct., non L.; Lam. Encycl. Méth. Bot. 1: 552. 1785, *pro parte*; Baker, Fl. Maurit. 16. 1877, *pro syn.*

Tree 10-15 meters tall, d.b.h. to 25 cm.; trunk without buttresses; outer bark yellowish or gray in patches, smooth, inner surface brown; under bark brownish red; inner bark pink; latex yellow, clear, sticky (*Coode 4174*).

Twigs slightly flattened, 1.5-3.5 mm. across, \pm 4-angled at first, soon striate, drying brown to dark brown when young, grayish when older, glabrous or sparsely brown-farinoso when young; axillary innovations lacking basal

scars; internodes 0.5–2.7(–4.5) cm. long; uppermost pair of axillary buds rounded, to 1.5 mm. long, spreading; terminal bud plump, 4–8 mm. long, with gray to brown, furfuraceous to subcrustaceous indumentum (hairs, FIGURE 16, p), underdeveloped internode absent. Petiole (0.7–)1.1–2.5 cm. long, concave to V-shaped above, convex below, glabrous when mature; lamina elliptic (ovate to oblong), (6.3–)8–18 by (2–)3.4–5.5(–6.8) cm., \pm acute (rarely subrounded) at apex, broadly cuneate to acute (narrowly decurrent) at base, undulate and slightly recurved at margin, coriaceous, typically drying greenish olivaceous above and olivaceous below, midrib and margins brownish, shiny (rarely near amber on both surfaces), glabrous (rarely sparsely subfarinose) on midrib below, the midrib above gradually narrowed from base, depressed, 0.3–1 mm. across at midpoint, becoming raised toward apex, below raised, \pm striate, the venation apparent above and below, raised, with (5 to) 7 to 12 veins/5 mm., angle of divergence 60–80°. Inflorescences from foliate axils, with 7 to numerous flowers, unbranched, or with 3-flowered branches to 2 cm. long, the axis 3–11 cm. long, glabrous or sparsely farinose toward base, lowest internode (0.2–)0.6–2.6 cm. long; bracts unknown; pedicels (0.6–)1.3–2.1 cm. long, glabrous or almost so. Flower (?)hermaphroditic; tepals 7 to 9, the outer pair broadly ovate, 7.5–11 by 6.5–9.5 mm., the inner ones obovate to elliptic, 11–17 by 4.5–9 mm.; stamens 200 to 355, the filaments to 7 mm. long, connate for up to 1 mm., the anthers oblong, 1.5–1.9 mm. long, \pm retuse at apex; ovary 2–3 mm. long, the style 4.5–5 mm. long, the stigma peltate, 1–1.3 mm. across, 3- or 4-radiate. Fruit ovoid, 3.7–4.3 by 2–2.3(–3.7) cm. across, \pm acute at apex, drying grayish to light brown, deeply wrinkled; outer layer not detaching very cleanly from stone, 2.5–4 mm. across, compact; stone ovoid to ellipsoid, 1.8–2.6(–3.1) by 1.4–2.1(–2.5) cm., (obtusely) pointed at apex, the walls 0.9–1.5 mm. thick, smooth, unmarked, with basal plug 4(–8?) mm. across; spongy layer (?)rather well developed, to 1 mm. thick.

DISTRIBUTION. Mauritius and Réunion (MAP 13).

SPECIMENS SEEN. See Stevens, *loc. cit.*

ECOLOGY. Rocks, recent lava flows, or primary or secondary forest, (0–)100–600(–900) m. alt. Flowering February and March (reported April and May, Bojer, *loc. cit.*); fruiting May, October, and November (fruit tastes like an apricot—Mallot & Jules 3).

Coode 4174 has galled leaves; the galls are pustular outgrowths of the lamina and sometimes completely deform it.

GERMINATION AND YOUNG PLANT. The radicle emerges just to one side of the basal plug, at a point where the stone is about half as thick as it is elsewhere. The basal plug is pushed out; the area of thin stone lost during germination—similar in size and shape to the basal plug—may also be delimited by a line of weakness. Three to five pairs of seedling leaves are produced, each pair separated by internodes (0.5–)1–4 cm. long. The lowest pair of leaves, which is probably sometimes reduced, had been lost in two of the

five seedlings seen. The seedling has a prominently four-angled stem. (Details from *Coode 4175* and *MAU 2851*.)

LOCAL NAMES. "Tatamaca," "tatamaca rouge," "tatamaca des hauts" (Mauritius and Réunion).

Calophyllum tacamahaca can be recognized by its striate, grayish-drying older twigs; its ovate-elliptic lamina that is more or less acute at the apex and that usually dries a characteristic olivaceous color and with a depressed midrib on the upper surface; and its fruit. The fruit is pointed at the apex and has a thick (2.5-4 mm. across) outer layer; the pointed stone has a plug at the base. The epithet *tacamahaca* is taken from the Mauritian name for the plant.

The relationship between *Calophyllum tacamahaca* and *C. inophyllum* has been discussed earlier (Stevens, *loc. cit.*); it should be noted that the length of the lower internode of the inflorescence is similar in the two species (cf. *loc. cit.*, table 1). The two species are clearly related to one another. (The name *C. inophyllum* var. *takamaka* has been given to the small-fruited form of *C. inophyllum* that is common in the western Indian Ocean; for further details, see the discussion after *C. inophyllum*.)

Details of the synonymy and infraspecific variation of *Calophyllum tacamahaca* are given in Stevens (*loc. cit.*). *MAU 14546* has fruits similar to those characteristic of *C. tacamahaca*, and although they are less deeply wrinkled (due to their immaturity), they have a well-developed woody layer. However, the leaves are more coriaceous, the apex of the lamina is subrounded, and the midrib and petiole are broad; as a result, the specimen approaches *C. eputamen* in appearance.

40. *Calophyllum comorense* H. Perr. Mém. Mus. Nat. Hist. Nat. Paris, n.s. 24: 78. 1948, in Humbert, Fl. Madagascar Comores, Fam. 137: 8. fig. 1, 1-3. 1951. TYPE: Comoro Islands, Grande Comore, May 1886, *Humboldt 1542* (holotype, ♀; isotypes, BM, ♀, W).

Tree ca. 20 meters tall; trunk and bark unknown.

Twigs slightly flattened, 2-3.5 mm. across, strongly 4-angled when young, soon becoming striate, drying brown, farinose-puberulent at first; axillary innovations apparently lacking basal scars; internodes 0.5-2 cm. long; uppermost pair of axillary buds rounded, ca. 1 mm. long, ± spreading, inconspicuous; terminal bud plump, 3-4 mm. long, with grayish brown, crustose indumentum, underdeveloped internode absent. Petiole 3.5-10 mm. long, broadly and shallowly concave above, convex below, glabrous; lamina elliptic to obovate, 4.3-7.8 by 2.2-3.8 cm., obtuse to rounded at apex, attenuate at base, distantly undulate and slightly recurved at margin, coriaceous, drying ± fulvous-umber on both sides, glabrous when mature, the midrib above gradually narrowed from base, depressed, 0.6-0.8 mm. wide at midpoint, below raised, striate, the venation above and below apparent, raised, 8 or 9 veins/5 mm., angle of divergence 65-70°. Inflorescences terminal and (?)axillary, with ca. 15 flowers, branches 3-flowered and ca. 1 cm. long, the axis ca. 3.5 cm. long,

puberulent toward base, lowest internode ca. 8 mm. long; bracts \pm elliptic, to 6 mm. long, foliaceous, not persistent; pedicels 5-6 mm. long, sparsely puberulent when young. Flowers known only in bud, (?)hermaphroditic; tepals 8, the two outer broadly ovate, ca. 6 by 4.5 mm.; stamens ca. 120, the anthers oblong, ca. 1 mm. long, strongly retuse at apex; ovary ca. 1.5 mm. long, the stigma peltate, ca. 0.6 mm. across, 3-radiate. Immature fruit subellipsoid, ca. 1.6 by 1.3 cm., obtuse at apex, drying smooth, brown; outer layer ca. 2 mm. thick, compact; stone ca. 10.5 by 8.5 mm., rounded at apex, the walls less than 0.2 mm. thick, smooth, (?)unmarked; spongy layer unknown.

DISTRIBUTION. The Comoro Islands (MAP 12); known only from the type specimen.

ECOLOGY. Type specimen has much moss on twigs, so was perhaps collected at 1000-1200 m. alt. in montane forest (see below).

Calophyllum comorense is a poorly known species best characterized by its small terminal bud, elliptic-obovate leaves separated by short internodes, terminal inflorescences, and ellipsoid fruits with a thick outer layer and an apparently thin stone wall. The epithet *comorense* is derived from the Comoro Islands, where this plant grows.

Calophyllum comorense is perhaps related to *C. tacamahaca*, which, however, has a longer terminal bud, axillary inflorescences, and a thick-walled stone. If *C. comorense* has ripe fruit with a thin stone wall, as seems probable, *C. eputamen* may prove to be its closest relative, although the terminal bud of that species is longer, its midrib and lamina are broader, its inflorescences are usually axillary, and its fruit is much larger.

Perrier de la Bâthie cited *Humboldt 1442* as the type specimen of *Calophyllum comorense* and thought that it was collected at 1000-1200 meters on Mt. Karthala, Grand Comore, since the twigs were covered with mosses. *Humboldt 1442* seems to be a misprint for 1542; the duplicate of this number at the British Museum has a stamped label with the locality given as "Angouan, Comoro Is." (probably Anjouan Island).

41. *Calophyllum recedens* Jumelle & H. Perr. Ann. Sci. Nat. Bot. IX: 281. 1910; H. Perr. Mém. Mus. Nat. Hist. Nat. Paris, n.s. 24: 78. 1948, in Humbert, Fl. Madagascar Comores, Fam. 136: 2, fig. 1, 4-7. 1951, *pro parte*. TYPE: Madagascar, Firingalava, sur l'Ikopa, entre Maevatanana et Andriba, Sept. 1897, *Perrier de la Bâthie 327* (holotype, \bar{v} ; (?)isotype, κ (s.n.)).

C. tacamahaca auct., non Willd.; O. Hoffmann, Fest. 200 Jarh. Werder's. Gymn. Berlin, 319. 1881; Vesque in C. DC. Monogr. Phanerog. 8: 547. 1893, *pro parte*; Engler in Engler & Prantl, Nat. Pflanzenfam. ed. 2. 21: fig. 81, g-f. 1923.

Tree 3-15(-?30) meters tall, d.b.h. to 30 cm.; outer bark blackish, becoming fissured; inner bark reddish; latex yellow, odorous (19291 SF, *Perrier de la Bâthie 327ter*).

Twigs somewhat flattened, 1.5–2.8 mm. across, not or obscurely 4-angled, drying brown to dark brown (grayish and striate when old), glabrous; axillary innovations lacking basal scars; internodes 0.5–2.5 cm. long; uppermost pair of axillary buds subrounded, less than 1 mm. long, \pm spreading; terminal bud plump, 4–8 mm. long, with grayish (rarely subferruginous), \pm crustaceous indumentum (hairs, FIGURE 16, n), underdeveloped internode to 8 mm. long. Petiole 1–1.8(–2.6) cm. long, broadly and rather shallowly concave above, convex below, glabrous when mature, slender; lamina ovate to suboblong, 4–11.7 by 1.6–4.4 cm., acuminate at apex, abruptly attenuate or rounded to acute at base, undulate but slightly or not recurved at margin, coriaceous, drying \pm olivaceous-sepia and nitid above, sepia below, glabrous when mature, the midrib above gradually narrowed from base, \pm sulcate at first (edges usually \pm clearly demarcated from rest of blade), 0.2–0.35 mm. wide at midpoint, becoming raised toward apex, below raised, \pm angled, venation above and below \pm apparent, slightly raised, 8 to 10 veins/5 mm., angle of divergence 60–75(–85) $^{\circ}$. Inflorescences from foliate axils along twigs, with 7 to 15 flowers, unbranched, the axis 2.2–7.5 cm. long, sometimes transiently brown-puberulent, especially in lower part, lowest internode (0.35–)0.7–2 cm. long; bracts ovate, ca. 2.5 mm. long, puberulent below, soon deciduous; pedicels 0.6–2 cm. long, glabrous or sparsely puberulent. Flower (?)hermaphroditic; tepals 8 (to 13), the outer pair suborbicular, 5–6 by 4.5–5 mm., the inner ones elliptic to obovate or oblong, 9–12 by 2.7–6 mm.; stamens 170 to 280, the filaments to 5.5 mm. long, connate for up to 2 mm., the anthers ellipsoid to oblong (0.5–)0.7–1(–1.5) cm. long, rounded to retuse at apex; ovary 1.2–2 mm. long, the style 3.5–5 mm. long, the stigma peltate, 0.5–0.9 mm. across, obscurely 3-radiate. Fruit ovoid to ellipsoid, 2.4–2.8 by 1.8–2.2 cm., \pm obtuse at apex, drying pruinose vinaceous-brown, \pm wrinkled (smooth when young); outer layer not detaching cleanly from stone, 1.6–2.5 mm. thick, compact; stone ellipsoid, 1.4–2 by 1.4–1.7 cm., rounded at apex, the walls 0.3–0.6 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. North-central Madagascar (MAP 13).

SELECTED SPECIMENS SEEN. Madagascar: vallée d'Ifasy, *Perrier de la Bâthie* 8153 (p); Vavatohe [Ambavatobe], *Hildebrandt* 3324 (G, M, P, US); Andranofasiaka, Ampasimatara, Mampikony, 19291 SF (p); Maevatanana, bassin moyen du Bemarivo (Boina), *Perrier de la Bâthie* 3274 (p); Beritsoka, E. du Maevatanana, *Perrier de la Bâthie* 327bis (p); Ambalanjanakomby, Bentaly-Maevatanana, 14942 SF (p); Besalampy, Bekodoka, Sahondra, 15235 SF (p); Ankorika, Ankarafantsika, 150–200 m., *Ursch* 147 (p); Morataitra, près de Maevatanana, *Perrier de la Bâthie* 5308 (p); forêt Bitomandry, 5349 SF (p); Maintirano, forêt Andranomena, 14781 SF (p); forêt Ambatomanga, N. du Anjozorobe, *Boiteau* s.n. (p).

ECOLOGY. Locally common in seasonal forest, usually along river banks on siliceous ground; low alt. Flowering February to April and August, September, and November; fruiting September and January (fruit somewhat fleshy; eaten by lemurs (*Perrier de la Bâthie* 3274), despite a somewhat terebinthlike taste).

TABLE 8. Differences between *Calophyllum vernicosum* and *C. recedens*.

	<i>C. vernicosum</i>	<i>C. recedens</i>
WHITISH WAXY COVERING ON TWIGS	Usually present	Absent
TERMINAL BUD LENGTH (mm.)	2.5-4	4-8
TERMINAL BUD INDUMENTUM	Reddish brown, short-tomentose	Usually grayish, subcrustaceous
LAMINA BASE	Acute	Abruptly attenuate or rounded to acute
MIDRIB ON UPPER SURFACE OF LAMINA	Indistinct	Usually distinct
VENATION DENSITY (veins/5 mm.)	(6 to) 8 to 12 (to 14)	8 to 18
ANTHER LENGTH (mm.)	0.9-1.8	(0.5-)0.7-1(-1.5)
OUTER LAYER OF FRUIT, THICKNESS (mm.)	0.6-1	1.6-2.5
APEX OF STONE	Apiculate	Rounded

LOCAL USES. The wood is used in the manufacture of furniture and canoes, and the latex has apparently been used in the local pharmacopeia (Perrier de la Bâthie, 1951, *loc. cit.*).

Calophyllum recedens can be recognized by its medium-sized leaf blades that are acuminate at the apex, often attenuate at the base, and with moderately dense venation. The terminal bud has subcrustaceous indumentum; the twigs are slightly angled. The inflorescences are angled, and the flowers usually have eight tepals. The ovoid to ellipsoid fruits are 2.4-2.8 cm. long, subobtusate at the apex, and with a compact outer layer 1.6-2.5 mm. thick. The epithet *recedens* means "receding" or "differing," possibly a simple allusion to the fact that the species was distinct.

Calophyllum recedens is perhaps related to *C. tacamahaca*, from the Mascarenes; Vesque (*loc. cit.*) cited *Hildebrandt* 3324 under the latter species. However, there are numerous differences between the two in twig, leaf, and fruit (Stevens, 1976, *table 1*). It should also be noted that *C. tacamahaca* has longer anthers (1.5-1.9 mm. vs. (0.5-)0.7-1(-1.5) mm.). The stone of the fruit of *C. tacamahaca* has a basal plug; such a plug has not been noticed in *C. recedens*. *Calophyllum recedens* has also been confused with *C. vernicosum*; for the differences between the two, see the latter species (TABLE 8).

42. *Calophyllum vernicosum* P. F. Stevens, sp. nov.

FIGURE 15, t.

C. recedens auct., non Jumelle & H. Perr.; H. Perr. in Humbert, Fl. Madagascar Comores, Fam. 136: 2. 1951, *pro parte*.

A speciebus aliis Calophylli in gemma terminalis 2.5-4.5 mm. longa indumento subfulva praedita, innovationes axillaribus cicatricibus basalibus haud ornatis, ramulo tegenti albescenti subpersistenti praedito, pagina superiore laminae nitida costa indistincta, et fructu ovoideo vel ellipsoideo apice plerumque acuto strato exteriori 0.6-1 mm. in transverso, differt.

Tree 9-12 meters tall; outer bark smooth at first, becoming similar to that of a pine (?fissured).

Twigs flattened, 1.3-2.7 mm. across, \pm rounded, drying blackish, color obscured by whitish (?)waxy covering, transiently rufous-puberulent; axillary innovations lacking basal scars; internodes 0.5-2.5(-4) cm. long; uppermost pair of axillary buds rounded, ca. 1 mm. long, spreading; terminal bud plump, 2.5-4 mm. long, with short-tomentose, rufous indumentum (hairs, FIGURE 16, o), underdeveloped internode to 2 mm. long. Petiole 1.2-2.3 cm. long, broadly concave above and convex below, glabrous; lamina ovate (elliptic), 5-11 by 1.6-3.5(-4.7) cm., acuminate at apex, acute at base, strongly but distantly undulate and not recurved at margin, coriaceous, drying \pm concave, shiny, greenish brown above and brownish below, glabrous at maturity, the midrib above gradually narrowed from base, at least margins raised, surrounding lamina also raised, sulcate, 0.25-0.7 mm. wide at midpoint, below slightly raised, \pm striate, not very conspicuous, the venation subobscure to apparent above and subapparent below, raised, (6 to) 8 to 12 (to 14) veins/5 mm., angle of divergence 60-75°. Inflorescences from foliate axils, with 7 to 15 flowers, unbranched, the axis 2.9-9 cm. long, puberulent, especially toward base, lowest internode (0.1-)0.4-1.5(-2.3) cm. long; bracts ovate, ca. 2 mm. long, soon deciduous; pedicels 0.5-2.4 cm. long, glabrous. Flower (?)hermaphroditic; tepals 8, the outer pair broadly ovate, 3.8-4.5 by 4.2-4.5 mm., the inner ones elliptic to lingulate, 6-9 by 2.5-6 mm.; stamens 75 to 180, the filaments to 4 mm. long, the anthers oblong, 0.9-1.8 mm. long, subtetuse at apex; ovary 1.2-1.4 mm. long, the style 3.5-4 mm. long, the stigma peltate, 0.7-1 mm. across, obscurely 3- or 4-radiate. Fruit ellipsoid to ovoid, (1.9-)2.5-3.4 by 1.6-1.9 cm., acute (rarely rounded) at apex, drying brown, wrinkled (almost smooth at maturity); outer layer detaching \pm cleanly from stone, 0.6-1 mm. thick, air spaces developing at maturity; stone \pm ellipsoid, 1.7-2.5 by 1.4-1.65 cm., apiculate, the walls 0.3-0.9 mm. thick, smooth, unmarked; spongy layer thin.

TYPE: Madagascar, Ambilobe, forêt dégradée au nord d'Ambilobe, 10 Nov. 1958, 18934 SF coll. Capuron (holotype, *p*; isotype, *p*).

DISTRIBUTION. Northern Madagascar (MAP 12).

ADDITIONAL SPECIMENS SEEN. **Madagascar:** Ambilobe, Mt. Ambohipiraka, près d'Ambilobe, *Perrier de la Bâthie* 18754 (*p*), 300-400 m., *Humbert & Cours* 32881 (*p*), 32903 (*p*), village d'Ankatoto, *Cours* 5650 (*p*), 100-300 m., 5671 (*p*); Ambilobe, *de Cary* 14842 (*o*, *p*), 5408 SF (*p*); plaine d'Ambilobe, 10507 SF (*p*); Beramanja, route Tafiara-Ambohimany, 1286 RN (*p*), 1287 RN (*p*); Massif de l'Ankarana, *de Cary* 14522 (*nm*, *k*, *p*, *us*), 14563 (*l*, *mo*, *p*); Diego Suarez, *Ursch* 264 (*p*); Sambirano, *Morat* 1416 (*p*); sino loco, *Baron* 6258 (*bm*, *k*, *p*).

ECOLOGY. Locally fairly common in light, sometimes rather dry colline forest, 100–400 m. alt. Flowering July, August, October, and November; fruiting January, August, October, and November (fruit yellowish green).

Elliptic, disk-shaped galls to 4.5 by 3 mm. with a slightly raised margin and a raised center sometimes occur on the lower surface of the lamina in a line at, or a little in from, the margin.

Calophyllum vernicosum can most readily be recognized by its short terminal bud; dark-drying twigs with a more or less transient whitish covering; leaf blades that dry very shiny, especially on the upper surfaces, and with a midrib not sharply distinguished from the rest of the lamina; and ellipsoid-ovoid fruits with a rather thin (less than 1 mm.) outer layer in which air spaces develop. The epithet *vernicosum* alludes to the shiny, varnished appearance of the upper surface of the dried lamina; this may also be noticeable in the living leaf, as the field label of *Cours 5650* suggests.

I originally included the specimens described above as *Calophyllum vernicosum* in *C. recedens*, but the resultant "taxon" was uncomfortably variable. However, when the specimens were re-sorted on the bases of bud size and color, such other characters as leaf type, anther size, and fruit type were found to show correlated variation. In addition, the uppermost internode of the innovation in *C. vernicosum* tends to be notably shorter than the others (although this is not nearly as marked as in *C. verticillatum*); there is not this size disparity in *C. recedens*. The differences between the two taxa are listed in TABLE 8; although there is some overlap in a few of the characters, many characters are involved and even sterile material can be identified easily. The two species have distinct geographic ranges (cf. *Mars 12, 13*).

43. *Calophyllum wallichianum* Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 277. 1862. TYPE: Malaya, Penang, *Wallich dist. 4843, pro parte* (holotype, G; isotypes, BM, FI, G, K).

Tree (3–)15–36 meters tall, d.b.h. to ca. 160 cm.; trunk usually unbuttressed; outer bark brown or gray to yellow-gray or mottled yellow, with vertical lines of lenticels or shallowly fissured, hoop marked or not, inner surface brown-orange to orange or yellowish and greenish mottled; under bark reddish orange to red; inner bark red; latex white, often turning yellowish (rarely clear yellow), rather sticky.

Twigs slightly flattened, (1.5–)2.3–6 mm. across, obscurely to strongly 4-angled, drying blackish to yellowish brown, rather inconspicuously gray to brown farinose-puberulent (rarely subtomentose) when young; axillary innovations lacking basal scars; internodes (0.7–)1–5 cm. long; uppermost pair of axillary buds rounded to pointed, to 4.5 mm. long, \pm erect to spreading; terminal bud plump to conical, (1.2–)1.6–3 cm. long, with gray to brown, crustaceous to subtomentose indumentum (hairs FIGURES 16, q–cc; 18, a–j), underdeveloped internode 1–6 mm. long. Petiole 1.2–2.5(–3.5) cm. long, broadly concave above, convex below, often drying blackish, glabrous or with indumentum obscure; lamina oblong to ovate, (5.3–)8.5–25(–32.5) by (2.1–)3–

6.8(-8) cm., acute to subacuminate at apex, acute or cuneate to rounded at base, distantly undulate and not recurved to moderately so at margin, coriaceous to thickly coriaceous, drying bay to sabelline above and fulvous to olivaceous below, subpersistently farinose-puberulent on midrib below and often above, the midrib above narrowing gradually or fairly quickly from base, often \pm depressed at first, becoming raised (surrounding lamina sometimes raised), 0.2-0.8 mm. wide at midpoint, below strongly raised, striate to angled, the venation subobscure to apparent above and below, \pm raised, (8 to) 10 to 17 veins/5 mm., angle of divergence 65-85°. Inflorescences from foliate axils, with 7 to 15 (to 19) flowers, unbranched (rarely with 5-flowered branches to 1.5 cm. long), the axis 1.7-7 cm. long, usually puberulo-tomentose toward base, puberulent toward top, lowest internode 4-11 mm. long; bracts ovate to elliptic, 4-10 mm. long, sometimes subpersistent, with dense, fawn-colored indumentum on both surfaces; pedicels 0.5-2(-2.5) cm. long, subglabrous to puberulent, slender in flower, to 4 mm. thick in fruit. Flower (?)hermaphroditic; tepals 4 (rarely 6), the outer pair ovate to elliptic, 5-7 by 3-3.5 mm., puberulent on back, the inner pair elliptic to obovate, 5.5-6 by 3.5-4 mm., sparsely puberulent in band down back, or glabrous, additional ones, if any, much smaller; stamens 90 to 185, the filaments to 3.5 mm. long, the anthers oblong, 0.5-1 mm. long, \pm retuse at apex; ovary 1.3-1.7 mm. long, the style ca. 1.7 mm. long, the stigma peltate, 0.6-0.8 mm. across, 2- or 3-lobed. Fruit ellipsoid, \pm ovoid or spherical, or obovoid, 2-3(-3.5) by 1.5-2.5(-3) cm., strongly apiculate or not, drying brown to blackish, sharply and shallowly wrinkled; outer layer detaching cleanly from stone, 1-3(-4) mm. thick, compact; stone broadly ovoid to subspherical or ellipsoid, 1.3-2.3 by 1.2-1.9 cm., rounded to apiculate at apex, the walls 0.3-1.1 mm. thick, smooth, usually unmarked (with discoloration at base to 4 mm. across); spongy layer thin.

Key to the Varieties of *Calophyllum wallichianum*

1. Lamina usually very coriaceous, the midrib on upper surface surrounded by raised blade, indistinct. 43c. var. *tahanense*.
1. Lamina usually coriaceous, the midrib on upper surface practically never surrounded by raised blade, distinct.
 2. Petiole (1-)1.2-2.2 mm. across; twigs (1.5-)2-3(-3.5) mm. across. 43a. var. *wallichianum*.
 2. Petiole (2-)2.5-5 mm. across; twigs 2.8-6 mm. across. 43b. var. *incrassatum*.

43a. *Calophyllum wallichianum* Planchon & Triana var. *wallichianum*

C. wallichianum Planchon & Triana; T. Anderson in Hooker f. Fl. Brit. India 1(2): 273. 1874, *pro parte*; Vesque in C. DC. Monogr. Phanerog. 8: 599. 1893, *pro parte*; M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 303. 1956, *pro parte*; Kochummen, Malayan Forest Rec. ed. 2. 17: 216. 1965, *pro parte*; T. C. Whitmore, Tree Fl. Malaya 2: 193. 1973, *pro parte*.

C. spectabile auct., non Willd.; Curtis, Jour. Straits Branch Roy. Asiatic Soc. 25: 78. 1894, *pro majore parte*; Ridley, Fl. Malay Penin. 1: 185. 1922, *pro parte*.

C. tetrapetalum Wall. Catal. 4843. 1831, non Roxb. ex G. Don (1831). *Nomen.*

Tree 12–30 meters tall; latex milky white, turning yellow on exposure, or opaque lemon-yellow.

Twigs (1.5–)2–3(–3.5) mm. across. Petiole (1–)1.2–2.2 mm. across; lamina ovate, coriaceous, the margins undulate, the midrib on upper surface usually raised, even at base, distinct, 0.15–0.3(–0.35) mm. wide at midpoint. Bracts not persistent.

DISTRIBUTION. Northwestern Malay Peninsula (MAP 15).

SELECTED SPECIMENS SEEN ("f" denotes specimen with fruits). MALAYA. KEDAH: Kuala Muda, Puah Reserve, *KEP 59630* (KEP); Kuala Nerang, Kampong Kuala, 120 m., *KEP 73532* (?) (KEP). PINANG: Government Hill, 366 m., *Curtis 1153* (f) (BM, K, SING); Pantai Acheh F.R., 150 m., *KEP 72564* (KEP); Pulau Pinang, 610 m., *FRI 20534* (KEP); Telok Bahang F.R., *KEP 66368* (KEP); Pulau Boetong Reserve, *Curtis = 1153* (SING). PERAK: Pangkor F.R., 120 m., *FRI 3021* (A, K, KEP, SAN, SING); Pangkor Is., S. Pinang F.R., 75 m., *FRI 3057* (A, K, KEP, SAN, SING); Kelidang Saiong F.R., *KEP 33634* (KEP, SING); Kinta, Tualang F.R., *KEP 63253* (KEP); Telok Kopia F.R., Dindings, 150 m., *FRI 3105* (A, K, KEP, SAN, SING); Dungun, Sagari-Melintang F.R., *KEP 69418* (f) (KEP, SING); Sembilan Is., 30 m., *KEP 76530* (f) (A, K, KEP, SING); Telok Muroh F.R., *KEP 76733* (KEP); Batu Undan F.R., *KEP 54225* (KEP); Gunung Bubu F.R., 914 m., *FRI 17585* (L, SAR); G. Bubu, 396 m., *FRI 11748* (K, KEP, L, SAR, SING); Sumpitan, *KEP 10407* (K). NEGRE SEMBILAN: Kuala Pilah, *KEP 93800* (KEP). KELANTAN: Kuala Mersing, Sungei Brok, 210 m., *FRI 5450* (f) (A, K, KEP, SING).

ECOLOGY. Colline forest, 30–610(–914) m. alt. Flowering and fruiting in January.



MAP 15. Distribution of *Calophyllum wallichianum* var. *wallichianum* (circles) and *C. wallichianum* var. *incrassatum* (squares) in Malasia.

GERMINATION AND YOUNG PLANT. The radicle breaks the stone to one side of the base. The seedling has two pairs of leaves separated by an internode less than 1 cm. long. (*KEP 10407*, from Perak; *FRI 6166*, from Kelantan.)

43b. *Calophyllum wallichianum* Planchon & Triana var. *incrassatum* (Henderson & Wyatt-Smith) P. F. Stevens, comb. nov.

- C. incrassatum* M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 302. pl. 2. 1956; Wyatt-Smith, Malayan Forest Rec. 17: 113. 1952, *nomen*; Kochummen, Malayan Forest Rec. ed. 2. 17: 216. 1965; T. C. Whitmore, Tree Fl. Malaya 2: 183. 1973; H. Keng, Gard. Bull. Singapore 28: 244. 1976; Corner, Gard. Bull. Singapore Suppl. 1: 104. 1978. TYPE: Singapore, Bukit Timah, "low" alt., 31 Dec. 1937, *SFN 34647* coll. *Ngadiman* (holotype, SING; isotypes, A, BO, K, KEP, LAE, P, SING).
C. griffithii auct., non King; Ridley, Jour. Straits Branch Roy. Asiatic Soc. 33: 47. 1900.

Tree (3-)15-36 meters tall; latex white, often turning yellowish (perhaps rarely initially yellow).

Twigs 2.8-6 mm. across. Petiole (2-)2.5-5 mm. across; lamina oblong to subovate (rarely ovate), coriaceous (rarely thickly coriaceous), the margins usually notably undulate, the midrib on the upper surface often more or less depressed at first, becoming raised, usually distinct, 0.3-0.8 mm. wide at midpoint. Bracts often subsistent.

DISTRIBUTION. Eastern Malaya to Borneo and perhaps Sulawesi (MAP 15).

SELECTED SPECIMENS SEEN. **Malaya.** SELANGOR: Bukit Lagong F.R., 455 m., *KEP 83729* (KEP); Semangkok, 915 m., *KEP 115248* (KEP). MALACCA: Pulau Besar, 13 km. from Malacca, *Stone 9033* (KLU); Bukit Sadanan, *Derry 515* (SING); S. side of Selandar Forest, *Burkill 2010* (BO, K, SING). KELANTAN: Kemahang F.R., *KEP 93580* (KEP). TRENGGANU: Jerengau State Land, *KEP 79859* (KEP); along Sungei Pelong, foothill, *FRI 14818* (K, KEP, SING); 59th Mile K. Trengganu-Khota Bharu road, *FRI 2524* (?) (K, KEP, SAR, SING); Ulu Dungun, 270 m., *FRI 9652* (KEP); Bukit Kajang, Kemaman, 150 m., *Corner s.n.*, 2 Nov. 1935 (SING); G. Padang Exped., Ulu Brang, 1219 m., *FRI 12646* (?) (A, K, KEP, SING). PAHANG: Bukit Santong, Rompin iron mine, 365 m., *FRI 3605* (A, K, KEP, SAR, SING); Lesong F.R., 180 m., *FRI 20008* (KEP, SAR); Kuantan, Bukit Goh Reserve, *KEP 3628* (K, SING); Kallam Ayer Reserve, *KEP 17250* (KEP, SING); G. Tapis, 575 m., *FRI 17692* (KEP); Tasek Bera F.R., 75 m., *FRI 16960* (KEP); Baloh F.R., *KEP 66645* (KEP); Temerloh, *KEP 5473* (SING). JOHORE: Mawai-Jemaluang road, *SFN 34911* (A, BO, K, KEP, LAE, P, SING); Kluang F.R., 90 m., *FRI 7536* (A, KEP, SAR, SING); Ulu Endau, summit of Bukit Kendok, 396 m., *KEP 105015* (A, K, KEP, SING); Banang F.R., *KEP 79420* (KEP); G. Ledang, 396 m., *FRI 19202* (A, KEP, SAN); Gunong Arong F.R., *KEP 84582* (KEP); Bukit Jelaboi, *FRI 9831* (KEP); G. Pulai, 610 m., *FRI 9919* (KEP); Jemaluang F.R., *KEP 69971* (KEP); Labis, 60 m., *KEP 104953* (KEP); Ma'Okil F.R., 6 m., *KEP 71279* (KEP); Renggam F.R., 75 m., *KEP 71269* (KEP); G. Pantil F.R., 395 m., *KEP 93775* (KEP). **Singapore:** Sungei Morai, *Ridley 5071* (BM, SING); Bukit Timah, *SFN 38846* (LAE, SING); Changi, *Ridley s.n.*, anno 1893 (?); Botanic Gardens, *SGN 1692* (SING). **Sumatra and adjacent islands.** RIAU: Kocantan, Poelau Kedondong, 100 m., *bb 24801* (BO, L, SING);

Upper Riau, Pakanbaru, Tenajan R., *Soepadmo 71* (BO, C, L, SING). UTARA: Hoogl. van Toba, Pandoemaän, 900 m., *bb 5695* (BO); Silindoeng, 1040 m., *bb 6620* (BO). BORNEO. SARAWAK. 1st Division: Semengoh F.R., 30 m., *Stevens et al. 282* (A); Serian, G. Penrissen, *S 16375* (A, L, SAN, SAR, SING). 3rd Division: Hose Mts., Bt. Lumut, Ulu Amau, 950 m., *S 21255* (A, BO, K, KEP, L, SAN, SAR, SING); Ulu Kapit, Pelagus Protected Forest, *S 33191* (KEP, KLU, SAN, SAR). SABAH. Kinabatangan: Karamuak, Bukit Meliau, 150 m., *SAN 39310* (SAN, SAR, SING); Lamag, E. of Sungei Meliau, 30 m., *SAN 53252* (SAN), Bukit Tavai, 240 m., *SAN 53316* (SAN). KALIMANTAN. Timur: Tidoengsche Landen, 7 m., *bb 18354* (A, BO); Tandjong Redeb, Labanan, *bb 11511* (BO). CELEBES. SULAWESI: Manado, Bol. Mangadan, Bonko, 50 m., *bb 13751* (BO).

ECOLOGY. Usually in well-drained, mixed dipterocarp lowland rainforest, sometimes in swamp forest or in mossy heath forest (*S 21255*); 6-400(-1220) m. alt. Flowering November to February (flower scented); fruiting March to May, sometimes September and November (fruit orange (*S 21255*)).

GERMINATION AND YOUNG PLANT. The seedling has two pairs of leaves separated by an internode less than 1 cm. long. Subsequently produced internodes are much longer, the terminal bud is functional, and the plant is erect. (*Stevens et al. 103, 106* (Johore, Malaya), *282* (Sarawak).)

The epithet *incrassatum* ("thickened") was coined because the pedicel becomes thickened in fruit.

43c. *Calophyllum wallichianum* Planchon & Triana var. *tahanense* (Henderson & Wyatt-Smith) P. F. Stevens, comb. nov.

C. tahanense M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 305, pl. 4, 1956; T. C. Whitmore, Tree Fl. Malaya 2: 168, 1973. TYPE: Malay Peninsula, Pahang, Gunong Tahan, Wray's Camp, ± 3500 feet [1067 m.], 27 Aug. 1928, *SFN 20601* coll. *Holtum* (holotype, SING; isotypes, A, BO, UC).

C. spectabile auct., non Willd.; Ridley, Jour. Fed. Malay States Mus. 2: 110, 1909.

Tree 6-20 meters tall; latex yellow or pale yellow, clear.

Twigs 2-5 mm. across. Petiole 1.5-3 mm. across; lamina ovate, slightly undulate at margin, thickly coriaceous, the midrib on upper surface slightly sunken at base, surrounded by raised lamina, indistinct, 0.2-0.4 mm. wide at midpoint. Bracts not persistent.

DISTRIBUTION. Malay Peninsula (MAP 16).

SELECTED SPECIMENS SEEN. MALAYA. NEGERI SEMBILAN: G. Angsi, 455 m., *FRI 17345* (K, KEP, SING). KELANTAN: Ulu Kelantan, Reali [Relai] F.R., *FRI 7256* (A, K, KEP, SAR, SING); path to G. Rabong, 762-975 m., *Shah 2510* (A, BRI, KEP, SING); Sungei Kerbut, Jeram Keteh, ca. 2 km. below K. Trenggan, 335 m., *FRI 20281* (K, KEP, L, SAN). PAHANG: G. Tahan, 1067 m., *SFN 8020* (BO, K, SING).

ECOLOGY. Colline or montane forest, 335-1067 m. alt. Flowering August

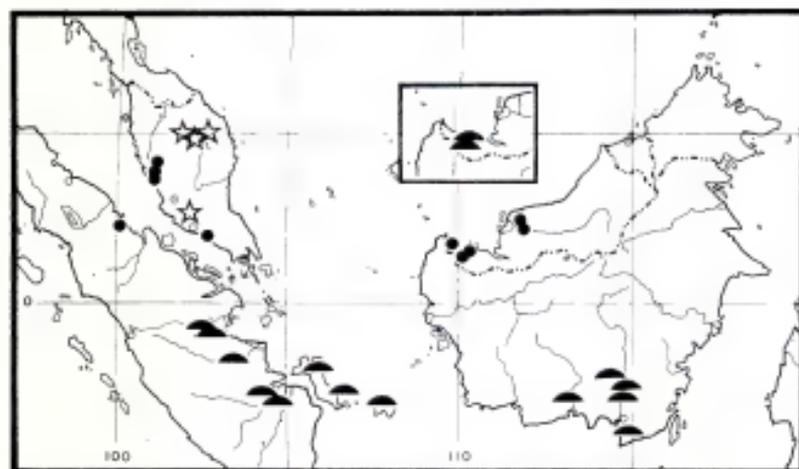
and September; fruiting February, March, June, and October (fruit dull yellow-green).

The type specimen was collected on Gunong Tahan, and this suggested the epithet.

Calophyllum wallichianum can be recognized by its plump terminal buds over 1 cm. long; its rather large, elliptic to ovate to oblong lamina with moderately dense venation; its unbranched inflorescence with farinose-puberulent to subtomentose indumentum; its flowers that usually have only four tepals, with the backs of the outer pair puberulent; and its medium-sized fruits that dry wrinkled and have a well-developed, compact outer layer 1-3(-4) mm. thick and stone walls 0.3-1.1 mm. thick. The hairs usually have a single, basal branch. The specific epithet commemorates the indefatigable botanist, N. Wallich.

Circumscription of *Calophyllum wallichianum*

The taxa and their limits in the *Calophyllum wallichianum*/*incrassatum*/*tahanense* complex have been quite troublesome. My original intention was to follow Henderson and Wyatt-Smith's treatment, although it was clear that, as they realized, *C. wallichianum* could be separated into northern and western (Kedah, Pinang, Perak) and southern and eastern (Trengganu, Johore, Singapore) parts, the former having basically opaque, white to yellow exudate and sparsely tomentose terminal buds, and the latter with clear, yellow exudate and more tomentose terminal buds. There were also slight differences in



MAP 16. Distribution of *Calophyllum wallichianum* var. *tahanense* (stars), *C. scriblitifolium* (circles), and *C. lowii* (half-circles) in Malesia. Inset: *C. lowii*.

leaf shape and terminal bud. *Calophyllum incrassatum* was separated from *C. wallichianum* by its more persistent bracts, usually white latex, smooth bark, and more prominent midrib. The northern populations of *C. wallichianum* are clearly intermediate between the southern populations and *C. incrassatum* in these characters, except those of the leaf, in which they agree with the southern populations.

However, the northern populations of *Calophyllum wallichianum* have basically spherical, moderate-sized fruits with the walls of the stones usually less than 0.8 mm. thick, like those of *C. incrassatum*, while the southern populations (with the partial exception of those in Trengganu) have large, often ellipsoid fruits with stone walls at least 1.3 mm. thick. Indumentum studies confirmed this relationship: the northern populations and *C. incrassatum* have hairs that are slightly birefringent, with apical cells little longer than the others; the southern populations have highly birefringent hairs, with the apical two cells much enlarged and very thick walled (FIGURE 18, a, b).

Specimens referable to *Calophyllum tahanense* have been variously identified as *C. incrassatum*, *C. wallichianum*, *C. flavo-ramulum*, or *C. austrocoriaceum*. *Calophyllum tahanense* is separated from the first two species by the key in Henderson and Wyatt-Smith (*op. cit.*) only because it grows at generally higher elevations than do these species. In both indumentum and fruit type it is similar to the northern populations of *C. wallichianum* and to *C. incrassatum*.

Hence, the complex must be reorganized taxonomically. The small-fruited form must bear the name *Calophyllum wallichianum*, because the type of that name came from such a specimen (see below). The erstwhile *C. incrassatum* can be distinguished varietally from *C. wallichianum* *sensu stricto* mainly by its broader twigs and petioles; it also has a more southerly distribution in Malaya. The erstwhile *C. tahanense* is also reduced to varietal rank. It can be distinguished by its more coriaceous leaves, its midrib type, and possibly also by bark differences; it is basically a montane form (but see below). For the plants that formed the southern group of *C. wallichianum*, I have taken up Henderson and Wyatt-Smith's manuscript name, *C. rufigemmatum*; *C. wallichianum* and *C. rufigemmatum* are readily distinguished by morphology, indumentum, and bark characters (TABLE 9). In the southern part of the Malay Peninsula (e.g., Renggam Forest Reserve, Johore) and on Singapore (e.g., Bukit Timah), the two species grow together.

It is clear that much work still has to be done on this complex, both to ascertain the variation within *Calophyllum wallichianum* as here defined, especially in Sumatra and Borneo, and also to establish more clearly the relationships between *C. rufigemmatum* and its probable relatives, and *C. lanigerum* and *C. ferrugineum* and their relatives, since all taxa have similar, very distinctive hairs. Seedling type and germination, practically unknown in *C. rufigemmatum* and in *C. lanigerum* and its relatives, is potentially significant. Growth patterns may also be important (does *C. rufigemmatum* produce one or two pairs of leaves per flush, and *C. wallichianum* more?), as is, of course, a better knowledge of the basic morphology of many of the taxa involved.

TABLE 9. Differences between *Calophyllum rufigemmatum* and *C. wallichianum*.

	<i>C. rufigemmatum</i>	<i>C. wallichianum</i>
LATEX	Clear yellow, rarely brown	Opaque white, often turning yellowish, rarely clear yellow
INDUMENTUM	Short-tomentose to tomentose	Crustaceous to short-tomentose, rarely tomentose
HAIR TYPE	Two apical cells much elongated, thick-walled, birefringent	Apical cells practically never much elongated, but if so, not thick-walled
TWIGS	Often with obscure transverse line at nodes	Obscure transverse lines not seen
INFLORESCENCE		
AXIS LENGTH (cm.)	0.3-1.3	1.7-7
NUMBER OF FLOWERS	5 to 7	7 to 15 (to 19)
PEDICEL LENGTH (cm.) AT ANTHESIS	0.35-0.7	0.5-2
FRUIT LENGTH (cm.)	(2.6-)3-4.4	2-3(-3.5)
STONE WALL THICKNESS (mm.)	(1-)1.3-2	0.3-1.1

Variation within *Calophyllum wallichianum* var. *incrassatum*

The majority of specimens of *Calophyllum wallichianum* var. *incrassatum* from Sumatra and Borneo have subconical, rather than plump, terminal buds (they are plump in *Soepadmo* 71); better-developed indumentum (it is even tomentose in *bb* 2971); a midrib with at least the edges raised, even at the very base; and large leaf blades (9.5-)15-32.5 by (2.8-)3.7-8 cm. In seedling type and general bark characters *Stevens et al.* 282, from Sarawak, was similar to plants seen in Malaya and Singapore, although the latex was pale yellow and opaque, rather than white (as might be expected, the latex of the twigs was white). Other specimens from the Sumatra-Borneo area are reported to have yellow (*Soepadmo* 71; *S* 16375), whitish (*SAN* 53316), or white (*SAN* 39310) latex. The fruits of this form are similar to those of Malayan specimens, although those of *S* 16375 are reported to be yellow. An interesting specimen from the western coast of Sumatra, *bb* 2971, has young, branched infructescences with tomentose indumentum; the branches have up to seven flowers and are up to 3.5 cm. long (see also below). Specimens of *C. wallichianum* var. *incrassatum* from Sumatra and Borneo tend to have

the cells at the apex of the hairs notably larger than those toward the base (FIGURE 18, g-k).

The specimens of *Calophyllum wallichianum* var. *incrassatum* from Malacca, particularly Stone 9033, are superficially similar to *Calophyllum lanigerum* var. *austrororiaceum*; *bb* 2971, from the western coast of Sumatra, has leaf blades drying the rich brown color of at least the Bornean specimens of *C. lanigerum*. However, *C. lanigerum* has better-developed indumentum, the hairs having strongly birefringent, expanded apical cells; a plumper terminal bud; usually less dense and clearer venation; an inflorescence that is glabrous toward the apex; and bark with yellow latex.

Two specimens of *Calophyllum wallichianum* var. *incrassatum* from G. Padang, Trengganu, which were collected at rather high altitudes for the species, are very robust and have a midrib approaching that of *C. wallichianum* var. *tahanense*. The fruits are spherical and sharply wrinkled and have an outer layer ca. 3 mm. thick and stone walls ca. 1 mm. thick. Henderson and Wyatt-Smith (*op. cit.*) cited *SFN* 31076 as *C. tahanense*, albeit with some hesitation; Whitmore determined *FRI* 12646 as *C. coriaceum*, which has similarly coriaceous leaves but is not otherwise comparable.

The specimens from Selangor are included with some hesitation. One specimen, *anon.*, 19 June 1951 (KEP), has slender petioles up to 3.5 cm. by up to 2.5 mm. *FRI* 2524 (Trengganu, Malaya) has ovate leaf blades that are rather narrowly acute at the apex; the inflorescences are more robust than those of other Malayan specimens and are tomentose; the pedicels are only 7 mm. long. The record of *Calophyllum wallichianum* var. *incrassatum* from the Celebes also needs to be confirmed; *bb* 13751 is a sterile specimen.

Typification of *Calophyllum wallichianum*

Wallich dist. 4843, the type of *Calophyllum wallichianum*, was collected at Pinang and Singapore; thus, as seen from the discussion above, it might have been taken from the small- or the large-fruited element in *C. wallichianum* as previously delimited. However, as Henderson and Wyatt-Smith (*loc. cit.*) noted, the type came from Pinang; the many-flowered inflorescences, as well as the hair type (FIGURE 16, x, y), confirm this.

When Planchon and Triana (*loc. cit.*) described *Calophyllum wallichianum*, they noted that *Wallich dist.* 4843 was a mixed collection, including also *C. spectabile* (properly *C. soulattri*) and a small piece of *C. polyanthum* (which I have not seen under this number). There is yet another species under this number, represented by leaves and fruits of *C. lanigerum* var. *austrororiaceum*; this element, at least, was probably collected in Singapore. Planchon noted on a sheet at Geneva that the fruits did not belong to "*C. insigne*," and Planchon and Triana (*loc. cit.*) suggested that Choisy had confused "*C. insigne*" with *C. wallichianum*. I have not found the name "*C. insigne*" elsewhere, and it appears to be an error for *C. spectabile* (= *C. soulattri*).

44. *Calophyllum rufigemmatum* Henderson & Wyatt-Smith ex P. F. Stevens,
sp. nov. FIGURE 17, b-h.

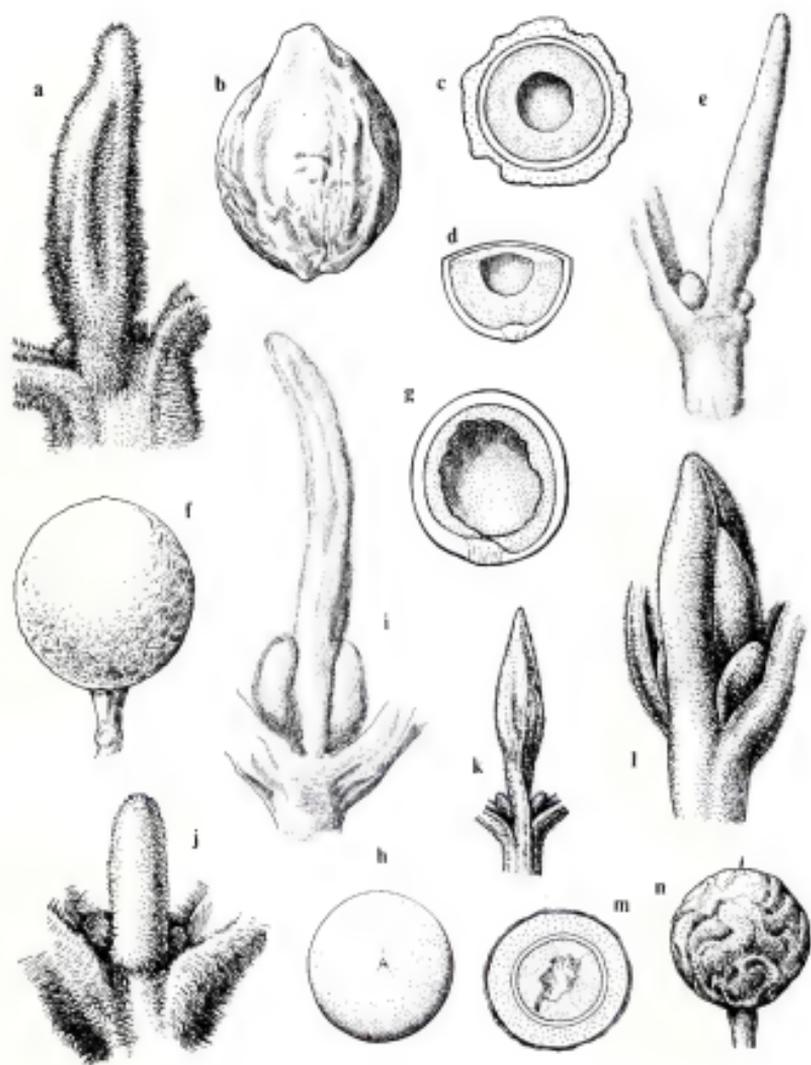


FIGURE 17. a, *Calophyllum* sp. 54 (bb 19334), terminal bud, $\times 3$. b-h, *C. rufigemmatum*. b-e, FRI 13796. b-d, fruit, $\times 0.75$: b, from outside; c, transverse section; d, longitudinal section. e, terminal bud, $\times 3$. f-i, FRI 3921. f-h, fruit, $\times 1$: f, from outside; g, longitudinal section; h, stone, from apex. i, terminal bud, $\times 3$. j, *Calophyllum* sp. 53 (S 24675), terminal bud, $\times 3$. k, *C. castaneum* (Stevens et al. 133), terminal bud, $\times 0.75$. l-n, *C. woodii*. l, terminal bud (SAN 42949), $\times 3$. m, n, fruit (SAN 16693), $\times 2$: m, transverse section; n, from outside.

C. wallichianum auct., non Planchon & Triana; M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 303. pls. 1C, 3. 1956, *pro parte*; Maheshwari, Bull. Bot. Survey India 2: 146. 1960, *pro parte*; Kochummen, Malayan Forest Rec. ed. 2. 17: 216. 1965, *pro parte*; T. C. Whitmore, Tree Fl. Malaya 2: 193. 1973, *pro parte*; H. Keng, Gard. Bull. Singapore 28: 245. 1976; Corner, Gard. Bull. Singapore Suppl. 1: 105. 1978.

A speciebuis aliis Calophylli in gemma terminalis (0.8-)1.2-1.8 cm. longa indumento tomentoso praedita, lamina mediocra venatione densa subobscura, inflorescentia brevi, et fructu plerumque 3-4.4 cm. longo putamine parietibus 1.3-2 mm. in transversis, differt.

Tree 20-48 meters tall, d.b.h. to 240 cm.; trunk usually without buttresses or spurs; outer bark brown to gray, becoming deeply fissured, the inner surface blackish, brown and orange mottled, or dirty orange-brown; under bark red; inner bark red to pink or dull brown; latex clear, yellow, sticky, or light brown (Sumatra).

Twigs flattened, 1.5-2.5(-3.5) mm. across, obscurely 4-angled, often with inconspicuous transverse raised line at nodes, drying blackish, subpersistently rufous-puberulent to -short-tomentose; axillary innovations lacking basal scars; internodes (0.5-)1-5(-6.5) cm. long; uppermost pair of axillary buds \pm pointed, to 3 mm. long, erect to \pm spreading; terminal bud plump to narrowly conical, (0.8-)1.2-1.8 cm. long, with rufous-puberulent to -tomentose indumentum (hairs, FIGURE 18, k, l), underdeveloped internode to 6 mm. long. Petiole (1-)1.2-2.7 cm. long, slender, concave above, convex below, subpersistently tomentose, drying black; lamina ovate to subelliptic, 7.3-14 by 2-5 cm., gradually (sub)acuminate to retuse at apex, acute or cuneate to broadly rounded and often slightly asymmetrical at base, rather distantly undulate and not recurved to slightly so at margin, coriaceous, drying umber to sabelline above and umber to khaki below, subpersistently puberulent to short-tomentose on midrib on both surfaces, the midrib above narrow at base or narrowing fairly quickly near base, \pm raised (surrounding lamina obscurely raised), 0.25-0.35 mm. wide at midpoint, below raised, striate, the venation on both surfaces usually subobscure (rarely subapparent), raised, (11 to) 13 to 18 veins/5 mm., angle of divergence 70-80°. Inflorescences from foliate axils, with 5 (to 7) flowers, unbranched, the axis 0.3-1.3 cm. long, puberulent, sometimes short-tomentose toward base, lowest internode 1-5 mm. long; bracts ovate, ca. 4 mm. long, often persistent at anthesis; pedicels 3.5-7 mm. long, to 12 mm. in fruit, short-tomentose. Flower (?)hermaphroditic; tepals 4 (to 8), the outer pair elliptic to subobovate, 5-7 by 2.2-4 mm., subtomentose on back, the next pair obovate, 8-8.5 by 3.5-4.5 mm., usually with strip of indumentum down back, additional ones, if any, to 9 by 3.1 mm.; stamens 140 to 250, the filaments to 4.5 mm. long, connate for up to 0.5 mm., the anthers oblong, 0.5-1.2 mm. long, \pm retuse at apex; ovary 1.2-2 mm. long, the style 2-2.2 mm. long, the stigma peltate, 0.5-0.7 mm. across, 3- or 4-radiate. Fruit ellipsoid (spherical or subobovoid), (2.6-)3-4.4 by 2.4-3.2 cm., \pm rounded at apex, drying brown or grayish brown, with broad, longitudinal ridges and/or fine wrinkles; outer layer detaching cleanly



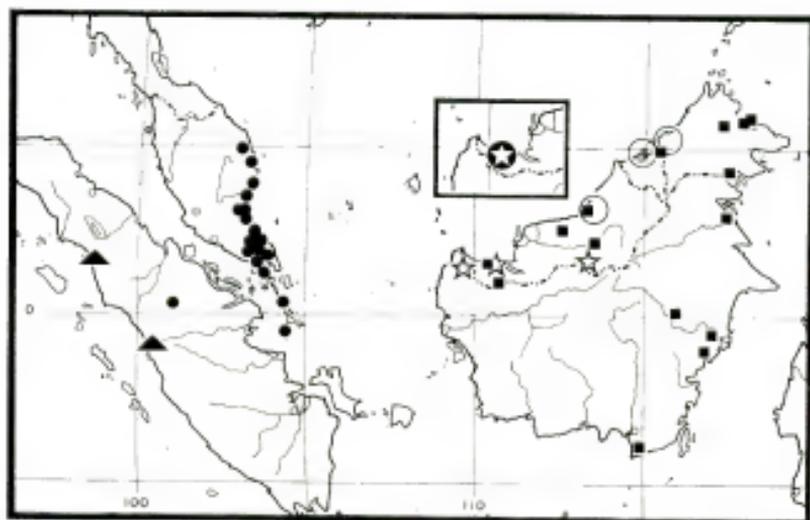
FIGURE 18. Hairs (from terminal bud). a-j, *Calophyllum wallichianum*. a, b, var. *wallichianum* (FRI 3105). c-h, var. *incrassatum*: c, d, bb 18354; e, f, FRI 3605; g, h, S 16375. i, j, cf. var. *incrassatum* (bb 24801). k, l, *C. rufigemmatum*: k, SFN 34642; l, KEP 74159. m, *C. aff. castaneum* (S 16559). n-q, *C. lanigerum*. n, o, var. *austrocoriaceum*: n, FRI 7846; o, Purseglove 5560. p, q, var. *lanigerum*: p, Kostermans 9591, hair to 600 μ m. long; q, Kostermans & Anta 490, hair ca. 550 μ m. long. r, *C. castaneum* (HLB 909, 68-72), hair ca. 540 μ m. long. Expanded apical cells in k-q all strongly birefringent in polarized light. Scale = 120 μ m.

from stone, 1.3–3.5 mm. thick, compact, \pm striate on inner surface; stone ovoid to ellipsoid, 2.2–3 by 2–2.4 cm., apiculate or not, the walls (1–)1.3–2 mm. thick, smooth, often with triradiate marking at apex; spongy layer thin.

TYPE: Singapore, Bukit Timah, "low" alt., 24 Dec. 1937, *SFN* 34632 coll. *Ngadiman* (holotype, A; isotypes, K, LAE, SING).

DISTRIBUTION. Southeastern Malaya, Singapore, Sumatra (MAP 17).

SELECTED SPECIMENS SEEN ("f" denotes specimens with fruits). **Malaya.** TRENGGANU: Ulu Dungun, *FRI* 9616 (KEP); Jerengau State Land, 285 m., *KEP* 76677 (f) (K, KEP, L, SING); Bauk F.R., 210 m., *FRI* 3921 (f) (A, K, KEP, SAR, SING). PAHANG: G. Lesong F.R., Rompin, 15 m., *KEP* 80955 (f) (A, K, KEP, L, SING); Aur F.R., 15 m., *KEP* 75881 (f) (KEP); Mile 17, Jalan Pekan–Batu Balek, *KEP* 82702 (KEP); Baloh F.R., *KEP* 77974 (KEP). JOHORE: G. Panti, Panti F.R., 305 m., *FRI* 13796 (f) (A, K, KEP, SAN, SING); Renggam F.R., *KEP* 71265 (KEP); Jalan Endau, Mersing, 21 m., *KEP* 74159 (f) (A, BO, K, KEP, SING); Jemaluang, *KEP* 73457 (f) (K, KEP); G. Arong F.R., *KEP* 77889 (f) (KEP); 15 m., *Stevens et al.* 80 (A); Kluang F.R., *KEP* 69919 (KEP); G. Pulai, *SFN* 7803 (f) (KEP); 6th Mile, Kota Tinggi–Mawai road, *SFN* 30987 (SING); Mersing F.R., *KEP* 77814 (f) (KEP, SING); Ulu Sedili F.R., *KEP* 63058 (KEP); Sungei Sarah W.C., 45 m., *KEP* 77733 (f) (K, KEP). **Singapore:** Bukit Timah, *SFN* 34546 (BO, SAR, SING), *Ridley* 6333 (f) (SING, w); Gardens Jungle, *SFN* 39451 (f) (A, K, KEP, SING); Mandai Forest, *SFN* 39605 (K, SING). **Sumatra and adjacent islands.** RIAU: Afd. Lingga, P. Lingkep, Oetam Njakur (Bakong), 100 m., *bb* 2040 (BO, L); bij Oetan djalan Setawar, *bb* 2705 (BO); Sei Tokak, *bb* 3861 (L), Djago, 10 m., *bb* 3939 (f) (BO); Tanjong Batang, 8 m., *bb* 4015



MAP 17. Distribution of *Calophyllum rufigemmatum* (solid circles), *C. castaneum* (stars), *C. aff. castaneum* (open circles), *C. woodii* (squares), and *Calophyllum* sp. 54 (triangles) in Malesia. Inset: *Calophyllum* sp. 53.

(80); B. Poempoeng, *bb* 4047 (80); upper Riau, Pakanbaru, Tenajan R., *Soepadmo* 222 (f) (A, BO, C, E, LAE, NY, SING).

ECOLOGY. An often large tree of ridges, slopes, or other well-drained habitats in mixed dipterocarp forest, 5–305 m. alt. Flowering February, September, November, and December (flower scented); fruiting January, March to August, and October (fruit pale or brownish green). *SFN* 33561, *bb* 3939, and *Soepadmo* 222 have neat holes bored in the stone wall and the seed eaten; these appear to be the exit holes made by some insect.

GERMINATION AND YOUNG PLANT. The radicle breaks the stone to one side of the base (*KEP* 77989). The seedling has two pairs of leaves separated by an internode ca. 1.4 cm. long (one seedling, from Singapore, *SFN* 39451). Subsequent internodes are somewhat longer, the terminal bud is functional, and the plant is erect.

LOCAL USE. The wood is an important timber since the trees attain large dimensions.

Calophyllum rufigemmatum can be recognized by its relatively slender twigs and petioles, and its ovate to subelliptic lamina that is obscurely and rather distantly undulate at the margin and has a more or less raised midrib, even at the base, and close venation. The inflorescences are short and congested, and the bracts are subsistent; the short pedicels elongate markedly after anthesis. The fruits are distinctive; they are typically large, longitudinally corrugated as well as closely wrinkled, and with a stone wall usually at least 1.3 mm. thick (but see below). The epithet *rufigemmatum* ("reddish brown buds") is quite appropriate.

The circumscription of *Calophyllum rufigemmatum* is discussed under *C. wallichianum*, in which it had previously been included. The rather appropriate manuscript name that Henderson and Wyatt-Smith coined for this taxon when they thought it was specifically distinct is retained.

Although *Calophyllum rufigemmatum* is generally distinguishable from *C. wallichianum* by numerous, albeit sometimes rather inconspicuous, characters (TABLE 9), specimens from Trengganu blur this distinction somewhat in Malaya. Fruiting specimens from the Bukit Bauk Reserve have spherical, reticulate (but not longitudinally corrugated) fruits, with the outer layer and stone walls 1–1.5 mm. thick (FIGURE 17, f–h). The single fruiting collection from Jerengau is intermediate between the specimens from Bukit Bauk and the typical form (see above). In other characters, these specimens agree well with *C. rufigemmatum* (see also the discussion after *C. wallichianum* and *C. castaneum*).

I collected an interesting specimen (*Stevens et al.* 48) from the Renggam Forest Reserve, Johore, thinking it to be *Calophyllum rufigemmatum* although the latex was slightly cloudy. However, the dried specimen has a facies similar to that of *C. lanigerum* var. *astrocoriaceum* and also, but less markedly, that of *C. molle*. The inflorescences are those of *C. rufigemmatum*, but the stamens have hairy filaments and glabrous anthers. The hairs on the terminal bud are like those of *C. rufigemmatum*.

At first sight saplings of *Calophyllum rufigemmatum* from Johore look

very different from the adult trees. There is dense, tomentose indumentum on the terminal bud and the stem, as well as on the midrib on the lower surface of lamina; the lamina itself is suboblong and measures up to 30 by 9 cm.

45. *Calophyllum lanigerum* Miq. Fl. Ind. Bat. Suppl. I(3): 498. 1961. TYPE: Bangka, prope Djebus, *Teysmann*, HB 3466 (holotype, u; isotypes, so, k (?), s.n.), l).

Tree (or shrub) 2-21 meters tall, d.b.h. to 48 cm.; trunk usually without buttresses (present in montane forest in Johore); outer bark ochre to yellowish (grayish or light brown), with vertical rows of lenticels or with boat-shaped fissures, inner surface orange to dark brown; under bark deep reddish to greenish; inner bark deep red to pale pinkish; latex usually clear yellow, sticky (\pm opaque, sulfur yellow, or milky).

Twigs moderately to strongly flattened, 1.5-5 mm. across, \pm rounded to strongly 4-angled, drying dark brown to black (rarely yellowish), \pm persistently tomentose; axillary innovations lacking basal scars; internodes 1-5(-7.5) cm. long; uppermost pair of axillary buds rounded, to 3 mm. long, \pm spreading; terminal bud plump, 0.5-3 cm. long, with brown tomentose or grayish brown subtomentose indumentum (hairs, FIGURE 18, n-q), underdeveloped internode to 5 mm. long. Petiole 0.4-3 cm. long, broadly and shallowly (rarely narrowly) concave above, convex and persistently tomentose below; lamina subovate to oblong or oval, 3.8-20 by 1-6(-7.3) cm., rounded to retuse or subacute at apex, rounded to cuneate or acute at base, not undulate to distantly so and flat to slightly recurved at margin, coriaceous, drying chestnut to olivaceous (greenish) above, umber to olivaceous (greenish) below, subsersistently tomentose (soon glabrescent) on midrib on both surfaces, the midrib above gradually to fairly quickly narrowed at base, raised, (0.15-)0.2-0.35 mm. wide at midpoint, below raised, rounded to striate, the venation subobscure to clear above and below (latex canals above as prominent as veins), 6 to 13 (to 15) veins/5 mm., angle of divergence (60-)70-85°. Inflorescences from foliate axils, with 3 to 21 flowers, unbranched (rarely with branches up to 2 cm. long and with 5 flowers), the axis 0.3-7 cm. long, tomentose at base, rest of axis subglabrous (rarely with indumentum its entire length), lowest internode (0.2-)0.4-2 cm. long; bracts to 10 by 2 mm., tomentose below, subsistent or not; pedicels 0.4-2.3 cm. long, glabrous. Flower (?)hermaphroditic; tepals 8 (rarely 6), the outer two ovate, 3.5-7 by 2.5-5 mm., sometimes with dorsal tuft of hairs at apex, the next pair elliptic to obovate, 7.5-12 by 3.5-6.5 mm., the inner ones \pm lingulate to obovate, 7-12 by 2.5-5 mm.; stamens (65 to) 105 to 165, the filaments to 6 mm. long, connate for up to 1 mm., the anthers suboblong, 0.5-1 mm. long, rounded to slightly retuse at apex; ovary 1.4-2 mm. long, the style 3-3.5 mm. long, the stigma peltate, 0.6-0.8 mm. across, 2- or 3-radiate. Fruit usually \pm spherical (ellipsoid to obovoid), 1.2-2.9 by 1.1-2.4 cm., usually apiculate, drying brown, sharply, closely, and shallowly wrinkled; outer layer detaching cleanly from stone, 1-3.5 mm. thick, compact; stone \pm spherical, 1.1-2.1 cm. long and

across, rounded at apex, the walls 0.7-1.3 mm. thick, smooth (with obscure triradiate marking at apex), discolored area at base 3.5-8 mm. across; spongy layer thin.

Key to the Varieties of *Calophyllum lanigerum*

1. Terminal bud 5-12(-16) mm. long; twigs 1.5-2.5(-3.5) mm. across; lamina 3.8-12.5(-15) cm. long. 45a. var. *lanigerum*.
1. Terminal bud 0.9-3 cm. long; twigs 3-5 mm. across; lamina 8.5-20 cm. long. 45b. var. *austrororiaceum*.

45a. *Calophyllum lanigerum* Miq. var. *lanigerum*

C. lanigerum Miq.; Kurz, *Natuurk. Tijdschr. Nederl.-Indië* 27: 192. 1864; F. Mueller in Walp. *Ann. Syst. Bot.* 7: 357. 1868; Scheffer, *Natuurk. Tijdschr. Nederl.-Indië* 31: 354. 1870, *ibid.* 32: 405. 1873; Vesque in C. DC. *Monogr. Phanerog.* 8: 606. 1893; Heyne, *Nutt. Pl. Indonesië*. ed. 3. 1: 1084. 1950.

C. frutescens Ridley, *Kew Bull.* 1938: 121. 1938; Masamune, *Enum. Phanerog. Born.* 475. 1942. TYPE: Dutch SE. Borneo [Kalimantan], Bangarmassing, *Motley 54* (holotype, K).

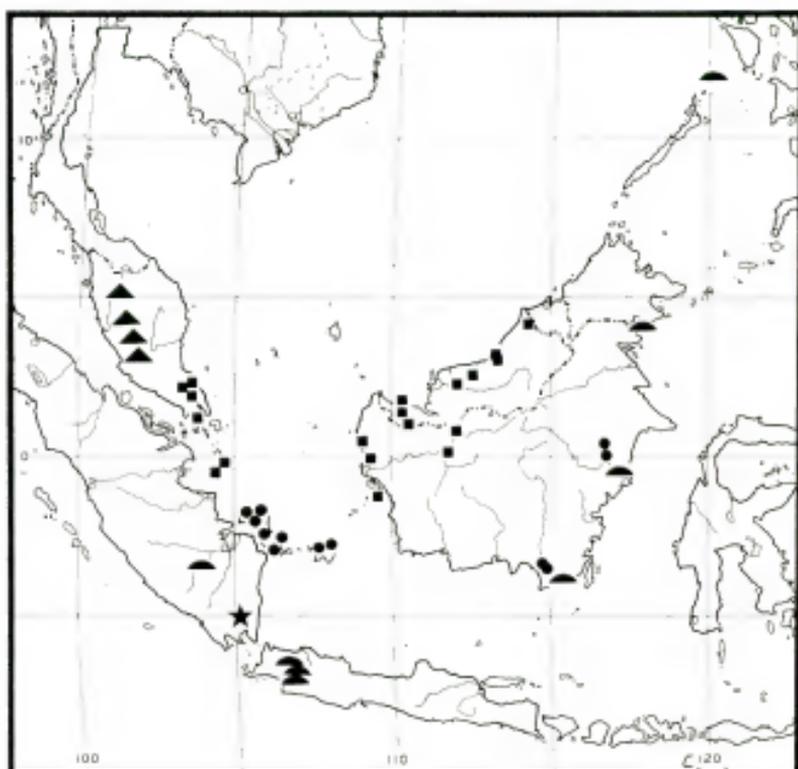
Shrub or tree 2-12 meters tall.

Terminal bud 5-12(-16) mm. long; twigs flattened, 1.5-2.5(-3.5) mm. across. Petiole 0.4-1.5(-1.9) cm. long; lamina oblong to oval, 3.8-12.5(-15) by 1.9-4.6(-7.3) cm., usually drying chestnut above, latex canals on upper surface not prominent, 6 to 11 veins/5 mm. Inflorescence with 3 to 7 (to 13) flowers; axis 0.3-2.5 cm. long, lowest internode (2-)4-11 mm. long. Fruit ± spherical, 1.2-1.9 cm. long; outer layer 1-2 mm. thick; stone to 1.6 cm. long, walls ca. 0.7 mm. thick.

DISTRIBUTION. Bangka, Belitung, and southeastern Borneo (MAP 18).

SELECTED SPECIMENS SEEN. **Sumatra and adjacent islands.** BANGKA: Djebus, *Teysmann, HB 3204* (BO, L, MEL, V); Soengei Selan, Bukit Raja, 140 m., *Bünnemeyer 2002* (BO, L); Kepo bij Toboali, 60 m., *Bünnemeyer 2315* (BO, K, L); Lobok Besar, 20 m., *Kostermans & Anta 45* (A, BO, K, L, SING); Pangkaljunang-Blinjoe, *Huitema 35* (BO); Serdang, *de Leeuw 5* (BO); Koela Soengei Redjein, *Burger 28* (BO); Gunung Padang, 100 m., *Kostermans & Anta 1000* (A, BO, K, L, LAE, P, SING); Soengei Liat dessa Bakem, *Teysmann s.n.* (BO). BELITUNG: Tandjong Pandan, *Teysmann s.n.* (BO); Kampong Began-tang, *de Veer s.n.*, May 1949 (BO). **Borneo and adjacent islands.** KALIMANTAN. TIMUR: W. Koetei, Kelindjau R., near Melan, *Kostermans 9591* (A, BO, K, SING), bij Benoewa toewa, 20 m., *Endert 1585* (A, BO, K). SELATAN: G. Pamatton, *Korthals s.n.* (L); km. 22 Bangarmasin to Martapura, 10 m., *Dransfield & Hamlali 4318* (BO); Martapoera, G. Padamaran, *bb 1211* (BO), G. Koepang, *bb 1212* (BO). JAVA. BARAT: cult. Hort. Bogor, sub *VI C 128* (BO, K, US).

ECOLOGY. Locally abundant, rather small tree of sandy soils, sometimes in padangs; 20-140 m. alt. Flowering September, October, and December; fruiting June, September, and November.



MAP 18. Distribution of *Calophyllum lanigerum* var. *lanigerum* (circles), *C. lanigerum* var. *austrocoriaceum* (squares), *C. dasypodum* (half-circles, localized; star, unlocalized), and *C. coriaceum* (triangles) in Malesia.

GERMINATION AND YOUNG PLANTS. Saplings (e.g., *Teymann*, HB 3260) have leaves with very short (ca. 3 mm.) stalks and blades that are broadly rounded to subcordate at the base.

LOCAL USES. The wood is used in house and ship building.

45b. *Calophyllum lanigerum* Miq. var. *austrocoriaceum* (T. C. Whitmore) P. F. Stevens, comb. et stat. nov.

C. austrocoriaceum T. C. Whitmore, Gard. Bull. Singapore 26: 269. 1973, Tree Fl. Malaya 2: 174. 1973; H. Keng, Gard. Bull. Singapore 28: 244. 1976. TYPE: Malaya, Johore, summit Gunong Panti Barat, 1684 feet [513 m.], 6 May 1968, FRI 7846 coll. Cockburn (holotype, K, SING; isotypes, A, SING).

Calophyllum sp. 10, M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 313. pl. 8. 1966.

Tree (2.1-)4.5-21 meters tall.

Terminal bud 0.9-3 cm. long; twigs rather strongly flattened, 3-5 mm. across. Petiole 1-3 cm. long; lamina narrowly ovate to oblong, 8.5-20 by 3.3-6.4 cm., usually drying umber to olivaceous above (often chestnut brown in Kalimantan), in Bornean specimens latex canals on upper surface often as prominent as veins, (5 to) 7 to 15 veins/5 mm. Inflorescences with 7 to 21 flowers; axis 3-7 cm. long, lowest internode 0.4-2 cm. long. Fruit spherical to ellipsoid or obovoid, (1.8-)2.2-2.9 by (1.7-)2-2.4 cm.; outer layer (1.8-)2.2-3.5 cm. thick; stone (1.1-)1.7-2.1 cm. long, walls 0.8-1.3 mm. thick.

DISTRIBUTION. Southern Malaya to the Lingga Archipelago, northwestern Borneo (MAP 18).

SELECTED SPECIMENS SEEN. **Malaya.** JOHORE: ridge between G. Panti E. and G. Panti W., 427 m., *FRI 13819* (A, K, KEP, SING); G. Blumut, 914 m., *FRI 7512* (A, KEP, SING); Kluang F.R., 457 m., *KEP 98038* (A, K, KEP, SING); Mersing, Jemaluang F.R., *KEP 71889* (K, KEP, SING). **Singapore:** MacRitchie Reservoir area, 30 m., *Burkill 1877* (A, K, LAE, SING); Gardens Jungle, "low" alt., *SFN 39452* (A, K, KEP, SING). **Sumatra and adjacent islands.** RIAU: Lingga, Poeloe Singkhep, Sei Manggoe, 15 m., *bb 3936* (BO); M. Tandai, *Teysmann s.n.* (BO). **Borneo.** SARAWAK. 1st Division: Bako Natl. Park, Lintang Path, 100 m., *S 19718* (K, L, SAN, SAR, SING), Sungei Selo, 60 m., *S 7664* (SAN, SING); G. Matang, 732 m., *S 12503* (BO, K, L, SAN, SAR, SING); near G. Siol, *Omar 373* (K, SING); Unjam F.R., 9 m., *S 7709* (SAR, SING); Batu 6 F.R. [Stapok], *FA 827* coll. *Egon*, 8 July 1940 (KEP). 3rd Division: Batang Igan, Sungei Tutus logging camp, *S 30169* (K, SAR). KALIMANTAN. Barat: Soengei Kenepai, *Hallier 2167* (BO, K, L); Danau Lamadgian [Seriang], *Beccari PB 3463* (FI); Poeloe Madjang, *Jaheri s.n.*, 1893 (BO), *Teysmann, HB 8042* (BO); Pontianak, *Dedi 864* (BO); Pasir Tondjong, 2 m., *bb 9779* (BO); N. of Mempawah, Pasir Pandjang, 1 m., *Polak 724* (BO, L).

ECOLOGY. Varied. Both in Johore, Malaya, and in the First Division, Sarawak, in colline forest—"occasionally one of the tallest [trees] in the forest" (*SFN 10723*, G. Blumut, Johore); at lower elevations in peat swamps (*S 30169*, Sarawak); heath forest (e.g., *S 12340*, Sarawak); sandy soil near sea (*Polak 724*, Kalimantan); or general mixed dipterocarp lowland rainforest (Johore, Singapore); to 950 m. alt. Flowering July, October, and November (Borneo); fruiting January to May (Borneo and Malaya), July (Singapore), and August (Sarawak).

GERMINATION AND YOUNG PLANT. The radicle breaks the stone wall immediately adjacent to the "plug," which is apparently not pushed out during germination. The seedling has two pairs of leaves separated by an internode of ca. 5 mm. Subsequent growth seems to be slow, with internodes less than 1 cm. long (*SFN 39452*). The young plant is erect, and the terminal bud is functional (pers. obs., Singapore). The leaves of saplings are long and narrow (11.8-50 by 1.7-5.4 cm.).

LOCAL USE. The wood is coarse grained and is used for planks.

The epithet *austrororiaceum* ("southern coriaceous") was coined because

Calophyllum austrocoriaceum was thought to be related to *C. coriaceum* and was found to the south of it.

Calophyllum lanigerum can be recognized by its plump, usually densely tomentose terminal bud; by its coriaceous, more or less oblong lamina, which has clear, not very dense venation on at least one surface; and by its sharply wrinkled, more or less spherical fruit with a thick outer layer that detaches cleanly from the stone. The spherical, thick-walled stone often has an obscure triradiate marking at the apex and a pluglike area at the base. The epithet *lanigerum* ("wool-bearing") emphasizes the well-developed tomentose indumentum characteristic of this species.

The description of the bark of *Calophyllum lanigerum* is almost wholly based on observations of (and field notes on specimens of) *C. lanigerum* var. *austrocoriaceum*. Both varieties have yellow latex.

The type specimens of *Calophyllum lanigerum* and *C. austrocoriaceum* are very different and at first sight appear to belong to different species. However, they are connected by intermediates, although the evaluation of the variation pattern is complicated since specimens in flower are not known from Malaya or Singapore. Specimens of *C. austrocoriaceum* from high altitudes in Malaya have less dense venation and less well developed indumentum than the specimens from Borneo, and the lamina is more or less acute, rather than rounded, at the base; specimens of *C. austrocoriaceum* from Borneo, and those collected at lower altitudes in Malaya and Singapore, are more like *C. lanigerum* in these respects. Specimens of *C. austrocoriaceum* from northwestern Borneo (e.g., S 12503, Sarawak) have fruits the same size as those of *C. lanigerum*, and there is also general agreement in details of flower, fruit structure, and indumentum distribution on the inflorescence (dense, tomentose indumentum restricted to the lowest internode). However, the inflorescences of specimens of *C. austrocoriaceum* from Singapore have indumentum for their entire length; there is perhaps a tendency toward a similar condition in Dedi 864 (*C. austrocoriaceum*; Pontianak, Kalimantan). Inflorescences of specimens of *C. austrocoriaceum* from Johore are glabrous above the lowest internode, but specimens in flower from the western part of the range of *C. austrocoriaceum* are needed to understand this variation. Hair structure of specimens from all areas and altitudes is similar (FIGURE 18, n-q): the base of the hair consists of often thin-walled short cells, with the walls not birefringent in polarized light; the upper part of the hair has elongated cells (often two) with strongly thickened walls that are birefringent under polarized light. The upper surface of the lamina of several specimens of *C. austrocoriaceum* from Kalimantan dries chestnut brown, as in *C. lanigerum*, rather than the lighter brown color characteristic of the other specimens of *C. austrocoriaceum*.

In view of the underlying similarity between *Calophyllum lanigerum* and *C. austrocoriaceum* and the noncorrelation of much of the variation within the complex as a whole, *C. austrocoriaceum* is reduced to varietal rank under *C. lanigerum*. *Calophyllum lanigerum* var. *austrocoriaceum* can be distinguished from var. *lanigerum* by the larger size of all its parts (except

the pedicels and the flowers) and by the frequently lighter brown color of the dried lamina.

There is little variation within *Calophyllum lanigerum* var. *lanigerum*. Specimens from mainland Borneo tend to have larger leaves than those from Bangka and Belitung; the type specimen of *C. frutescens* is a specimen of the former type. Some of the variation within var. *austrocoriaceum* has been discussed above. A few specimens from Malaya (Grubb s.n., 25 Sept. 1970; Shah & Ahmad 2923) have twigs that dry yellowish and leaf blades that dry greenish, but in other respects these specimens are unremarkable.

Specimens of *Calophyllum lanigerum* var. *austrocoriaceum* from low altitudes in Johore and Singapore were cited under *C. incrassatum* by Henderson & Wyatt-Smith (*op. cit.*, p. 202), albeit with hesitation. However, they have the densely tomentose terminal bud, the distinctive hairs, the clear and rather distant venation, and the yellow latex of the former taxon.

46. *Calophyllum castaneum* P. F. Stevens, sp. nov.

FIGURE 17, k.

A speciebus aliis Calophylli in gemma terminali magna 2.1-3 cm. longa indumento tomentoso castaneo vel badio praedita, folia magna basi cucullata venulis lateralibus densis 11 ad 22 per 5 mm., et infructescentibus ramosis pedicellis brevibus 2-3.5 mm. longis, differt.

Tree 27-38 meters tall, d.b.h. to 58 cm.; trunk without buttresses; outer bark at first yellow-brown, smooth except for long cracks, becoming brown, fissured, scaly, when freshly exposed dark brown, the inner surface orange-brown; under bark dark brown, orange-brown, or reddish; inner bark red to pale rose; latex yellow, opaque, viscous or not.

Twigs flattened, 3.5-5.5 mm. across, more or less 4-angled, drying yellowish or grayish brown, color often obscured by dense indumentum, persistently tomentose, the hairs bay to chestnut, to 1 mm. long; axillary innovation (?) without basal scars; internodes 4-6 cm. long; uppermost pair of axillary buds rounded, ca. 2 mm. long, more or less spreading; terminal bud plump, 2.1-3 cm. long, with bay to chestnut, tomentose indumentum (hairs, FIGURE 18, r), underdeveloped internode 3-8 mm. long. Petiole 1-2 cm. long, shallowly concave above, convex below, persistently tomentose; lamina elliptic to oblong, (6-)10-25 by (3.5-)4.3-9.5 cm., short-acuminate at apex, rounded to cuneate and more or less cucullate at base, slightly undulate and slightly and narrowly recurved at margin, marginal thickening ca. 0.35 mm. wide, coriaceous, drying bay to umber above and umber below, tomentose on midrib on both surfaces and over entire lower surface, the midrib above narrowing rather abruptly near base, raised, or narrowing gradually, flat at first and becoming raised toward apex, 0.25-0.4 mm. wide at midpoint, below raised, prominent, strongly striate, the venation subapparent on both surfaces, slightly raised, 11 to 22 veins/5 mm., angle of divergence 70-75°. Infructescences from foliate axils, with scars of ca. 15 flowers, branched, the branches 3-flowered, to 7.5 mm. long, the axis ca. 2.5 cm. long, sparsely tomentose, especially toward base, lowest internode 3-6 mm. long; bracts not known; pedicels 2-3.5 mm. long, \pm glabrous. Flower not known. Immature fruit

ca. 1.5 by 1 cm., subacute at apex, drying vinaceous-brown, wrinkled; outer layer ca. 1 mm. thick; stone and spongy layer unknown.

TYPE: Sarawak, 3rd Division, Kapit, Sungai Mengiong, 1500 feet [457 m.], 7 Oct. 1969, S 29755 coll. *Suib* (holotype, SAR).

DISTRIBUTION. Northwestern Borneo (MAP 17).

ADDITIONAL SPECIMENS SEEN. **Borneo.** SARAWAK. 1st Division: Semengoh Arboretum (Tree 4671), ca. 50 m., *Stevens et al.* 133 (A); Semengoh F.R., 30 m., *Stevens et al.* 291 (A). KALIMANTAN. Barat: Damerar Tangkawang, *de Vries* (27) HLB 909,68-60 & -72 (both L); Sambas, Perigi Limoes, 300 m., *bb* 7044 (BO). Sine loco [probably Pontianak or Sintang], *de Vries & Teijsmann s.n.* HLB 903,343-214, -216, & -217 (all L); *Teijsmann s.n.* HLB 903,343-215 (L), *de Vries s.n.* (BO, U).

ECOLOGY. Lowland and colline mixed dipterocarp forest, 30-457 m. alt. Fruiting in October.

Calophyllum castaneum is a distinctive species, even when sterile. It is recognizable by its large leaf blades that have dense venation and are cucullate at the base; its large terminal bud at least 2 cm. long; and its persistent, dark brown, tomentose indumentum on terminal bud, twig, and leaf. The very short pedicels are unusual in a species of *Calophyllum* that has fruits of a moderate size and are a noteworthy feature of *C. castaneum*. The descriptions of the infructescence and the immature fruit are taken from the type specimen, which is a unicate. The chestnut color of the indumentum suggested the specific epithet, *castaneum*.

Calophyllum cucullatum, from the Philippine Islands, also has a large leaf blade that is cucullate at the base and dries a rich brown color. However, *C. cucullatum* has a terminal bud less than 8 mm. long, very different hairs, a much smaller inflorescence, long and slender pedicels, and a fruit only ca. 1 cm. long. *Calophyllum cucullatum* is not closely related to *C. castaneum*.

There is a perplexing group of specimens from Sarawak (e.g., S 16599, 3rd Division), Brunei (BRUN 3058), and adjacent Sabah (e.g., SAN 36872, Beaufort) (MAP 17) that in many ways resembles *Calophyllum castaneum*. The specimens have castaneous indumentum with hairs similar to those of *C. castaneum* in that the two apical cells are much enlarged and are birefringent; however, the cells are not as much enlarged as they are in that species (FIGURE 18, m). The leaves have similarly dense venation, and the lamina base is rounded and slightly cucullate. The pedicels seem to be short, and the fruit moderate in size. However, the specimens are much more gracile in appearance, the twigs are less than 3 mm. across, and the terminal bud is less than 1.5 cm. long. Although these specimens are possibly related to *C. castaneum* (and perhaps to *C. rufigemmatum*), their identification awaits better collections. Meijer (Bot. Bull. Herb. Forest Dept. Sabah 7: 15. 1967) used the name *C. rotundatum* for these specimens; this is a *nomen nudum*.

47. *Calophyllum coriaceum* Symington ex M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 323. pl. 10. 1956; Wyatt-Smith, Malayan

Forest Rec. 17: 113. 1952, *nomen*; Kochummen, Malayan Forest Rec. ed. 2. 17: 216. 1965; T. C. Whitmore, Tree Fl. Malaya 2: 177. 1973, *pro parte*. TYPE: Malaya, Pahang, Cameron's Highlands, Robinson's Falls, 12 July 1928, KEP 13627 coll. Mead (holotype, SING; isotype, KEP).

C. ?spectabile auct., non Willd.; Henderson, Jour. Malay Branch Roy. Asiatic Soc. 5: 243. 1927.

C. near griffithii auct., non King; Henderson, Gard. Bull. Straits Settl. 4: 93. 1927.

Tree 4-30 meters tall, d.b.h. to 58 cm.; trunk without buttresses; outer bark yellowish, slightly fissured; under bark deep red-brown; inner bark pink; latex white, sticky or rather fluid, or yellow, thick (smelling like soup stock—KEP 51818).

Twigs slightly flattened, 3-4.5 mm. across, \pm 4-angled, drying brown to blackish, reddish farinose to subtomentose when young; axillary innovations lacking basal scars; internodes 2-5 cm. long; uppermost pair of axillary buds \pm rounded, to 1.5 mm. long, suberect; terminal bud plump, 1-1.8(-2.7) cm. long, with brown, subcrustaceous to puberulo-tomentose indumentum (hairs, FIGURE 19, a-c), underdeveloped internode to 4 mm. long. Petiole 1-3.1 cm. long, broadly and shallowly concave above, convex below, glabrous when mature; lamina elliptic to oblong, 8-18.5 by 4.6-8.3 cm., broadly rounded to shallowly retuse and finally short-acute to obtuse at apex, rounded and finally short-acute to acute or cuneate at base, not undulate and slightly to strongly recurved at margin, marginal thickening to 0.8 mm. wide, very coriaceous, drying olivaceous-honey to amber above and honey to amber below, puberulent on midrib on both surfaces when young, glabrescent or not, the midrib above narrowing gradually from or rather quickly near base, \pm level at first, becoming raised, (0.35-)0.5-0.7 mm. wide at midpoint, center sulcate, below strongly raised, striate or subangled, the venation obscure on both surfaces, slightly raised, 5 to 12 veins/5 mm., angle of divergence 70-80°. Inflorescences terminal and/or from adjacent foliate axils, with many flowers, branched, the axis at least 6 cm. long, farinose-puberulent, lowest internode ca. 2 cm. long; bracts unknown; pedicels 0.7-2.2 cm. long, puberulent, in fruit to 2 mm. thick. Flower (?)hermaphroditic; tepals 8 (reportedly also 9), the outer pair elliptic-ovate, ca. 10 by 6.5 mm., \pm puberulent on back, the next pair broadly elliptic, ca. 14 by 10.5 mm., \pm puberulent toward base on back, the inner ones probably ca. 14 by 17 mm.; stamens ca. 370, the filaments ca. 7 mm. long, the anthers oblong, 0.9-1.3 mm. long, subretuse at apex; ovary ca. 2.5 mm. long, the stigma peltate, ca. 1 mm. across, 3-radiate. Fruit ellipsoid, 3-4.5 by 2-2.3 cm., subcuneate to apiculate at apex, drying vinaceous-brown, with deep, rounded wrinkles; outer layer detaching cleanly from stone, 1.5-3 mm. thick, compact except for air spaces developing under skin; stone ellipsoid, 2.4-2.7 by 1.7-1.8 cm., rounded at apex, the walls 1-1.3 mm. thick, smooth, unmarked; spongy layer thick at first.

DISTRIBUTION. Malay Peninsula, the Main Range (MAP 18).

SELECTED SPECIMENS SEEN. **Malaya.** SELANGOR: G. Nuang F.R., Ulu Langat, *KEP 51818* (BO, KEP, SING); PAHANG: Fraser's Hill, 1219 m., *KEP 87303* (A, BO, K, KEP, SING); Cameron's Highlands, 1402 m., *SFN 23653* (A, BO, K, KEP, SING); Sungei Parang, Jalan Kuda, *KEP 27192* (KEP); Berenchang, *KEP 34015* (K, KEP); trail to G. Jesar, 1463 m., *FRI 15459* (KEP, SAN, SAR); Sungei Insar, *KEP 25174* (KEP).

ECOLOGY. Montane rain forest, 1219–1463 m. alt. Flowering in July (flower scented); fruiting May and November (fruit green, eaten by birds (*KEP 51818*)).

Calophyllum coriaceum can be recognized by its rather large, very coriaceous lamina with more or less broadly recurved margins, profuse, terminal inflorescence, and ellipsoid fruit that has a stone with walls at least 1 mm. thick. The very coriaceous leaf blades suggested the epithet *coriaceum*.

Calophyllum coriaceum does not seem particularly closely related to any other species. It is vegetatively similar to *C. scribbitifolium*; this is discussed further under the latter species. Whitmore (1973) believed that *C. austrocoriaceum* was related to *C. coriaceum*. *Calophyllum austrocoriaceum*, however, has axillary inflorescences and hairs of a very different structure; it is here reduced to varietal rank under *C. lanigerum*.

Whitmore (*loc. cit.*) reported *Calophyllum coriaceum* from Gunong Padang, Trengganu. The specimens on which this report was based (e.g., *FRI 12646*) are referred here to *C. wallichianum* var. *incrassatum*, although their very coriaceous leaf blades are somewhat atypical. The inflorescences are axillary, and the subspherical fruits are closely wrinkled—both characters of *C. wallichianum* var. *incrassatum*.

48. *Calophyllum dasypodum* Miq. Fl. Indiae Batavae 1(2): 511. 1859, *nomen novum* for *C. lanceolatum* Teijsm. & Binn.; F. Mueller in Walp. Ann. Syst. Bot. 7: 357. 1868; Backer & Bakh. f. Fl. Java 1: 386. 1963, *excl. syn.*; *C. teysmannii* Zoll. ex Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 275. 1862, non Miq. 1861, *excl. descr. et spec. cit.*, *nomen novum* for *C. lanceolatum* Teijsm. & Binn.; *C. lanceolatum* Teijsm. & Binn. Nat. Tijdschr. Nederl.-Indië 4: 398. 1853, non Blume, 1825; Kreyenb. Bull. Soc. Imp. Nat. Moscou 27: 259. 1854; Teijsm. & Binn. Nederl. Kruidk. Arch. 3: 395. 1855; F. Mueller in Walp. Ann. Syst. Bot. 7: 357. 1868. TYPE: Java, Duizend gebergte, *van Gesker s.n.* (l, u).

C. hasskarlii Teijsm. & Binn. ex Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 273. 1862; Vesque in C. DC. Monogr. Phanerog. 8: 581. 1893,

FIGURE 19. Hairs (from terminal bud, unless otherwise mentioned). a–c, *Calophyllum coriaceum*: a, b, Stevens *et al.* 17; c, *KEP 78303*, persistent base only. d–g, *C. dasypodum*: d, e, *Kostermans 6882*; f, g, *Marche B 371*. h–p, *C. canum*: h, *S 23960*; i, *A 859*; j, *Clemens 31859*; k, *KEP 99519*; l, *SAN 83502*; m, *Kostermans 10369*; n, o, *Soepadmo 39*; p, *S 23968*, from axillary bud. q, r, *Calophyllum* sp. 53 (*S 24675*). Scale = 60 μ m. (in q, r, scale = 120 μ m.).



- pro parte*; Koord. & Valetton, Meded. s'Lands Plant. 61(Bijd. Booms. Java 9): 384. 1903; Koord.-Schum. Svst. Verzeich. I(Fam. 187): 4. 1912; Koord. Exkursionsfl. Java 2: 618. 1912; Heyne, Nutt. Pl. Indonesië. ed. 3. 1: 1082. 1950. TYPE: Java, in sylvis, Zollinger 3457, *pro parte* (holotype, G; isotypes, BM, G, P).
- C. pulcherrimum* auct., non Wall. ex Choisy; Choisy in Zoll. Syst. Verzeich. 2: 149. 1854, Pl. Javan. 9. 1858.
- C. tomentosum* auct., non Wight; Miq. Pl. Jungh. 291. 1854, Fl. Indiae Batavae I(2): 514. 1859; Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 294. 1862.

Tree 20-30 meters tall, d.b.h. to 50 cm.; trunk without buttresses; outer bark yellow-brown with short, boat-shaped fissures, or dark gray, deeply fissured, the inner surface orange-straw; under bark dark red; inner bark pale pinkish; latex clear yellow, sticky.

Twigs slightly flattened, 1.8-3 mm. across, strongly 4-angled, soon becoming subterete, drying blackish brown, subpersistently grayish to brownish puberulent to submentose; axillary innovations lacking basal scars; internodes (0.2-)1-2.5 cm. long; uppermost pair of axillary buds plump, 2-5 mm. long, suberect; terminal bud plump, 6-8 mm. long, with brown, puberulent indumentum (hairs, FIGURE 19, d-g), underdeveloped internode 1-4 mm. long. Petiole 0.7-1.1 cm. long, concave above, convex and \pm persistently puberulent below; lamina ovate to elliptic, 5.5-12.5 by 1.5-3.4 cm., acute to acuminate at apex, cuneate to acute at base, strongly and distantly undulate and flat to slightly recurved at margin, coriaceous, drying amber and shiny above, amber to sepia below, glabrescent or persistently puberulent on midrib below (also above), the midrib above gradually narrowed from base, margins usually somewhat raised but \pm sulcate at first, 0.2-0.8 mm. across at midpoint, becoming raised in top $\frac{1}{3}$, below raised, striate, the venation \pm apparent on both surfaces, slightly raised, 8 to 15 veins/5 mm., angle of divergence 60-75°. Inflorescences from foliate axils along stem, with 7 to 11 flowers, unbranched, the axis 3-5.5 cm. long, puberulent, lowest internode 1-5 mm. long; bracts \pm ovate, ca. 2.5 mm. long; pedicels 0.4-1.3 cm. long, puberulent. Flower (?)hermaphroditic; tepals 4 or 6, or 8 in terminal flowers, sometimes glabrous, the two outer \pm ovate, ca. 4.5 by 3 mm., the inner ones slightly larger; stamens 30 to 55, to 70 in terminal flowers, the filaments to 2 mm. long, the anthers suboblong, 0.6-0.9 mm. long, slightly retuse at apex; ovary ca. 1 mm. long, the style ca. 1.5 mm. long, the stigma peltate, ca. 0.5 mm. across, slightly lobed. Fruit spherical, 1.4-1.7 cm. long and across, rounded at apex, drying vinaceous-brown, smooth; outer layer detaching cleanly from stone, 2-3 mm. thick, compact; stone spherical, 1.1-1.5 by 1-1.4 cm., rounded at apex, the walls 0.5-0.6 mm. thick, smooth, unmarked or with obscure triradiate apical lines, with a lighter-colored area (?plug) up to 5 mm. across at base; spongy layer thin.

DISTRIBUTION. Southern Sumatra, western Java, southern Borneo, (?)Philippine Islands (Map 18).

SELECTED SPECIMENS SEEN. **Sumatra.** SELATAN: Lematang Oeloe, 150 m.,

Lambach 1258 (BO, L (s.n.)); Sepoetik, Soewikis, 25 m., *bb 2851* (A, BO). **Borneo and adjacent islands.** KALIMANTAN, TIMUR: Sebatik Is., 10 m., *Kostermans 9154* (A, BO, K, NY, P, SING); Nunukan Is., N. part, *Kostermans 8958* (BO, L); Lor Haur, W. of Samarinda, 40 m., *Kostermans 6882* (A, B, BO, CANB, K, LAE, NY, P, SING). Selatan: Pleihari, Kintap, 25 m., *bb 2748* (BO); (?)Doesson, *Korthals s.n.* (BO, L, U). **Philippine Islands.** CALAMIAN, Busuanga: Malbato, *Marche 371* (?) (A, P). Java. BARAT: Djasinga, Tjurug, *Meijer 2894* (BO); Salak, *Zollinger 1711* (L ("fragm. ex herb. P")); Preanger, Soekaboemi, Palabocnratoe, *Koorders 2890* (BO); Bogor, Palace Gardens, *Kostermans s.n.*, Aug. 1953 (A, BO, BRI, K, NY, P, SING).

ECOLOGY. Sandy soil (Kalimantan), 10-150 m. alt. Flowering March, August, and October (flower scented); fruiting March, May, and September.

Calophyllum dasypodum can be recognized by its plump terminal bud; its rather stout twigs with puberulent-subtomentose indumentum; its rather narrow, ovate-elliptic lamina with a deeply undulate margin, a depressed midrib, and a shiny upper surface when dry; its puberulent inflorescence axis; and its spherical, cherry-sized fruits. The epithet *dasypodum* means "hairy foot" and alludes to the conspicuous indumentum on the inflorescence.

The only specimen of *Calophyllum dasypodum* from the Philippine Islands, *Marche 381*, is sterile. It has dried a color similar to that of the other specimens, but its leaf blades are dull, and although the indumentum is subtomentose, the hairs are typical for the species (FIGURE 19, f, g). *Marche 381* may also approach *C. pisiferum*.

Van Gesker s.n. agrees quite well with the description of *Calophyllum lanceolatum* Teijsm. & Binn. and is possibly the specimen on which the original description was based.

The way in which the name *Calophyllum teysmannii* Zoll. ex Planchon & Triana was published makes it, perhaps inadvertently, a new, but superfluous, name for *C. lanceolatum* Teijsm. & Binn. Planchon and Triana placed *C. lanceolatum* in the synonymy of their *C. teysmannii*, and in the discussion after the species noted that it was almost certainly a synonym of *C. teysmannii*. However, both their description and the specimens that they cited are of another taxon, the Javanese form of *C. calaba*. The name *C. teysmannii* Zoll. ex Planchon & Triana was published shortly after *C. teysmannii* Miq.; for further discussion, see *C. teysmannii*.

The confusion between *Calophyllum dasypodum* and the Javanese form of *C. calaba*, which resulted in Backer and Bakhuisen's (*loc. cit.*) inclusion of the two in one species, apparently also occurs in *C. hasskarlii*, a synonym of *C. dasypodum*. In many herbaria *Zollinger 3457*, the type number of *C. hasskarlii*, is a mixed collection, with part being the Javanese form of *C. calaba* (see Vesque, *op. cit.*, p. 582); the two species are not at all closely related.

Calophyllum calaba in Malesia lacks the well-developed indumentum of *C. dasypodum*, its lamina usually has much more dense venation, and its twigs are thinner and are often strongly flattened. The fruits of *C. calaba* are spherical to ellipsoid and are about two thirds the length of those of

C. dasypodum, the thinner outer layer becomes disorganized by air spaces, and the stone walls are about a third as thick.

49. *Calophyllum scriblitifolium* M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 326, pl. 12. 1956; J. Anderson, Gard. Bull. Singapore 20: 154. 1963; Smythies, Common Sarawak Trees, 64. 1965; Kochummen, Malayan Forest Rec. ed. 2. 17: 217. 1965; T. C. Whitmore, Tree Fl. Malaya 2: 192. 1973; J. Anderson, Trees Peat Swamp Sarawak, 88, pl. 27D. 1973. TYPE: Malaya, Perak, Utan Melintang Forest Reserve, 12 Oct. 1949, KEP 69001 coll. Shaari (holotype, KEP).

C. wallichianum auct., non Planchon & Triana; Merr. Bibl. Enum. Bornean Pl. 394. 1921, pro parte.

C. revolutum Wyatt-Smith, Malayan Forest Rec. 17: 43. 1952. *Nomen*.

Tree 24–44 meters tall, d.b.h. to 96 cm.; trunk without buttresses or stilt roots, but knee roots sometimes present (Sarawak); outer bark reddish brown or brown and soft, flaky, to gray, fissured and scaling, to chocolate, the inner surface (bronze) brown; under bark orange-brown; inner bark red to pink; latex white to creamy white, slightly sticky to sticky, turning gray-cream on exposure.

Twigs (slightly) flattened, 3.5–6.5 mm. across, \pm 4- or 8-angled when young, drying blackish to dark brown (rarely grayish), farinose to puberulent at least when young; axillary innovations perhaps with scars within 5 mm. of base; internodes (0.3–)0.7–3 cm. long; uppermost pair of axillary buds subrounded, to 1.5 mm. long, spreading; terminal bud plump, 1.2–2.2(–2.9) cm. long, with grayish to brown, crustaceous to subtomentose indumentum (hairs, FIGURE 20, d, e), underdeveloped internode to 4.5 mm. long. Petiole 1.3–2.8 cm. long, broadly concave above, convex below, \pm persistently puberulent; lamina oblong to elliptic, 7.8–19 by 1.8–7.6 cm., rounded to retuse (mucronate near midrib) at apex, cuneate to acute at base, slightly undulate but strongly and broadly recurved at margin, very coriaceous, drying olivaceous to honey color above and umber-sepia to fulvous below, usually persistently puberulent on midrib on both surfaces, the midrib above abruptly to gradually narrowed at base, depressed at first, becoming \pm raised, 0.3–0.5 mm. wide at midpoint, below strongly raised, rounded to striate, the venation apparent to subobscure on both surfaces, 9 to 16 veins/5 mm., angle of divergence (60–)80–85°. Inflorescences from foliate axils along twigs, with 9 to 11 flowers, unbranched, the axis 3.5–5.5 cm. long, densely puberulent, lowest internode

FIGURE 20. Hairs (from terminal bud, unless otherwise mentioned). a–c, *Calophyllum woodii*: a, Stevens et al. 160; b, SAN 35504; c, bb 34418. d, e, h, *C. scriblitifolium*: d, e, S 16170, from stem (d, from above); h, Native collector 1276. f, g, *C. lowii*: f, Grashoff 709, common hair type of species; g, van Rossum 44. i, *C. glaucescens* (Haviland 2058). j–l, *C. nodosum*: j, k, SAN 52956; l, S 29914. m, *C. depressinervosum* (KEP 98808). n, *C. complanatum* (Stevens et al. 407). o–q, *Calophyllum* sp. 54 (bb 19334), hairs from stem. Scale = 60 μ m. (in p, q, scale = 120 μ m.).



1.8–2.8 cm. long; bracts unknown; pedicels 0.6–1.2 cm. long, densely puberulent. Flower (?)hermaphroditic; tepals 4, the outer pair ovate, 6–7 by 5.5–6 mm., puberulent on back, the inner pair obovate, ca. 12.5 by 6 mm., puberulent in strip down back; stamens ca. 200 plus, the filaments to 6 mm. long, the anthers oblong, 0.9–1.5 mm. long, retuse at apex; ovary ca. 2.5 mm. long, style and stigma unknown. Fruit ellipsoid, ca. 3.4 by 2 cm., rounded at apex, drying blackish, smooth or with inconspicuous longitudinal wrinkles; outer layer detaching cleanly from stone, 1.3–1.5 mm. thick, compact; stone ellipsoid, ca. 2.7 by 1.6 cm., rounded at apex, the walls ca. 0.5 mm. thick, smooth, with faint reticulations but otherwise unmarked; spongy layer unknown.

DISTRIBUTION. Malay Peninsula, Sumatra, and Sarawak (MAP 16).

SELECTED SPECIMENS SEEN. **Malaya.** PERAK: Tanjong Tualang F.R., *KEP 45675* (KEP). SELANGOR: state land between Sungei Bennam and Sungei Tinggi, 1.5 m., *KEP 71563* (KEP). JOHORE: Muar, Bukit Atong, Jalan Yong Peng, *KEP 70211* (KEP, SING); 30th mile Muar–Pant Subag Road, 3 m., *KEP 80558* (KEP, SING). **Sumatra.** UTARA: Laboean batoe, Laboean bilik, 5–10 m., *bb 4950* (BO). **Borneo.** SARAWAK. 1st Division: Setapok F.R., *S 16170* (L, SAR, SING); Gunung Pueh F.R., *S 6419* (SAR); Buntal, *anon.*, March 1912 (SAR). 3rd Division: Loba Kobang South Protected Forest, *S 2740* (KEP, SAR); Naman F.R., Sungei Assan, 6 m., *S 7361/10* (SAR, SING). Sine loco, *native collector 1276* (?) (A, BO, P, UC).

ECOLOGY. Rather large tree of peat swamps, rarely also in kerangas forest in Sarawak; below 10 m. alt. Flowering and fruiting in October.

GERMINATION AND YOUNG PLANT. The radicle probably breaks through the stone to one side of the base. The seedling has but a single pair of leaves. The first flush of growth generally consists of two pairs of leaves: first an internode 5–(10) mm. long, then a pair of scale leaves, then an internode ca. 3 cm. long, and finally a pair of fully expanded leaves (13 of the 15 seedlings seen). Scale leaves are rarely absent (2 of the 15 seedlings seen). The terminal bud is functional, and the young plant is erect (*Stevens et al. 147A*).

Calophyllum scriblitifolium is best recognized by its coriaceous leaf blades with their strongly and broadly revolute margins; its axillary, grayish puberulent inflorescences; its flowers, which have four tepals, the outer pair of which is grayish puberulent on the back; and its ellipsoid, almost smooth-drying fruit that is rounded at the apex and the base. Fresh fruits of *Calophyllum scriblitifolium* are about 5.7 by 2.2 cm., with the outer layer ca. 5 mm. thick, to judge from fallen fruits seen in Sarawak. The leaves, with their strongly recurved margins, seem to have suggested the specific epithet (*scriblitifolium* means "tartlike leaves").

Calophyllum scriblitifolium is perhaps most closely related to *C. canum*, which at least in Borneo frequently grows in swamps, and which also has white latex, flowers with four tepals, and a similar distribution of indumentum on inflorescence axis and flower. However, the vegetative and fruit characters

given above readily separate the two, and the hairs of the two differ in structure (FIGURE 20, d, e; cf. 19, h-p). *Calophyllum scriblitifolium* is vegetatively similar to *C. coriaceum*, another species with white latex. However, *C. coriaceum* has fruits that are pointed-ellipsoid and dry sharply wrinkled, with stone walls at least 1 mm. thick; the inflorescences are terminal. *Calophyllum coriaceum* is a tree of montane forest, and *C. scriblitifolium* one of peat swamps; the two are not closely related.

More collections of *Calophyllum scriblitifolium* are needed. The variation in hair type in Sarawak is not understood (FIGURE 20, h).

50. *Calophyllum canum* Hooker f. Fl. Brit. India 1: 271. 1874; King, Jour. Asiatic Soc. Bengal, II. 59: 177. 1890; Vesque in C. DC. Monogr. Phanerog. 8: 573. 1893; Curtis, Jour. Straits Branch Roy. Asiatic Soc. 25: 78. 1894; Ridley, Fl. Malay Penin. 1: 185. 1922, *pro parte*; I. H. Burkill & M. R. Henderson, Gard. Bull. Straits Settl. 3: 347. 1925; Heyne, Nutt. Pl. Indonesië, ed. 3. 1: 1082. 1950; M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 306. 1956; J. Anderson, Gard. Bull. Singapore 20: 153. 1963; Pukul & Ashton, Checklist Brunei Trees, 93. 1964; Smythies, Common Sarawak Trees, 59. 1965; Kochummen, Malayan Forest Rec. ed. 2. 17: 219. 1965; Burkill, Dict. Econ. Prod. Malay Penin. ed. 2. 1: 412. 1966; Meijer, Bot. Bull. Herb. Forest Dept. Sabah 7: 16. 1967, *pro parte*; T. C. Whitmore, Tree Fl. Malaya 2: 176. 1973; Corner, Gard. Bull. Singapore Suppl. 1: 104. 1978. TYPE: Malaya, Malacca, 26 March 1865/1866, *Maingay 1645* (*Kew dist. 175*) (holotype, k).
- C. borneense* Vesque, Epharosis 2: ff. 28, 29. 1889, in C. DC. Monogr. Phanerog. 8: 580. 1893; Merr. Bibl. Enum. Born. Pl. 393. 1921; Masamune, Enum. Phanerog. Born. 475. 1942; Keith, N. Borneo Forest Rec. ed. 2. 2: 313. 1952. TYPE: Borneo [Sarawak, Kuching], *Beccari, PB 2101* (holotype, v; isotypes, \wedge (frag.), Fl. G, K, M).
- C. spectabile* auct., non Willd.; Curtis, Jour. Straits Branch Roy. Asiatic Soc. 25: 78. 1894.
- C. retusum* auct., non Choisy; J. Anderson, Gard. Bull. Singapore 20: 154. 1963, *quoad syn.*
- C. lowii* auct., non Hooker f.; J. Anderson, Trees Peat Swamp Sarawak, 85. 1973, excl. ill.

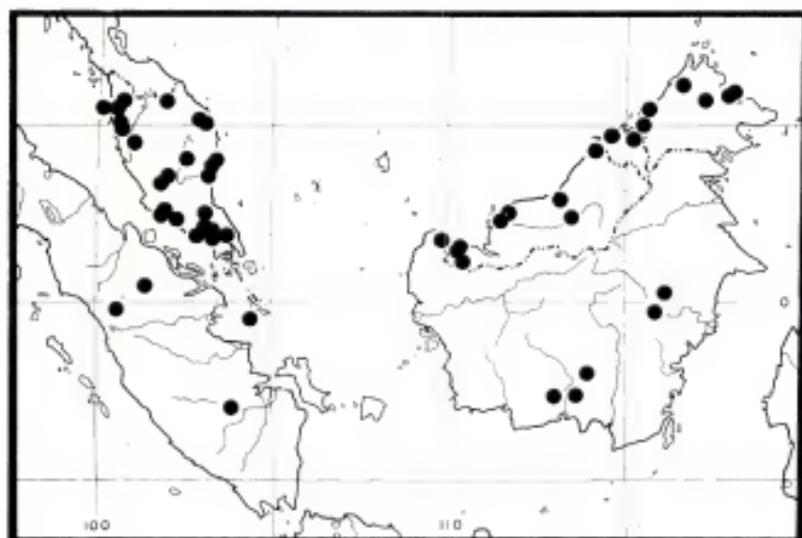
Tree 7.5-36 meters tall, d.b.h. to 77 cm.; trunk without buttresses or spurs; outer bark yellowish or light brown to almost black, with rather close lines of lenticels, or finely cracked, scaling or not, hoop marked, the inner surface dirty brown to orange-brown; under bark reddish to orange, or blackish and red mottled; inner bark pale reddish; latex white, not sticky, in Malaya also reported to be clear yellow-brown and sticky, in Borneo opaque to clear yellow, sticky or becoming sticky.

Twigs slightly to strongly flattened, 2-3(-4.5) mm. across, obscurely to strongly 4-angled, drying blackish to dark brown, grayish to brownish farinose-puberulent when young; axillary innovations lacking basal scars; internodes 1-9 cm. long; uppermost pair of axillary buds rounded, to 1 mm. long, spreading

or pointed, ca. 3(–8) mm. long, erect; terminal bud plump to narrowly conical, (0.3–)1–2.2 cm. long, with short, grayish brown to rufous, compact indumentum (hairs, FIGURE 19, h–p), underdeveloped internode 1.5–5(–11) mm. long. Petiole 1–2(–2.5) cm. long, usually broadly concave above, convex to subangled below, drying blackish, glabrescent; lamina ovate or elliptic to suboblong, (3.3–)9–22 by (1.2–)3.5–7.5 cm., acuminate (rarely acute) at apex, rounded to acute at base, strongly to moderately undulate and slightly recurved at margin, coriaceous, drying brown-vinaceous to sabelline above and umber to fulvous below, often nitid, entire lamina subconcave or not, glabrous to transiently farinose to puberulent on midrib above and especially below, the midrib above narrowing gradually from base, depressed, margins raised, becoming ± raised, or narrowed abruptly near base (Borneo only), depressed at first, soon becoming raised, (0.15–)0.25–0.6 mm. wide at midpoint, below raised, ± striate, the venation above and below ± apparent, raised, 10 to 18 (to 21) veins/5 mm., angle of divergence 70–80°. Inflorescences from foliate axils usually near ends of twigs (rarely terminal—eastern Borneo), with 7 to numerous flowers, usually unbranched (or flowers flabellately arranged, branches to 1 cm. long, with up to 5 flowers), the axis 3–7(–12.5) cm. long, grayish- to rufous-puberulent, lowest internode (0.5–)1–3.5 (–4.8) cm. long; bracts ± ovate, to 1.2 by 0.6 cm., deciduous; pedicels 0.5–1.5 cm. long, puberulent. Flower (?)hermaphroditic; tepals 4 (rarely 5 to 8), the outer pair elliptic to broadly ovate, (4.5–)5–6.5 by (2.5–)3.5–5 mm., puberulent on back, the inner ones elliptic to ovate, 5.5–8.5 by 3–5(–6) mm., usually puberulent in strip down back (rarely entirely puberulent or puberulent only near base); stamens (180 to) 350 to 600 (to 900 plus), the filaments to 3.5 mm. long, the anthers elliptic to oblong, 0.4–1 mm. long, slightly retuse at apex (very rarely with hairs (Borneo)); ovary 1.2–1.5 mm. long, the style (1.5–)2.8–4.5 mm. long, the stigma peltate, 0.5–0.7 mm. across, 2- to 4-radiate. Fruit spherical to ovoid, 1.5–2.2 by 1.4–1.8 cm., usually stoutly and sharply apiculate, drying brown, rather closely and sharply wrinkled; outer layer not detaching cleanly from stone, 0.6–1.4 mm. thick, compact; stone ± spherical, 1.2–1.7 by 1.1–1.5 cm., rounded at apex, the walls 0.3–0.4(–0.8) mm. thick, smooth, unmarked; spongy layer (?)thin.

DISTRIBUTION. The typical form in Malaya, Sumatra, and northwestern Borneo; the variant only in Borneo (MAP 19).

SELECTED SPECIMENS SEEN. (Specimens from Borneo that closely match the type specimen of *C. borneense* denoted by "b"; specimens that are ± typical *C. canum* denoted by "c.") **Malaya.** KEDAH: Gunong Bongsu F.R., 610 m., *FRI 6956* (K, KEP, SING); Bukit Enggang F.R., *KEP 81345* (KEP). PINANG: Government Hill, 305 m., *Curtis 1543* (K, SING); road to the Spout, 240 m., *Curtis = 1153* (SING); Waterfall Garden, 30 m., *SFN 3695* (SING). PERAK: Larut, G. Boobo Range, 240–457 m., *King's collector 7704* (G, UC); Larut, less than 30 m., *King's collector 5420* (E, FI, P, SING); Batu Gaja, *Wells s.n.*, Feb. 1918 (KEP); Pondok Tanjung F.R., *KEP 63467* (KEP); Tualang F.R., *KEP 63269* (KEP). SELANOR: Weld Hill F.R., 60 m., *KEP 99519* (A, CANB, K, KEP, LAE, SAN, SAR, SING); F.R.I. [Forest Research Institute], Kepong, *KEP 99629* (A, KEP, SAN, SAR, SING); Ginting Simpah ridge, 914 m., *KEP 70994* (KEP).

MAP 19. Distribution of *Calophyllum canum* in Malasia.

NEGERI SEMBILAN: Sungei Menyala F.R., *anon.* (KEP); Senawang F.R., *KEP 609* (BO, K, KEP, SING). MALACCA: Batang Malaka, *Goodenough 1791* (SING). KELANTAN: Kemahang F.R., 36 m., *KEP 92427* (KEP). TRENGGANU: Sungei Kerbat at Jerem Ketch, 335 m., *FRI 20277* (KEP); Dungun, Jerengau, 30 m., *KEP 79694* (KEP). PAHANG: Gunung Lesong F.R., *KEP 10013* (K, KEP); Kuantan, Pekan Road, *KEP 43188* (KEP); Bukit Setongkol, *KEP 883* (KEP, SING); Pekan, *Haviland s.n.*, April 1890 (SING); Ulu Peroh, *KEP 11213* (KEP); Bentong, Kemesul F.R., 45 m., *KEP 78718* (KEP); Temerloh F.R., *KEP 5464* (KEP, SING); Balok F.R., *KEP 97919* (KEP, SING). JOHORE: Sungei Sedili, *SFN 36891* (A, KEP, SING); Ma' Okil F.R., *KEP 71284* (KEP); Kluang F.R., *KEP 78994* (KEP); Renggam F.R., 225 m., *KEP 71294* (KEP); Banang F.R., 150 m., *KEP 80557* (KEP). **Sumatra and adjacent islands.** RIAU: Lingga Arch., Pulau Singkep, Koeloe Laboeh, 9 m., *bb 5370* (BO); Pakanbaru, Tenajan R., low alt., *Soepadmo 39* (A, BO, C, E, KEP, L, LAE, SING). SELATAN: Rawas, 80 m., *Dumas 1523* (BO, L); Banjoearin, Koebroestreken, *Grashoff 732* (BO, L). BARAT: Pajakombo, Oeloe Air, 1130 m., *bb 6593* (BO). **Borneo.** SARAWAK. 1st Division: Lundu, *Hewitt 47* (c) (SAR); Kuching, *Haviland 27* (c) (SING); Semengoh F.R., 20 m., *Stevens et al. 290* (c) (A); Sabal Tapang, 105 m., *Stevens et al. 167* (b) (A); G. Matang, 290 m., *Stevens et al. 257* (b) (A); G. Santubong, 54 m., *Stevens et al. 295* (b) (A); Stapok F.R., 5 m., *Stevens et al. 154* (c) (A). 3rd Division: Lepah P.F., *Anderson 10/2* (c) (SAR); Batang Igan, Sungei Tutus logging camp, *S 30255* (c) (SAR). 4th Division: Sungei Kelaput, ca. 5 m. S. of Pulau Bruit, *S 28* coll. *Anderson*, 13 Nov. 1952 (c) (KEP, SAR); Sambas Road near Poak, *C. Hose s.n.*, 7 Dec. 1911 (c) (BM). BRUNEI: Anduki F.R., *KEP 32605* (c) (KEP); Temburong, Labu F.R., 15 m., *SAN 17433* (c) (A, BO, K, KEP, SAN, SAR, SING). SABAH. Sipitang: Sipitang, *KEP 80046* (c) (KEP). Beaufort: Mesapoh F.R., *SAN 43268* (c) (K, L, SAN);

1.6 km. NE. of Beaufort township, 105 m., *SAN 15056* (A, BO, BRI, K, KEP, L, SAN, SING); Beaufort Hill, *San 58588* (SAN). Ranau: Kinabalu Natl. Park, 457 m., *SAN 54034* (K, L, SAN); Penibukan, 1219 m., *Clemens 31859* (A, L, NY). Labuk & Sugut: Mile 87½, Telupid Road, Hap Seng logging area, 120 m., *SAN 83502* (A). Sandakan: Sibuga, Kebun China, *SAN 37454* (A, K, KEP, L, SAN, SAR, SING); Sepilok F.R., *A 859* (A, BO, K, KEP, L, SING); Sungei Mayan, 30 m., *Stevens et al. 375* (A). KALIMANTAN. TIMUR: E. Kutei, Belajan R. near Long Bleh, 50 m., *Kostermans 10369* (b) (A, BO, CANB, K, KEP, L, LAE, P, SING); W. Kotei, Long Bleh, 30 m., *bb 16065* (c) (A, BO, L); Keloempang, *bb 16927* (BO, L); Boven Mahakam, Liroeng Poedoeng, 50 m., *bb 20620* (?) (A, BO). Tengah: Koeala Kapeoas, Goehoeng, *bb 2171* (?c) (BO, L); Sampit, Karoeng, 10 m., *bb 9924* (BO); Tamoelian, *bb 2477* (BO).

ECOLOGY. Well-drained mixed dipterocarp forest in Malaya, the variant in Borneo in similar habitats; typical form in Borneo and Sumatra usually in peat swamps; to 1220 m. alt. Flowering April to June, September, and December (advanced bud in January); flower scented. Fruiting May, August, and October (submature fruit December and January); fruit greenish.

YOUNG PLANT. The young plant is erect, and the terminal bud is functional (Bornean form).

LOCAL USES. It is used in tuba fishing (species of *Derris* Lour. probably the poison) in Sarawak. The wood is good for masts and spars (Malaya, Sabah).

The typical form of *Calophyllum canum* can be recognized, even when sterile, by its plump terminal bud and its distinctive leaf blades, which usually dry shiny and brown-vinaceous on the upper surface and have a strongly undulate margin; the midrib is more or less depressed and narrows gradually from the base. The flowers of the typical form usually have four tepals, and there are usually very numerous (350 plus) stamens. The dried fruit is sharply pointed at the apex and has a strongly wrinkled surface. In the Bornean form of *C. canum* (see also below), the leaves do not dry such a dark brown color, the margin of the lamina is less strongly undulate, and the midrib narrows rather quickly near the base. The epithet *canum* means "hoary" or "gray"; it is very appropriate since the indumentum often makes the whole inflorescence look grayish.

The delimitation of *Calophyllum canum* has been somewhat troublesome. The species is most closely related to *C. lowii*; the differences separating the two are discussed under the latter. The typical form of *C. canum* shows relatively little variation, although in Borneo it seems to prefer peat swamps and in Malaya it usually grows in better-drained ground. However, although a number of specimens from Borneo seem referable to *C. canum* on characters of flower and fruit, they differ somewhat vegetatively. These Bornean specimens have a leaf blade that usually dries fulvous above, the margin is not notably undulate, and the midrib narrows abruptly at the base. Fresh leaves of the Bornean form are broadly V-shaped (those of the typical form are (?) always flat), and the inflorescences are sometimes terminal (e.g., *SAN 37454*). More surprising variation occurs in three specimens from western

Sabah that have hairs on the anthers (*SAN 15056* (a few only), *SAN 54034*, *Clemens 31859*). The single flower of *Clemens 31859* examined has ca. 180 stamens, the terminal bud is only ca. 0.3 mm. long, and the hairs are much branched (FIGURE 19, j); the two flowers of *SAN 54034* dissected have 220 and over 450 stamens, respectively, and the hairs are also strongly branched. There is no indication of a relationship between these specimens and *C. molle*, *C. gracillimum*, or *C. rubiginosum*, the other species with hairy anthers.

Collections such as *S 23913*, *23960*, and *25043* growing in colline forest in the 3rd Division of Sarawak have the facies of *C. canum*, but somewhat different hairs (FIGURE 19, h). They are probably to be placed in *C. wallichianum*, the variation of which in Borneo is poorly understood.

The specimen from which *Calophyllum borneense* was described is similar to the Bornean variant of *C. canum*, although its leaf blade has dried very flat, the inflorescence is usually only five-flowered, and the flowers have four to eight tepals. Further collections referable to *C. borneense* sensu stricto were made in Sarawak (see especially *Stevens et al. 257*). In field characters these specimens were very similar to the form of *C. canum* growing near Sandakan, Sabah, and the two have ovoid fruits and similar flowers. However, in *Stevens et al. 257* (*C. borneense*, Gunong Matang, Sarawak) the submature fruits are ca. 1.9 by 1.5 cm., with the outer layer ca. 2.5 mm. thick and the stone walls ca. 0.8 mm. thick. In *Stevens et al. 375* (near Sandakan, Sabah; submature fruits at about the same stage of development) the fruits are ca. 3.2 by 2.3 cm., the outer layer being ca. 5.5 mm. and the stone walls only ca. 0.4 mm. (all measurements from material preserved in alcohol). Although further studies of the whole *C. canum* complex in Borneo are needed, *C. borneense* seems best reduced to synonymy under *C. canum*.

Calophyllum canum is close to *C. lowii* but can be distinguished by the characters given in TABLE 10.

51. *Calophyllum lowii* Hooker f. *Trans. Linn. Soc.* 33: 163. 1860; Planchon & Triana, *Ann. Sci. Nat. Bot.* IV. 15: 271. 1862 ("C. lowei"); F. Mueller in Walp. *Ann. Syst. Bot.* 7: 357. 1868; Vesque in C. DC. *Monogr. Phanerog.* 8: 604. 1893; Merr., *Bibl. Enum. Born. Pl.* 393. 1921; Masamune, *Enum. Phanerog. Born.* 476. 1942. TYPE: in ora septentrionali insulae Borneo [?Sarawak], *Low s.n.* (holotype, κ ; isotypes, κ , ν (frag.)).

C. palustre Ridley, *Kew Bull.* 1938: 121. 1938; Masamune, *Enum. Phanerog. Born.* 476. 1942. TYPE: Dutch SE. Borneo [Kalimantan], *Bangarmassing, Motley 1129* (holotype, κ).

C. wallichianum auct., non Planchon & Triana; Merr. *Bibl. Enum. Born. Pl.* 394. 1921, *pro parte*; Heyne, *Nutt. Pl. Indonesië. ed. 3. 1:* 1086. 1950.

Tree to 20 meters tall, d.b.h. to 50 cm.; trunk and bark unknown; latex yellow, clear.

Twigs flattened, 3-5.5 mm. across, \pm 4-angled when young, or with rounded edges, drying blackish, shortly gray-brown-puberulent when young; axillary

TABLE 10. Some differences between *Calophyllum canum* and *C. lowii*.

	<i>C. canum</i>	<i>C. lowii</i>
TWIGS	2-3(-4.5) mm. across	3-5.5 mm. across
LAMINA	Often nitid above, 10 to 18 (to 21) veins/5 mm., margin strongly undulate	Often \pm dull above, 10 to 15 veins/5 mm., margin somewhat undulate
BRACTS	Conspicuous in young inflorescence, to 1.2 cm. long	Inconspicuous
INFLORESCENCES	Rarely branched or flabellate; flowers often rather congested	Usually branched, flabellate; flowers not congested
STAMENS	(180 to) 350 plus, the anthers 0.4-1 mm. long	Fewer than 210 (to 310), the anthers 1-2 mm. long
FRUIT	Apex sharply pointed; surface densely and sharply wrinkled	Apex rounded; surface at most shallowly and distantly striate
STONE WALLS	0.3-0.4(-0.8) mm. thick	Less than 0.2 mm. thick
HAIRS	Apical cells rarely thin-walled	Apical cells thin-walled

innovations lacking basal scars; internodes 2-7.5 cm. long; uppermost pair of axillary buds pointed, to 3 mm. long, spreading; terminal bud plump, (0.8-)1-2.2 cm. long, with grayish brown, crustaceous indumentum (hairs, FIGURE 20, f, g), underdeveloped internode 0.4-1.5 cm. long. Petiole 1.4-3 cm. long, shallowly and broadly concave above, convex below, drying blackish, glabrous when mature; lamina narrowly ovate to elliptic, 11-25 by 1.5-8.5 cm., or ovate, ca. 18 by 7.2 cm., gradually acuminate at apex, acute at base, distantly undulate and narrowly or not recurved at margin, coriaceous, drying olivaceous above and umber to hazel below, puberulent on midrib on both surfaces, or glabrous, the midrib gradually narrowed from base, depressed at first with edges \pm raised, becoming raised at ca. $\frac{1}{3}$ length of leaf, drying blackish, 0.2-0.5 mm. across at midpoint, raised and \pm striate below, the venation on both surfaces \pm apparent (subobscure), raised, 8 to 15 veins/5 mm., angle of divergence 70-80°. Inflorescences from upper foliate axils (very rarely terminal—*bb* 2635), with 11 to numerous flowers, often lowest flowers flabellately arranged, usually with branches up to 5 cm. long and with 7 flowers, the axis 5-15 cm. long, puberulent, lowest internode 1.5-7.5 cm. long; bracts ovate, to 6.5 mm. long, soon deciduous; pedicels 0.9-2.5 mm. long, puberulent, rather slender, incrassate in fruit, to 2.5 mm. across. Flower (?)hermaphroditic; tepals 4 (to 7), the outer two

ovate to broadly elliptic, 6-6.5 by 4.5 mm., puberulent on back, the inner ones suboblong to broadly elliptic, 9.5-10.5 by 4.5-8.5 mm. (rarely suborbicular, ca. 9 mm. long and across), puberulent in strip toward base of back; stamens 130 to 210 (to 310), the filaments to 5 mm. long, the anthers oblong, 1-2 mm. long, retuse at apex; ovary ca. 2 mm. long, the style ca. 3 mm. long, the stigma peltate, ca. 1.2 mm. across, 3-radiate. Fruit spherical to ellipsoid, 2-2.5 by 1.8-2 cm., rounded at apex, or apiculate, drying brown, finely striate; outer layer not detaching cleanly from stone, 0.9-1 mm. thick, compact, rather hard; stone \pm ellipsoid, 1.8-2.3 by 1.6-1.8 cm., rounded at apex, the walls less than 0.2 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Sumatra to Borneo (MAP 16).

SELECTED SPECIMENS SEEN. **Sumatra and adjacent islands.** RIAU: Indragirische bovenlanden, Kwala Belilas, 60 m., *bb* 27643 (BO, L), Pagaroembei (Tjenako-Rivier), 8 m., *bb* 26108 (BO, L, SING), Belimbing, 6 m., *bb* 28464 (BO, L, MO), Keritang, 5 m., *bb* 28691 (BO, NY). DJAMBI: Djambi, Gergai, 5 m., *bb* 11328 (BO). SELATAN: Bangoeasin, Koeboestrecken, 20 m., *Grashoff* 709 (BO, L); Palembang, *Grashoff* 907A (L). BANGKA: Lobok Besar, 5 m., *bb* 34046 (A, BO, L); Bikang, *bb* 15095 (BO); B[e]linjoe, *Grashoff* 40 (BO, L). BELITUNG: Tandjong Pandan, Bantan, 30 m., *bb* 4106 (BO). **Borneo.** SARAWAK. 1st Division: near G. Siol, *Omar* 379 (K, SING); near Kuching, *Haviland & Hose* 3343 (BM, BO, K, L, SAR, UC). KALIMANTAN. Selatan: ond. afd. Pleihari, Pematang Landjar, *bb* 2129 (BO, L). Tengah: Sampit, bij Seramau, *bb* 653 (BO), Mandawei, 10 m., *bb* 2635 (BO); ond. afd. Beneden Djak, Sei. Teroesan, *bb* 2091 (BO, L), P. Kladan, 5 m., *bb* 12251 (BO); Koeala Kapoeas, Sungei Mangkoetoep, *Dachlan* 2197 (BO), P. Telo, *bb* 2174 (BO); Beneden Merlan, Sungei Kemdeinangan, 1 m., *bb* 14417 (BO).

ECOLOGY. Lowland rainforest, frequently periodically inundated, below 60 m. alt. Flowering October to December and March; fruiting in February.

LOCAL USES. The wood is used in house building. The latex boiled with coconut milk is used as a remedy for itching and skin infection (Heyne, *loc. cit.*).

Calophyllum lowii is apparently related to *C. canum*; for the differences distinguishing the two see TABLE 10. *Calophyllum lowii* is larger in all parts (but has fewer stamens) than *C. canum*; its fruit is rounded at the apex, dries almost smooth, and has a thin-walled stone; its pedicel is notably incassate in fruit; and its leaf does not often dry the brown-vinaceous color common in *C. canum*. The epithet commemorates H. Low, the collector of the type specimen. A number of sterile specimens cited under *C. lowii* (e.g., those from the Indragiri region (Sumatra)) are included here only provisionally.

Planchon and Triana's description of *Calophyllum lowei* (sic) appears to be independent of that of Hooker, published the preceding year. Planchon and Triana cited the specimens that they saw as "Low in herb. Hook. [the holotype of *C. lowii* Hooker f.] et inde in herb. Planch.>"; fruiting material

that they thought was another species of *Calophyllum* is referable to *C. soulattri*.

The type specimen of *Calophyllum palustre* is a good match with that of *C. lowii*; both have profuse inflorescences and large leaf blades with a rather broad, blackish drying midrib.

52. *Calophyllum woodii* P. F. Stevens, sp. nov.

FIGURE 17, 1-n.

C. molle auct., non King; Meijer, Bot. Bull. Herb. Forest Dept. Sabah 7: 15, 1967.

A speciebus aliis *Calophylli* in indumento tomentoso gemmis, ramulis, costis laminarum, axibus inflorescentiarum, pedicellis et tepalis exterioribus praedito, ramulis in siccitate saepe pallide coloratis, lamina elliptica vel oblonga 9-22.5 cm. longa venulis lateralibus (6 ad) 8 ad 16 (ad 20) per 5 mm., et fructu subsphaerico strato exteriore 2.5-3 mm. crasso e putamine haud munde secedenti et putamine parietibus 0.4-0.6(-0.9) mm. crassis, differt.

Tree 21-30 meters tall, d.b.h. to 80 cm.; trunk without buttresses; outer bark yellowish brown to brown, shallowly fissured or with lines of lenticels, becoming strongly fissured, the inner surface orange-red or brown-orange; under bark dark red or greenish straw; inner bark brown-red or pale red; latex brownish, opaque or pellucid, not viscous (rarely yellow (*Kostermans 6618*) or viscous (*Stevens et al. 160*)).

Twigs strongly flattened, 2.3-3.5 mm. across, rounded to \pm 4-angled, drying pale brown or yellowish to grayish, subsersistently brown-tomentose, hairs to 0.8 mm. long, puberulent; axillary innovations lacking basal scars; internodes 1-4 cm. long; uppermost pair of axillary buds rounded, 1-2.5 mm. long, \pm spreading; terminal bud plump to subconical, 0.6-1.2(-1.7) cm. long, with brown, tomentose indumentum (hairs, FIGURE 20, a-c), underdeveloped internode to 3(-6) mm. long. Petiole 1-1.9 cm. long, concave to V-shaped above, convex below, with subsistent indumentum; lamina elliptic to oblong, 9-22.5 by 3.4-6.3(-8) cm., subrounded to acuminate at apex, broadly cuneate to subrounded (slightly cucullate) at base, broadly undulate and slightly recurved at margin, coriaceous, drying sepia to umber above and below, often shiny, usually tomentose on midrib on both surfaces, the midrib above abruptly to gradually narrowed at base, raised, 0.25-0.35 mm. wide at midpoint, below raised, slightly striate, the venation subobscure to apparent above and apparent below, raised, (6 to) 8 to 16 (to 20) veins/5 mm., angle of divergence 70-80°. Inflorescences from foliate axils, with 7 to 11 flowers, unbranched, short-tomentose, the axis 2-5.5 cm. long, lowest internode 0.4-1.7 cm. long; bracts ovate, to 5 mm. long, tomentose below, deciduous; pedicels 0.7-2.3 cm. long, slender, short-tomentose. Flower (?) hermaphroditic; tepals 4 (rarely 5), the outer pair ovate, ca. 5.5 by 4.5 mm., tomentose on back, the inner pair subelliptic, ca. 8.5 by 5.5 mm., with strip of tomentum down back; stamens 190 to 270, the filaments to 5.5 mm. long, the anthers elliptic, 0.8-1 mm. long, rounded at apex; ovary ca. 2.5 mm. long, the style ca. 3.5 mm. long, the stigma peltate, ca. 1.4 mm. across, 3-rotate. Fruit

subspherical to ellipsoid, 1.3–2 by 1.2–1.7 cm., rounded at apex, drying brown, wrinkled; outer layer generally detaching cleanly from stone, 2.5–3.3 mm. thick, compact, but with air spaces developing under skin; stone ellipsoid to subspherical, 0.7–1.3 by 0.65–1.1 cm., rounded to mucronulate at apex, the walls 0.4–0.6(–0.9) mm. thick, smooth, unmarked; spongy layer initially thick.

TYPE: North Borneo, Sandakan, mile 8, Labuk road, outside Sibuga F.R., 1 Sept. 1964, *SAN* 42949 coll. *Burgess* (holotype, L; isotypes, K, SAR).

DISTRIBUTION. Borneo, mostly in the eastern part (MAP 17).

ADDITIONAL SPECIMENS SEEN. **Borneo, SARAWAK.** 1st Division: Sabal Tapang, 140 m., *Stevens et al.* 160 (A, SAR); Semengoh F.R., 30 m.; *Stevens et al.* 124 (A). 3rd Division: Bukit Raya, Btg. Rejang, *Ashton* 6004 (A). **SABAH.** Sipitang: Ulu Mendalong, 10 km. SSE. of Malaman, 533 m., *SAN* 16725 (A, BO, BRI, KEP, L); Ulu Moyah, 13 km. SSE. of Malaman, 838 m., *SAN* 16693 (A, BO, KEP, L, SAN, SING). Labuk & Sugut: Mile 42, Labuk Road, *SAN* 71708 (SAN). Sandakan: Mile 8 plantation (tree originating from Sepilok), *SAN* 35504 (K, KEP, L, SAN, SAR, SING); Sepilok F.R., 30 m., *SAN* 19728 (KEP, SAR), *Stevens et al.* 331 (A), 335 (A); Plantation boundary, Gum Gum, mile 17, 12 m., *SAN* 81224 (SAN); Arboretum, mile 14, *SAN* 72843 (SAN), 82500 (A). Tawau: ca. 5 km. from Brantian on Tawau road, 45 m., *Stevens et al.* 434 (A). **KALIMANTAN.** Timur: Salembatue, 100 m., *bb* 11293 (BO). Samarinda: Loa Djanan, W. of Samarinda, *Kostermans* 6618 (A, BO, L, P, SING); Boven Mahakam, Loempobo, 90 m., *bb* 20667 (A, BO, L); mouth of Mahakam R., Tandjong Bangko, 20 m., *Kostermans* 7229 (BO, L); Balikpapan, Sungai Wain, 20 m., *bb* 34418 (BO, L); W. Koetai, Moejoer, 25 m., *bb* 16764 (A, BO), Kahalu, 25 m., *bb* 28354 (BISH, BO, P). Selatan: Pleihari, *bb* 2033 (BO).

ECOLOGY. Well-drained lowland to colline mixed dipterocarp forest, sometimes in swamps; 30–838 m. alt. Flowering April and September (flower smells like syringa (*SAN* 35504)); fruiting June, September, October, and December (fruit greenish to pale cream).

GERMINATION AND YOUNG PLANT. Young plants ca. 30 cm. tall are erect and have functional terminal buds.

Calophyllum woodii can be recognized by the tomentose indumentum on twigs, terminal buds, midrib of the lamina, inflorescence, pedicels, and tepals; the hairs appear to be rough when viewed under high magnification since almost every cell has a small protrusion. The lamina is elliptic to oblong, with fine, moderately dense, and rather widely ascending venation. The inflorescences are axillary and unbranched, and the flowers usually have four tepals. The fruit is generally subspherical and dries wrinkled; the outer layer is 2.5–3.3 mm. thick, and the stone usually has walls less than 0.6 mm. thick. The specific epithet commemorates G. H. S. Wood, who made some of the earliest collections of this species in Sabah.

Calophyllum molle has been confused with *C. woodii*, but in the former the hairs are smooth, the stamens are more numerous, and the anthers,

ovary, and fruit are hairy. *Calophyllum woodii* is closely related to *Calophyllum* sp. 53; the differences between the two are discussed under the latter.

The specimens of *Calophyllum woodii* from Sarawak and adjacent western Sabah have a narrower terminal bud than those from eastern Sabah, and the base of the lamina is not cucullate to slightly so. However, all specimens agree in general facies and in hair type. *Stevens et al.* 160 (Sarawak) had sticky latex, whereas in other specimens seen in both Sarawak and Sabah the latex was free flowing, and the fruits had stone walls about 0.9 mm. thick—somewhat thicker than those of other specimens.

53. *Calophyllum* sp.

FIGURE 17, j.

Tree to 25 meters tall, d.b.h. to 80 cm.; trunk without buttresses or spurs; outer bark yellowish brown, with lines of close-set lenticels, not clearly hoop marked, the inner surface dull yellow-gray or greenish slate and orange-brown mottled; under bark mid-brown or dark reddish; inner bark red; latex clear yellow, sticky, becoming cloudy.

Twigs flattened, 3.3–4 mm. across, obscurely 2- or 4-angled, soon becoming rounded, drying yellowish brown or grayish brown, subpersistently brown-tomentose, hairs to 1 mm. long; axillary innovations lacking basal scars; internodes 1.5–6(–10) cm. long; uppermost pair of axillary buds rounded, 1–2(–3.5) mm. long, \pm spreading; terminal bud obtusely conical, 6.5–9 mm. long, brown-tomentose (hairs, FIGURE 19, q, r), underdeveloped internode absent. Petiole 0.8–1.2 cm. long, broadly and deeply concave above, convex and tomentose below; lamina elliptic to oblong, 12.5–20 by 4.6–6.8 cm., broadly rounded and finally mucronate or slightly retuse at apex, broadly rounded and slightly cucullate at base, slightly and distantly undulate and recurved at margin, coriaceous, drying khaki above and sabelline below, persistently tomentose on midrib below, the midrib above narrowing quickly at or near base, raised, center \pm sulcate, 0.3–0.4 mm. wide at midpoint, below strongly raised, striate, the venation \pm apparent above and apparent below, raised, 11 to 13 veins/5 mm., angle of divergence 75–85°. Inflorescences terminal and from upper foliate axils, with ca. 15 flowers, flabellate, with 3-flowered branches to 1.2 cm. long, the axis 2.8–5.2 cm. long, densely tomentose, basal internode 1.3–2 cm. long; bracts unknown; pedicels 1–1.5 cm. long, tomentose. Flower (?)hermaphroditic; tepals (?)4, the outer pair ovate-elliptic, ca. 6 by 5 mm., tomentose on back, the inner pair \pm obovate, ca. 10 by 5 mm., with strip of tomentum down back; stamens (?)numerous, the filaments ca. 5 mm. long, the anthers elliptic-obovate, ca. 0.5 mm. long, strongly retuse at apex; ovary ca. 2 mm. long, style and stigma unknown. Immature fruit spherical, ca. 8 mm. long and across, rounded at apex, drying brownish, smooth; outer layer ca. 1.8 mm. thick.

DISTRIBUTION. Northwestern Borneo (MAP 17).

SPECIMENS SEEN. **Borneo.** SARAWAK. 1st Division: Semengoh Arboretum, *Stevens et al.* 129 (A); Semengoh F.R., 30 m., *Stevens et al.* 289 (A), S 24675 (A, L, SAR, SING).

ECOLOGY. Lowland mixed dipterocarp forest; ca. 30 m. alt.

GERMINATION AND YOUNG PLANT. The seedling has two pairs of leaves separated by an internode less than 7 mm. long. Subsequently produced internodes are longer, the terminal bud is functional, and the plant is erect (*Stevens et al.* 129).

Calophyllum sp. 53 is a distinctive taxon recognizable by its oblong lamina, which is broadly rounded both toward the apex and at the more or less cucullate base, and which dries a khaki color on the upper surface; the venation is fine but distinct. The inflorescence is apparently at least sometimes terminal, and there is tomentose indumentum on the back of the outer pair of tepals. The short branches of the hairs (FIGURE 19, q, r) are visible at a magnification of $\times 30$; the hairs appear rough.

Although the leaves of *Calophyllum* sp. 53 dry in a fashion similar to those of *C. woodii*, and both species have rough hairs, the latter has smaller leaf blades that are more or less acute at the apex, an inflorescence that is not (?ever) terminal, and a plump terminal bud. However, the two taxa are probably more closely related to one another than to other species of *Calophyllum*.

The leaf blades of the young plant are obovate in shape, acuminate at the apex, and narrowly cuneate at the base.

54. *Calophyllum* sp.

FIGURE 17, a.

?Tree; trunk and bark unknown.

Twigs slightly flattened, ca. 5 mm. across, rounded or with 4 raised lines, drying brown to blackish, persistently tomentose; axillary innovations lacking basal scars; internodes 1-4 cm. long; uppermost pair of axillary buds rounded, ca. 0.7 mm. long, spreading, inconspicuous; terminal bud plump, ca. 1.5 cm. long, tomentose (hairs, FIGURE 20, o-q), underdeveloped internode absent. Petiole 1.6-3 cm. long, narrowly concave above, convex below, short-tomentose; lamina subobovate to subelliptic or suboblong, 11.5-19.5 by 4-7 cm., obtuse to short-acuminate at apex, cuneate to subrounded at base, strongly and distantly undulate and slightly recurved at margin, coriaceous, drying greenish olivaceous and shiny above and amber-sabelline below, persistently tomentose on midrib above and on entire lower surface, the midrib above gradually narrowed from base, raised, 0.25-0.35 mm. wide at midpoint, below raised, \pm striate, the venation apparent on both surfaces, raised, 8 to 14 veins/5 mm., angle of divergence 70-75°. Infructescences terminal and from adjacent foliate axils, with scars of ca. 11 flowers, (?)branched, the axis to 6.5 cm. long, short-tomentose, lowest internode ca. 2.2 cm. long; bracts unknown; pedicels 1.5-2 cm. long, tomentose. Flower unknown. Immature fruit ca. 1.2 cm. long, furfuraceous.

DISTRIBUTION. Sumatra (MAP 17).

SPECIMENS SEEN. Sumatra. UTARA: Sibolga, 200 m., *bb* 19334 (A, BO); Provincia di Padang, a Sungei bulu (\pm 0 m.), *Beccari* PS 953 (F, K, L, MEL).

Calophyllum sp. 54 can be readily recognized by the more or less tomentose indumentum that persists on all parts of the plant except the upper surface of the lamina and the ovary, by its terminal inflorescences, and by its furfuraceous fruits.

Calophyllum sp. 54 is perhaps superficially similar to *C. molle* and *C. rubiginosum*, but both of these species differ in their tomentose ovaries and their leaves that do not dry so bicolored; *C. molle* also has axillary inflorescences. *Calophyllum woodii* and *Calophyllum* sp. 53, two Bornean species with tomentose indumentum, both have hairs with numerous papillae and short branches, and leaves that do not dry bicolored and have denser venation; *C. woodii* has axillary inflorescences.

55. *Calophyllum cucullatum* Merr. Philip. Jour. Sci. 17: 288. 1920, Enum. Philip. Fl. Pl. 1: 78. 1923. TYPE: Philippine Islands, Mindanao, Surigao Province, 25 April 1909, BS 34518 coll. Ramos & Pascasio (isotypes, A, BM, BO, K, NY, P, US).

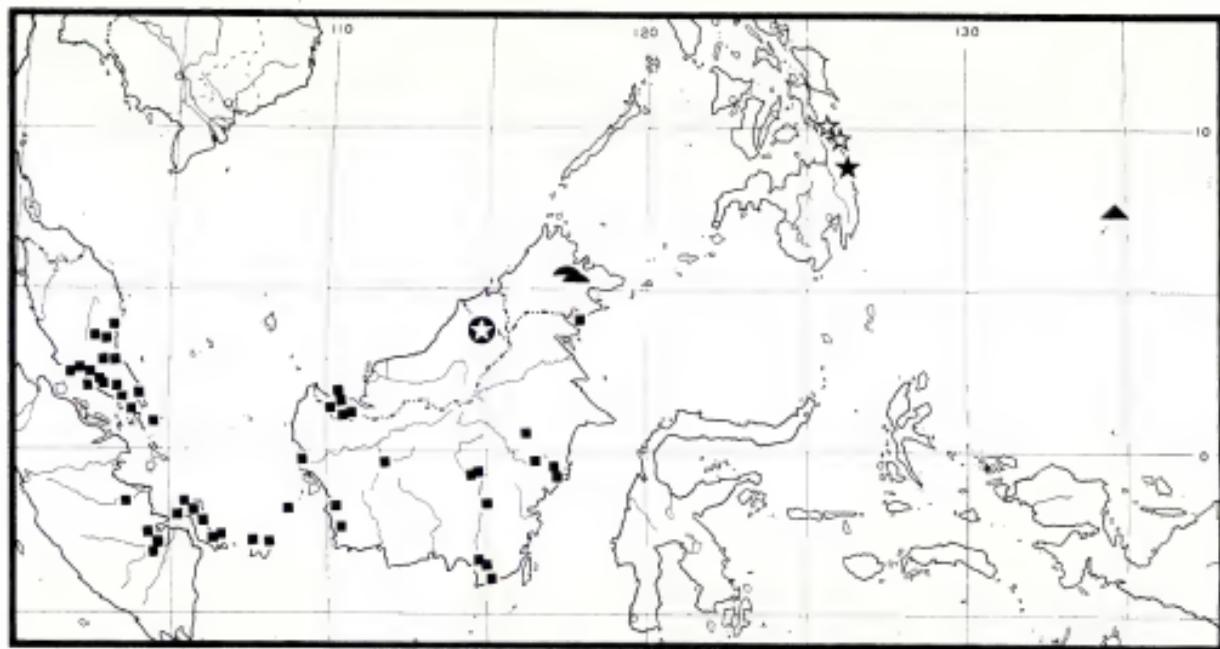
Small tree; trunk and bark unknown.

Twigs slightly flattened, 2.2–2.6 mm. across, with rounded edges, drying black, at first brown-tomentose, hairs to 2 mm. long; axillary innovations lacking basal scars; internodes 8.5–11.5 cm. long; uppermost pair of axillary buds rounded, ca. 1.5 mm. long, suberect; terminal bud 4.5–6.5 mm. long, brown-tomentose, long hairs obscuring shape (hairs, FIGURE 22, a, b), underdeveloped internode absent. Petiole 1–1.5 cm. long, narrowly concave above, convex below, drying black, subsersistently tomentose below; lamina ovate to suboblong, 9.5–20.5 by 4.8–8.8 cm., (short-)acuminate at apex, rounded and cucullate at base, not undulate and slightly recurved at margin, coriaceous, drying amber above and below, with sparse, subsistent hairs toward base on midrib on both surfaces, the midrib above abruptly narrowed near base, raised, ca. 0.2 mm. wide at midpoint, below raised, rounded, slightly striate, the venation above usually subobscure, below clear, slightly raised, 7 to 10 veins/5 mm., angle of divergence 65–70°. Infructescences from foliate axils, flabellate, with scars of ca. 15 flowers, with 3-flowered branches to 1 cm. long, the axis 3–5.5 cm. long, sparsely tomentose toward base, lowest internode 0.5–3 cm. long; bracts narrowly elliptic, ca. 5.5 mm. long, tomentose beneath, subsistent; pedicels 1.1–2.3 cm. long, glabrous. Flower unknown. Fruit ellipsoid, ca. 1 by 0.8 cm., apiculate, drying grayish, smooth; outer layer not detaching cleanly from stone, very thin—when pressed less than 0.3 mm. across, with large air spaces developing; stone ellipsoid, ca. 9 by 7 mm., rounded at apex, the walls ca. 0.3 mm. thick, at base fibrous and ca. 0.5 mm. thick, smooth, (?)unmarked; spongy layer thin.

DISTRIBUTION. The Philippine Islands, Mindanao, known only from the type collection (MAP 20).

ECOLOGY. Thickets along streams at an iron deposit (Merrill, 1920, *loc. cit.*); fruiting in April.

Calophyllum cucullatum is a distinctive species that can be recognized



MAP 20. Distribution of *Calophyllum pulcherrimum* (squares), *Calophyllum* sp. 61 (star in solid circle), *C. complanatum* (half-circles), *C. oliganthum* (open stars), *C. cucullatum* (solid star), and *C. pelewense* (triangle) in Malaysia.

by its tomentose indumentum; relatively short terminal bud; large, ovate-oblong leaf blades that are cucullate at the base; branched inflorescence; and small, ellipsoid fruits that have a thin outer layer disorganized by air spaces. The epithet alludes to the cucullate (hooded) base of the lamina.

Merrill (1920, *loc. cit.*) compared *Calophyllum cucullatum* with *C. soulattri*, but noted that *C. cucullatum* differed in its cucullate lamina base. *Calophyllum cucullatum* also differs in drying a much darker color, in its short terminal bud, and in its fruits, which have a thin outer layer; the outer layer of the fruit of *C. soulattri* is characteristically at least 1 mm. thick.

56. *Calophyllum glaucescens* Ridley, Kew Bull. 1938: 120. 1938; Masamune, Enum. Phanerog. Born. 475. 1942. TYPE: Sarawak, Kuching, Dec. 1892, *Haviland 2058* (holotype, κ ; isotypes, L, P (frag.), SING).

Small tree ca. 7 meters tall; outer bark smooth, gray, hoop marked; inner bark light brown, finely laminated; latex yellow.

Twigs slightly flattened, 1.5–2 mm. across, with 4 obscure raised lines, drying yellowish to whitish, glabrous; axillary innovations apparently with basal scars; internodes 2.5–5 cm. long; uppermost pair of axillary buds rounded, less than 0.5 mm. long, inconspicuous; terminal bud rather plump, 1–1.8 mm. long, with brown, puberulent indumentum (hairs, FIGURE 20, i), underdeveloped internode inconspicuous. Petiole 1–1.5 cm. long, broadly concave above, convex below, drying black; lamina elliptic to suboblong, 7–14.6 by 3.3–6.6 cm., acuminate at apex, acute to broadly cuneate at base, not undulate but narrowly recurved at margin, coriaceous, drying umber above and livid-vinaceous below, glabrous, the midrib above narrowing gradually from base, flat, adjacent lamina raised, 0.4–0.7 mm. wide at midpoint, below raised, rounded, the venation on both surfaces subobscure, ca. 25 veins/5 mm., angle of divergence 75–80°. Inflorescences from foliate axils along stem, with ca. 7 flowers, unbranched, the axis 1–1.5 cm. long, glabrous, lowest internode ca. 0.5 mm. long; bracts broadly ovate, ca. 2 mm. long, brown-puberulent beneath, persistent until anthesis; pedicels 6–9 mm. long, glabrous. Flower known only from advanced bud, (?)hermaphroditic; tepals 4, the outer two obovate, ca. 5.5 by 4 mm., subcucullate, the inner two \pm obovate, ca. 6 by 4.5 mm.; stamens 50 to 70, the filaments to 2.7 mm. long, the anthers ellipsoid, 0.5–0.7 mm. long, rounded to subretuse at apex; ovary ca. 1.3 mm. long, the style ca. 2 mm. long, the stigma slightly expanded, 0.3 mm. across. Fruit unknown.

DISTRIBUTION. Borneo (western Sarawak), local (MAP 23).

ADDITIONAL SPECIMEN SEEN. Borneo, SARAWAK. 1st Division: Sempadi F.R., 9 m., S 6012 (SAR).

ECOLOGY. Small tree on dry podzol, 9 m. alt. (S 6012). Flowering in December.

Calophyllum glaucescens is a distinctive, albeit poorly known, species recognizable by its very short terminal bud, pale-drying twigs, and lamina with dense venation. The midrib on the upper surface of the lamina is

surrounded by raised blade, and the lower surface of the lamina dries a livid-vinaceous color. The epithet alludes to the rather glaucous underside of the leaf.

Calophyllum glaucescens is somewhat similar to *C. cucullatum*, but the latter species has larger leaf blades at least 9.5 cm. long with a sharply raised midrib on the upper surface, a rounded, cucullate base, less dense venation, and a lower surface that is not pruinose. *Calophyllum cucullatum* also has a longer (4.5–6.4 mm.) terminal bud, tomentose indumentum, and inflorescences up to 5 cm. long. Although better material is needed for confirmation, *C. glaucescens* appears to have scars at the bases of the axillary innovations; such scars are lacking in *C. cucullatum*.

57. *Calophyllum nodosum* Vesque, Epharosis 2: *tt.* 10, 11. 1889, in C. DC. Monogr. Phanerog. 8: 559. 1893; Merr. Bibl. Enum. Born. Pl. 393. 1921; Masamune, Enum. Phanerog. Born. 476. 1942; M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 337. 1956; Meijer, Bot. Bull. Herb. Forest Dept. Sabah 7: 14. 1967; T. C. Whitmore, Tree Fl. Malaya 2: 171. 1972. TYPE: Sarawak [1st Division], Gunong Poe, July 1866, *Beccari PB 2440* (holotype, ♀; isotypes, ♂ (frag.), FI, K).

FIGURE 21, c.

- C. microphyllum* T. Anderson in Hooker f. Fl. Brit. India 1: 272. 1874, non Planchon & Triana (1862) nec Scheffer (1873); King, Jour. Asiatic Soc. Bengal, II. 59: 173. 1890; Ridley, Jour. Straits Branch Roy. Asiatic Soc. 35: 8. 1901; *C. kingianum* Engler in Engler & Prantl, Nat. Pflanzenfam. 3(6): 221. 1893 (7 Nov.), *nomen novum*; *C. parvifolium* Vesque in C. DC. Monogr. Phanerog. 8: 604. 1893 (Dec.), non Choisy (1823), *nomen novum*; Ridley, Fl. Malay Penin. 1: 182. 1922. TYPE: Malaya, Malacca, Mt. Ophir, Aug. 1867–68, *Maingay 2576* (*Kew dist.* 165) (lectotype, K).
- C. depressinervosum* auct., non M. R. Henderson & Wyatt-Smith; Pukol & Ashton, Checklist Brunei Trees, 93. 1964; Smythies, Common Sarawak Trees, 99. 1965.
- C. pulcherrimum* auct., non Wall. ex Choisy & *C. rupicola* auct., non Ridley; Meijer, Bot. Bull. Herb. Forest Dept. Sabah 7: 14. 1967.

Shrub 15 cm. tall to tree to 25(–36) meters tall, d.b.h. to 42 cm.; trunk without spurs or buttresses; outer bark yellowish (brown), with lenticels or boat-shaped fissures, very brittle in old trees, the inner surface black to dull orange-brown; under bark mid to deep red; inner bark reddish; latex clear (rarely cloudy) yellow, sticky.

Twigs slightly flattened, 0.5–1.5 mm. across, 4-angled to 4-angulate, drying brown, glabrous or sparsely and transiently puberulent; axillary innovations with (sub)basal pair of scars, nearly always with additional pair within 5 mm. of base; internodes 0.3–2.5 cm. long; uppermost pair of axillary buds rounded, to 0.5 mm. long, inconspicuous; terminal bud rather plump, 0.5–1 mm. long, with short, grayish to brownish, subadpressed indumentum (hairs, FIGURE 20, j–l), often not functional, underdeveloped internode to 3.5 mm. long. Petiole 1–5.5 mm. long, deeply concave above, convex below, glabrous;

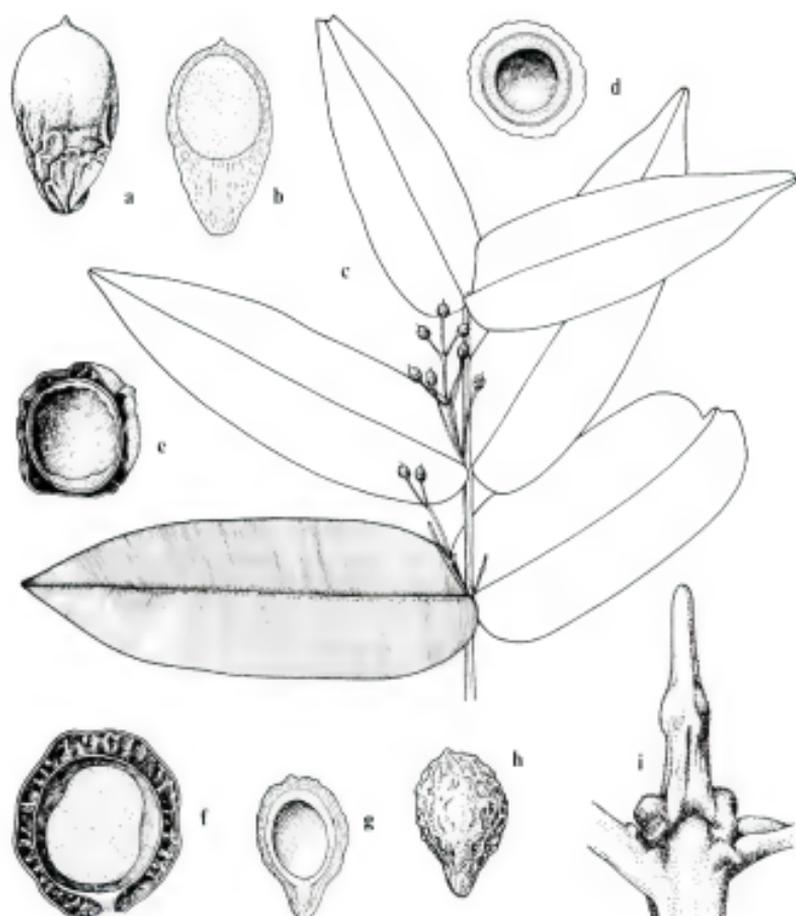
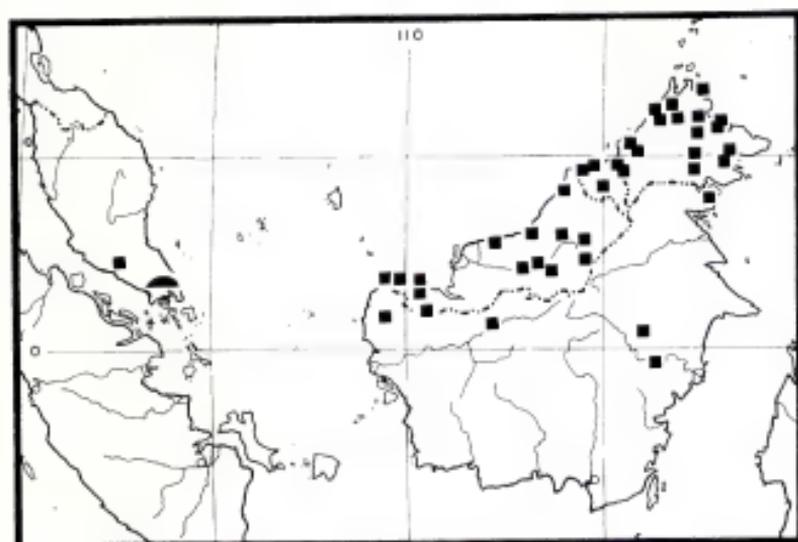


FIGURE 21. a, b, *Calophyllum stipitatum* (FRI 3656), fruit, $\times 1.5$: a, from outside; b, longitudinal section. c, *C. complanatum* (SAN 53254), habit, $\times 0.5$. d, *C. pulcherrimum* (Chew 1365), fruit, transverse section, $\times 1$. e, *C. nodosum* (S 19726), fruit, transverse section, $\times 3$. f, *C. depressinervosum* (KEP 104281), fruit, longitudinal section, $\times 3$. g-i, *C. roseocostatum*. g, h, fruit (S 14941), $\times 0.75$: g, longitudinal section; h, from outside. i, terminal bud (S 26299), $\times 6$.

lamina obovate or elliptic to subcuneiform or narrowly elliptic, (0.7-)1.4-6.5 (-10) by (0.15-)0.4-2.5(-3.6) cm., rounded to shortly and bluntly acuminate at apex, narrowly cuneate at base, usually minutely and abruptly rounded at very base, slightly undulate and not recurved at margin, thinly coriaceous, drying amber to near grayish olive above and amber to near sabelline or olive below, glabrous, the midrib above gradually narrowed from base, \pm

level to sulcate, surrounding lamina slightly raised, 0.5-1.5(-2) mm. wide at midpoint, often disappearing ca. 2 mm. short of apex, below level to slightly depressed, inconspicuous, striate, the venation subapparent to subobscure above and below, slightly raised (latex canals sometimes clearly impressed), 6 to 13 (to 15) veins/5 mm., angle of divergence 50-70(-75)°. Inflorescences from foliate axils along stem, with 1 to 9 (to 13) flowers, unbranched, the axis to 3.5 cm. long, glabrous (rarely puberulent) at base, lowest internode less than 2 mm. long; bracts ovate, ca. 1.7 mm. long, soon deciduous; pedicels 0.5-2.2 cm. long (-3 cm. long in fruit), glabrous, slender. Flower (?)hermaphroditic; tepals 4 (to 8), the two outer ovate (rarely subtriangular), 3-3.5 by 2.2-3 mm., sometimes puberulent on back at apex, the inner two elliptic to obovate, 3.5-5.5 by 2.3-3.7 mm. (5 by 2.2 mm), any others often much smaller; stamens 27 to 50 (to 60), the filaments to 3 mm. long, the anthers (elliptic-)oblong, 0.5-1 mm. long, slightly retuse at apex; ovary 1.2-1.5 mm. long, the style 2-2.5 mm. long, the stigma peltate, ca. 0.4 mm. across, \pm 3-radiate to infundibular. Fruit spherical, (4-)5.5-10 mm. long and across, rounded to apiculate at apex, drying grayish brown to yellowish brown, smooth or shallowly wrinkled; outer layer not detaching cleanly from stone, ca. 0.3(-0.7) mm. thick, with large air spaces developing; stone ellipsoid to subspherical, (3.5-)5-7.5 by (3-)5-6.5 mm., rounded at apex, the walls less than 0.15 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Malay Peninsula, local; Borneo, widespread in the northwest (MAP 21).



MAP 21. Distribution of *Calophyllum nodosum* (squares; half-circle, reported locality) in Malasia.

SELECTED SPECIMENS SEEN ("f" denotes Bornean specimens with fruits). **Malaya.** JOHORE: G. Mering and G. Ledang, *Ridley* 3222 (BM, SING); G. Ledang (Mt. Ophir), 975 m., *FRI* 12351 (K, KEP). **Borneo.** SARAWAK. 1st Division: Lundu, G. Berumpet, 1463 m., *S* 15099 (A, K, SAN, SAR, SING); Sampadi F.R., *A* 532 coll. *Mashor*, 14 Aug. 1948 (KLU); Bako Natl. Park, Lintang Path, 120 m., *Sinclair & bin Tassim* 10317 (A, B, BM, E, K, M, NY, SAR, SING); Mt. Matang, 1021 m., *Clemens* 22353 (NY); G. Pueh F.R., 30 m., *S* 7530 (SAR); Bungoh Range, Bau, 792 m., *S* 29022 (A, SAR); Sabal Tapang, 190 m., *Stevens et al.* 183 (A). 3rd Division: Ulu Sama, Batang Rajang, *SFN* 36057 (A, K, KEP, L, LAE, SING); Hose Mts., Ulu Temalad, Mujong, 305 m., *S* 17236 (A, K, KEP, SAN, SAR, SING); Bintulu, Merurong Plateau, 853 m., *S* 8714 (SAR); Kapit, Melinau, Bukit Pantu, 732 m., *S* 25720 (KEP, L, SAR, SING); Balingian, Ulu Sungei Arip, Bukit Iju, 180 m., *S* 23786 (A, BO, K, KEP, SAN, SAR, SING); Usun Apau Plateau, R. Julai, 965 m., *S* 3811 (SAR, SING). 4th Division: Baram distr., Kelabit Highland, 1067 m., *S* 35343 (K, SAR); Lambir proposed Natl. Park, Miri, *S* 24064 (A, K, KEP, SAN, SAR). 5th Division: Malignan Range, 1494 m., *S* 33035 (SAR). BRUNEI: Bukit Sagan, 549 m., *BRUN* 3110 (L, SAR); Batu Ketam, Ulu Ingei, 255 m., *BRUN* 5608 (L, SAR); Bukit Patoi, 240 m., *Ashton* s.n., Aug. 1958 (SAR); Berakas F.R., 15 m., *S* 7822 (BO, BRI, K, L, NY, SAR, SING); Andalau F.R., 21 m., *Sinclair & bin Tassim* 10448 (A, E, K, KEP, SAR, SING); G. Pagon Periok, 1860 m., *BRUN* 2389 (L, SAR); Bados, *KEP* 35589 (KEP); between Danau and Tutong, *van Niel* 3736 (L, MO); Sungei Singap, *KEP* 34570 (KEP); Kuala Belait, *S* 10652 (SAR). SABAH. Sipitang: Menggalong F.R., Sibubu R., *SAN* 21829 (KEP, SAN, SAR); Mesapol, Teck Guan Co., 210 m., *SAN* 50620 (SAN). Beaufort: Bukit Sunngau, Weston, *SAN* 55658 (f) (L, SAN, SAR, SING); Beaufort Hill, *SAN* 35227 (SAN). Kota Belud: Mt. Templer F.R., S. of Sungei Talupid, 610 m., *SAN* 76266 (K, SAN, SAR). Tenom: Kapulu, way to Rendum, 1097 m., *SAN* 72058 (f) (K, SAN); Mandalom F.R., *SAN* 31948 (SAN). Keningau: Mile 9, Kampong Nalayan, *SAN* 58461 (f) (K, L, SAN); Mile 10, Rashna road, Nabawan, 305 m., *SAN* 83839 (f) (A, K). Tambunan: Trusmadi F.R., above Ulu Koingaran R., 1514 m., *SAN* 41779 (K, L). Ranau: Kinabalu Natl. Park, Tohubang near Kampong Kiau, 918 m., *SAN* 51428 (SAN). Labuk & Sugut: Jambongan Is., 3 m., *SAN* 3899 (BO, K); Bukit Gambaran near Telupid, 457 m., *SAN* 51525 (K, SAN, SAR); Bukit Tangkunan, 425 m., *Stevens et al.* 408 (A). Sandakan: Sungei Paitan W.C., *SAN* 23977 (f) (K, KEP, L, SAN, SAR, SING); Mt. Walker F.R., 30-60 m., *SAN* 53171 (K, KEP, L, SAN, SAR, SING); Kiabau Hill, 150 m., *SAN* 43814 (SAN); Sungei Mayan, 40 m., *Stevens et al.* 381 (A). Kinabatangan: Brassey Range, 810 m., *Stevens et al.* 481 (A); Lamag, Bukit Kuamat, *SAN* 70729 (SAN); S. slope of G. Lotung Inarat, 1036 m., *SAN* 83312 (A). Lahad Datu: Pulau Sakar, Look Magulang, 39 m., *SAN* 15524 (f) (K, L, SAN, SAR); Bakapit, Silabukan Falls, 457 m., *SAN* 52956 (K, L, SAN); Mt. Silam, 457 m., *SAN* 22711 (SAN). KALIMANTAN. Timur: Nonoekan, 3 m., *bb* 26213 (?) (BO, L); W. Kutai, Belajan R., Mt. Palimasan near Tabang, *Kostermans* 12913 (f) (BO, CANB, K, L, P, SING); bij L. Petah, 800 m., *Endert* 3209 (f) (BO, L). Barat: between S. & G. Kenepai, *Hallier* 1948 (A, BO, K, L); Bengkajang, G. Bawang, 1400 m., *bb* 9667 (BO); Palo, *Becking* 23 (f) (BO).

ECOLOGY. Common in kerangas forest on acid and often sandy soil, sometimes in waterlogged places; 13-1860 m. alt. Unusually plastic in form: "procumbent shrub 2 ft. tall rooting along branches" (*Purseglove* 5604); "cushion plant" 20-40 cm. tall (*S* 4447); "shrub 6"-1 ft. high" (*Sinclair* 10317)—the last

specimen, at least, is fertile. Near Sandakan, Sabah, to 42 cm. d.b.h.; other individuals nearby somewhat smaller. Flowering February to June; somewhat less frequently July to December. Fruiting January to November (June and December on Malay Peninsula); fruit yellowish to grayish.

GERMINATION AND YOUNG PLANT. The radicle breaks the stone near the base of the seed. The seedling has four to six (or seven) pairs of scale leaves and (one or) two pairs of expanded leaves, all separated by well-developed internodes; the internode between the cotyledons and the first pair of scale leaves is ca. 5(-11) mm. long. The terminal bud is at least initially functional, and young plants ca. 30 cm. tall are erect (*Stevens et al.* 381A).

Calophyllum nodosum is distinguished by its small leaf blades with the midrib above surrounded by raised lamina and below level or slightly depressed; its axillary innovations with basal scars; and its small fruits with a thin outer layer and a thin stone wall. The epithet *nodosum* alludes to the rather closely set nodes, which are especially prominent after the leaves have fallen off.

Calophyllum nodosum is difficult to separate from *C. pulcherrimum* when not in fruit, and it appears also to be related to *C. depressinervosum*; for the differences separating these species see TABLE 11 and the discussion after *C. pulcherrimum*. *Calophyllum nodosum* is also related to *C. complanatum* (q.v.).

Calophyllum nodosum is extremely variable in leaf size, shape, and—to a certain extent—color on drying. Specimens from the 4th Division of Sarawak (Miri: S 24064) and from Batu Ketam and Bukit Patoi in Brunei have a narrowly elliptic to obovate lamina 2.5-4.4(-7.5) by 0.15-0.75(-1) cm. and are at first sight different from the other specimens. S 24064 is in fruit; the fruits are somewhat smaller (4 mm. long) than normal. In all other features the narrow-leaved specimens agree well with the broader-leaved ones. They appear to represent one extreme of the considerable variation in leaf shape and size shown by *C. nodosum*, and they grow in the same habitat; it does not seem worthwhile to give them formal recognition.

The terminal buds in mature plants of *Calophyllum nodosum* are sometimes functional; those of the young plants seen were functional.

Specimens of *Calophyllum nodosum* from Borneo agree well with those from southern Malaya, despite the considerable distance between the two areas. Ridley (1901, *loc. cit.*; as *C. microphyllum*) suggested that *C. nodosum* may also occur on Gunong Panti, Johore. The apparent absence of *C. nodosum* from Sumatra is perhaps surprising in view of the abundance and rather wide altitudinal range of the species in Borneo.

Calophyllum microphyllum T. Anderson is lectotypified by *Maingay 2576* at Kew. Anderson also cited specimens collected by Lobb and Griffith.

58. ***Calophyllum depressinervosum*** M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 335, pl. 17. 1956; *C. depressinerve* Wyatt-Smith, Malayan Forest Rec. 17: 113. 1952, *nomen*; Kochummen, Malayan Forest Rec. ed. 2. 17: 220. 1965; Meijer, Bot. Bull. Herb. Forest Dept. Sabah 7: 15. 1967; Corner & Watanabi, Illus. Guide Trop. Pl.

181. *fig.* 1969; T. C. Whitmore, *Tree Fl. Malaya* 2: 179. 1973; Corner, *Gard. Bull. Singapore Suppl. I*: 104. 1978. TYPE: Malaya, Pinang, Moniot's Road, 1000 feet [305 m.], May 1886, *Curtis 830* (holotype, SING; isotypes, K, SING). FIGURE 21, f.

Calophyllum sp. near *floribundum* Hooker f.; Curtis, *Jour. Straits Branch Roy. Asiatic Soc.* 35: 79. 1894.

Tree 4-36 meters tall, d.b.h. to 86 cm.; trunk without buttresses or spurs; outer bark brown to yellowish, with shallow, rather numerous, short, boat-shaped fissures, not hoop marked, the inner surface (dark) brown (blackish); under bark reddish to red-brown; inner bark dark red to pink; latex yellow, clear, or becoming cloudy, or cloudy, always sticky. Branches \pm pendulous.

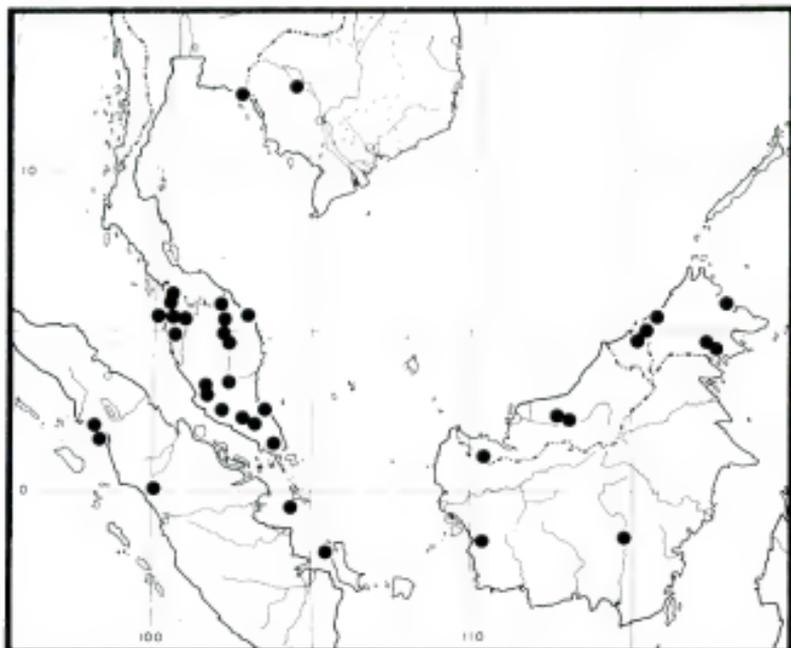
Twigs slightly flattened, 1-1.7(-2.5) mm. across, obscurely 4-angled, soon becoming rounded, drying brown, glabrous; axillary innovations with 1 to 3 pairs of scars within 3 mm. of base; internodes (0.5-)-1-6 cm. long; uppermost pair of axillary buds rounded, ca. 0.5 mm. long, spreading, not conspicuous; terminal bud plump to conical, 1.5-2.2 mm. long, with short, subadpressed, brownish indumentum (hairs, FIGURE 20, m), usually not functional, underdeveloped internode absent. Petiole 3.5-8 mm. long, (deeply) concave above, convex below, glabrous; lamina ovate to obovate or subelliptic, 3.2-10 by 1.2-4.1 cm., strongly acuminate at apex, acumen ca. 1 cm. long, cuneate to acute at base, slightly and distantly undulate and not recurved to slightly so at margin, thinly coriaceous (rarely coriaceous), drying umber to olivaceous above and cinnamon to sabelline below, glabrous, the midrib above gradually narrowed from base, slightly raised (adjacent leaf raised), 0.1-0.25(-0.35) mm. wide at midpoint, below flat to depressed, striate (rarely somewhat raised), the venation on both surfaces subobscure (subapparent), raised, latex canals frequently (and rarely veins) impressed above, 4 to 10 veins/5 mm., angle of divergence 55-70°. Inflorescences from foliate axils along stem, with 7 to 13 flowers; unbranched, the axis 0.5-5 cm. long, glabrous, lowest internode to 2 mm. long; bracts unknown; pedicels (0.25-)-0.4-1.3 cm. long, glabrous, slender; to 1 mm. thick in fruit. Flower (?) hermaphroditic; tepals 4, the outer two broadly ovate, ca. 3 mm. long and across, the inner two obovate, ca. 5.5 by 2.5 mm.; stamens ca. 40, the filaments to 3 mm. long, the anthers subelliptic, 0.4-0.7 mm. long, rounded to retuse at apex; ovary ca. 1.2 mm. long, the style ca. 2 mm. long, the stigma peltate, ca. 0.4 mm. across, (?) lobed. Fruit spherical, 0.8-1.1 cm. long and across, apiculate, drying orange-brown, smooth or broadly wrinkled, wrinkles rounded; outer layer not detaching cleanly from stone, 0.2-0.7 mm. thick, with large air spaces developing; stone ellipsoid, 6-8 by 5-6.5 mm., rounded at apex, the walls less than 0.1 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Cambodia and Thailand to Borneo, excluding Java (MAP 22).

SELECTED SPECIMENS SEEN. **Cambodia:** Pursat, entre Anlong Krauch et Veal Veng, 500 m., *Martin 1797* (p). **Thailand:** Chantabuli, *anon.*, 13 Aug. 1933 (BKF). **Malaya:** KEDAH: Gunong Jerai F.R., *KEP 7745* (K, KEP, SING); Bukit Lada Acheh, *KEP 7570* (KEP); Gunong Inas F.R., *FRI 4632* (KEP); Perangin

TABLE 11. Differences between *Calophyllum pulcherrimum*, *C. nodosum*, and *C. depressinervosum*.

	<i>C. pulcherrimum</i>	<i>C. nodosum</i>	<i>C. depressinervosum</i>
LAMINA			
LENGTH (cm.)	(2.7-)4-8(-11)	(0.7-)1.4-6.5(-10)	3.2-10
APEX ACUMINATE	+	-(+)	+
VENATION DENSITY (veins/5 mm.)	7 to 13 (to 17)	6 to 13 (to 15)	4 to 10
LATEX CANALS IMPRESSED WHEN DRY	-	-(+)	+(-)
VEINS VISIBLE ON LOWER SURFACE	+(and sometimes latex canals)	+(and latex canals)	-
CINNAMON-SABELLINE BELOW WHEN DRY	-	-(+)	+
FRUIT			
LONGER THAN 1.4 CM.	+	-	-
OUTER LAYER AT LEAST 1 MM. THICK	+	-	-
STONE WALLS AT LEAST 0.3 MM. THICK	+	-	-
SEED AT LEAST SOMETIMES POLYEMBRYONIC	-(?)	+	+
YOUNG PLANT CA. 20 CM. TALL, ERECT	-	+?	+?



MAP 22. Distribution of *Calophyllum depressinervosum* in Southeast Asia and Malasia.

F.R., 90 m., *KEP 79284* (KEP); Enggang F.R., 37 m., *KEP 74991* (KEP). PINANG: Tiger Hill Road, 457 m., *Haniff 265* (C, UC). PERAK: road from Kampong Ayer to G. Bubu massif, 396 m., *FRI 13898* (A, K, KEP, SAR, SING); Kiritu, K[elelan] Saiong F.R. *KEP 65947* (KEP); Ulu Kenderong, *KEP 11038* (KEP). SELANGOR: Kepong, Bukit Lagong F.R., 150 m., *KEP 98701* (A, K, KEP, SAR, SING); Kuang, *KEP 22059* (KEP, SING); Bangi F.R., Kajang, *KEP 14578* (K, KEP, SING); Sungei Buloh F.R., *KEP 14926* (KEP). NEGRI SEMBILAN: Kuala Pilah, Kepis F.R., *KEP 62954* (A, BO, K, KEP, SING); Hutan Simpon Paseh, *KEP 100176* (KEP). KELANTAN: Ulu Temiang F.R., *KEP 104281* (A, K, KEP, L, SAN, SING); G. Rabong, 366 m., *Soepadmo & Mahmud 1198* (A, K, KEP, KLU, L, SING); Bukit Hubil, 762 m., *KEP 98808* (A, BO, KEP, SING); Bukit Lina, 762 m., *KEP 98801* (KEP); Kemahang F.R., 30 m., *KEP 93626* (KEP). TRENGGANU: 3 km. N. of Kuala Trengganu, *FRI 20289* (KEP). PAHANG: Jengka F.R., Temerloh, *KEP 98594* (K, KEP, SAN, SAR); Mentakab, *KEP 7922* (KEP); G. Tahan, *Wong & Wyatt-Smith 49* (KEP). JOHORE: Mawai, *Corner s.n.*, 7 Oct. 1934 (KEP, SING); Kluang F.R., 30 m., *KEP 69922* (KEP); Mersing, G. Arong F.R., 30 m., *KEP 84703* (KEP); Labis, Segamat, Mambai F.R., *KEP 69862* (KEP). Sumatra and adjacent islands. RIAU: Lingga, P. Singhap, oetan darat Njakar (Bakong), 150 m., *bb 2043* (?) (NO, L); Ngina, *Ri/1-8* (BO). BARAT: Loeboek Sikaping, Tandjoeng Boengi, 370 m., *bb 6502* (BO). UTARA: Sibolga, P. Poene, 10 m., *bb 3783* (BO); Baroes, Pangkalan Tapoes, 25 m., *bb 29524* (BO, L); Morsala

Is., Silabua, 10 m., *Kostermans' collector 13*, Jan. 1951 (A, BO, SING). BANGKA: W. Bangka, Penganah, 30 m., *bb 26138* (BO, SING). BORNEO. SARAWAK. 1st Division: Sadong, Sabal F.R., *S 13454* (A, BO, K, L, SAN, SAR). 2nd Division: Bukit Ubah Ribu, Ulu Sungei Kaup, 610 m., *S 33782* (K, KEP, SAN, SAR). BRUNEI. Temburong, mile 1¼ Bangar-Batu Apas road, 9 m., *SAN 17093* (A, BO, K, KEP, L, SAN, SING). SABAH. Sipitang: Mile 8, Sipitang road, *SAN 35125* (KEP, L, SAN, SAR, SING); Mesapoh F.R., *SAN 73347* (SAN). PAPAR: Mandahan Hill, 225 m., *SAN 78001* (SAN). Sandakan: Sepilok Extension, sea level, *SAN 24912* (K, KEP, L, SAN, SING). TAWAO: Brantian, 30 m., *Stevens et al. 435* (A); Brassey Range, 660 m., *Stevens*, sight record. KALIMANTAN. Tengah: Midden Doeson, Lemoedajak, 60 m., *bb 11596* (BO). Barat: Moeara Kajang, 10 m., *bb 7465* (BO).

ECOLOGY. Mixed dipterocarp forest, on ridges and other well-drained places, sometimes in forest approaching kerangas forest (Sarawak) or swamp forest (Johore—Corner, *loc. cit.*; the single tree I saw in a swamp was on an eminence ca. 1.5 m. above surrounding swamp); to 762 m. alt. In Malaya flowering January, May, November, and December; fruiting January to March and May, November, and December. In Borneo fruiting March, April (most), and June. Ripe fruit yellowish.

GERMINATION AND YOUNG PLANTS. Vigorously growing young plants up to 1.2 meters tall with functional terminal buds have been seen (Sarawak, Sabal Tapang).

Calophyllum depressinervosum can be most readily recognized by its moderate-sized to small leaf blades that are strongly acuminate at the apex, that usually have obscure, rather distant venation when dry, and that often have clearly impressed latex canals. The lower surface of the dried leaf blades is often a yellowish brown, at least in specimens that are not too old. The flowers have four tepals. The fruits are small (about 1 cm. long), and the stone has thin walls. The epithet *depressinervosum* really refers to the latex canals, which are depressed when the leaf is dry (note that the veins are rarely depressed!).

Calophyllum depressinervosum is similar to *C. nodosum* and, to a lesser extent, to *C. pulcherrimum*; some differences between the species are listed in TABLE 11. *Calophyllum depressinervosum* also has less dense venation than does *C. nodosum*: four to ten veins/5 mm. vs. six to thirteen (to fifteen) veins/5 mm. Leaf blades and fruits of specimens of *C. nodosum* from Sarawak (e.g., *S 17236, 21136, 21243*) dry a similar color to those of *C. depressinervosum*, but the species are not otherwise similar.

The above-cited specimens of *Calophyllum depressinervosum* from Cambodia and Thailand are sterile, but there is no doubt as to their identity. The specimens from Kalimantan and some from elsewhere in Borneo (e.g., *SAN 17093*, from Brunei) are robust, with twigs up to 2.5 mm. in thickness, and the leaf blades are rather coriaceous and tend to dry boat shaped. *SAN 17093* has fruits characteristic of *C. depressinervosum*, albeit borne on rather short pedicels. The specimens from Kalimantan are sterile.

59. *Calophyllum complanatum* P. F. Stevens, sp. nov.

FIGURE 21, c.

A speciebus aliis *Calophylli* in lamina lingulata vel oblonga basi cordata costa supra lamina elevata circumdata infra non nisi vel leviter elevata, et inflorescentia axillari internodio infimo 0-1 mm. longo, differt.

Tree ca. 9 meters tall, d.b.h. ca. 5 cm.; outer bark yellow-green.

Twigs strongly flattened, 1.2-2.6 mm. across, strongly 4-angled, drying brown, glabrous; axillary innovations with pair of basal scars and often another pair within 5 mm. of base; internodes 2-4 cm. long; uppermost pair of axillary buds rounded, less than 0.5 mm. long, inconspicuous; terminal bud plump, 1.5-3 mm. long, with short, brown, tomentose indumentum (hairs, FIGURE 20, n), underdeveloped internode absent. Petiole 1-2 mm. long, shallowly concave above, convex below, glabrous; lamina lingulate to suboblong, 9.5-14.8 by 1.5-4.5 cm., subacuminate to acute at apex, cordate at base, slightly undulate and recurved at margin, thinly coriaceous, drying grayish sepia above and sabelline below, glabrous at maturity, the midrib above abruptly narrowed near base, raised, surrounding lamina also raised, 0.1-0.25 mm. wide at midpoint, below raised, angled to substrate, the edges subdepressed, the venation \pm apparent above, slightly raised, below subobscure, latex canals slightly impressed above and strongly impressed below, 5 to 7 veins/5 mm., angle of divergence ca. 80°. Inflorescences from foliate axils, with ca. 7 flowers, unbranched, the axis 1.2-3 cm. long, glabrous, slender, lowest internode to 1 mm. long; bracts not known; pedicels 0.7-2.2 cm. long, glabrous. Flower (?)hermaphroditic; tepals 4, the outer pair ovate-elliptic, ca. 3.3 by 2 mm., the inner pair \pm obovate, 5-6 by 3-4 mm.; stamens ca. 75, the filaments to 3 mm. long, very slender, the anthers elliptic, 0.4-0.5 mm. long, retuse at apex; ovary ca. 0.7 mm. long, the style ca. 2.7 mm. long, the stigma slightly expanded, ca. 0.3 mm. across. Immature fruit (?)subspherical, ca. 5 mm. long; outer layer ca. 0.2 mm. thick; stone with walls ca. 0.2 mm. thick.

TYPE: Sabah, Kinabatangan, Karamuak, Lamag, east of Sg. [Sungei] Meliau, 45 m., 17 June 1965, SAN 53254 coll. *Teorodop* (holotype, κ ; isotype, SAN).

DISTRIBUTION. Northeastern Borneo (MAP 20).

ADDITIONAL SPECIMEN SEEN. Borneo, SABAH. Labuk & Sugut: Mile 86, Bukit Tangkunan, 425 m., *Stevens et al.* 407 (λ).

ECOLOGY. On soils derived from ultramafic rock, 45-425 m. alt. Flowering in June.

Calophyllum complanatum can readily be distinguished from the other species of the genus even when sterile: its axillary innovations have basal scars, and its leaf blades are cordate at the base, with the midrib on the upper surface flat and surrounded by raised lamina. The twigs are notably flattened, hence the specific epithet.

Calophyllum complanatum is probably most closely related to *C. nodosum*, which also has innovations with basal scars, the upper surface of the lamina

with the midrib broadly raised, inflorescences with short basal internodes, and flowers with four tepals. *Calophyllum nodosum* differs most obviously from *C. complanatum* in its smaller leaf blades that are never cordate at the base. The two species grow within a few meters of each other on Bukit Tangkunan (for *C. nodosum* see Stevens et al. 408); young plants of *C. complanatum* up to 3 meters tall were quite common but showed little variation.

The fruits of *Calophyllum complanatum* are known only from the isotype at Sandakan. These fruits are small and have been distorted during pressing, but they have a well-defined stone wall ca. 0.2 mm. thick. It is therefore likely that the mature fruits of *C. complanatum* are less than 1 cm. long.

60. *Calophyllum pulcherrimum* Wall. ex Choisy, Mém. Guttif. Inde, 41. 1849, Mém. Soc. Phys. Hist. Nat. Genève 12: 421. 1851; Wall. Catal. 4848. 1831, *nomen*; Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 274. 1862; T. Anderson in Hooker f. Fl. Brit. India 1: 271. 1874, *pro parte*; Kurz, Jour. Asiatic Soc. Bengal, II. 39: 64. 1870; Pierre, Fl. Forest. Cochinch. 1: pl. 104B. 1885, *pro parte*; King, Jour. Asiatic Soc. Bengal, II. 59: 174. 1890, *pro parte*; Vesque in C. DC. Monogr. Phanerog. 8: 570. 1893, *pro parte*; Ridley, Jour. Straits Branch Roy. Asiatic Soc. 33: 47. 1900, Fl. Malay Penin. 1: 182. 1922, *pro parte*; Heyne, Nutt. Pl. Indonesië. ed. 3. 1: 1085. 1950; M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 334. 1956; Gilliland, Common Malay Pl. 37. 1958; Kochummen, Malayan Forest Rec. ed. 2. 17: 220. 1965; Burkill, Dict. Econ. Prod. Malay Penin. ed. 2. 1: 416. 1966; Corner & Watanabi, Illus. Guide Trop. Pl. 183. fig. 1969; T. C. Whitmore, Tree Fl. Malaya 2: 181. 1973; H. Keng, Gard. Bull. Singapore 28: 244. 1976; Corner, Gard. Bull. Singapore Suppl. 1: 104. 1978. TYPE: Singapore, Sept. 1822, Wallich dist. 4848, *pro parte* (holotype, G; isotypes, BM, E, FI, G, K, M, MEL, NY, P, W). FIGURE 21, d.

- C. plicipes* Miq. Fl. Indiae Batavae Suppl. 1(3): 499. 1861; Kurz, Nat. Tijdschr. Nederl.-Indië 27: 192. 1864; F. Mueller in Walp. Ann. Syst. Bot. 7: 357. 1868. TYPE: Bangka, prope Djeboes, Teysmann, HB 3209 (holotype, v; isotypes, bo, l).
- C. mesuaefolium* Wall. Catal. 4850. 1831; Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 293. 1862. *Nomen*.
- C. retusum* auct., non Choisy; King, Jour. Asiatic Soc. Bengal, II. 59: 176. 1890, *pro minore parte*.
- C. pulcherrimum* Wall. var. *gracile* (Miq.) Boerl. Catal. Horto Bogor. 2: 82. 1901, *quoad spec. cit.*
- C. foetidum* Ridley, Jour. Straits Branch Roy. Asiatic Soc. 54: 18. 1910, *pro minore parte*.

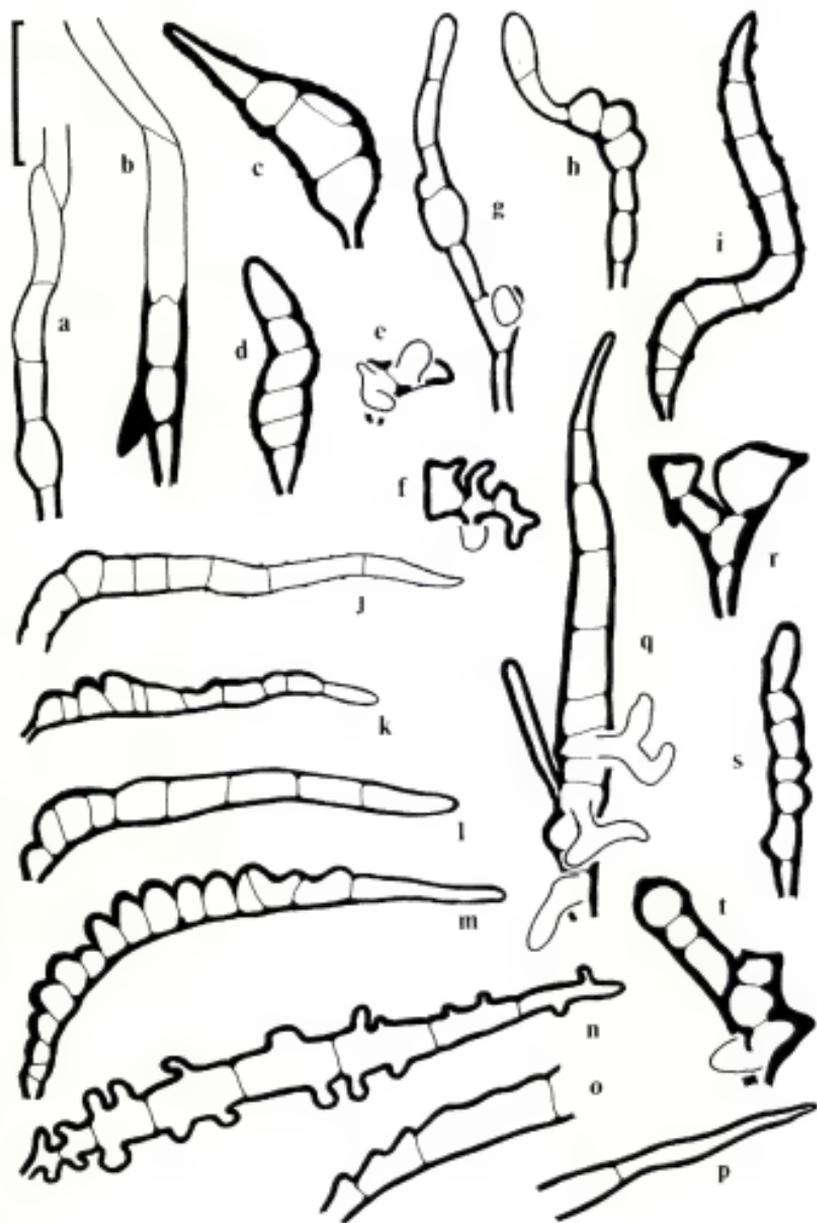
Tree 10-23(-30) meters tall, d.b.h. to 40 cm.; trunk rarely with buttresses to 1 meter tall; outer bark yellowish brown, often mottled, with vertical lines of lenticels, or cracked (rarely slightly scaly), or with boat-shaped fissures, the inner surface red-brown to reddish black; under bark green-brown, red, or blackish, outer bark often detaching only with difficulty; inner bark pinkish

to mid-red; latex usually clear yellow (rarely cloudy yellow or brown-yellow), sticky. Branches often pendulous.

Twigs somewhat flattened, 0.7–1.2 mm. across, strongly 4-angled, drying brown or dark brown, glabrous; axillary innovations with 1 (or 2) pair(s) of basal scars; internodes 1–4.5 cm. long; uppermost pair of axillary buds rounded, less than 1 mm. long, spreading, inconspicuous; terminal bud conical (plump), 0.7–1.3 mm. long, with subadpressed, brownish indumentum (hairs, FIGURE 22, j), usually not functional, underdeveloped internode absent (–3.5 mm. long). Petiole 3–11 mm. long, deeply concave above, convex below, glabrous; lamina elliptic to suboblong (rarely obovate), (2.7–)4–8(–11) by (0.8–)1.6–3.4(–4.2) cm., bluntly acuminate (rarely acute to subrounded) at apex, acute to attenuate toward base, very base minutely rounded, slightly undulate and not recurved at margin, coriaceous, drying umber to sepia above and umber to sabelline below (often with thin, grayish, waxy covering, especially on the upper surface), glabrous, the midrib above gradually narrowed from already narrow base, raised, surrounding leaf raised, 0.15–0.3(–0.55) mm. wide at midpoint, below flat to depressed, striate, the venation subobscure to apparent above and below, slightly raised, 7 to 13 (to 17) veins/5 mm., angle of divergence 65–70(–80)°. Inflorescences from foliate axils along twigs, with 7 to 11 (to 17) flowers, unbranched, the axis 1.5–4.5 cm. long, glabrous, lowest internode less than 2.5 mm. long; bracts ovate to obovate, ca. 2 mm. long, soon deciduous; pedicels 0.4–3 cm. long, glabrous, slender. Flower (?) hermaphroditic; tepals 4 (rarely 8), the two outer ovate to elliptic, 3.5–5.5 by 2.5–4 mm., very rarely with few hairs near apex on back, the inner ones ± obovate to elliptic, 6–9 by 2.5–3.5 mm., rarely glabrous; stamens (25 to) 65 to 140, the filaments to 5 mm. long, connate for up to 1 mm., the anthers oblong, 0.6–1.2 mm. long, ± retuse at apex; ovary 1.3–1.5 mm. long, the style 2–3.2 mm. long, the stigma peltate, 0.4–0.8 mm. across, 3-lobed. Fruit ovoid to spherical, 1.5–1.7 by 1.2–1.8 cm., when young ovoid, sharply pointed at apex, smooth, when older apiculate or not, drying brown, prominently wrinkled; outer layer detaching cleanly from stone, 1–2.2 mm. across, compact; stone subspherical, 1–1.3 by 0.95–1.3 cm., rounded at apex, the walls 0.3–0.5 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Southern Malaya to western Borneo, excluding Java (MAP 20).

FIGURE 22. Hairs (from terminal bud). a, b, *Calophyllum cucullatum* (BS 34518). c, d, *C. oliganthum* (BS 34520). e, f, *C. andersonii*: e, S 24679; f, Haviland = 1812. g, h, *C. pelewense* (Kanehira 386). i, *Calophyllum* sp. 61 (S 4732). j, *C. pulcherrimum* (Shah & Shukor 2395). k, *C. roseocostatum* (S 26299). l, *C. stipitatum* (FRI 3656). m, *C. confertum* (SAN 17146). n–p, *C. praetermissum* (Haviland & Hose 3342), papillae in only one plane (o, p, apex and base of hair ca. 500 μ m. long). q, *C. flavo-ramulum* (FRI 7521). r–t, *C. celebicum* (Cel./II-213), the few thin-walled apical cells fall off, leaving flat tops. Scale = 60 μ m.



SELECTED SPECIMENS SEEN ("f" denotes Bornean specimens with fruits).

Malaya. NEGERI SEMBILAN: Pengkalen Kempas, *KEP* 4213 (k, SING); Pasir Panjang, *KEP* 4202 (k, SING); Port Dickson, Cape Rachado, 120 m., *KEP* 71340 (KEP); Sungai Menyala F.R., 45 m., *KEP* 64091 (KEP). MALACCA: Pulu Besar, *Maingay* 1065 (*Key dist.* 169, *pro parte*) (k); Sungai Udang, *Goodenough* 1738 (SING, w); Merlimau, *Derry* 156 (SING); Bukit Sabukor, *Derry* 104 (BM). PAHANG: Sungai Rompin, Bukit Leuting, *KEP* 3230 (k, SING); E. edge of Chini F.R., 150 m., *FRI* 14560 (A, k, KEP, SING); Baloh F.R., *KEP* 6842 (k); Lesong F.R., ridge N. of Sungai Jekatih, 180 m., *FRI* 20006 (KEP, SAR); Menchali F.R., *KEP* 29655 (KEP); Temerloh, 64 $\frac{3}{4}$ miles Maran Road, 180 m., *KEP* 77964 (KEP). JOHORE: Sungai Kayu, *SFN* 31990 (k, KEP, SING); G. Ledang (Mt. Ophir), Ulu Sungai Belemang, *FRI* 12327 (A, k, KEP, SING); Banang F.R., 270 m., *FRI* 2122 (A, k, KEP, SAN, SING); 10th mile Mersing-Endau Road, *FRI* 2783 (k, KEP, SING); Tg. Penawar, Johore Coast, 15 m., *FRI* 7624 (k, KEP, SING); Pulau Tinggi, *KEP* 70936 (KEP); Batu Pahat, Soga F.R., *KEP* 79519 (KEP); G. Arong F.R., *KEP* 94884 (KEP, SING); G. Pulau F.R., 455 m., *FRI* 17553 (KEP); G. Lambak microwave station, Renggam F.R., *FRI* 17755 (k, KEP, SAR, SING); Panchor, Tg. Sewat Rogei, *KEP* 62814 (KEP); Kota Tinggi, 115 chains in from E. coast, 60 m., *KEP* 118195 (A, k, KEP, SING). **Singapore:** Seletar Reservoir, Mandai Road, *Shah & Shukor* 2370 (A, BRI, C, KEP, KLU, SING); Tanjong Gul, *Sinclair* 10762 (B, FI, G, K, SING); Fairy Point, Changi, *Hullett* 801 (k, SING); Pulau Damar Laut, *Sinclair* 5299 (E); Chan Chu Krang, *Ridley s.n.*, Nov. 1894 (SING); MacRitchie Reservoir, *SFN* 39477 (B, K, M, NY, SING); Bukit Timah F.R., *SFN* 34440 (A, BO, K, LAE, SING); Tampenis, *Ridley* 4639A (FI, SING); Garden Jungle, *Ridley* 13305 (BM, K, SING); Keranji, *Ridley* 260 (BM, SING). **Sumatra and adjacent islands.** RIAU: RIOUW, Tandjong Pinang, Kelong, P. Ngalim Besar, 12 m., *bb* 11444 (BO); Lingga, P. Singkep, Tandjong Batang, 15 m., *bb* 4019 (BO); Marok Toewa bij Soengei Air Tawar, *bb* 1687 (BO). DJAMBI: Djambi, Sei Oeron, 43 m., *bb* 12277 (BO). SELATAN: Banjoeasin en Koeboestrecken, 15 m., *134 E 1 P* 1036 (BO, L); Koemerling Oeloe, 80 m., *Grashoff* 565 (BO); Kaju Agung, *Kostermans* 14089 (L). BANGKA: Lobok Besar, G. Pading, 20 m., *Kostermans & Anta* 964 (A, BO, K, KEP, LAE, NY, SING); G. Mangkol, 50 m., *Kostermans & Anta* 716 (A, BO, K, LAE, NY, P, SING); prope Djeboes, *Teysmann*, *HB* 3214, *pro parte* (BO); G. Maras, 20 m., *Kostermans & Anta* 1241 (A, BO, CANB, K, KEP, LAE, P, SING); Belinjoe, 28 m., *Grashoff* 72 (BO, L); Muntoh, Majang, *bb* 7302 (BO); Soengei Liat, *Teysmann*, *HB* 7565 (C, FI, MEL); G. Rebo, 295 m., *Bünnemeijer* 1886 (BO, L); Plangas, *Teysmann*, *HB* 3251 (BO); S. Bangka, Mindik, 25 m., *bb* 10689 (BO), *Toboali*, *bb* 1941 (BO, L). BELITUNG: Tandjong Padan, Bantan, 30 m., *bb* 7377 (BO); N. von Manggor, *Ham* 18 (BO). **Borneo and adjacent islands.** SARAWAK. 1st Division: Mt. Santubong, *S* 21510 (f) (A, BO, K, KEP, P, SAN, SAR, SING); Matang, *Beccari* *PB* 1647 (f) (FI); Bako Natl. Park, summit of Bukit Gondol, 270 m., *S* 20924 (A, K, SAN, SAR, SING); Serian, G. Penrissen, *S* 16306 (f) (A, BO, K, SAN, SAR, SING); G. Buri, 490 m., *S* 36950 (f) (SAR). KALIMANTAN. TIMUT: Nunukan, 100 m., *Kostermans* 9024 (A, BO, CANB, K, L, SING); W. Koetai, near M. Moentai, 15 m., *Endert* 2009 (A, BO, K), Mt. Maranga on Tandjung Plateau, 200 m., *Kostermans* 12542 (BO, K, L, P, SING); E. Koetai, Godong Lengah (Bengalon), 15 m., *bb* 7952 (BO); Loa Djanan, W. of Samarinda, *Kostermans* 9868 (A, BO, K, KEP, L, P, SING); Sg. Tiram complex, SW. of Samarinda, *Kostermans* 6056 (A, BO, K, L). Selatan: Bangarmassing, *Motley* 561 (k, P); Kintap, Pleihari, *Dachlan* 2049 (BO, L); Martapoera, Kaläan, 400 m., *bb* 12040 (BO), G. Melati, *Dachlan* 2156 (BO); G. Pamatton,

Korthals s.n. (f) (L). Tengah: Karrau R., *S. Müller s.n.* (L); Poeroek Tjahoe, M[oea]rja Djaan, 100 m., *bb 10485* (BO), M[oea]rja Laoeng, 80 m., *bb 10099* Kelapeh, 200 m., *bb 1033* (BO). Barat: Karimata Arch., Poelau Seroetoe, *Mondi[h] 170* (f) (BO, K, L, NY, SING, U); Pontianak, *Dedi 865* (BO); Melawi Tjatit, B. Gontoe, 180 m., *bb 27014* (f) (A, BISH, BO, K, NY, P, SING); B. Tengkojoeng, 450 m., *bb 25115* (BO, L, MO); Afd. Beneden Matan, S. Kendawangan, 10 m., *bb 14428* (BO, L). **JAVA. BARAT:** cult. in hort. Bogor. (seed from Bangka) sub *VI C 47* (BO, BRI, G, K, LAE, MO, NY, P, SING, US).

ECOLOGY. Mixed dipterocarp forest, to 300(-590) m. alt. Sometimes on sandy soil; on beach; on dry land with patches of low scrub; in swamp forest. Flowering all year, mostly June to September (flower scented, sometimes foetid (*Ridley 13305*)); fruiting October to June (fruit dull green). Fruit eaten by fruit bat (*Pteropus edulis*) in Malaya (*Ridley, 1930*); however, this report may properly refer to fruits of *C. tetrapterum*.

Anthony (1974) reported several galls on *Calophyllum pulcherrimum* in Singapore. A psyllid made the leaf revolute with undulations and crisped edges; the midrib became abaxially curved, and the petiole twisted. A possibly undescribed species of the midge genus *Bruggmanniella* caused fleshy spheroid galls, which were often attached to the midrib on the abaxial surface of the leaf; another midge gall caused swellings of the stem, petiole, and midrib. A moth larva formed an elongated swelling of the lamina roughly parallel to the midrib.

GERMINATION AND YOUNG PLANT. The radicle emerges after the stone wall to one side of the base has been broken. The seedling has usually three, but sometimes up to five, pairs of scale leaves and two pairs of normal leaves, all separated by well-developed internodes; the first pair of scale leaves is borne 0.5-1.8 cm. from the cotyledonary node. The terminal bud may produce the first flush of leaves; scale leaves are not produced at the beginning of this flush. However, in the forest even the first flush is often produced by an axillary bud (the terminal bud being damaged?), subsequent flushes seem always to be produced by axillary buds, and there are scale leaves at the bases of the innovations. The young plant is strongly arched, but as the plant gets older the lower part of the stem straightens. (*Stevens et al. 47*; seedlings from *Stevens et al. 333* grown at Kuching but unfortunately later eaten by a dog. Details of the young plant sent by P. J. Martin.)

LOCAL USES. The wood is good for poles, fishing stakes, masts, and similar objects, and is also used in construction and for ships' knees. The fruit is sour but edible.

Specimens of *Calophyllum pulcherrimum* can be recognized by their usually nonfunctional terminal buds, axillary innovations with basal scars, and leaf blades with the midrib flat to depressed below and broadly raised and continuous with the leaf surface above. The fruit is ovoid, at least 1.5 cm. long, and strongly wrinkled when dry; the outer layer of the fruit is 1-2.2 mm. thick, and the stone walls are 0.3-0.5 mm. thick. The epithet *pulcherrimum* means "most beautiful," a not inappropriate name for the often very floriferous specimens of this species.

Sterile or flowering specimens of *Calophyllum pulcherrimum* are very difficult to distinguish from *C. nodosum*, and some of the specimens of *C. pulcherrimum* from Kalimantan cited above may be wrongly identified. *Calophyllum nodosum* in turn is very similar in both flower and fruit to *C. depressinervosum* (FIGURE 21), although vegetatively the two can be distinguished fairly easily. The differences between the three species are summarized in TABLE 11, but work is needed to confirm the possible differences in seedling and in the growth of the young plant. All three species were found growing by a logging road at Sabal Tapang (Sarawak), and in undisturbed forest there trees of *C. pulcherrimum* and *C. depressinervosum* were growing within 30 meters of each other on a ridge.

Calophyllum pulcherrimum has often been confused with *C. floribundum* (= *C. tetrapterum* var. *tetrapterum*), and although Henderson and Wyatt-Smith (*loc. cit.*) clearly separated the two, the confusion still seems to persist, to judge by determinations on specimens. The two species can be separated very easily, even in the absence of flowers and fruits. *Calophyllum tetrapterum* has a functional terminal bud, its axillary innovations usually lack basal scars, and the midrib on the lower (and usually also on the upper) surface of the lamina is clearly raised (FIGURE 7, c). The fruits of *C. tetrapterum* are usually less than 1.3 cm. long and lack the relatively thick outer layer and stone walls of those of *C. pulcherrimum*. Although the leaf margin of *C. tetrapterum* is often markedly paler than the rest of the blade when dry, this is not always the case, and the margin of the blade may be a similarly pale color in some specimens of *C. pulcherrimum*.

The confusion between the two species is of long standing. There are specimens of *Calophyllum floribundum* *sensu stricto* in some herbaria mounted with the label of *Wallich dist. 4848*, the type number of *C. pulcherrimum*. One of the three numbers collected by Maingay and cited as *C. floribundum* in the original description of that species is a specimen of *C. pulcherrimum* (see the discussion after *C. tetrapterum*). Some synonyms of *C. tetrapterum* have been cited under *C. pulcherrimum*, and Boerlage (*loc. cit.*) reduced *C. gracile*, a synonym of *C. tetrapterum* and a good match with the lectotype of *C. floribundum*, to varietal rank under *C. pulcherrimum*. Specimens of *C. pulcherrimum* with the name *C. pulcherrimum* var. *gracile* were widely distributed (cult. Hort. Bogor. sub VI C 47). Finally, on one sheet of *Pierre 3645* at Paris (*C. tetrapterum* var. *tetrapterum*, collected in Cambodia), there are some small pieces of fruiting *C. pulcherrimum*. I have not seen any other material of *C. pulcherrimum* from north of Malaya, and the fragments of this species on *Pierre 3645* probably came from Maingay's specimen that *Pierre* (*loc. cit.*) used to illustrate the fruits of his *C. pulcherrimum* (properly *C. tetrapterum* var. *tetrapterum*).

61. *Calophyllum* sp.

Tree ca. 4.5 meters tall; trunk and bark unknown.

Twigs slightly flattened, 1.2–1.8 mm. across, rounded to obscurely 4-angled, drying brown, sparsely puberulent when very young; axillary innovations with basal scars; internodes 0.8–3.2 cm. long, first-developed internode often

twice as long as others; uppermost pair of axillary buds rounded, ca. 0.6 mm. long, suberect, sometimes subglabrous; terminal bud plump, 1-1.5 mm. long, with subadpressed, brown indumentum (hairs, FIGURE 22, i), underdeveloped internode to 1 mm. long. Petiole 3-4 mm. long, concave above and convex below, puberulent at edge when very young; lamina obovate, 2-3.7 by 0.9-2.3 cm., rounded to shallowly retuse at apex, cuneate at base, slightly undulate and not recurved at margin, coriaceous, drying umber above and umber or sepia below, glabrous even when young, the midrib above abruptly narrowed at base, flat at first, becoming slightly raised, 0.15-0.25 mm. wide at midpoint, below slightly raised, striate, inconspicuous, the venation apparent above and below, raised, 5 to 7 veins/5 mm., angle of divergence 45-55°. Inflorescences from foliate axils, with 7 to 11 flowers, unbranched, the axis 4-6 cm. long, glabrous, lowest internode and first pair of flowers not developed, next internode 1.8-3.5 cm. long, others 0.8-1.5 cm. long; bracts foliaceous, to 2.6 by 2 cm., persistent; pedicels ca. 8 mm. long, glabrous. Flower (?)hermaphroditic, known only in bud; tepals 8; stamens ca. 120, the anthers elliptic, ca. 0.3 mm. long; stigma peltate. Fruit unknown.

DISTRIBUTION. Known only from one collection made in the 4th Division, Sarawak (MAP 20).

SPECIMEN SEEN. Sarawak: Baram, G. Api, 1219 m., 12 July 1961, S 4732 coll. Anderson (K, SAR).

ECOLOGY. Exposed submontane forest on limestone hill, 1219 m. alt.

Calophyllum sp. 61 is a distinctive taxon. It has a small terminal bud, axillary (and terminal) innovations with basal scars, and small leaf blades in which the midrib is flat on the upper surface and more or less raised on the lower. The axillary inflorescences, with their basal scars, foliaceous, persistent bracts, and long, first fully developed internodes are striking. However, until the fruits are known, it seems premature to name this taxon.

62. *Calophyllum pelewense* P. F. Stevens in Fosberg & Sachet, *Smithson. Contr. Bot.* 45: 12. 1980. TYPE: Pelew Islands, July-Aug. 1929, Kanehira 386 (holotype, A; isotypes, BISH, NY). FIGURE 24, f.

C. cholobtaches auct., non Lauterb.; Kanehira, *Bot. Mag. Tokyo* 45: 329. 1931, *Fl. Micronesica*, 233. fig. 105. 1933, *Jour. Dept. Agr. Kyushu Imp. Univ.* 4: 370. 1935.

Tree; trunk and bark not known.

Twigs flattened, 1.5-2 mm. across, strongly 4-angled to subulate, drying brown, glabrous; axillary innovations with basal scars; internodes (0.5-)-1-3 (-5.5) cm. long; uppermost pair of axillary buds rounded, ca. 0.5 mm. long, spreading; terminal bud plump, 1-2.5 mm. long, with short, gray, adpressed indumentum (hairs, FIGURE 22, g, h), underdeveloped internode 1-2.5 mm. long. Petiole 0.9-1.5 cm. long, shallowly and narrowly to broadly concave above, convex below, glabrous; lamina elliptic to ovate (rarely obovate), 3.5-10.2 by 2.1-4.9 cm., acuminate (rarely \pm rounded) at apex, acute to

attenuate at base, undulate and slightly recurved at margin, coriaceous, drying umber on both surfaces, glabrous, the midrib above gradually narrowed from base, not depressed or slightly so, the edges not raised or slightly so, 0.35-0.6 mm. wide at midpoint, below raised, \pm striate, the venation subapparent on both surfaces, raised, 5 to 10 veins/5 mm., angle of divergence 55-70°. Inflorescences from foliate axils (rarely terminal), with 9 to 17 flowers, unbranched, the axis 1.3-8 cm. long, puberulent at base, lowest internode to 2 mm. long; bracts subobovate, ca. 3.5 mm. long, soon deciduous; pedicels 1-2.5 cm. long, glabrous. Flower (?)hermaphroditic; tepals 8 to 11, the outer pair broadly ovate, ca. 4 mm. long and across, the inner ones obovate, 5.5-6 by 3.5-4.5 mm., glabrous; stamens 125 to 230, the filaments ca. 3 mm. long, the anthers suboblong, 0.8-1 mm. long, retuse at apex; ovary ca. 2 mm. long, the style ca. 2.2 mm. long, the stigma peltate, 0.7-1.2 mm. across, \pm 3-radiate. Fruit probably ellipsoid, ca. 1.5 by 1 cm., rounded at apex, drying viaceous-brown, wrinkled; outer layer (?)not detaching cleanly from stone, ca. 0.5 mm. thick, with air spaces developing; stone with walls ca. 0.2 mm. thick; spongy layer unknown.

DISTRIBUTION. The Caroline Islands, Palau group (MAP 20).

ADDITIONAL SPECIMENS SEEN. **Caroline Islands:** Korrör, *Raymondus* 334 (?) (WRSL); Palau, Garusamao, *Takamatsu* 1556 (BISH, US); Amiliki [Aimiriik], *Hosokawa* 7216 (BISH); Aimiriik, *Kanehira* 1984 (K, P, NY, US); Almatan [Armitin], 8 m., *Takamatsu* 1525 (BISH); Airai, *Kanehira* 2380 (NY); Ngerikill R., *Fisher* 25 (US), 55 (US); sine loco, *Ledermann* 14489 (K).

ECOLOGY. River banks at landward edge of mangroves. Flowering in March (flower scented); submature fruit in March, young fruit July and August.

Calophyllum pelewense can be recognized by its very short terminal bud; axillary innovations with basal scars; axillary inflorescences with a short basal internode; usually elliptic to ovate leaf blades with rather prominent, distant venation, flowers with eight to eleven tepals; and fruits of moderate size (ca. 1.5 cm. long). The epithet *pelewense* is derived from Pelew (Palau) Islands, where this species grows.

Specimens of *Calophyllum pelewense* have been labeled *C. cholobtaches* (= *C. soulattri*), but the two species are not at all close. *Calophyllum soulattri* has a longer terminal bud, a greenish-drying lamina, a branched inflorescence, flowers with four tepals, and a spherical fruit with a thick, compact outer layer.

63. *Calophyllum pyriforme* P. F. Stevens, sp. nov.

FIGURE 23, a-c.

A speciebus aliis Calophylli quibus fructibus stipitatis habent in lamina longiore magnis tenuiter coriacea apice longe acuminata pagina infra indumento subpersistenti praedita et fructu apice rotundato, non acuto, differt.

Tree 4.5-7.5 meters tall, d.b.h. to 9 cm.; trunk without buttresses; outer bark brown, yellowish, or gray-black, sometimes with shallow fissures, exfoliating in thin scales; inner bark red-brown or yellowish white; latex yellow.



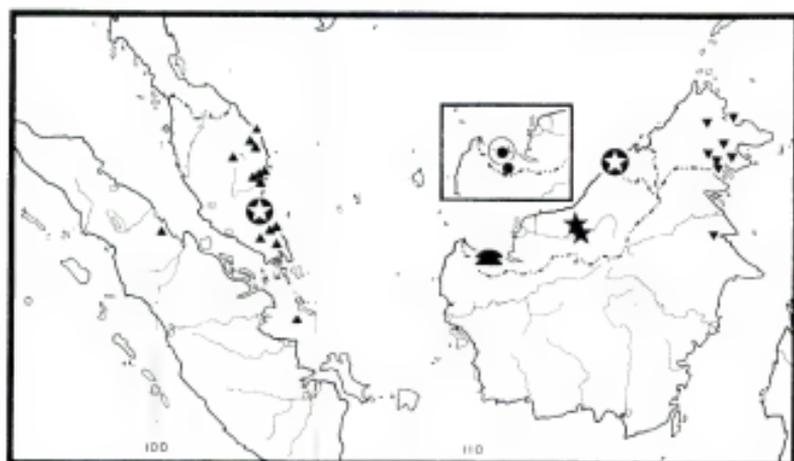
FIGURE 23. a-c, *Calophyllum pyriforme*: a, habit (SAN 64779), $\times 0.5$; b, terminal bud (SAN 21748), $\times 0.75$; c, fruit (SAN 19092), longitudinal section, $\times 1$. d-f, *Calophyllum* sp. 65 (S 23854). d, e, fruit, $\times 1.25$; d, from outside; e, longitudinal section. f, terminal bud, $\times 6$.

Twigs slightly flattened, 2-2.5 mm. across, slightly 4-angled, drying brown, at first tomentose, glabrescent; axillary innovations with basal scars, or scars up to 1.8 cm. from base; internodes (1)-1.5-7(-8) cm. long; uppermost pair of axillary buds rounded, to 2 mm. long, \pm spreading, not conspicuous; terminal bud conical, 4.5-11 mm. long, with short, tomentose, brown indumentum (hairs, FIGURE 27, c), underdeveloped internode absent. Petiole 1-1.7 cm. long, narrowly channeled above, convex below, subsersistently tomentose; lamina elliptic to suboblong, 11.5-23 by (3.7)-5-8.8 cm., abruptly acuminate at apex, acumen to 1.5 cm. long, acute at base, undulate and sharply but

narrowly recurved at margin, thinly coriaceous, drying umber to olivaceous above and honey to pale olivaceous below, tomentose on midrib above and over entire lower surface, the midrib above abruptly narrowed near base, raised, sulcate at first, 0.1–0.2 mm. wide at midpoint, below raised, substrate, the venation apparent to subobscure on both surfaces, raised, 6 to 9 (to 11) veins/5 mm., angle of divergence 70–80°. Inflorescences from foliate axils (very rarely terminal), with 5 to 9 flowers, unbranched, the axis 1.2–3.5(–7.5 in fruit) cm. long, subsersistently tomentose, lowest internode (absent to) 3–8 mm. long; bracts narrowly ovate, ca. 4 mm. long, deciduous; pedicels 0.8–1.2(–2.2) cm. long, subsersistently tomentose. Flower (?)hermaphroditic; tepals 8, the outer pair broadly ovate to elliptic, 5–6 by 4–4.5 mm., short-tomentose on back, the next pair elliptic, 8.5–9.5 by 4–6 mm., the inner ones narrowly elliptic, 8–10 by ca. 3 mm. (rarely ca. 7.5 by 4 mm.); stamens 190 to 265, the filaments to 5.7 mm. long, connate for up to 2 mm., the anthers elliptic-oblong, 0.5–0.8 mm. long, shallowly retuse at apex; ovary ca. 2 mm. long, the style 4–5 mm. long, the stigma peltate, ca. 0.6 mm. across, 4-radiate. Fruit obovoid, 1.7–3 by 1.3–1.6 cm., apiculate, stipe fibrous and 6–10 by 5–7 mm., drying dark brown, sharply wrinkled; outer layer not detaching cleanly from stone, 0.6–1 mm. thick, compact, fibrous; stone ellipsoid, 1.6–1.75 by 1.1–1.3 cm., rounded at apex, the walls less than 0.1 mm. thick, smooth, (?)unmarked; spongy layer thin.

TYPE: North Borneo [Sabah], Bettotan, near Sandakan, 10 Aug. 1927, SFN 19092 coll. *Boden Kloss* (holotype, L; isotypes, K, LAE, NY, SING, UC).

DISTRIBUTION. Eastern Borneo (MAP 23).



MAP 23. Distribution of *Calophyllum flavo-ramulum* (erect triangles), *C. stipitatum* (stars in solid circles), *C. glaucescens* (half-circles), *Calophyllum* sp. 65 (solid stars), and *C. pyriforme* (inverted triangles) in Malesia. Inset: *C. elegans* (solid circles), *C. roseocostatum* (open circle).

ADDITIONAL SPECIMENS SEEN. **Borneo.** SABAH. Labuk & Sugut: Mile 80 Labuk Road, 150 m., SAN 38780 (SAN). Kinabatangan: timber camp at Daramakud, SAN 16863 (A, BO, KEP, L, SING); Brassey Range, 620 m., Stevens et al. 475A (A); G. Rara F.R., ca. 32 km. NW. of Luasong camp, 366 m., SAN 75782 (K, L, SAN, SING); ca. 48 km. NW. of Luasong camp, 488 m., SAN 75654 (A, L, SAN, SING); Old Road, Luasong, 27 m., SAN 64779 (K, L, SAN). Lahad Datu: Mostyn, Tingkayu area, 90 m., SAN 54523 (SAN); N. of Camp 3, Ulu Sg. Danum, SAN 85237 (A, KLU). Tawau: Mile 33, main road Kalabakan, SAN 65829 (K, L, SAN). **KALIMANTAN.** TIMUR: Berau, near Telukbajur, *Koster-mans* 21748 (BO, CANB, G, L, P, SAR, SING).

ECOLOGY. Along river banks or in periodically inundated forest, also hilly country, sometimes on sandy soil; to 620 m. alt. Flowering March and April; fruiting August and September (fruit pale green).

Calophyllum pyriforme is perhaps the most distinctive species in the group of taxa that have stipitate fruits with a fibrous outer layer and a thin-walled stone; these species all have scars at or near the bases of the axillary innovations (see TABLE 12). It can be recognized by its rather large leaf blades that are long-acuminate at the apex and that have subsistent, tomentose indumentum on the lower surface; by the tomentose indumentum on the inflorescence axis, pedicels, and the backs of the outer tepals; and by its fruits, which are rounded at the apex. The hairs are distinctive, with the thickening of the walls so poorly developed that the cross walls are invisible (FIGURE 27, b). The pear-shaped fruits suggested the specific epithet.

Calophyllum pyriforme has been confused with *C. rubiginosum*; however, the two species are only superficially similar and are not closely related. *Calophyllum pyriforme* has twigs that dry brown, not yellow; inflorescences that are nearly always axillary, rather than terminal; and anthers that are glabrous, not hairy. The pyriform fruits of *C. pyriforme* are not furfuraceous, while the ellipsoid fruits of *C. rubiginosum* are.

Some specimens appear to have rather regular variation in internode length along the main stem. Internodes are periodically shorter; the leaves at the nodes above these short internodes are soon deciduous. These shorter internodes are probably the first of the flush. The presence of scars at the start of axillary innovations is not as constant as it is in other members of this group.

64. *Calophyllum roseocostatum* P. F. Stevens, sp. nov. FIGURE 21, g-i.

A speciebus aliis Calophylli quibus fructibus stipitatis habent in ramulis tenuis 1.3-2.2 mm. in transversis, internodio terminali innovationis aliis subaequant, lamina in siccitate nitida costa (rubro-)brunnea cetera paginae olivacea, et fructu apice saepe rotundato, differt.

Tree 14-27 meters tall, d.b.h. to 70 cm.; trunk without buttresses (spurred); outer bark yellow-brown to grayish, with deep, distant, boat-shaped fissures, the inner surface orange-red or blackish; under bark dark red to chestnut; inner bark dark red; latex yellow, opaque, not viscous.

Twigs somewhat flattened, 1.3–2.2 mm. across, 4-angled, drying brown, glabrous (farinose when young); axillary innovations usually with pair of scars within 5 mm. of base; internodes 1–5 cm. long; uppermost pair of axillary buds rounded, less than 1 mm. long, subspreading; terminal bud narrowly conical to \pm plump, 2.5–4 mm. long, with compact, brown indumentum (hairs, FIGURE 22, k; cf. 22, l), underdeveloped internode to 3 mm. long. Petiole 1–1.6 cm. long, slender, concave above and convex below, glabrous; lamina elliptic to oblong, 5.7–11.1 by 2.3–3.1 cm., acuminate at apex, narrowly cuneate to acute at base, undulate and slightly recurved at margin, coriaceous, drying olivaceous and shiny above, greenish olivaceous-buff below, glabrous, the midrib gradually narrowed from base, slightly raised, center \pm sulcate, 0.25–0.4 mm. wide at midpoint, below raised, striate, the venation apparent on both surfaces, raised, 11 to 15 veins/5 mm., angle of divergence 65–75°. Infructescences from foliate axils, with scars of 5 to 7 flowers, not branched, the axis 0.7–2 cm. long, puberulent, lowest internode to 2 mm. long; bracts not known; pedicels 1–1.5 cm. long, puberulent (glabrous toward apex). Flowers not known; tepals (from scars) 8. Fruit obovoid, 2.6–4.2 by 1.7–2 cm., rounded to obtuse at apex, stipe fibrous and 0.6–1.2 cm. by ca. 6 mm., drying brown, wrinkled; outer layer not detaching cleanly from stone, ca. 1.5 mm. thick, compact, but air spaces developing under skin; stone ellipsoid, ca. 2 by 1.3 cm., rounded at apex, the walls less than 0.1 mm. thick, smooth, unmarked; spongy layer becoming thin.

TYPE: Sarawak, Kuching, Semengoh F.R., 90 m., Sept. 1961, S 14941 coll. Galau (holotype, k; isotypes, l, sar).

DISTRIBUTION. Northwestern Borneo, known only near Kuching (MAP 23).

ADDITIONAL SPECIMENS SEEN. **Borneo.** SARAWAK. 1st Division: 12th Mile, Penrissen Road, Semengoh F.R., S 26299 (A, K, L, SAN, SAR, SING), S 25388 (K, L, SAR, SING), 60 m., S 14760 (K, SAR); outside Arboretum, S 33541 (A, SAN, SAR), Stevens et al. 136 (A).

ECOLOGY. Well-drained mixed dipterocarp forest, ca. 60 m. alt. Fruiting April, September, and October.

Calophyllum roseocostatum can be recognized by its slender twigs, the scars of the bases of the axillary innovations, its short terminal buds, and its medium-sized, elliptic to oblong lamina with the midrib on the upper surface drying reddish brown and almost level. The fruits are stipitate. The epithet alludes to the color of the midrib on the upper surface of the dried lamina.

Calophyllum roseocostatum is a member of the group of taxa centered around *C. pyriforme*; the differences separating the taxa in the group are given in TABLE 12. Further collections may change the rank of the taxa recognized here; it is perhaps a little surprising that *C. roseocostatum* is at least locally quite common around Kuching, but has not yet been found elsewhere.

TABLE 12. Differences between *Calophyllum pyriforme* and its relatives.

	<i>C. pyriforme</i>	<i>C. stipitatum</i>	<i>C. roseocostatum</i>	<i>Calophyllum</i> sp. 65	<i>C. elegans</i>
HAIRS BRANCHED, ALL CELLS UNTHICKENED	+	-	-	-	-
GENERAL INTERNODE LENGTH (cm.)	1.5-7	1.2-3.5	1-5	1-3.5	1.5-3
TERMINAL INTERNODE LENGTH (cm.)	1.5-7	0.2-0.6	1-5	1-3.5	(0.3-)0.5-1
TWIG THICKNESS (mm.)	2-2.5	2-2.5	1.3-2.2	2-2.3	1.6-2.5
TOMENTUM SUBPERSISTENT ON STEM AND LOWER SURFACE OF LEAF BLADE	+	-	-	-	-
LEAF BLADE LENGTH (cm.)	11.5-23	5.4-10.5	5.7-11.1	6-9.2	(3-)4.6-8.5
MIDRIB NARROWING GRADUALLY FROM BASE	-	+	+	+	+
MIDRIB SHARPLY RAISED	-	-	-	+	+
VENATION LESS PROMINENT ON LOWER THAN ON UPPER SURFACE	-	-	-	+	-±
TEXTURE	Thinly coriaceous	Coriaceous	Coriaceous	Coriaceous	Coriaceous
APEX	Long-acuminate	Acuminate	Acuminate	Acuminate	Retuse to subacuminate
FRUIT ROUNDED AT APEX	+	+	+(-)	-	(?)-
GEOGRAPHIC DISTRIBUTION	E. Sabah E. Kalimantan	Malaya (?)Brunei	SW. Sarawak	NE. Sarawak	SW. Sarawak

65. *Calophyllum* sp.

FIGURE 23, d-f.

Tree ca. 21 meters tall, d.b.h. ca. 48 cm.; trunk and bark unknown.

Twigs slightly flattened, 2-2.5 mm. across, strongly 4-angled, drying brown, glabrous when mature; axillary innovations with basal scars; internodes 1-3.5 cm. long; uppermost pair of axillary buds rounded, ca. 1 mm. long, \pm spreading; terminal bud plump, 2-3 mm. long, with brown, subadpressed indumentum (hairs, cf. FIGURE 22, k), underdeveloped internode ca. 2 mm. long. Petiole 6-10 mm. long, deeply concave above, convex below, glabrous; lamina obovate to elliptic, 6-11 by 2.4-4 cm., acuminate at apex, cuneate to acute at base, strongly undulate but only slightly recurved at margin, coriaceous, drying with \pm persistent, grayish, waxy covering, olivaceous above and sabelline below, midrib and margin fulvous on both surfaces, glabrous at maturity, the midrib above narrowing gradually from base, raised, 0.2-0.3 mm. wide at midpoint, below raised, striate, the venation subapparent, clearer above than below, raised, 12 to 15 veins/5 mm., angle of divergence ca. 70°. Infructescences from foliate axils, with scars of 5 to 9 flowers, unbranched, the axis 2.3-4 cm. long, glabrous, lowest internode to 0.5 mm. long; bracts unknown; pedicels 1.6-2 cm. long, glabrous. Flower unknown. Fruit obovoid-ellipsoid, 2.6-3.5 by 0.7-1.3 cm., sharply pointed at apex, stipe 1-1.3 cm. by ca. 8 mm., drying tawny, wrinkled; outer layer not detaching from stone, ca. 1 mm. thick, compact, fibrous; stone ca. 1.15 by ca. 1 cm., rounded at apex, the walls ca. 0.2 mm. thick, smooth, unmarked; spongy layer initially thick.

DISTRIBUTION. Known only from Sarawak (MAP 23).

REPRESENTATIVE SPECIMENS SEEN. **Borneo.** SARAWAK. 3rd Division: Bukit Raya, Kapit, Sibul, 180 m., S 23854 (A, BO, K, KEP, L, SAN, SAR, SING). 4th Division: Bukit Mersing, Ashton 6005 (A).

ECOLOGY. Ridge forest, 180 m. alt. Submature fruit in October.

Calophyllum sp. 65 can be recognized by its axillary innovations with basal scars, its small terminal bud and relatively long underdeveloped internode, and its lamina, which has a grayish covering, a fulvous midrib, and venation that tends to be more prominent on the upper than on the lower surface. The fruits are stipitate and have a fibrous outer layer and a thin-walled stone.

Calophyllum sp. 65 is closely related to such species as *C. stipitatum* and *C. pyriforme*; the differences distinguishing it from these taxa are given in TABLE 12.

66. *Calophyllum stipitatum* P. F. Stevens, sp. nov.

FIGURE 21, a, b.

A speciebus aliis *Calophylli* quibus fructibus stipitatis et innovationibus axillaribus cicatricibus basalibus habent in lamina mediocra in siccitate infra olivacea costa supra plus minusve depressa, et fructu apice rotundato, differt.

Tree ca. 18 meters tall, d.b.h. to 38 cm.; trunk probably without buttresses; outer bark \pm smooth, with broad, shallow, distant, boat-shaped fissures; latex yellow, clear, greenish near cambium.

Twigs flattened, 2–2.5 mm. across, 4-angled or not, drying blackish, at maturity smooth, glabrous; axillary innovations with one or two pairs of basal scars; internodes 1.2–3.5 cm. long, terminal internode 2–6 mm. long; uppermost pair of axillary buds rounded, to 1 mm. long, spreading; terminal bud broadly conical, 2.3–3 mm. long, with short, tomentose, brown indumentum (hairs, FIGURE 22, 1), underdeveloped internode to 2 mm. long. Petiole 0.7–1.5 cm. long, broadly concave above and convex below, glabrous; lamina elliptic to obovate, 5.4–10.5 by 2.3–4 cm., acuminate at apex, narrowly acute to long-attenuate at base, margin rather distantly undulate and slightly recurved, coriaceous, drying with grayish covering, sepia above and olivaceous below, the margins pale, glabrous at maturity, the midrib above gradually narrowed from base, \pm depressed, edges slightly raised, 0.2–0.35 mm. wide at midpoint, below raised, striate, the venation subobscure to apparent on both surfaces, raised, latex canals on lower surface subraised to clearly impressed, 7 to 10 veins/5 mm., angle of divergence 65–70°. Infructescences arising from foliate axils, with scars of 9 to 13 flowers, unbranched, the axis 2.7–4 cm. long, sometimes puberulent at base, lowest internode less than 1 mm. long; bracts not known; pedicels 0.8–1.4 cm. long, glabrous. Flower not known. Fruit (submature) obovoid, ca. 1.8 by 0.9 cm., subsersistently apiculate, stipe fibrous and ca. 8 by 4 mm., drying dark brown with apical part smooth and stipe closely wrinkled; outer layer not detaching cleanly from stone, ca. 0.5 mm. thick, compact, fibrous; stone ellipsoid, ca. 9 by 7.5 mm., rounded at apex, the walls ca. 0.1 mm. thick, smooth, (?)unmarked; spongy layer thick in young fruit.

TYPE: Malaya, Pahang (southeast), Aur forest, reserve at Sungei Aur, flood plain Sungei Aur, 11 May 1967, *FRI 3656* coll. *Whitmore* (holotype, κ ; isotypes, α , KEP , L , SAR , SING).

DISTRIBUTION. The Malay Peninsula, probably also northwestern Borneo, local (MAP 23).

ADDITIONAL SPECIMENS SEEN: **Borneo.** BRUNEI: Andalau, *Ashton s.n.* (SAR); Kuala Belait, *S 10681* (SAR).

ECOLOGY. Lowland rainforest. Submature fruit in May.

Calophyllum stipitatum is clearly related to the other species from Borneo that have stipitate fruits, scars at the bases of the axillary innovations, and inflorescences with very short basal internodes (*C. elegans*, *C. pyriforme*, *C. roseocostatum*, *Calophyllum* sp. 65). The main differences between these species are listed in TABLE 12. The epithet *stipitatum* alludes to the stipitate fruits.

Although the specimens from Brunei cited above as *Calophyllum stipitatum* have several pairs of scars at the bases of the axillary innovations, they agree with that species, rather than with *Calophyllum* sp. 65, in vegetative

characters. However, the identity of these specimens can be confirmed only by the collection of fruiting material.

67. *Calophyllum elegans* Ridley, Kew Bull. 1938: 118. 1938; Masamune, Enum. Phanerog. Born. 475. 1941; Smythies, Common Sarawak Trees, 59. 1965. TYPE: Sarawak, near Kuching, 8 Jan. 1892, *Haviland 968* coll. *Garai* (holotype, K; isotypes, BM, L, P, SAR).

Tree 6–22 meters tall, d.b.h. to 20 cm.; trunk without buttresses; outer bark brown to yellowish brown, with broad, shallow, boat-shaped fissures, not hoop marked, the inner surface deep red to reddish brown; under bark deep red to chestnut brown; inner bark pale red; latex opaque to clear yellow, sticky.

Twigs slightly flattened, 1.6–2.5 mm. across, \pm 4-angled when young, later with 6 \pm raised lines, drying brown to blackish, sparsely puberulent when young; axillary innovations with pair of (sub)basal scars, terminal innovations with ca. 3 pairs of near basal scars; internodes 1.5–3 cm. long; uppermost internode of innovation usually (0.3–)0.5–1 cm. long; uppermost pair of axillary buds rounded, to 1.5 mm. long, spreading; terminal bud plump, 3–3.5 mm. long, abruptly narrowed at apex, with short, subadpressed, brown indumentum (hairs, FIGURE 25, c, d), underdeveloped internode to 2 mm. long. Petiole (0.4–)0.8–1.5 cm. long, deeply concave above, convex below; lamina elliptic to oblong or subobovate, (3–)4.6–8.5 by (1.3–)2.7–4.7 cm., retuse to obtuse (subacuminate) at apex, cuneate to acute at base, slightly undulate and recurved at margin, coriaceous, drying amber to olivaceous above and amber to near sabelline below, glabrous when mature, the midrib above gradually narrowed from base, sharply raised, 0.2–0.45 mm. wide at midpoint, sulcate, below raised, rounded toward apex, striate toward base, the venation rather apparent above, apparent to subobscure below, raised, 6 to 11 veins/5 mm., angle of divergence 70–80°. Inflorescences from foliate axils, with 9 to 11 flowers, unbranched, the axis 1.2–3 cm. long, glabrous, lowest internode lacking; basal bracts broadly ovate, ca. 1.7 mm. long, coriaceous, persistent, upper bracts ovate-elliptic, to 3 mm. long, chartaceous, subpersistent; pedicels 7–9 mm. long, glabrous. Flower (?)hermaphroditic; tepals 8, glabrous, the outer pair ovate to elliptic, 3–3.5 by 2.2–3 mm., \pm keeled, the next pair subobovate, ca. 5 by 2.2 mm., the innermost ones oblong-elliptic, to 3.5 by 1.4 mm.; stamens ca. 95, the filaments to 3.5 mm. long, the anthers elliptic-oblong, 0.6–1 mm. long, retuse at apex; ovary ca. 1.8 mm. long, the style ca. 1.8 mm. long, the stigma infundibular, ca. 0.3 mm. across. Immature fruit ellipsoid-obovoid, shape distorted by drying, ca. 2.2 by 0.8 cm., sharply apiculate, stipe ca. 8 mm. long.

DISTRIBUTION. Western Sarawak, local (MAP 23).

SELECTED SPECIMENS SEEN. **Borneo.** SARAWAK. 1st Division: Semengoh Arboretum, 15 m., *S 5383* (A, BO, K, KEP, L, P, SAN, SAR, SING); G. Matang, 580 m., *Stevens et al. 274* (A); Sempadi F.R., 15 m., *S 6095* (SAR); Sabal Tapang, 190 m., *Stevens et al. 185* (A); Stapok F.R., 10 m., *Stevens et al. 153* (A).

ECOLOGY. Edge of swamp forest, mixed dipterocarp forest on sandy clay soil, and kerangas forest; 10-580 m. alt. Flowering January and February (flower scented).

Calophyllum elegans is characterized by its rather small, thinly coriaceous lamina that has a variously shaped apex, a sharply raised midrib on the upper surface, and apparent venation. The bracts toward the apex of the inflorescence are thinner and less persistent than the coriaceous, persistent basal bracts. The innovations have (sub)basal scars, and the uppermost internode of each innovation is nearly always markedly shorter than the others, the terminal pair of leaves being smaller than the rest (figures in parentheses in the description above). Although only immature fruits are known, they are clearly of the stipitate type. The specific epithet *elegans* ("elegant," "fine") is appropriate for the neat-looking specimens of this species.

Calophyllum elegans is related to the groups of species centered on *C. pyriforme*. For the differences separating it from other taxa in this group, see TABLE 12.

Although *Calophyllum elegans* is superficially similar to some of the forms of *C. tetrapterum*, the two species are not at all close. The internodes of *C. tetrapterum* are usually about the same length, and its innovations usually lack basal scars; the terminal bud is not acutely pointed; the lowest internode of the inflorescence is more or less well developed, and if the inflorescence bracts are subpersistent, they are never small and coriaceous; the fruit is subspherical and lacks a stipe.

68. *Calophyllum oliganthum* Merr. Philip. Jour. Sci. 17: 289. 1920, Enum. Philip. Fl. Pl. 3: 80. 1923. TYPE: Philippine Islands, Mindanao, Surigao del Norte Province, Bucas Grande Island, 10 June 1919, BS 35110 coll. Ramos & Pascasio (isotypes, A, BM, BO, K, P, US).

Tree 1-5 meters tall, d.b.h. to 10 cm.; trunk and bark unknown; branches pendulous.

Twigs slightly flattened, 0.6-1.3 mm. across, not angled, drying blackish when young (grayish when older), glabrous or \pm transiently puberulent; axillary innovations (?) always lacking basal scars; internodes 1.5-7 cm. long; uppermost pair of axillary buds rounded, 0.5-1 mm. long, suberect, not conspicuous; terminal bud conical, (1.5-)2-3 mm. long, with adpressed indumentum (hairs, FIGURE 22, c, d), underdeveloped internode absent (to 2 mm. long). Petiole (0.4-)0.6-1.1 cm. long, shallowly concave above, convex below, usually becoming glabrous; lamina elliptic to ovate (rarely obovate), (2-)3-8 by (0.7-)1.2-3.5 cm., acuminate at apex, (narrowly) cuneate at base, not undulate to slightly so and recurved at margin, coriaceous, drying sepia to sabelline-sepia above, umber to fulvous below, glabrous or with few hairs on midrib below when very young, the midrib above narrowing gradually from base, flat, obscure, surrounding lamina \pm raised, 0.2-0.3 mm. wide at midpoint, below slightly raised to raised, rounded, the venation subobscure above, \pm apparent

and raised below, 8 to 15 veins/5 mm., angle of divergence 60–70°. Inflorescences from foliate axils along stem, with 3 to 5 (to 7) flowers, unbranched, the axis 1–2.5(–3.7) cm. long, sometimes sparsely and transiently subtomentose, at least toward base, lowest internode 0.3–1(–1.7) cm. long; bracts ovate, ca. 1.5 mm. long, caducous; pedicels (0.6–)1–1.8 cm. long, glabrous. Flower (?)hermaphroditic; tepals 4 to 8, the outer two suborbicular, ca. 4 mm. long and across, the next two broadly elliptic, ca. 6 by 4–4.5 mm., others, if present, probably much smaller; stamens 45 to 80, the filaments to 3.5 mm. long, the anthers suboblong, 0.5–1 mm. long, retuse at apex; ovary ca. 1 mm. long, the style ca. 4.5 mm. long, very slender, the stigma ca. 0.4 mm. across, 2- or 3-radiate. Fruit ellipsoid, 1–1.3 by ca. 0.8 cm., rounded at apex, drying dark brown, ± smooth; outer layer not detaching cleanly from stone, less than 0.5 mm. thick, air spaces developing; stone ellipsoid, 8–11 by 5–7 mm., rounded at apex, the walls 0.15–0.3 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. The Philippine Islands, Mindanao (MAP 20).

SELECTED SPECIMENS SEEN. **Philippine Islands.** MINDANAO. Surigao del Norte: Dinagat Is., BS 83812 (NY); sine loco, BS 34520 (A, K, P, US).

ECOLOGY. Small tree, low alt. On Dinagat Island growing on iron deposit. Flowering in June; fruiting April and June.

Calophyllum oliganthum can be recognized by its small, probably nonfunctional terminal buds, its lamina with the midrib on the upper surface flat and the adjacent blade slightly raised, and its axillary inflorescences with a well-developed basal internode. The ellipsoid fruit has a thin outer layer and a thin-walled stone. The epithet *oliganthum* ("few flowers") was coined because the inflorescences have few flowers.

Calophyllum oliganthum is superficially similar to *C. nodosum* and *C. depressinervosum*. All three species have more or less profuse branching due to a weak or nonfunctional terminal bud, leaves with a rather similar midrib on the upper surface, flowers with usually four tepals and few, small stamens, and fruits of similar structure. However, in *C. oliganthum* the axillary innovations lack basal scars, the midrib on the lower surface of the lamina is raised, rather than depressed, the inflorescence is only three to five flowered and lacks flowers close to the base, and the fruit is ellipsoid, rather than spherical; polyembryony has not been observed. Venation density and prominence are more like those of *C. nodosum*, but the lamina is larger and dries darker, and the internodes are much longer.

69. *Calophyllum garcinioides* P. F. Stevens, sp. nov.

FIGURE 24, a–e.

C. cuneatum auct., non M. R. Henderson & Wyatt-Smith; Meijer, Bot. Bull. Herb. Forest Dept. Sabah 7: 15. 1967.

A speciebus aliis *Calophylli* in lamina coriacea canalibus laticibus venulis lateralibus oblique transgressentibus, innovationibus axillaribus cicatricibus basalibus ornatis, floribus cum 12 ad 16 tepalis, et fructu subsphaerico 1.6–2 cm. longo putamine parietibus minoribus 0.2 mm. crassis, differt.

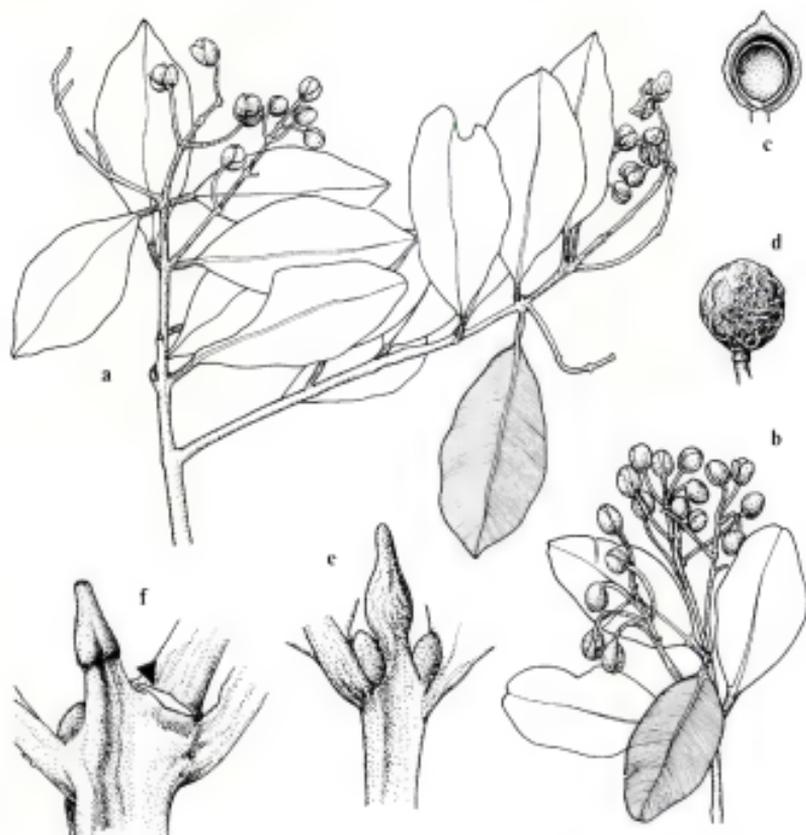


FIGURE 24. a-e, *Calophyllum garcinioides*. a, b, habit, $\times 0.5$: a, SAN 71859; b, SAN 31788. c, d, fruit (SAN 62033), $\times 0.75$: c, longitudinal section; d, from outside. e, terminal bud (SAN 26052), $\times 3$. f, *C. pelewense* (Kanehira 386), terminal bud and axillary inflorescence with basal scar (arrow), $\times 6$.

Tree (1.8-)-9-25(-39) meters tall, d.b.h. to 63 cm.; trunk without buttresses; outer bark usually yellowish brown (brown or gray), fissured, the inner surface brown to greenish brown; under bark red to reddish brown; inner bark red; latex yellow, transparent, sticky (rarely white).

Twigs flattened, 1.5-3.9 mm. across, at first slightly 2-, 4-, or 6-angled, soon becoming rounded, drying blackish brown, glabrous or sparsely farinose-puberulent; axillary innovations with scars 1.5-7 mm. from base; internodes 0.5-3 cm. long; uppermost pair of axillary buds rounded, ca. 1 mm. long, spreading; terminal bud plump, 2.5-6 mm. long, with adpressed, brown to grayish indumentum (hairs, FIGURE 25, e, f; cf. 22, k), underdeveloped internode to 3(-6) mm. long. Petiole 3.5-7 mm. long, broadly and shallowly concave above and convex below, glabrous; lamina obovate or trapeziform to elliptic

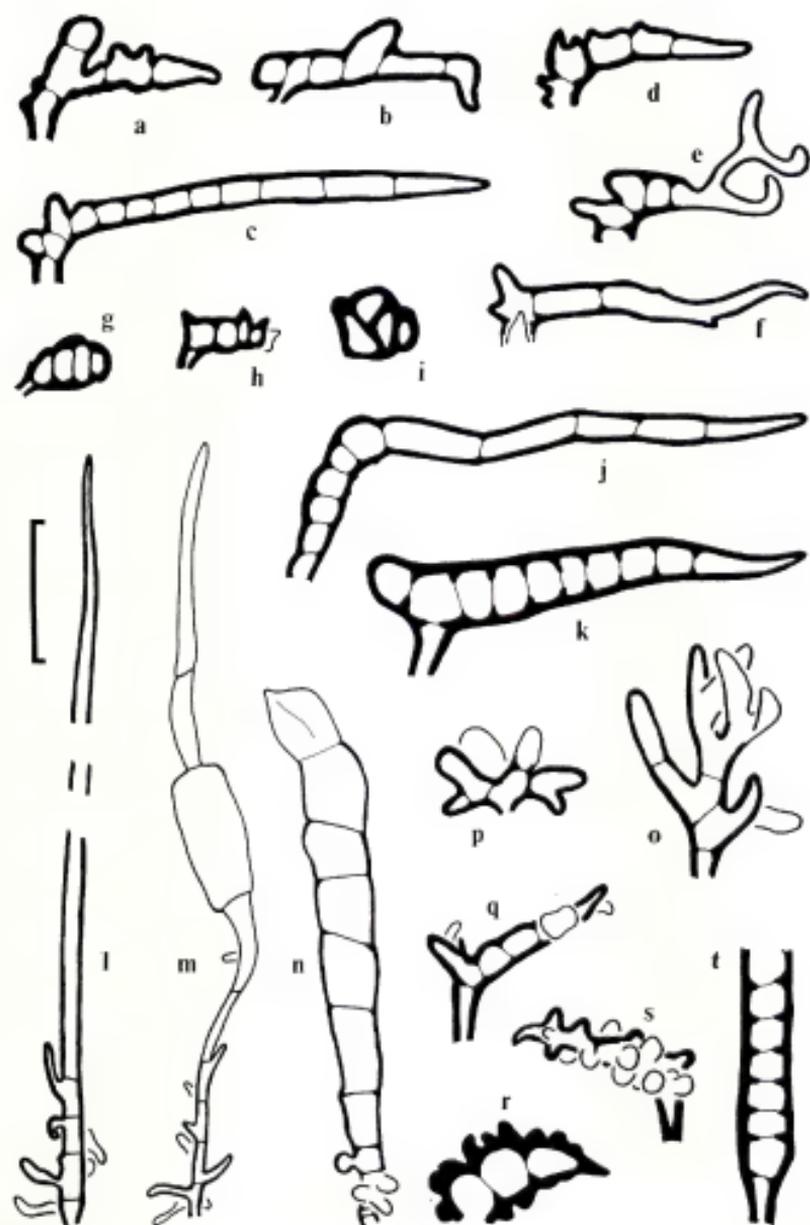
(rarely ovate), 2.5–9.3 by 1.4–5 cm., usually subacuminate to acute (rarely retuse) at apex, narrowly cuneate to rounded at base, distantly and shallowly recurved and at most slightly recurved at margin, coriaceous, drying umber or sabelline above and umber to sepia below, glabrous, the midrib above narrowing gradually or abruptly at base, usually subdepressed (\pm raised), 0.2–0.5(–0.7) mm. wide at midpoint, below raised, obscurely angled to striate, the venation apparent to obscure on both surfaces, raised, beneath usually with latex canals ascending obliquely over veins, 7 to 15 veins/5 mm., angle of divergence 50–75°. Inflorescences terminal and from adjacent foliate axils, with 7 to 17 flowers, branched when terminal (rarely so when axillary), the axis 3–9.5 cm. long, glabrous or puberulent toward base, lowest internode to 3(–11) mm. long; bracts usually soon deciduous (very rarely foliaceous, to 3 cm. long, persistent—*Clemens* 32480); pedicels 0.7–2 cm. long, glabrous. Flower (?)hermaphroditic; tepals 12 to 16, the outer pair broadly ovate to elliptic, 9.5–10.5 by 5.5–9 mm., the inner ones obovate to elliptic, 11–13 by 5–10 mm.; stamens 240 to 330, the filaments to 6 mm. long, connate for up to 0.6 mm., the anthers oblong, 1.1–1.5 mm. long, rounded to slightly retuse at apex; ovary 2–3 mm. long, the style ca. 4 mm. long, the stigma peltate, 1.1–1.4 mm. across, 3- or 4-lobed. Fruit subspherical, 1.6–2 by 1.1–1.4 cm., rounded to strongly apiculate at apex, drying brown, sharply wrinkled; outer layer detaching cleanly from stone, ca. 1 mm. thick, compact; stone subspherical, 1.5–1.9 by 1–1.3 cm., rounded at apex, the walls less than 0.2 mm. thick, smooth, unmarked; spongy layer thin.

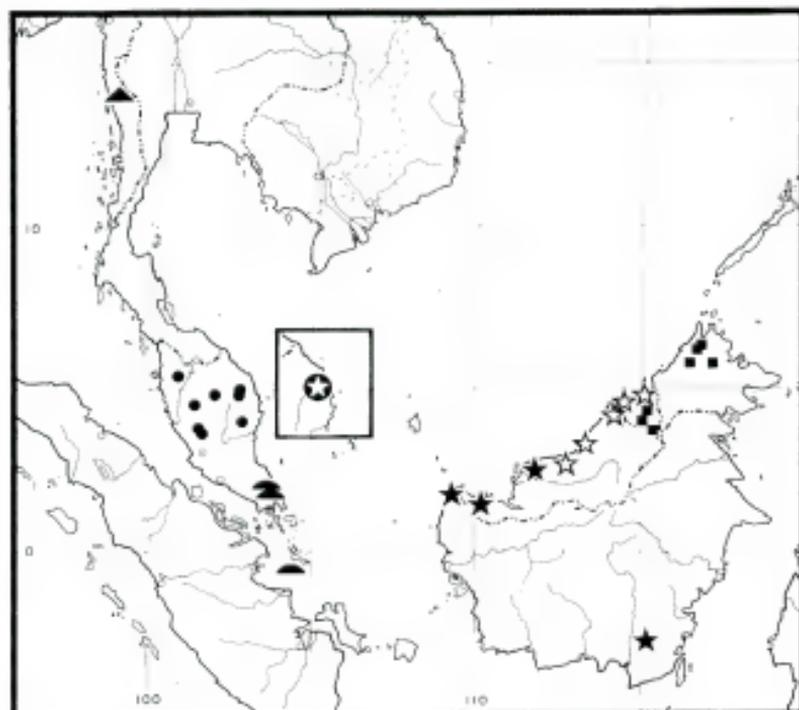
TYPE: North Borneo [Sabah], Ranau, above Mosilau Camp, 15 Aug. 1963, *SAN* 36197 coll. *Mikil* (holotype, *SAN*; isotypes, *A*, *K*, *KEP*, *L*, *SAR*, *SING*).

DISTRIBUTION. Northeastern Borneo (Map 24).

SELECTED SPECIMENS SEEN ("w"—white latex; "y"—yellow latex). **Borneo and adjacent islands.** SARAWAK. 4th Division: Baram, G. Mulu, 1554 m., *Anderson & Keng* *K* 3 (*A*, *BO*, *K*, *L*, *SAN*, *SAR*, *SING*), 1696 m., *S* 4259 (*K*, *L*, *SAN*, *SAR*, *SING*), 1524 m., *Chew* 383 (*A*, *L*, *SING*), 1600–2200 m., *Hotta* 14731 (*L*). 5th Division: Lawas, G. Murut, Ba Kelalan, 2149 m., *S* 26502 (*L*, *SAR*, *SING*), 1829 m., *S* 26372 (*L*, *SAN*, *SAR*). BRUNEI: G. Pagon Periok, 1859 m., *BRUN* 2386 (*K*, *L*, *SAR*). SABAH. Tambunan: Trusmadi, 2134 m., *SAN* 31788 (*K*, *L*, *SAN*). Ranau: Kinabalu Natl. Park & vicinity, 2438 m., *KEP* 71640

FIGURE 25. Hairs (from terminal bud, unless otherwise mentioned). a, b, *Calophyllum parkeri* (*Parker* 2313), from outside of basal scale on inflorescence. c, d, *C. elegans* (*S* 5383). e, f, *C. garcinioides* (*Clemens* 34390, from axillary bud). g–i, *C. sclerophyllum*: g, *Kostermans* 8020; h, *S* E-1 P-649; i, *A* 398, from above. j, *C. havilandii* (*Haviland & Hose* = 3345). k, t, *C. cordato-oblongum* (*CP* 3823) (t, base of hair ca. 450 μ m. long); l–o, *C. teysmannii* var. *inophylloide*: l, *Kostermans* 12792, hair ca. 600 μ m. long; m, *FRI* 5873; n, *Kostermans* 12734; o, *bb* 31797. p, q, *C. hosei* (*Native collector* 889) (q, an uncommon type). r, *C. grandiflorum* (*Kostermans* 23822). s, *C. calcicola* (*Kostermans* 13837). Scale = 60 μ m. (in l, m, scale = 120 μ m.; in r = 30 μ m.).





MAP 24. Distribution of *Calophyllum parkeri* (triangle), *C. fraseri* (circles), *C. enervosum* (half-circles), *C. praetermissum* (solid stars), *C. confertum* (open stars), and *C. garcinioides* (squares) in Southeast Asia and Malesia. Inset: *Calophyllum* sp. 73.

(KEP), 1219 m., SAN 16232 (BO, BRI, KEP, L, SING), 1829 m., 37989 (K, KEP, SAN, SAR, SING), 1219 m., 38068 (?) (Y) (A, KEP, SAN, SAR), 2438 m., 38325 (Y) (K, L, SAN), 71849 (Y) (K, L, SAN, SING), 1524 m., RSNB 4308 (W) (K, L, SAN, SING), 1829 m., 4731 (W) (CANB, K, L, SAN, SING), Clemens 32442 (A, B, BO, G, K, L, M, NY, UC), 1676 m., 33992 (A, BO, G, L, NY, UC), Marai Parai, 1524 m., Clemens 32480 (probable) (A, BO, L, M, NY, UC), 1524 m., 33194 (probable) (A, BO, NY). Kinabatangan: Lamag, Karamuak, Mt. Tavai, 990 m., SAN 51744 (SAN, pro parte).

ECOLOGY. Locally common in lower montane and montane forest, sometimes in soil derived from ultramafic rock; 990–2438 m. alt. Flowering March (Sarawak) and July to September (Sabah); fruiting February to April and June to August (fruit greenish).

GERMINATION AND YOUNG PLANT. The young plant is erect, and the terminal bud is functional. Young plants about 0.5 meters tall have axillary innovations with basal scars.

Although *Calophyllum garcinioides* is at first sight like other small- and coriaceous-leaved species of *Calophyllum* found on mountains, it can readily be distinguished from these other species by the scars at the bases of the axillary innovations, the obliquely ascending latex canals on the lower surface of the lamina, the axillary and terminal inflorescences that usually both have a very short basal internode, the flowers with 12 to 16 tepals, and the subspherical fruit with a thin-walled stone. The characteristic latex canals on the underside of the lamina are not always readily visible on dried specimens; however, they have been observed on specimens from all mountains where it grows. They look like the latex canals of *Garcinia* L.; hence, the specific epithet.

Similar inflorescences, leaves, and axillary innovations occur in some specimens of the poorly known *Calophyllum fraseri*, from Malaya (q.v.). However, that species always has axillary inflorescences, flowers with at most eight tepals, and fruits about twice as large with stone walls ca. 1 mm. thick.

There is considerable variation in leaf shape within *Calophyllum garcinioides*, but the extremes are connected by intermediates. Specimens taken from trees reported to have white latex (all collected by the expedition of the Royal Society, London) tend to have thicker leaf blades that are more obtuse at the apex, while specimens from trees reported to have yellow latex have thinner leaf blades that are more acute at the apex. However, *SAN 29128*, with yellow latex, has a lamina that is rounded at the apex.

Specimens from Mt. Kinabalu that are cited above with a question mark have relatively small, thin leaf blades that are more or less acuminate at the apex and axillary innovations that lack basal scars. *SAN 60644*, which has larger leaf blades that are subacuminate at the apex and scars ca. 7 mm. from the base of the axillary innovations, is intermediate between these and more normal specimens. Further variation is shown by the specimens collected by the Clemenses from Marai Parai, which have leaf blades that are strongly retuse at the apex and rounded at the base, while the specimen of *Clemens 32480* at λ has persistent, foliaceous bracts.

The single specimen seen from Mt. Tavai, in Kinabatangan, is sterile.

70. *Calophyllum fraseri* M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 344. pls. 24, 25. 1956; T. C. Whitmore, Tree Fl. Malaya 2: 182. 1973, *pro parte*. Type: Malaya, Pahang-Selangor border, Fraser's Hill, 28 Sept. 1923, *SFN 11282* coll. *Nur* (holotype, SING; isotype, KEP).
- C. ?praineanum* auct., non King; King, Jour. Fed. Malay States Mus. 7: 39. 1916.
- C. canum* auct., non Hooker f.; Henderson, Gard. Bull. Straits Settl. 4: 93. 1927.
- C. symingtonianum* M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 338. 1956, *pro minore parte*; T. C. Whitmore, Tree Fl. Malaya 2: 192. 1973, *pro parte*.

Tree 15-36 meters tall, d.b.h. to 58 cm.; trunk without buttresses or stilt roots; outer bark dirty deep gray to yellow-brown, dimpled or with shallow fissures at wide intervals; inner bark pale yellow-cream to pink; latex milky (Maxwell's Hill) or clear yellow, resinous (G. Mengkuang, Kelantan); wood yellow.

Twigs rather strongly flattened, 1.8-2.5 mm. across, not 4-angled to slightly so, soon becoming rounded, drying blackish to dark brown, puberulent when young; axillary innovations with or apparently lacking basal scars; internodes 1.5-3(-4.5) cm. long; uppermost pair of axillary buds rounded to subacute, to 1.5 mm. long, adpressed to terminal bud or not; terminal bud plump, 4.5-7 mm. long, with short, subadpressed, ferruginous indumentum (hairs, cf. FIGURE 20, m), underdeveloped internode to 2.5 mm. long. Petiole 0.7-1.2 cm. long, usually shallowly concave above, convex below, glabrous when mature; lamina ovate to elliptic, 5-12.8 by 1.8-4.8 cm., \pm acuminate at apex, acute to cuneate at base, broadly undulate but not recurved or slightly so at margin, coriaceous, drying cinnamon-drab above and sabelline below, glabrous when mature, the midrib above narrowing rather gradually from base, at least margins raised, 0.2-0.6 mm. wide at midpoint, below strongly raised, striate, the venation above and below \pm apparent, raised, at least sometimes crossed by obliquely ascending latex canals, (7 to) 9 to 14 veins/5 mm., angle of divergence 60-70(-80) $^{\circ}$. Inflorescences from foliate axils, sometimes two per axil, with up to 11 flowers, unbranched, the axis 1-4 cm. long, puberulent, especially toward base, or glabrous, lowest internode to 2.5 mm. long; bracts unknown; pedicels 0.5-1.8 cm. long, glabrous, to 2.5 mm. thick in fruit. Flower (?)hermaphroditic; tepals 4 or 8, the outer pair ovate, 4-7 by 3.5-5 mm., the next pair ovate to suboblong, 5-8 by 3-4.5 mm., inner ones, where present, suboblong, ca. 9 by 4 mm.; stamens (?)numerous, the filaments to 3.5 mm. long, the anthers oblong, ca. 1.6 mm. long, retuse at apex; ovary ca. 1.5 mm. long, the style ca. 3.5 mm. long, the stigma peltate, 0.8-1.4 mm. across, (?)3-lobed. Fruit ellipsoid, 2.6-3.3 by 2.3-5.2 cm., apiculate or not, drying vinaceous-brown, deeply reticulate or shallowly corrugate; outer layer detaching \pm cleanly from stone, 1.5-2.5 mm. across, compact; stone ellipsoid, 2.1-3 by 1.6-2.15 cm., rounded at apex, the walls 0.8-1.1 mm. thick, to 3 mm. thick at base, smooth, unmarked; spongy layer initially thick.

DISTRIBUTION. Malaya (MAP 24).

SELECTED SPECIMENS SEEN. **Malaya.** KEDAH: Kedah Peak, 914 m., *Robinson & Boden Kloss 6039* (SING); Gunong Inas F.R., 914 m., *FRI 9262* (KEP). PAHANG: Fraser's Hill, 1219 m., *F.M.S. Mus. 11576* (BO, KEP), path to Pine Tree Hill from Weld Hill, *KEP 28955* (KEP); Bentong, ridge above Sungei Tanglin to G. Mengkuang, 1067 m., *KEP 79614* (KEP); Gunong Berumbun, *Ridley 13910* (prob.) (K, SING); Sungei Ikan, *KEP 27634* (prob.) (SING); Bukit Percival, *KEP 35944* (KEP); Maxwell's Hill, bend 57, 762 m., *KEP 76333* (K, KEP); ridge to G. Tapis, 914 m., *FRI 10974* (A, K, KEP, SAR). KELANTAN: G. Rabong, 1295 m., *FRI 20685* (KEP, SAN). TRENGGANU: G. Padang, 1219 m., *SFN 31878* (KEP, SING); Ulu Brang, camp 3, *FRI 1755* (KEP).

ECOLOGY. Colline or montane rainforest, 760–1295 m. alt. Flowering March and September; submature fruit September and October.

Bilabiate, purselike galls probably caused by coccids (see *Calophyllum teysmannii*) occur fairly commonly (KEP 27634, 35944, 66601; Robinson & Boden Kloss 6126; Ridley 13910).

Calophyllum fraseri is characterized by its elliptic leaf blades that are more or less acute at the base and acuminate at the apex and that have rather clear venation on both surfaces, and by its relatively large (ca. 3 cm. long) fruit that has a compact outer layer and a stone with walls ca. 1 mm. thick. The specific epithet commemorates L. J. Fraser, a trader and mule train operator, who disappeared in 1916 on what was subsequently called Fraser's Hill.

Calophyllum fraseri is perhaps related to *C. garcinioides*, from northeastern Borneo. Leaves of the two species dry similarly and have latex canals ascending obliquely to the venation; both species also have axillary innovations with scars at the bottom (but see below). However, *C. garcinioides* has a smaller (less than 2 cm. long) fruit with a thin-walled (less than 0.2 mm.) stone and larger flowers with 12 to 16 tepals. The base of the lamina in *C. garcinioides* is usually more or less rounded or cuneate; in *C. fraseri* it is acute. *Calophyllum fraseri* is perhaps also close to the poorly known *C. parkeri* (q.v.).

Despite recent collections made from Kelantan and Trengganu, *Calophyllum fraseri* is a very poorly known species, and its variation is not yet understood. Specimens from Fraser's Hill (the type locality) have a small (less than 1.2 cm. long) inflorescence axis that is puberulent toward the base and has a clear basal internode; the flowers have four tepals. Only one specimen with flowers has been collected elsewhere; this specimen (FRI 20685, from Kelantan) has an inflorescence axis at least 2 cm. long that lacks a clear basal internode, and flowers with eight tepals. Axillary innovations with basal scars have been seen only in specimens from Kedah Peak, Kelantan, Trengganu, and perhaps from Cameron's Highlands; much of the material is too poor for confirmation of the presence or absence of these scars, although they appear to be absent on material from Fraser's Hill. Specimens with these scars have more coriaceous leaf blades than the other specimens, and obliquely ascending latex canals are visible on the lower surface. Fruits are known only from Trengganu (G. Padang), and Pahang (Maxwell's Hill and G. Tapis) (i.e., not from the type locality).

Despite this confusing situation, the following points may be noted. First, the specimens of *Calophyllum fraseri* that are most similar to *C. garcinioides* in vegetative characters can be clearly distinguished from that species by characters of both flower and fruit. Second, because fruits are not known from the type locality of *C. fraseri*, it remains to be established whether or not *C. fraseri* from Fraser's Hill is conspecific with the other material cited. Henderson and Wyatt-Smith (*op. cit.*) thought that their *C. cuneatum* was close to *C. fraseri*; *C. cuneatum* (= *C. calaba* var. *cuneatum*) also has flowers with four tepals, but differs most obviously in its very much shorter petioles. Third, the specimens cited that have bilabiate coccid galls are mostly

sterile; I do not know of specimens with both galls and scars at the bases of the axillary innovations. Some specimens determined as *C. fraseri* by T. C. Whitmore have been removed to *C. teysmannii* var. *inophylloide* (q.v.), which has similar galls. The latter taxon is quite variable, and it is possible that some specimens still included in *C. fraseri* will also have to be removed to *C. teysmannii*.

71. *Calophyllum parkeri* Fischer, Kew Bull. 1926: 455. 1926. TYPE: Burma, Tavoy, Nwalabo, 1050 m., 2 Dec. 1924, *Parker 2313* (holotype, κ ; isotype, λ).

Small tree; outer bark cracked into irregular plates, otherwise unknown.

Twigs slightly flattened, 2.5–3.2 mm. across, rounded, drying blackish, glabrous; axillary innovations unknown; internodes 0.5–2.5 cm. long; uppermost pair of axillary buds and terminal buds unknown (hairs, FIGURE 25, a, b). Petiole 5–8 mm. long, broadly and shallowly concave above, convex below, glabrous; lamina elliptic, 5.2–8.5 by 1.6–3.4 cm., cuneate at apex, rounded to subcuneate at base, slightly undulate and somewhat recurved at margin, coriaceous, drying umber above and below, glabrous, the midrib above gradually narrowed from base, flat or slightly raised, 0.3–0.6 mm. wide at midpoint, below raised, striate to subangled, the venation subapparent on both surfaces, slightly raised, 6 to 10 veins/5 mm., angle of divergence 50–60°. Inflorescences axillary and terminal, with up to 13 flowers, unbranched (terminal inflorescences sometimes branched), the axis 3–4 cm. long, glabrous, lowest internode to 1 mm. long; bracts unknown; pedicels to 1.3 cm. long, glabrous. Flower (?)hermaphroditic; tepals 12 (rarely 13), the outer pair orbicular, 3–3.5 mm. long and across, the next pair suborbicular, 6.5–7 by 5.5–6.5 mm., the inner ones elliptic to obovate, 9–12 by 4.5–7.5 mm.; stamens ca. 310, the filaments to 7.5 mm. long, connate for up to 1 mm., the anthers oblong, 1–1.2 mm. long, retuse to rounded at apex; ovary 2–2.5 mm. long, the style ca. 5.5 mm. long, the stigma peltate-infundibular, ca. 1.5 mm. across, not radiate. Fruit unknown.

DISTRIBUTION. Burma (MAP 24); known only from the type specimen.

Calophyllum parkeri is an imperfectly known species that can be recognized by its rounded twigs; moderate-sized, elliptic leaf blades that are cuneate at the apex and subrounded at the base and have a more or less flat midrib on the upper surface; axillary and terminal inflorescences (the former, at least, have a very short or nonexistent basal internode); and 12-tepaled flowers. It is quite possible that the axillary innovations have basal scars. The epithet commemorates the collector, R. N. Parker.

If the axillary inflorescences and axillary innovations of *Calophyllum parkeri* have basal scars, it may be related to the specimens of *C. fraseri*, from the eastern part of Malaya, and to *C. garcinioides*, from Borneo. *Calophyllum fraseri* apparently has four- to eight-tepaled flowers and axillary inflorescences. Although *C. garcinioides* has both axillary and terminal inflorescences and flowers with at least twelve tepals, the tepals of the outermost pair are

about three times the size of those of *C. parkeri*; it also has obliquely ascending latex canals on the lower surface of the lamina.

72. *Calophyllum flavo-ramulum* M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 310. *pls. IC*, 6. 1956; Kochummen, Malayan Forest Rec. ed. 2. 17: 219. 1965; T. C. Whitmore, Tree Fl. Malaya 2: 181. 1973. TYPE: Malaya, Trengganu, Kemaman, Bukit Kajang, 500 feet [150 m.], 8 Nov. 1935, *SFN 30321* coll. *Corner* (holotype, SING; isotypes, A, BO, K, KEP, LAE).

Tree 30-38 meters tall, d.b.h. to 88 cm.; trunk without buttresses; outer bark yellowish to greenish brown, strongly fissured, flaking, ca. 8 mm. thick, in transverse section with orange lines demarcating brown islands; the under surface \pm bright orange; under bark pale straw; inner bark reddish; latex clear yellow, sticky.

Twigs \pm flattened, 2-3 mm. across, rounded or obscurely 4-angled, drying dark to blackish brown when young, yellowish when older, subsersistently reddish brown-puberulent or not; axillary innovations with basal scars; internodes 1.5-4.5 cm. long; uppermost pair of axillary buds rounded, up to 1.5 mm. long; terminal bud plump, 2.5-6 mm. long, with reddish brown-tomentose to grayish puberulent indumentum (hairs, FIGURE 22, q), underdeveloped internode absent. Petiole 0.6-1.4 cm. long, shallowly (deeply) concave above, convex below, subsersistently puberulent or not; lamina oblong (elliptic), 7.5-16 by 1.7-4.8 cm., \pm gradually to abruptly acuminate at apex, cuneate to attenuate at base, undulate and slightly recurved at margin, entire lamina \pm concave, coriaceous, drying brown-vinaceous to umber above and umber to fulvous below, often persistently puberulent on midrib above and especially below, the midrib above usually narrowing gradually from rather narrow base, raised, usually sulcate at first, 0.15-0.35 mm. wide at midpoint, below raised, striate, the venation \pm apparent above and below, raised, 10 to 19 veins/5 mm., angle of divergence 70-80°. Inflorescences terminal and from adjacent foliate axils, with 7 to 15 (axillary inflorescences) to many (terminal inflorescences) flowers, unbranched (flabellate), or with 3-flowered branches to 1 cm. long, the axis 2.4-7 cm. long, reddish puberulo-tomentose (rarely subglabrous except at base), lowest internode of axillary inflorescences to 3 mm. long; bracts not seen, early deciduous; pedicels 0.5-1.5(-2.2) cm. long, puberulent (rarely glabrous), slender at first, in fruit to 3 mm. thick. Flower (?)hermaphroditic; tepals 8, the outer two broadly ovate, ca. 5 by 3.5-4.5 mm., \pm puberulent on back, the next pair obovate, 6.5-10 by 3.5-7 mm., sometimes puberulent on back near base, the inner ones obovate, 7.5-11 by 3-5 mm., stamens 100 to 135, the filaments to 3 mm. long, the anthers oblong-elliptic, 0.5-0.7 mm. long, rounded at apex; ovary ca. 1.5 mm. long, the style ca. 3 mm. long, the stigma peltate, ca. 0.5 mm. across, \pm 3-lobed. Fruit ellipsoid to subspherical, 2.5-3.5 by 2-2.6 cm., rounded to sharply pointed at apex, drying vinaceous-brown, with shallow, fairly dense, rounded wrinkles, or almost smooth (Sumatra); outer layer detaching \pm cleanly from stone, 1.5-2.3 mm. thick, compact; stone ellipsoid, 2-2.6 by 1.75-2.2 cm.,

rounded at apex, the walls 0.9–1.2 mm. thick, thinner to one side of base, smooth, unmarked, perhaps with basal plug ca. 5 mm. across; spongy layer thin.

DISTRIBUTION. The eastern part of the Malay Peninsula, the Lingga Archipelago, perhaps in northeastern Sumatra (MAP 23).

SELECTED SPECIMENS SEEN. **Malaya.** TRENGGANU: Kuala Trengganu, 45 m., *KEP 76064* (KEP); Dungun, Karteh Ulu Chukai F.R., 150 m., *KEP 93882* (KEP); Jerengau State Land, *KEP 76661* (KEP); Bukit Bauk F.R., 150 m., *KEP 93973* (KEP); Kemaman, Bukit Kajang, 150 m., *SFN 30565* (KEP, SING). PAHANG: Kuantan, Bukit Goh F.R., *KEP 77978* (K, KEP); G. Tahan, *Wong & Wyatt-Smith 34* (?) (KEP); Sungei Kelui, G. Tapis, *FRI 10083* (?) (KEP); Baloh F.R., *KEP 40216* (KEP). JOHORE: Kluang F.R., 90 m., *FRI 7521* (A, KEP, SING); Mersing F.R., 15 m., *KEP 77944* (KEP); Jemaluang F.R., *KEP 73552* (KEP); Panti F.R., 366 m., *KEP 99237* (KEP); Lenggong F.R., 35 m., *Stevens et al. 57* (A). **Sumatra and adjacent islands.** RIAU: Lingga, P. Singkep, Marok Toewa bij Soengei Soelit, *bb 1708* (= *Amat 22*) (BO, L), S. Poelak, 25 m., *bb 4031* (= *Amat 6*) (BO). UTARA: Laboehan Batoe, Rattosan, Basau, 50 m., *bb 8978* (?) (BO).

ECOLOGY. Lowland or colline mixed dipterocarp forest, 15–427 m. alt. Flowering January, April, July, and August; fruiting February, May, and July (fruit mauvish black—*KEP 77978*).

Some inflorescences of *SFN 30321* are galled, having been converted into cauliflowerlike structures ca. 1 cm. across.

Calophyllum flavo-ramulum can be distinguished from the other large-leaved species of *Calophyllum* by its short terminal bud, axillary innovations with basal scars, leaf blades that dry boat shaped, and terminal inflorescences. (Although *C. flavo-ramulum* was described as having axillary inflorescences, some inflorescences, even on the type specimen, are terminal.) The older twigs of *C. flavo-ramulum* dry a yellowish color, hence the specific epithet.

Calophyllum flavo-ramulum has been confused with *C. dasypodum*, but the two species are not close. The terminal bud of *C. dasypodum* is longer, its older twigs do not dry yellow, its leaves do not dry boat shaped, its inflorescences are axillary, and its flowers usually have four tepals.

The specimens cited from the Lingga Archipelago are very similar to those from the Malay Peninsula, although they have somewhat smaller flowers and ellipsoid fruits that dry almost completely smooth, with only faint striations. The fruits of the Malayan specimens are variable in shape, but dry wrinkled. In the ellipsoid fruits of *KEP 99237*, the outer layer is much thickened (7 mm.) at the base.

73. *Calophyllum* sp.

Tree ca. 20 meters tall, d.b.h. to 32 cm.; trunk without buttresses; outer bark pale gray to yellow, smooth except for diamond-shaped fissures; latex golden, clear, very sticky.

Twigs slightly flattened, ca. 2 mm. across, not angled, drying pale brownish,

shiny, glabrous; axillary innovations with several pairs of basal scars; internodes 2-3.5 cm. long, uppermost pair of axillary buds rounded, ca. 0.7 mm. long, inconspicuous; terminal bud plump, 2-5 mm. long, consisting of several pairs of glabrous, imbricate scales up to 2.5 by 4 mm., underdeveloped internode absent. Petiole 0.7-1.3 cm. long, shallowly concave above, convex below, drying blackish, glabrous; lamina elliptic to suboblong, 7-13.5 by 3.4-5 cm., acuminate at apex, acute at base, slightly recurved and undulate at margin, entire lamina \pm concave, coriaceous, drying \pm vinaceous-brown above and subchestnut-brown below, glabrous, the midrib above gradually narrowed from base, raised, 0.25-0.5 mm. across at midpoint, below rather narrow, raised, rounded, the venation on both surfaces apparent, raised, 9 to 14 veins/5 mm., angle of divergence 75-80°. Inflorescences, flowers, and fruits not known.

DISTRIBUTION. The Malay Peninsula, Trengganu (MAP 24).

SPECIMENS SEEN. **Malaya.** TRENGGANU: Dungun, Bukit Bauk F.R., 30 m., KEP 53353 (KEP), 77983 (KEP).

Calophyllum sp. 73 is a remarkable taxon that is easily recognized, even when sterile, by its terminal buds, which are composed of a number of decussate, glabrous, imbricate perulae. Such buds are unique in the genus, and fertile material of this taxon is much needed.

KEP 53353 was cited as *Calophyllum ?flavoramulum* by Henderson and Wyatt-Smith (1956), but in that species a pair of indumentum-covered perulae completely enclose the rest of the bud.

74. *Calophyllum enervosum* M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 352. pl. 32. 1956; Kochummen, Malayan Forest Rec. ed. 2. 17: 221. 1965; T. C. Whitmore, Tree Fl. Malaya 2: 180. 1973. TYPE: Malaya, Johore, Mersing, Jemaluang F.R., 30 m., 20 April 1954, KEP 71894 coll. Wyatt-Smith (holotype, KEP; isotypes, BO, K, SING).

Tree 24-33 meters tall, d.b.h. to 50 cm.; trunk without buttresses; outer bark greenish olive to yellowish, smooth to rough and cracking very finely, hoop marked, the inner surface dull brownish orange; under bark dull reddish; inner bark reddish, laminated; latex clear yellow, very sticky, reported to turn cloudy (Henderson & Wyatt-Smith, *loc. cit.*).

Twigs slightly flattened, 2-2.7 mm. across, (obscurely) 4-angled, soon becoming rounded, drying blackish when young, later whitish to brown, \pm brown-tomentose when young; axillary innovations with pair of scars 2-5 mm. from base; internodes 1-3 cm. long; uppermost pair of axillary buds rounded, less than 1 mm. long, inconspicuous; terminal bud plump, 2-4 mm. long, with ferruginous, puberulo-tomentose indumentum (hairs, FIGURE 27, a), underdeveloped internode absent. Petiole (0.3-).0.5-1 cm. long, flat to broadly and shallowly concave above, convex below, glabrous; lamina elliptic to obovate, 3-9 by 1.4-4.8 cm., rounded to shortly and rather obscurely acuminate at apex, narrowly cuneate to attenuate and finally decurrent at base, not or broadly and rather distantly undulate and not or slightly recurved

at margin, marginal thickening ca. 0.3 mm. wide, coriaceous, drying umber above and below, transiently tomentose on midrib below when young, otherwise glabrous, the midrib above narrowing gradually from sulcate base, becoming flat to slightly raised, 0.15–0.3 mm. wide at midpoint, below raised, striate, the venation \pm obscure above and below, slightly raised or not, 7 to 10 veins/5 mm., angle of divergence 65–75°. Inflorescences terminal and from foliate axils along twigs, with 7 to 11 flowers, usually unbranched (sometimes with 3-flowered branches to 4 mm. long), the axis 1.5–2.5 cm. long, \pm persistently short-tomentose, lowest internode 1–2 mm. long; bracts ovate, ca. 4 mm. long, subpersistent, short-tomentose below; pedicels in fruit 5–10 mm. long, persistently subtomentose or not. Flowers known only in very young bud. Submature fruit ellipsoid to obovoid, 1.4–1.7 by 1.1–1.2 cm., \pm rounded at apex, drying vinaceous-brown, deeply and sharply wrinkled; outer layer detaching cleanly from stone, 1–1.8 mm. thick, compact, except for air spaces developing under skin; stone ellipsoid to obovoid, ca. 1.1 by 0.8–0.95 cm., rounded at apex, the walls ca. 0.15 mm. thick, smooth, unmarked; spongy layer thick at first.

DISTRIBUTION. The Malay Peninsula (Johore) and the Lingga Archipelago (MAP 24).

ADDITIONAL SPECIMENS SEEN. **Malaya, JOHORE:** Mersing, *KEP 5823* (κ); Sungei Serah, Mersing F.R., 30 m. plus, *KEP 92104* (*KEP*); Jemaluang F.R., 15 m., *KEP 72907* (*KEP*), *Stevens et al. 72* (α); G. Panti E., *Jumali & Kuswata 194* (atypical, ?sapling) (*so*). **Sumatra and adjacent islands, RIAU:** Lingga Arch., P. Singkhep, Sungei Roengkil, 10 m., *bb 4082* (*so*); Tandjong Batang, 8 m., *bb 4016* (*so*).

ECOLOGY. Mixed dipterocarp forest, 8–40 m. alt. Locally common, at least on Lingga Archipelago. Submature fruit April and May.

GERMINATION AND YOUNG PLANT. The young plant is erect, and the terminal bud is functional. When young the leaf blades are bright red with a broad green stripe ca. 5 mm. wide down the middle.

Calophyllum nervosum is an easily recognized species because of its rather small, coriaceous leaf blades that dry nearly flat with almost invisible venation and that are narrowly cuneate to decurrent at the base. The rather small, deeply wrinkled fruit with its relatively thick outer layer is also distinctive. The almost invisible venation of the dried leaves suggested the specific epithet.

The specimens cited above from the Lingga Archipelago are good matches with those from Malaya, although their indumentum is somewhat longer and their leaf blades are a little more pointed at the apex. Fruits are known from both areas and are identical; they have not been described before.

Erratum—On page 43 of Volume 61, number 1, of the *Journal of the Arnold Arboretum*, January, 1980, the caption to FIGURE 1 should read as follows: FIGURE 1. Z. Wang, discoverer of *Metasequoia glyptostroboides*, right, with his teacher, Professor T. N. Liou, seated, and S. Y. Hu, left, July, 1975.

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COVER: The shoots and fruits (about natural size) and a single trichome (magnified nearly 160 times) of a Fijian endemic, *Calophyllum leucocarpum* A. C. Smith, form the basis of this year's stylized cover design. A row of trichomes is used in the device on the back cover, while a cluster of leaves appears on the offprints. As in recent years, the designs, based on holotype material in the herbarium of the Arnold Arboretum, were drawn by Karen Stoutsenberger.

Calophyllum L. (Guttiferae) is a wide-ranging genus of tropical forest trees in both the New and Old Worlds, and some species are of considerable economic importance as sources of valuable timber. Its use on the cover of this volume of the *Journal of the Arnold Arboretum* is appropriate since the April and July numbers are devoted to P. F. Stevens's revision of the Old World representatives of this genus.—S. A. S.

JOURNAL
OF THE
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VOLUME 61

JULY 1980

NUMBER 3

A REVISION OF THE OLD WORLD SPECIES OF
CALOPHYLLUM (GUTTIFERAE)*

P. F. STEVENS

75. *Calophyllum confertum* P. F. Stevens, sp. nov. FIGURE 26, f, g.

A speciebus aliis *Calophylli* Malesianae quibus internodia terminali innovationis brevioris aliis habent in ramulo in siccitate minute reticulato, pagina superiore laminae in siccitate brunnea pagina inferiore pallidioris et venulis lateralibus 3 usque ad 6 per 5 mm. (in speciebus aliis 5 usque ad 19 per 5 mm.), differt.

Tree ca. 36 meters tall; trunk and bark not known.

Twigs slightly flattened, 1.8–2.2 mm. across, 4-angled, drying brown to yellowish, surface minutely reticulate, glabrous; axillary innovations lacking basal scars; internodes mostly 1–3 cm. long; uppermost internode of innovation up to 7 mm. long; uppermost pair of axillary buds rounded, less than 0.5 mm. long, inconspicuous; terminal bud plump to narrowly conical, 1.3–2.5 mm. long, with adpressed, brown indumentum (hairs, FIGURE 22, m), underdeveloped internode absent. Petiole 0.4–1 cm. long, deeply concave above and convex below, glabrous; lamina obovate, (3.2–)5–8.5(–18) by (1.1–)2.3–4(–7.1) cm., rounded to subacute at apex, narrowly cuneate at base, slightly undulate and somewhat recurved at margin, coriaceous, drying cinnamon above and sepia below, glabrous at maturity, the midrib above subabruptly narrowed near base, slightly depressed at first, becoming subelevated, inconspicuous, 0.15–.3 mm. wide at midpoint, below raised, somewhat striate, the venation subapparent above and subobscure below, slightly raised, 3 to 6 veins/5 mm., angle of divergence 40–50°. Inflorescences from foliate axils near ends of twigs, with scars of 5 to 7 flowers, unbranched, the axis 3–5 cm. long, glabrous, lowest internode 3.3–3.7 cm. long; bracts not known; pedicels 0.7–2 cm. by ca. 1.8 mm., glabrous. Flower not known. Fruit spherical, 1.5–1.8 cm. long and across, rounded at apex, drying with shallow and rounded wrinkles, sharply wrinkled when young, pale brown; outer layer detaching cleanly from stone, 1.7–2 mm. thick, compact; stone spherical,

*Continued from Volume 61, page 424.

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Journal of the Arnold Arboretum, 61: 425–690. July, 1980.

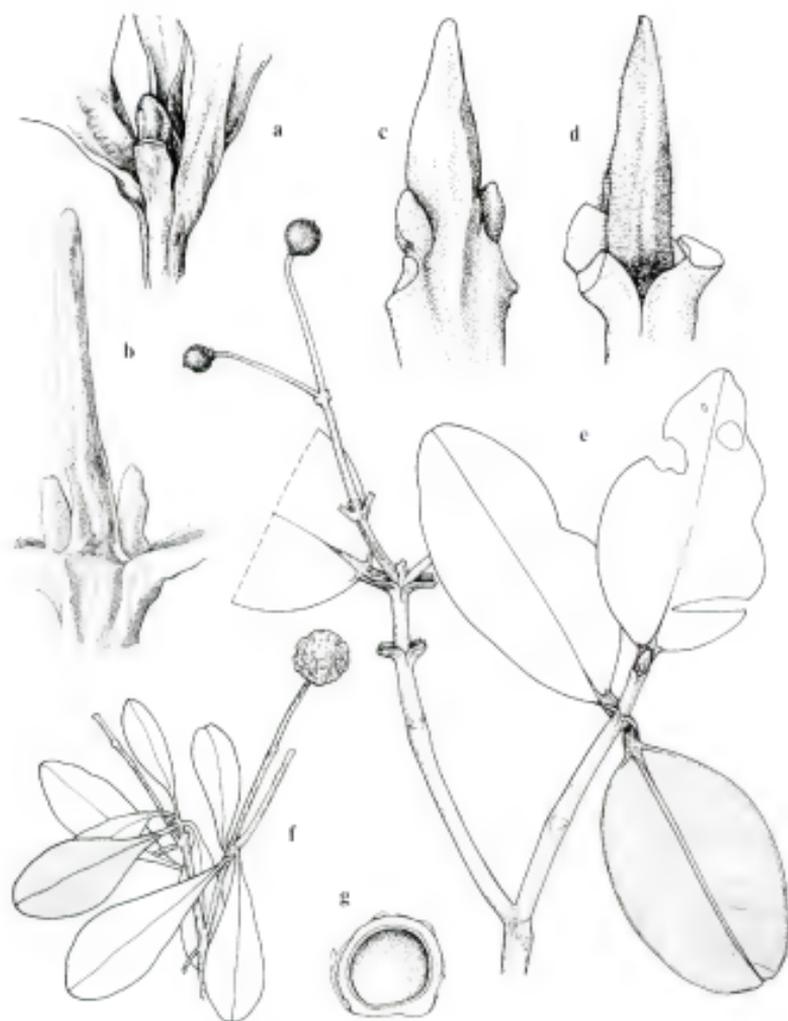


FIGURE 26. a, *Calophyllum praetermissum* (Haviland & Hose 3342), terminal bud, $\times 3$. b, *C. aerarium* (Cel./II-354), terminal bud, $\times 6$. c, *C. andersonii* (Haviland = 1812), terminal bud, $\times 6$. d, e, *C. teysmannii* var. *bursiculum* (S 17230): d, terminal bud, $\times 4$; e, habit, $\times 0.5$. f, g, *C. confertum* (SAN 17146): f, habit, $\times 0.5$; g, fruit, transverse section, $\times 1$.

0.5 mm. long; terminal bud conical, 2-3 mm. long, with short, tomentose, brown indumentum (hairs, FIGURE 22, n-p), underdeveloped internode absent. Petiole 4-7 mm. long, broadly concave above, convex below, drying blackish, when young with few hairs on edges; lamina obovate, 3.2-7.4(-12) by 1.5-3.6(-4) cm., rounded to retuse at apex, acute to cuneate at base, not undulate and slightly to clearly and narrowly recurved at margin, coriaceous, drying dark brick above and sepia below, glabrous, the midrib above rather abruptly narrowed at base, somewhat depressed at first, becoming slightly raised, 0.1-0.2 mm. wide at midpoint, below slightly raised, striate, the venation on both surfaces \pm apparent, raised, 5 to 9 veins/5 mm., angle of divergence 50-65°. Inflorescences from uppermost foliate axils, with 5 to 9 flowers, unbranched, sometimes flabellate, the axis 4.5-9.5 cm. long, glabrous or very sparsely puberulent toward base when young, lowest internode 2-7 cm. long; bracts ovate, ca. 1 mm. long, subtomentose below, not persistent; pedicels 1-2.2 cm. long, glabrous. Flower known only from bud, (?)hermaphroditic; tepals 4, the outer pair broadly ovate to orbicular, ca. 5 by 4.5 mm.; stamens 80 to 110, the anthers oblong, 1.5-2.2 mm. long, slightly retuse at apex; ovary ca. 1.5 mm. long, glabrous, the style ca. 3 mm. long, the stigma peltate, ca. 0.6 mm. across. Immature fruit subspherical, ca. 8 by 7 mm., drying finely wrinkled, brown; outer layer ca. 1.3 mm. thick.

TYPE: Sarawak, near Kuching, 24 Nov. 1894, *Haviland & Hose* 3342 (holotype, BM; isotype, K).

DISTRIBUTION. Northwestern Borneo (MAP 24).

ADDITIONAL SPECIMENS SEEN. **Borneo.** SARAWAK. 1st Division: near Kuching, *Bartlett s.n.*, anno 1893 (BM); Selang F.R., *S 7360* (?) (SAR). 3rd Division: Batang Igan, Sungei Tutus logging camp, *S 30526* (SAR); Loba Kabang South Protected Forest, *S 2761* (SAR). **KALIMANTAN.** Selatan: Amoentai, Rantau Kodjang, 10 m., *bb 7787* (BO). Barat: Palo, 5 m., *Becking 41* (BO).

ECOLOGY. Swamp forest, low. alt. Late bud in November.

Calophyllum praetermissum differs most obviously from *C. confertum* in its twigs, which do not dry finely reticulate, and in its leaf blades, which have denser venation and dry darker on the upper surface than on the lower. Although the two taxa have a similar distinctive inflorescence type and leaf arrangement, they have different hairs and ecology. The epithet *praetermissum* ("overlooked") refers to the superficial similarity of this species and *C. confertum*.

At first sight sterile specimens of *Calophyllum praetermissum* are somewhat like those of *C. andersonii*. However, in the latter species only the older twigs dry a pale gray-brown color, so there is less contrast between dark petiole and light twigs; the lamina is concave toward the base rather than broadly convex as in *C. praetermissum*. Neither the inflorescence nor the leaf arrangement of *C. andersonii* is like that of *C. praetermissum*.

S 7360 is a fragmentary specimen and is included here with hesitation.

77. *Calophyllum andersonii* P. F. Stevens, sp. nov.

FIGURE 26, c.

C. fragrans Ridley, Kew Bull. 1938: 120. 1938, *typo excepto*; J. Anderson, Gard. Bull. Singapore 20: 154. 1963, Trees Peat Swamp Forest Sarawak, 85. pl. 27A. 1972.

A speciebus aliis *Calophylli* in gemma terminalis corpulenta, lamina mediocra obovata apice plus minusve retusa venulis lateralibus subdistantibus validisque, tepalis 4, et fructu ovoideo usque ad 1.6 cm. longo apice acuto strato exteriori circa 1.5 mm. crasso et putamine parietibus circa 0.8 mm. crassis, differt.

Tree 15-23(-30) meters tall, d.b.h. to 20 cm.; trunk with buttresses to 0.9 meters tall, or stilt roots to 1.2 meters tall; outer bark dark brown to pale yellowish gray, narrowly fissured, the inner surface dull orange-brown; under bark dull orange-brown; inner bark reddish to dark brown; latex sparse, whitish, (?)sticky or not.

Twigs slightly flattened, 1.3-3 mm. across, rounded, striate when old, drying brown when young, when older grayish to yellow-brown, glabrous or brown-farinoso when young; axillary innovations lacking basal scars; internodes 0.5-4(-5.5) cm. long; uppermost pair of axillary buds rounded, to 1.5 mm. long, erect; terminal bud plump (narrowly conical), 3-6 mm. long, with gray-brown, subcrustaceous to puberulent indumentum (hairs, FIGURE 22, e, f; some also moruloid), underdeveloped internode to 2.5 mm. long. Petiole 0.7-2.1 cm. long, broadly concave above and convex below, glabrous, drying blackish; lamina obovate, 2.6-10(-13) by 1.8-5.5(-6.7) cm., retuse to rounded (rarely cuneate) at apex, acute to cuneate at base, slightly and distantly undulate and somewhat recurved at margin (with submarginal vein 0.4 mm. from margin, or vein obscured by thickening), coriaceous, drying sabelline to greenish olivaceous above and sepia to fulvous below, when young farinose-puberulent on midrib below, the midrib above narrowing gradually from base, subdepressed at first, becoming raised, 0.1-0.2 mm. wide at midpoint, below raised, rounded to subangled, the venation subobscure to apparent above and apparent below, raised, 4 to 9 (to 12) veins/5 mm., angle of divergence 45-70°. Inflorescences from foliate axils along twigs, with 7 to 11 flowers, unbranched, the axis 1.3-2.7 cm. long, puberulent at least near base, lowest internode 2-9 mm. long; bracts elliptic, to 3 mm. long, deciduous; pedicels 0.5-1.3 cm. long, frequently farinose when young, slender. Flower (?)hermaphroditic; tepals 4, the outer pair broadly ovate, 3.5-4.5 by ca. 4 mm., the inner pair broadly obovate, ca. 6 by 4.3 mm.; stamens 70 to 85, the filaments to 2.5 mm. long, the anthers oblong, 0.8-1.2 mm. long, ± retuse at apex; ovary ca. 1.3 mm. long, the style ca. 1.5 mm. long, the stigma subpeltate, 0.55-0.7 mm. across, not clearly radiate. Fruit ovoid, 1.4-1.6 by ca. 1 cm., acute at apex, drying vinaceous-brown, closely and rather shallowly wrinkled; outer layer detaching cleanly from stone, 1.2-1.8 mm. thick, compact; stone ellipsoid, 8.5-10 by 6.5-7 mm., acute to obtuse at apex, the walls 0.7-0.8 mm. thick, smooth, unmarked; spongy layer (?)thin.

TYPE: Sarawak, 3rd Division, Sibü [Loba Kabang South Protected Forest],

20 Feb. 1954, S 480 coll. *Ahmady* (holotype, SAR; probable isotypes "coll. *Anderson*," KEP, SAR, SING).

DISTRIBUTION. Northwestern Borneo (MAP 33).

ADDITIONAL SPECIMENS SEEN. **Borneo.** SARAWAK. 1st Division: ca. 3 km. from Kuching, *Haviland 1812* (BM, L, SAR, SING), = 1812 (BM, BO, GH, L); Stapok F.R., S 24679 (A, L, SAR, SING), 30590 (SAR); (?)G. Puch F.R., S 7523 (SAR); Sabal Tapang, 150 m., *Stevens et al. 178* (A). 3rd Division: Rantau Panjang, S 2739 (SAR); Loba Kabang South Protected Forest, S 2698 (SAR); Sungai Tutus logging camp, S 30543 (SAR). **BRUNEI:** H. Simpai Berakas, S 2003 (SAR). **KALIMANTAN.** BARAI: Palo, 5 m., *Becking 76* (BO).

ECOLOGY. Usually in peat swamp (alan forest dominated by *Shorea albida* Symington), also in mixed dipterocarp forest on low hills at Sabal Tapang; 5-150 m. alt. Flowering August, September, and December (flower scented); submature fruit in February.

Calophyllum andersonii can be recognized by its short, plump terminal buds, its twigs, which dry a grayish- or yellowish-brown when older, and its obovate leaf blades with retuse apices and relatively distant venation. The flowers have four tepals, and the small fruits have a well-developed outer layer and stone walls about 0.8 mm. thick. The epithet commemorates J. A. R. Anderson, well known for his work on the peat swamps of northwestern Borneo where this species usually grows.

Calophyllum andersonii is somewhat like *C. teysmannii* var. *inophylloide*; the latter has similar bark, but the latex is yellow. However, living leaves of *C. andersonii* are notably less rigid than those of *C. teysmannii* var. *inophylloide*, the midrib is not raised (seen also in the dried leaf), and the older twigs dry striate and pale yellowish brown, in contrast to the blackish petioles. *Calophyllum teysmannii* var. *inophylloide* also has larger fruits that are rounded at the apex and have a relatively much thinner stony layer. The filaments of *C. andersonii* appear to be papillate toward the apex, a character that has not been noticed in *C. teysmannii*, but more material is needed to confirm this difference.

The paratype of *Calophyllum fragrans*, *Haviland 1812*, is to be referred to *C. andersonii*. However, the two species are not at all close, *C. fragrans* (= *C. hosei*) having, for example, axillary innovations with basal scars, leaf blades with much denser venation, and ellipsoid fruits.

S 5935 (Brunei, Andalau F.R., 45 m.) may be a specimen of *Calophyllum andersonii*, but it has leaf blades with very broadly recurved margins and a terminal bud 6.5-9 mm. long on an underdeveloped internode 0.4-1.5 cm. long. There are two types of fruit associated with the specimen, although neither has been seen attached to a shoot. One is somewhat similar to that of *C. andersonii*, although a little larger (to 1.8 by 1.4 cm.) and more deeply wrinkled. The other is spherical, ca. 2 cm. long, and has an outer layer about 0.5 mm. thick; it is perhaps similar to that of *C. alboramulum* (see that species; KEP 80089 is also similar to S 5935).

78. *Calophyllum teysmannii* Miq. Fl. Indiae Batavae Suppl. 1(3): 499. Dec. 1861. TYPE: Sumatra, prope Paja-kombo, *Teymann*, HB 650 (holotype, v; isotypes, BO, L, P).

Tree 3-40 meters tall, d.b.h. to 95 cm.; trunk very often but not always with spurs or small buttresses to 70 cm. tall; outer bark brown to gray-brown, fissured and scaling, not hoop marked, the inner surface dirty orange-brown to blackish; under bark dark orange-brown to deep red; inner bark red; latex yellow, clear to opaque, sticky to fluid; sapwood pink to yellow; heartwood hard.

Twigs slightly to definitely flattened, (1-)1.5-3.5(-5) mm. across, not or 2-, 4-, or 6-angled, often with transverse lines at nodes, drying brown to blackish, transiently puberulent to subpersistently tomentose; axillary innovations lacking basal scars; internodes 0.5-3(-5) cm. long; uppermost pair of axillary buds rounded, to 1.5 mm. long, erect to spreading; terminal bud plump to conical, (2-)3.5-9.5(-12.5) mm. long, with subrustose grayish to tomentose, erect to adpressed, brown indumentum (hairs, FIGURES 25, 1-o; 27, c-i; some also moruloid), underdeveloped internode to 5 mm. long. Petiole 0.35-2.2(-3.5) cm. long, broadly and shallowly concave above, convex below, sometimes subpersistently tomentose; lamina obovate (elliptic, oblong, cuneiform, subovate, or suborbicular), (2-)3.3-13.8 by (1.3-)2.1-6.6 cm., retuse (rounded or acute) at apex, acute to cuneate (rarely rounded) at base, flat to slightly undulate and sharply recurved at margin, marginal thickening absent to 1.2 mm. wide, coriaceous to very coriaceous, drying bay to umber (pale khaki) above and umber (fulvous) below, usually \pm transiently puberulent on midrib on both surfaces, or subpersistently tomentose—also on margin when young, the midrib above often narrowing \pm abruptly near or gradually from base, raised (adjacent blade obscurely raised) (\pm depressed), 0.1-0.8 mm. wide at midpoint, below strongly raised, striate to angled, the venation above subobscure to apparent, below \pm apparent, raised, (4) to 6 to 12 (to 21) veins/5 mm., angle of divergence 50-80°. Inflorescences from foliate axils near apex and along twigs, with 3 to 11 flowers, unbranched (rarely 3-flowered branches to 1.2 cm. long, and/or flabellate), the axis (0.5-)1.3-6 cm. long, puberulent (tomentose) especially toward base, lowest internode (0.1-)0.5-3.4 cm. long; bracts unknown; pedicels 0.5-3.5(-4.3) cm. long, glabrous (rarely puberulent). Flower (?)hermaphroditic; tepals 4 to 8, the outer pair ovate to suborbicular, (4-)5.5-7.5 by (3.5-)5-6(-6.5) mm., strongly concave, the next pair broadly elliptic, 5.5-10 by 4-7 mm. (rarely 7 by 6 mm.), the inner ones, if any, obovate to lingulate, 6.5-10 by 4-6.5 mm. (rarely 10 by 3 mm.); stamens 65 to 145, the filaments to 4.5 mm. long, the anthers oblong, 1.2-2 mm. long, slightly retuse to truncate at apex; ovary 1-2 mm. long, the style 2-3 mm. long, the stigma peltate, 0.5-1.2 mm. across, 2- or 3-radiate. Fruit spherical to ellipsoid, 1.7-3.7 by 1.4-3.2 cm., rounded (rarely pointed) at apex, drying dark vinaceous-brown, faintly striate to smooth; outer layer rarely detaching cleanly from stone, (1-)1.5-3 mm. thick, compact and rather hard; stone spherical to ellipsoid, 1.4-3 by 1.1-2.6 cm., rounded at apex, the walls 0.1-0.4(-0.6) mm. thick, smooth, unmarked; spongy layer thin; cotyledons of dried embryo separating easily.

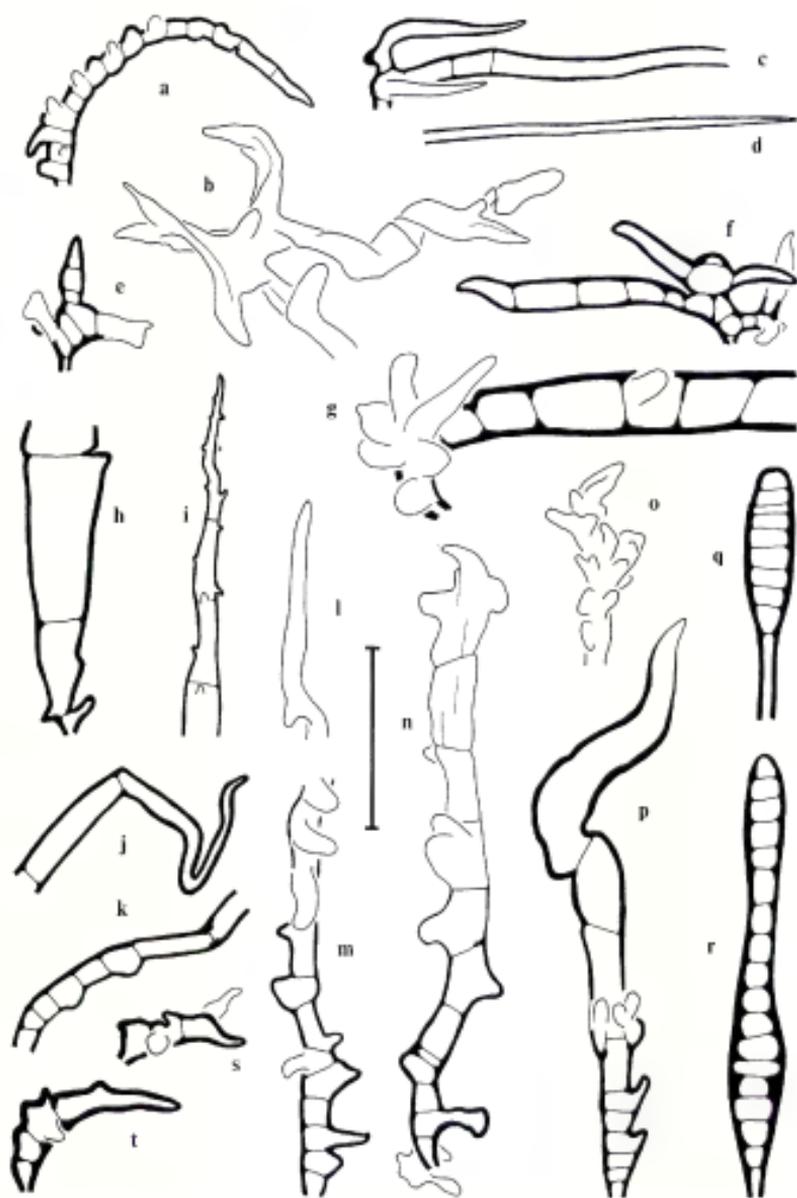
Key to the Varieties of *Calophyllum teysmannii*

1. Terminal bud usually \pm conical, initially enclosed by petiole bases of uppermost pair of leaves; stem often with horizontal lines at node; lamina drying \pm flat; inflorescences borne in upper leaf axils; pedicels (0.5-) 1-3.5(-4.3) cm. long.
 2. Twig with prominent, V-shaped lines at node. 78b. var. *bursicum*.
 2. Twig with at most obscure horizontal lines at node. 78a. var. *teysmannii*.
1. Terminal bud often plump, rarely enclosed by petiole bases of uppermost pair of leaves; stem practically never with horizontal lines at nodes; lamina often drying concave; inflorescences often borne in leaf axils along stem; pedicels 0.5-1.8(-3.5) cm. long. 78c. var. *inophylloide*.

78a. *Calophyllum teysmannii* Miq. var. *teysmannii*

- C. teysmannii* Miq.; F. Mueller in Walp. Ann. Syst. Bot. 7: 357, 1868; H. Keng, Gard. Bull. Singapore 28: 245, 1975; *C. miquelii* Vesque in C. DC. Monogr. Phanerog. 8: 607, 1893, *nomen novum* for *C. teysmannii* Miq.
- C. intramarginale* M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 342, pl. 22, 1956. TYPE: Malaya, Trengganu, Gunong Padang, 4000 feet [1218 m.], June 1937, SFN 31900 coll. Moysey & Kiah (holotype, SING; isotypes, A, K, KEP).
- C. inophylloide* King var. *singaporense* M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 316, pl. 9, 1956; Kochummen, Malayan Forest Rec. ed. 2, 17: 215, 1965; Smythies, Common Sarawak Trees, 61, 1965, excl. spec. cit.; T. C. Whitmore, Gard. Bull. Singapore 26: 270, 1973, Tree Fl. Malaya 2: 186, 1973; Corner, Gard. Bull. Singapore Suppl. 1: 104, 1978. TYPE: Singapore, MacRitchie Reservoir, 10 Nov. 1936, SFN 32518 coll. Corner (holotype, SING; isotypes, K, KEP).
- C. inophylloide* auct., non King; Ridley, Jour. Straits Branch Roy. Asiatic Soc. 34: 47, 1900, Fl. Malay Penin. 1: 186, 1922, *pro parte*.
- C. rhizophorum* auct., non Teijsm. & Binn.; Meijer, Bot. Bull. Forest Dept. Sabah 7: 15, 1967.

FIGURE 27. Hairs (from terminal bud, unless otherwise noted). a, *Calophyllum enervosum* (KEP 71894), from abaxial surface of bract, most hairs completely unthickened. b, *C. pyriforme* (SAN 75654). c-i, *C. teysmannii*. c-f, var. *teysmannii*: c, d, S 11249, apex and base of hair ca. 1200 μ m. long; e, f, FRI 12644. g, var. *bursicum* (S 17230), base of moderately birefringent hair ca. 1300 μ m. long. h, i, var. *inophylloide*: h, S 16397, base of slightly birefringent hair ca. 390 μ m. long; i, bb 27611, apex of hair ca. 1000 μ m. long. j-p, *C. ferrugineum*, expanded apical cells strongly birefringent. j-m, var. *ferrugineum*: j, k, KEP 105163, apex and base of hair ca. 720 μ m. long; l, m, SFN 28196, apex and base of hair ca. 660 μ m. long. n, var. *oblongifolium* (FRI 2594). o, p, var. *orientale* (BRUN 5697), hairs to 1450 μ m. long; o, from stem. q, r, *C. macrocarpum* (S 15898), rare hair type from inside bud. s, t, *C. aerarium* (Cel./II-354). Scale = 120 μ m. (in c, d, scale = 240 μ m.).



C. ?cymosum auct., non Miq.; Koord.-Schum. Syst. Verzeich. 2: 39. 1910, *quoad* Koorders 10336.

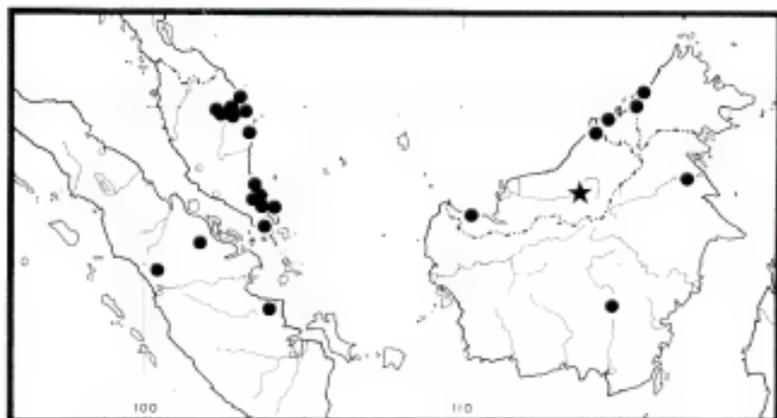
Calophyllum sp. 44 M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 350, pl. 30. 1956; T. C. Whitmore, Tree Fl. Malaya 2: 173. 1973; Corner, Gard. Bull. Singapore Suppl. 1: 105. 1978.

Tree 3–36 meters tall; sometimes with loop roots; latex from cut bark yellow, fluid, clear, becoming opaque when rubbed.

Twigs (1–)1.5–2.5 mm. across, with obscure raised lines at nodes; terminal bud conical or ± plump, (2–)3–8 mm. long, with sericeous to tomentose indumentum. Lamina usually obovate (rarely cuneiform, suboblong, suborbicular, or subovate), (2.6–)3.4–9 by (1.3–)2.1–4.6 cm., slightly recurved at margin, marginal thickening 0.4–0.8(–1.2) mm. wide, drying ± flat, the midrib flat to raised, 0.15–0.3(–0.4) mm. wide at midpoint. Inflorescences from upper foliate axils, sometimes two together, lowest internode (0.7–)1.5–3.4 cm. long; pedicels (0.5–)1–3.5 cm. long.

DISTRIBUTION. Northeastern and southeastern Malay Peninsula to Borneo (MAP 25).

SELECTED SPECIMENS SEEN. **Malaya.** KELANTAN: G. Rabong, 671 m., *FRI* 20622 (KEP); Sungei Perias near K. May, 305 m., *FRI* 4114 (K, KEP). TRENGGANU: along Sungei Pelong, *FRI* 14854 (K, KEP, SING); Ulu Brang, near K. Lallang, 305 m., *FRI* 12593 (K, KEP, SING); G. Padang, 1219 m., *FRI* 12644 (A, KEP, SAN, SING); Ulu Sungei Loh, 716 m., *FRI* 10840 (A, K, KEP, SING); Kuala Trengganu–Sengau, *KEP* 81266 (KEP); Jerengau State Land, *KEP* 79853 (KEP); Bukit Bauk F.R., 120 m., *KEP* 77980 (KEP); Dungun, Bukit Besi, *KEP* 66957 (KEP); Rasau Kerli F.R., 310 m., *KEP* 67753 (A, BO, K, KEP, SING); Kemaman, Bukit Kajang, Ulu Bendong, 150 m., *Corner s.n.*, 3 Nov. 1935 (?) (SING). PAHANG: G. Tahan, *Wong & Wyatt-Smith* 168 (KEP); Taman Negara near



MAP 25. Distribution of *Calophyllum teysmannii* var. *teysmannii* (circles) and *C. teysmannii* var. *bursiculatum* (star) in Malasia.

Kuala Tahan, 210 m., *FRI 20136* (KEP). JOHORE: G. Arong F.R., 30 m., *KEP 54250* (BO, K, KEP, SING); Kluang F.R., 305 m., *KEP 98026* (K, KEP, SING); Jemaluang F.R., *KEP 73551* (KEP); G. Blumut, 518 m., *FRI 8839* (KEP); G. Panti E., 305-457 m., *Shah & Ahmad 2917* (A, KEP, LAE, SING, UC); Kota Tinggi, Panti F.R., 210 m., *KEP 70184* (KEP, SING); Kg. Hubong, Endau, *Kadim & Noor 321* (K, L, SING); Jason Bay, Sungei Semadan, *Corner s.n.*, 30 April and 16 June 1934 (KEP, SING); Tanjong Jurat, *Lake & Kelsall s.n.*, anno 1892 (SING); Mawai, *Corner s.n.*, 21 May 1934 (SING). **Singapore:** Seletar Reservoir, Mandai Road, *Shah & Shukor 2398* (A, C, SING); Botanic Gardens, *SFN 28662* (A, BO, K, KEP, LAE, SING); MacRitchie Reservoir, *SFN 32518* (KEP); Stag Mount, *Ridley s.n.*, anno 1909 (K); Bukit Timah, *Baker 5339* (G, KEP, NSW). **Sumatra:** RIAU: Siak-Tanggana, *Koorders 10336* (?) (BO). DJAMBI: Djambi, Simpang, 45 m., *bb 13162* (BO). BARAT: Taram, E. of Pajakumbuh, 500-1000 m., *Meijer 6914* (L). **Borneo.** SARAWAK. 1st Division: Kuching, Stapok Road, *Brooke 9413* (G, L). 4th Division: Baram, Marudi F.R., *S 8289* (K, L, SAN, SAR). BRUNEI: Bukit Pua, 24 m., *Ashton s.n.*, Aug. 1958 (SAR). SABAH. Beaufort: Lumut, on railway line, mile 2½, *SAN 58410* (L, SAN). Papar: Kimanis F.R., 6 m., *KEP 80288* (KEP); Bongawan F.R., *A 397* (A, K, KEP, L, SING). KALIMANTAN. Timur: Boolongan, Binai, *Rutten 17* (U). Tengah: Bonjoet, bij Boentok, *Obi 1880* (= *bb 578*) (BO, L).

ECOLOGY. Peat swamps, "secondary forest on mangroves" (*SAN 58410*), flat-lying mixed dipterocarp forest, kerangas vegetation, and ridges in lower montane rain forest; to 1220 m. alt. Flowering February, June to August, November, and December (flower scented); fruiting March to May, and July (inside of fruit magenta—*FRI 8839*). Lotong (wolverines) eat fruit (*Corner s.n.*, 8 Feb. 1935).

Bilabiate, purselike galls (FIGURE 5, h) occur on plants of this taxon throughout its range (e.g., Malaya, *Shah & Shukor 2398*; Sumatra, *Meijer 7037*; Sarawak, *Brooke 9413*). These galls seem to be most common on young plants. Caused by a coccid (Lecanodiaspididae—*Amorphococcus* sp.), they develop abaxially on the midrib and shorten the internodes (Anthony, 1974). Anthony also reports psyllid galls that may affect each half of the leaf separately, thus causing it to become revolute. Elongate, slitlike galls on the lower and sometimes also on the upper surface of the lamina, generally found along the midrib or near the margin, are also known (e.g., *KEP 66957*, Malaya; *SFN 32518*, Singapore). *Teysmann, HB 650*, from Sumatra, has a row of raised, pustular swellings on either side of the midrib on the upper surface of the lamina.

GERMINATION AND YOUNG PLANT. The radicle breaks the stone wall ca. 5 mm. to one side of the base. The seedling usually has two pairs of leaves separated by an internode less than 8 mm. long. (Some seedlings apparently have up to four pairs of leaves separated by internodes of ca. 1 cm. or more; the lowest two pairs of leaves drop off (*Stevens et al. 108*.) Subsequent growth is erect, the terminal bud is functional, and the internodes produced are well developed (more than 1 cm. long). In the young plant at least the terminal bud has tomentose indumentum. Leaves produced by young plants are oval-elliptic, less than 12 cm. long, and usually rounded (to subacute) at the apex. (*KEP 77881, 99236; Stevens et al. 108.*)

78b. *Calophyllum teysmannii* Miq. var. *bursiculum* P. F. Stevens, var. nov.

FIGURE 26, d, e.

A varietatibus aliis *Calophylli teysmannii* in ramulis teretibus ad nodos lineis elevatis V-formatis basibus foliorum conflantibus ornatis et lamina elliptica mediocri plana percussa, differt.

Tree 15–21 meters tall; latex unknown.

Twigs 3.5–4 mm. across, with prominent, V-shaped lines at nodes, otherwise terete; terminal bud conical, 6–9 mm. long, sericeous. Lamina elliptic to suboblong (rarely suborbicular), 7.2–10.3 by 3.6–5.4 cm. (rarely ca. 4.2 by 4 cm.), slightly recurved at margin, marginal thickening not obvious, drying flat, the midrib slightly depressed, 0.15–0.55 mm. wide at midpoint. Inflorescences from upper foliate axils, lowest internode 2–2.5 cm. long; pedicels in young fruit 2.4–4.3 cm. long.

TYPE: Sarawak, 3rd Division, Hose Mountains, Mujong, Ulu Telamud, 310 m., 25 March 1964, *S 17230* coll. Ashton (holotype, K; isotypes, A, BO, L, SAN, SAR, SING).

DISTRIBUTION. Sarawak, known only from the 3rd Division (MAP 25).

ADDITIONAL SPECIMEN SEEN. **Borneo.** SARAWAK. 3rd Division: Tatai Memuas, Ulu Tiau, Mujong, Balleh, 180 m., *S 21225* (K, L, SAR, SING).

ECOLOGY. Heath forest on Kakus sandstone plateau, 180 m. alt. (*S 21225*); pole forest on dacite knoll, 310 m. alt. (*S 17230*).

Elongate, slitlike galls ca. 1 cm. long occur on the lower surface of the lamina (*S 17230*).

The name *bursiculum* ("little purse") alludes to the way in which the terminal bud is enclosed by the petiole and lamina bases.

78c. *Calophyllum teysmannii* Miq. var. *inophylloide* (King) P. F. Stevens, comb. nov.

C. inophylloide King, Jour. Asiatic Soc. Bengal, II. 59: 178. 1890; Vesque in C. DC. Monogr. Phanerog. 8: 549. 1893; Ridley, Fl. Malay Penin. 1: 186. 1922, *pro parte*; *C. inophylloide* King var. *inophylloide* M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 315. 1956; Pukol & Ashton, Checklist Brunei Trees, 93. 1964; Kochummen, Malayan Forest Rec. ed. 2. 17: 213. 1965; T. C. Whitmore, Tree Fl. Malaya 2: 183. 1973. TYPE: Malaya, Perak, Batang Padang district, Aug. 1885, 300–500 feet [90–150 m.], King's collector [Kunstler] 8112 (isotypes, K, UC).

C. marginatum Wall. Catal. 4845. 1831; Choisy, Mém. Soc. Phys. Hist. Nat. Genève 12: 424. 1849; Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 293. 1862; T. Anderson in Hooker f. Fl. Brit. India 1: 276. 1874; Vesque in C. DC. Monogr. Phanerog. 8: 608. 1893. *Nomen*.

C. borneense auct., non Vesque; Pukol & Ashton, Checklist Brunei Trees, 93. 1964, *pro parte*.

C. fraseri auct., non M. R. Henderson & Wyatt-Smith; T. C. Whitmore, Tree Fl. Malaya 2: 182. fig. 3. 1973, *pro parte*.

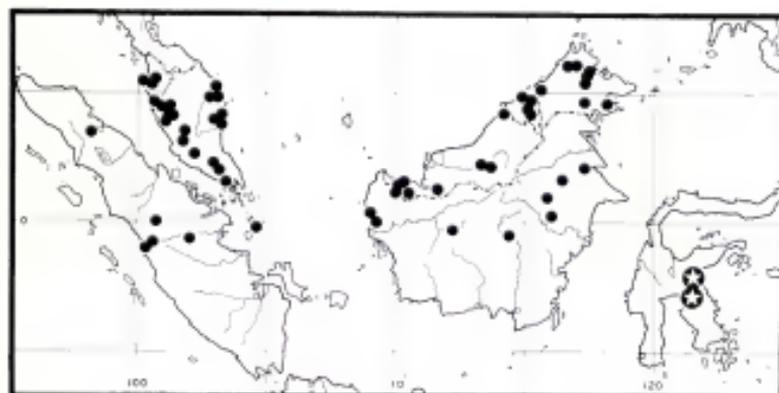
C. cymosum auct., non Miq.; Koord.-Schum. Syst. Verzeich. 2: 39. 1910, *quoad* Koorders 10335.

Tree 18–40 meters tall; latex from cut bark yellow, clear, sticky, rather fluid, becoming opaque when rubbed.

Twigs 2–5 mm. across, rarely with raised lines joining opposing leaf bases; terminal bud plump to conical, with grayish subcrustaceous to brown-tomentose indumentum. Lamina obovate to elliptic or oblong, (3.3–)5–13.8 by (2.2–)2.6–8 cm., somewhat recurved at margin to strongly so, marginal thickening to 0.2–0.8 mm. wide, tending to dry \pm boat shaped, the midrib depressed to \pm raised, 0.15–0.7 mm. wide at midpoint. Inflorescences usually from foliate axils along stem, lowest internode (0.1–)0.3–1(–2) cm. long; pedicels 0.5–1.8 (–3.5) cm. long.

DISTRIBUTION. Malay Peninsula to Borneo (MAP 26).

SELECTED SPECIMENS SEEN (letters refer to discussion in text). **Malaya.** KEDAH: Kedah Selatan Kulim, G. Inas, 305 m., *KEP 105249* (KEP). PINANG: Telok Pahang, *KEP 66369* (KEP); Pantai Acheh F.R., *KEP 27793* (KEP); Pulau Penang, *Curtis s.n.*, anno 1894 (SING). PERAK: near Tapah, *Ridley 3014* (K); Larut, *KEP 15* (KEP, SING); Keroh F.R. (near Gri), *KEP 31086* (KEP); Changkat Jong F.R., 30 m., *FRI 5873* (A, K, KEP); Taipeng, Selama, *KEP 273* (KEP); Parit, Kinta, *KEP 39464* (KEP); Bruas F.R., 60 m., *KEP 69406* (KEP); Chikus F.R., *KEP 3071* (KEP); Pondok Tandjong, *KEP 65558* (KEP); Batang Padang F.R., 15 m., *KEP 65053* (KEP, SING); Piah F.R., 853 m., *FRI 9051* (f) (KEP). SELANGOR: Bukit Lagong F.R., *KEP 13281* (KEP, SING); Ulu Gombak F.R., *KEP 24703* (KEP, SING), 768 m., *KEP 94716* (f) (A, K, KEP, SAN, SAR, SING); near Gap, 800–900 m., *Ando et al. 88* (f) (KEP); Kanching, *KEP 30106* (KEP). NEGERI SEMBILAN: Kuala Pilah, Serting, *KEP 62956* (KEP, SING). TRENGGANU: along Sungai Pelong, *FRI 14856* (K, KEP, SING); Dungun, Jerengau State Land, *KEP 81407* (KEP); Kemaman, Ulu Bendong, Bukit Kajang, *Corner s.n.*, 6 Nov.



MAP 26. Distribution of *Calophyllum teysmannii* var. *inophylloide* (circles) and *C. celebicum* (stars in solid circles) in Malaya.

1935 (SING); Kuala Trengganu, proposed Belara F.R., 60 m., *KEP 76066* (KEP); Bukit Bauk F.R., 150 m., *KEP 104709* (KEP); 28th Mile Jalan Trengganu, 30 m., *KEP 78551* (KEP); Mandi Angin exped., S. watershed of Sungei Loh, 792 m., *FRI 12034* (f) (A, KEP, SING); Sungei Trengganu near Kuala Panchor, 610 m., *FRI 20561* (f, *pro parte*) (KEP). G. Padang exped., Ulu Brang, 1006 m., *FRI 17776* (f) (A, KEP, SING). PAHANG: Sungei Kelui, G. Tapis, 518 m., *FRI 10052* (KEP); Pekan Road, Kuantan, *KEP 43102* (KEP); Ulu Kali, 914 m., *FRI 15643* (f) (KEP); Fraser's Hill, Bukit Jeriau, 1036 m., *FRI 20412* (f) (KEP, SING). JOHORE: Bukit Jelakoi, Kluang F.R., 225 m., *KEP 76290* (BO, K, KEP, SING, US); Labis F.R., *FRI 3843* (KEP); Ginting Simpah, 610 m., *KEP 71248* (KEP); G. Pulau F.R., 610 m., *FRI 9955* (KEP). **Sumatra and adjacent islands.** RIAU: Lingga, Sei. Soeling, *Ri/1-3* (BO); Indrag. Bovenlanden, Kwala Belilas, *Buwalda 6754* (BO, L); Beneden Langkat, Aloer Goetra, 50 m., *bb 16592* (A, BO). BARAT: bij Padang, 80 m., *Koorders 10335* (BO); Bangkinang, Katoer, 300 m., *bb 23395* (BO, L, MO); Sidjoendoeng, Moearo, 150 m., *bb 9098* (BO). **Borneo.** SARAWAK. 1st Division: Semengoh F.R., Arboretum, 60 m., *S 32979* (K, SAN, SAR, SING); G. Matang, 305 m., *Stevens et al. 231* (A), *241* (c) (A); Sabal Tapang, 120 m., *Stevens*, sight record; G. Penrissen, 914 m., *S 16397* (c) (A, BO, K, L, SAN, SAR, SING). 2nd Division: Simanggang, Kampong Mentu, 305 m., *S 6527* (c) (K, L, SAR, SING). 3rd Division: Bukit Raya, Kapit, Pelagus, 270 m., *S 14359* (K, L, SAR, SING); Hose mts., Bukit Kajang Carapa, 900 m., *S 19090* (A, BO, L, SAR, SING). 4th Division: Miri, NE. Lambir Hills, Tukau formation, 120 m., *S 16756* (c) (K, L, SAR). BRUNEI: G. Pagon Periok, 1829 m., *BRUN 2442* (?) (SAR); Sagan Hill, 365 m., *S 18711* (c) (SAR); Temburong, Kuala Sekurop, 457 m., *BRUN 733* (BRI, K, L, SAR, SING); Kuala Belait, Andalau F.R., 60 m., *SAN 17476* (c) (A, BO, K, KEP, L, P, SING); Berakas F.R., 30 m., *S 2004* (c) (KEP, SAR, SING); Ulu Sugei, 60 m., *S 1013* (K, SAN, SAR, SING); Kuala Belalong, 610 m., *Ashton s.n.*, Nov. 1959 (SAR). SABAH. Beaufort: Beaufort Hill, 20 m., *SAN 44588* (K, L, SAN, SAR, SING). Ranau: Penibukan, 1524 m., *Clemens 40563* (prob.) (A, NY); Kinabalu, E. Rentis, Base Camp, Mesilau, 1829 m., *SAN 42189* (k) (A, SAN); Pinusok Plateau (Padang Golf), 2134-2438 m., *SAN 75844* (k) (SAN). Colombon Basin, 1524 m., *Clemens 40003* (k) (A, BO, L, NY, UC). Labuk & Sugut: Bukit Malawali, Labuk Road, *SAN 51770* (SAN); Mt. Meliau near Kiabau, 457 m., *SAN 51505* (c) (SAN); Bidu-Bidu hills above Kiabau, *SAN 43803* (c) (SAN); near Sungei Binuang, NW. of Sapi, 457 m., *SAN 44001* (?) (SAN); Bukit Tangkunan, Mile 86 Labuk Road, 425 m., *Stevens et al. 410* (?) (c) (A), 75 m., *Stevens et al. 414* (A). Kinabatangan: Lamag, Karamuak, E. of Sungei Meliau, 60 m., *SAN 53255* (c) (SAN); Bukit Tavai, 150 m., *SAN 53312* (SAN). Lahad Datu: Silam Mining Camp, 610 m., *SAN 37481* (SAN, SAR). TAWBU: Brassey Range, 770 m., *Stevens et al. 475* (A). KALIMANTAN. Timur: Tidoengsche Landen, *bb 18240* (A, BO, L); Berouw, Telowek Daoen, Sungei Kasei, 75 m., *bb 12195* (BO); W. Kutei, Mt. Palimasan near Tabang on Belajan R., 190 m., *Kostermans 13144* (c) (BO, K, L, SING); 500 m., *Kostermans 12792* (c) (BO, L), 600 m., *Kostermans 12878* (BO, CANB, K, L, P), near Mt. Kemoel, 1200 m., *Endert 3458* (k) (BO, L); Long Bleh, Sei Pemetok, 50 m., *bb 29603* (BO, L). Tengah: Peeroek Tjahoe, Taheedjan, 150 m., *bb 21166* (A, BO, L); Mocara Teweh, Pepas, 15 m., *bb 27766* (BO, L). Barat: Melawi Tjait, B. Goentok, 180 m., *bb 27004* (BO, K, L, SING); Landak, Ngabang, 40 m., *bb 6402* (BO); Mempawa, Toho, 300 m., *bb 12388* (BO).

ECOLOGY. Usually well-drained lowland to colline mixed dipterocarp forest.

also in Trengganu (Malaya) in freshwater swamp, in Sarawak and Brunei in kerangas vegetation, in Kalimantan on (waterlogged) acid white sands, in Sabah on ultramafic rock; 4-1400(-2438?) m. alt. Flowering April, June to August, and September to November; fruiting December to February, April, August, and September (fruit greenish).

Bilabiate, purselike coccid galls are known from Malaya (e.g., *KEP 15*, *Stevens et al. 30*) and from Kalimantan (*Kostermans 12840*). Elongate, slitlike, pustular galls on the lower surface of the lamina are known from Sarawak (*Stevens et al. 275*, FIGURE 5, d).

GERMINATION AND SEEDLING. AS FOR *Calophyllum teysmannii* var. *teysmannii*. The leaves of the young plant are often larger (up to 22 by 7.5 cm.) and are shortly, but markedly, acuminate at the apex. (*KEP 62957, 76055, 79305; FRI 23084; Stevens et al. 30, 137, 231, 410.*)

LOCAL USE. The wood is rather hard and is used in construction.

The epithet *inophylloide* ("like [the leaves of] *Calophyllum inophyllum*") was chosen because the leaves of the type of *C. inophylloide* are similar to those of *C. inophyllum*.

Although *Calophyllum teysmannii* is a variable taxon, it can generally be readily recognized by its moderate-sized, obovate (to oblong) leaf blades that are retuse at the apex and usually distinctly thickened at the margin. The axillary inflorescences are few flowered, and the flowers have four to eight tepals. The fruit is of moderate to large size and is more or less smooth when dry; the outer layer is thick ((1-)1.5-4 mm. across) and compact, and the stone walls are 0.1-0.4(-0.6) mm. thick. The hairs are usually branched at the base and are moderately birefringent under polarized light, or they may be almost moruloid but still obviously branched. The seedlings nearly always have two pairs of leaves separated by an internode less than 8 mm. long. Young plants of vars. *inophylloide* and *teysmannii* may have characteristic bilabiate, purselike, coccid galls, while adult plants of all three varieties are known to have slitlike galls. The outer bark is brown, fissured, and scaly; stilt roots or spurs occur frequently. The specific epithet commemorates the indefatigable collector, J. E. Teijsmann.

Specimens of saplings of *Calophyllum teysmannii* from Malaya have been confused with sterile specimens of *C. subhorizontale*. Although the two have similar terminal buds, the venation density of the leaves of *C. teysmannii* saplings is greater than that of *C. subhorizontale*, the twigs of the former do not dry the greenish color of the latter, and the thickened margin of the leaf common in *C. teysmannii* is not found in *C. subhorizontale*.

Some of the specimens of *Calophyllum teysmannii* with very coriaceous leaf blades may be confused with *C. sclerophyllum*. The two species have similar fruits, and *C. sclerophyllum* also has hard heartwood and well-developed stilt roots. In the low-lying forest of southern Johore, *C. sclerophyllum* and *C. teysmannii* var. *teysmannii* (the former described as *Calophyllum* sp. 44 by Henderson & Wyatt-Smith, *loc. cit.*) grow together, but they are quite distinct. In Sarawak both the local representative of *C. teysmannii* var.

inophylloide and its thick-leaved variant are quite distinct from the *C. sclerophyllum* there, although in this case there is no ecological overlap. *Calophyllum sclerophyllum* differs most obviously from *C. teysmannii* in having the lower surface of the lamina often punctate, the terminal bud never enclosed by the bases of the petioles, the seedling with but a single pair of leaves and with subsequently produced leaves alternate, and the young plant without purselike coccid galls.

Variation within *Calophyllum teysmannii*

The variation within *Calophyllum teysmannii* is mostly in terminal bud shape and indumentum; leaf size, texture, and indumentum; inflorescence position; pedicel length; and fruit size. There is a certain amount of variation in the young plant and also in bark characters. Even when dealing with the Malayan plants, Henderson and Wyatt-Smith had trouble deciding at which rank to recognize *C. inophylloide* var. *inophylloide* (= *C. teysmannii* var. *inophylloide*) and *C. inophylloide* var. *singaporense* (= *C. teysmannii* var. *teysmannii*). This problem has become exacerbated by the wider altitudinal, ecological, and geographic range of the species as here circumscribed. Much more collecting is still needed, especially from higher altitudes in both Malaya and Sabah, and also of the large, very coriaceous-leaved form that occurs throughout Borneo.

Although there are a number of differences between *Calophyllum teysmannii* var. *teysmannii* (and var. *bursiculum*) and *C. teysmannii* var. *inophylloide*, these differences intergrade. The conical terminal bud of *C. teysmannii* var. *teysmannii* is often enclosed by the upright petioles of the terminal pair of leaves, whereas the plump bud of var. *inophylloide* is not often so enclosed since the petioles are spreading. Young plants of *C. teysmannii* var. *inophylloide* have transverse lines across the stem at the nodes, and each innovation seems to consist of only a single pair of leaves. The former, and probably also the latter, are characteristic of adult plants of the other two varieties, but *C. teysmannii* var. *inophylloide* probably produces more pairs of leaves each innovation. In Malaya and Singapore, the latex of the two varieties differs: in *C. teysmannii* var. *teysmannii* it is clear and fluid, turning opaque when rubbed; in var. *inophylloide* it is clear but sticky. There are perhaps a few exceptions. The latex of KEP 76055 (Trengganu; var. *inophylloide*) was reported to be nonsticky; however, it was also slow to appear, while the nonsticky latex of var. *teysmannii* flowed freely. In Sarawak, on the other hand, the slash characters and, to a certain extent, the leaf characters (e.g., Stevens et al. 273, 275) of *C. teysmannii* var. *inophylloide* are those of var. *teysmannii* in Malaya; unfortunately, I did not see any trees of var. *teysmannii* in Sarawak.

It therefore seems most appropriate to reduce *Calophyllum inophylloide* to a variety of *C. teysmannii*. On Bukit Jelakoi, at the Kluang Forest Reserve, Johore, Malaya, the two varieties may grow quite near one another (KEP 76290, 225 m., var. *inophylloide*; KEP 76291, 210 m., var. *teysmannii*); this may also happen in northeastern Malaya.

Calophyllum teysmannii var. *bursiculum* is described because, although

it has the bud, hair type, and inflorescence characteristic of var. *teysmannii*, it can be readily distinguished by its very coriaceous, short-petioled leaves that lack obvious marginal thickening. Its distinctive twigs, with their V-shaped lines at the nodes, also distinguish var. *bursiculatum* from both other varieties.

There is relatively little variation within *Calophyllum teysmannii* var. *teysmannii* as circumscribed. Specimens referable to *Calophyllum* sp. 44 (Henderson & Wyatt-Smith, *loc. cit.*) were seen in a swamp in southern Johore; in all characters of seedling and bark slash they were identical with *C. teysmannii* var. *teysmannii*. Some specimens tend to have a rather narrow lamina with a length : breadth ratio of 2-3 (that of fertile specimens of *C. teysmannii* var. *teysmannii* is usually less than 2). The fruit has an outer layer 1-1.3 (vs. more than 1.5) mm. thick. These are slight differences; *Calophyllum* sp. 44 is a local variant of var. *teysmannii* not distinct enough for formal recognition.

Two specimens from Trengganu (*FRI 12593, 14854*) have obovate to cuneiform leaf blades and ellipsoid fruits that are more or less pointed at the apex; the outer layer of the fruit is only ca. 1 mm. thick and detaches cleanly from the stone. The subtomentose indumentum on the twigs, midrib, and base of the inflorescence is better developed than is usual in adult plants of *Calophyllum teysmannii* var. *teysmannii*. Although these specimens are referred to this variety, the characters listed above suggest that they may be hybrids with *C. ferrugineum* var. *oblongifolium*, which grows in the same area.

Another specimen collected in the mountains of Trengganu, *FRI 12644*, looks similar to the form of *Calophyllum teysmannii* var. *inophylloide* growing on the same mountain (Gunong Padang, see below). However, it has the terminal bud and transversely lined nodes of var. *teysmannii*, and it is included in this taxon.

Calophyllum teysmannii var. *inophylloide* is a heterogeneous taxon as delimited here. Whitmore (1973, *loc. cit.*) included in his concept of *C. fraseri* specimens that seem to represent a local high-altitude form of *C. teysmannii* var. *inophylloide* ("f" in the list above). They sometimes have the stilt roots of the latter taxon, while *C. fraseri* lacks them. Stones and germinating seeds of *FRI 23084* (from Fraser's Hill) are identical to those of *C. teysmannii*, and hairs of specimens of this type, although very small, can perhaps be compared to the branched bases of the low-altitude form. These specimens have rather narrow, long-petiolate leaves with the blades lacking the obvious thickened margin of *C. teysmannii*. *FRI 19869* (Pahang, 792 m.) has bilabiate coccid galls. Specimens collected from The Gap (Selangor) seem to show a transition between this form and more typical *C. teysmannii* var. *inophylloide*, as suggested by the series of specimens collected by Ando *et al.* (88 (the form), 85, 151, 125 (close to var. *inophylloide*)).

There are a number of specimens from Borneo with large, very coriaceous leaf blades that are strongly recurved at the margin and that have a more or less depressed midrib ("c" in the above list). These robust specimens are at first sight very different from the rest of *Calophyllum teysmannii* var. *inophylloide*. However, specimens like *Kostermans 13144* have a more

or less raised midrib, while others such as *Kostermans 12743* and *S 1115* (the latter is in fruit) have lines across the stems at the nodes. Indumentum is quite variable: *Kostermans 12743* and *Stevens et al. 241* have short, tomentose indumentum on the bud, stem, midrib, and leaf margin; *SAN 17476* and *Kostermans 13144* have short, grayish, almost furfuraceous indumentum on the terminal bud and little obvious indumentum elsewhere. The shape of the terminal bud varies from conical to plump. It would be unwise to recognize these large, coriaceous-leaved specimens formally, but it should be emphasized that this variation is not understood. On Gunong Matang (Sarawak) two forms, ordinary var. *inophylloide* and a very coriaceous-leaved form with subtomentose indumentum, grow on the same ridge; on Mt. Palimasan (Kalimantan) two similar forms, as well as a very coriaceous-leaved form that lacks tomentose indumentum, grow in the same general area.

In northern Borneo there are some specimens that dry rather similar to the local form of *Calophyllum biflorum*. One of these is *Stevens et al. 125* (from Sarawak), which has the bark and slash characters of *C. teysmannii* var. *inophylloide*. Another, *S 1013* (from Brunei), has leaves drying somewhat like those of *C. ferrugineum* var. *orientale* (close to *C. biflorum*, see below), as well as the inconspicuous tomentose indumentum of that species. However, the hairs have many expanded, rather thin-walled apical cells in comparison to the two to four thick-walled cells found in *C. ferrugineum* var. *orientale*. The field characters of *S 1013* are those of *C. teysmannii*.

On the lower slopes of Mt. Kinabalu, Sabah, and on Mt. Kemoel, Kalimantan, there is perhaps another form of *Calophyllum teysmannii* var. *inophylloide* ("k" in the above list). In the young plants the terminal buds are protected by the petiole bases (*Stevens et al. 495*), and the hair, bark, and slash characters are compatible with those of this variety. However, the only specimen with flowers (*Clemens 40003*) has puberulo-tomentose indumentum on the inflorescence axis and pedicels, and the flowers have 175 to 325 stamens. Fruits are unknown. More collections of this form are needed to establish its status; it has not been incorporated in the description.

Synonymy and Nomenclature

There is no doubt about the synonymy of the names listed under *Calophyllum teysmannii* var. *teysmannii*. The type specimen of *C. teysmannii* has rather small, obovate leaf blades with a prominent thickened band at the margin, and inflorescences with few rather large, long-pedicelled flowers. *Calophyllum intramarginale* was described from similar specimens that were growing at lower altitudes, but that otherwise closely match the type specimen of *C. teysmannii*.

The publication of *Calophyllum teysmannii* Miq. just antedates that of *C. teysmannii* Zoll. ex Planchon & Triana. That part of the supplement to Miquel's *Flora Indiae Batavae* in which the name *C. teysmannii* Miq. is validly published came out in December, 1861 (the name is also mentioned on p. 193 of the supplement published in June, 1861 (Stafleu, 1967)). However, the portion of Planchon and Triana's "Mémoire sur la famille des Guttifères"

in which the name *C. teysmannii* Zoll. ex Planchon & Triana was published appeared early in 1862.¹⁴ *Calophyllum teysmannii* Zoll. ex Planchon & Triana is itself a superfluous name for *C. dasypodum* (q.v.).

Calophyllum marginatum, a manuscript name of Wallich, has been something of a mystery to earlier authors. Vesque (*loc. cit.*) said that the name made him think of *C. pulcherrimum* (properly *C. tetrapterum*), the leaves of which often have a pale margin. However, the specimen of Wallich *dist.* 4845 at Kew was taken from a young plant of *C. teysmannii* var. *inophylloide* and has a thickened leaf margin, lines across the twigs at the nodes, and purselike galls.

79. *Calophyllum aerarium* P. F. Stevens, sp. nov.

FIGURE 26, b.

A specibus aliis Calophylli in gemma terminali 0.6–1.5 cm. longa, lamina oblonga vel obovata apice rotundata in siccitate acrata, inflorescentiis axillari-bus puberulentibus, et fructu circa 2 cm. longo in siccitate arcte rugoso strato exteriori valido circa 1.3 mm. crasso putamine parietibus tenuissimis, differt.

Tree ca. 30 meters tall, d.b.h. ca. 50 cm.; trunk and bark unknown; latex yellow.

Twigs flattened, 2.5–4 mm. across, \pm 4-angled when young, often with obscure horizontal line at nodes, drying brown, transiently brown-farinose; axillary innovations lacking basal scars, internodes (1–)2–8.5 cm. long; uppermost pair of axillary buds rounded to pointed, 1–3 mm. long, spreading, conspicuous; terminal bud narrowly conical, 0.6–1.5 cm. long, with brown, \pm furfuraceous indumentum (hairs, FIGURE 27, s, t), underdeveloped internode 1–3 mm. long. Petiole 1–3 cm. long, shallowly concave above, convex below, drying blackish, transiently farinose; lamina obovate or suboblong to elliptic, 6.5–14 by 3.5–7 cm., broadly rounded at apex, whether or not apiculate, acute at base, rather deeply but distantly undulate and strongly recurved at margin, coriaceous, drying umber above and sabelline-sepia below, \pm transiently farinose on midrib on both surfaces, the midrib above narrowing gradually from base, \pm flat at first, center sulcate, becoming raised (surrounding lamina obscurely raised), 0.2–0.4 mm. wide at midpoint, below raised, angled (rounded toward base), venation \pm apparent above and below, raised, 6 to 10 veins/5 mm., angle of divergence 65–76°. Infructescences from uppermost foliate axils, with ca. 5 flowers, unbranched, the axis 2–3.5 cm. long, puberulent, lowest internode 0.4–2.2 cm. long; bracts unknown; pedicels 4–10 mm. long, \pm puberulent. Only damaged flowers known, (?)hermaphroditic;

¹⁴The type specimen of *Quilina decalmeana* Planchon & Triana, published in the same part of Planchon and Triana's article (p. 315), is cited as "Guyana (Melinon, serres du Muséum, 1862)." In an earlier article in the same volume (H. F. Hance, "Symbolae ad floram Sincicam," pp. 220–230), specimens are cited as having been collected in Canton as late as October, 1861 (p. 229), while on page 220 Hance wrote "*Whampoa sinensium* Scripsi m. Nov. 1861. H. F. H." This makes a publication date of early 1862 for Planchon and Triana's article very probable. (I am extremely grateful to Dr. H. Heine, Paris, for drawing this evidence to my attention.)

tepals 6 (?always), the outer pair broadly ovate, ca. 6 by 7.5 mm., puberulent on back, the inner ones to 13 by 6.5 mm.; stamens numerous, the filaments to 4.5 mm. long, the anthers oblong, ca. 1.2 mm. long, retuse at apex; ovary ca. 2.5 mm. long, style and stigma unknown. Fruit \pm spherical, ca. 2.1 by 1.9 cm., apiculate, young fruit ovoid and sharply apiculate, drying brown, closely, sharply, and rather shallowly wrinkled; outer layer not detaching cleanly from stone, ca. 1.3 mm. thick, compact and very tough; stone spherical, ca. 1.6 cm. long and across, rounded at apex, the walls less than 0.05 mm. thick, smooth, (?)unmarked; spongy layer thin.

TYPE: Celebes, Malili, Oesoe, 100 m., 2 May 1921, *Cel./II-354* coll. *Waturandang* (holotype, HO).

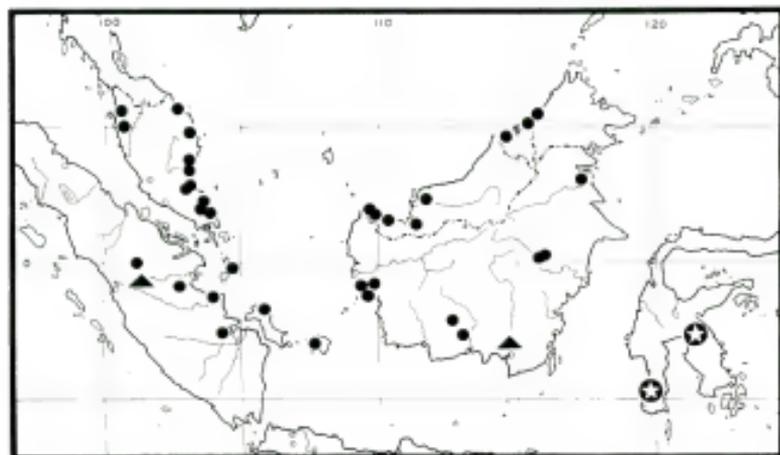
DISTRIBUTION. Celebes (MAP 27).

ADDITIONAL SPECIMENS SEEN. **Celebes**, SULAWESI: Malili, Oesoe, 100 m., *Cel./II-354* coll. *Reppie* (HO), *Cel./II-354* coll. *anon.* (A, L); Pankadjene, *Teysmann*, *HB 12086* (HO); Baleh-angien, *Teysmann*, *HB 12496* (HO).

ECOLOGY. Fruiting in February.

Crateriform, pustular galls occur just in from the margin on the lower surface of the lamina in *Cel./II-354* coll. *Waturandang*.

Calophyllum aerarium can be recognized by its long, narrow, terminal bud; its long petioles; its fairly large, obovate to elliptic lamina that is broadly rounded at the apex (whether or not the very apex is apiculate); its axillary, puberulent inflorescences; and its closely wrinkled fruit with a well-developed, compact, very strong outer layer and a very thin stone wall. The leaves



MAP 27. Distribution of *Calophyllum sclerophyllum* (circles, localized specimens; triangles, unlocalized specimens) and *C. aerarium* (stars in solid circles) in Malesia.

dry a color close to bronze, hence the specific epithet *aerarium* ("made of copper or bronze").

Calophyllum aerarium is superficially like *C. alboramulum*, but the latter has uppermost axillary buds that are suberect, leaf blades that are acuminate at the apex, twigs that dry a paler color, and terminal inflorescences. It also approaches *C. sclerophyllum*, but can be distinguished by its larger flowers and hairs, longer terminal buds, and thinner leaves drying a different color.

80. *Calophyllum celebicum* P. F. Stevens, sp. nov.

FIGURE 28, a-c.

A speciebus aliis Calophylli in ramulis valde 4-angulatis, lamina suboblonga plus minusve valde coriacea spissescenti marginali 0.5-0.8 mm. lati, floribus cum 8 tepalis, fructu strato exteriore valido 1-1.2 mm. crasso, putamine parietibus tenuissimis, differt.

Tree 20-30 meters tall, d.b.h. to 50 cm.; trunk and outer bark not known; latex yellow to yellowish pink.

Twigs slightly flattened, 3.5-5.5 mm. across, strongly and persistently 4-angled to 4-alate, drying blackish brown to blackish, transiently brown-farinose; axillary innovations lacking basal scars; internodes 1-3.5 mm. long; uppermost pair of axillary buds subrounded, ca. 1(-2) mm. long, \pm spreading, inconspicuous; terminal bud plump, 7-9 mm. long, with crustaceous, gray to brown indumentum (hairs, FIGURE 22, r-t; some also moruloid), underdeveloped internode 1-3 mm. long. Petiole 0.8-2 cm. long, broadly and shallowly concave above and convex below, glabrous, drying black; lamina oblong or elliptic to obovate, (7.5-)10-20.2 by (3.7-)4.6-9.6 cm., rounded (rarely obtuse or shallowly retuse) at apex, cuneate to broadly rounded at base, slightly and distantly undulate and somewhat recurved at margin, marginal thickening 0.5-0.8 mm. wide, very coriaceous, drying sepia above and amber below, transiently to subpersistently farinose on midrib below, the midrib above usually abruptly narrowed at (rarely narrowing gradually from) base, depressed, the margins raised or not, 0.35-0.6 mm. wide at midpoint, becoming slightly raised toward apex, below raised, angled, but striate toward base, the venation subapparent above and apparent below, raised, 5 to 8 (to 10) veins/5 mm., angle of divergence 65-75°. Inflorescences from foliate axils, with 7 to 9 flowers, sometimes flabellate, unbranched, the axis 2.2-5.5 cm. long, sparsely farinose, especially toward base, lowest internode 0.4-1.3 cm. long; bracts ovate, to 5 mm. long, deciduous; pedicels ca. 1 cm. long, \pm glabrous, in fruit 1.8-2.6 cm. by up to 3.5 mm. Flower known only in bud, (?)hermaphroditic; tepals 8, inner ones glabrous; stamens ca. 150, the anthers oblong, 1-1.6 mm. long; stigma peltate, ca. 0.7 mm. across. Fruit ovoid to ellipsoid, 2-2.3 by 1.6-1.7 cm., rounded to acute at apex, drying brown, finely striate; outer layer not detaching cleanly from stone, 1-1.2 mm. thick, compact, tough; stone ca. 1.7 by 1.3 cm., rounded at apex, the walls less than 0.1 mm. thick, smooth, (?)unmarked; spongy layer thin.

TYPE: Celebes, Ond. Malili, Oesoe, 200 m., 27 Jan. 1934, *Cel./II-213* coll. *Waturandang* (holotype, α ; isotype, β).

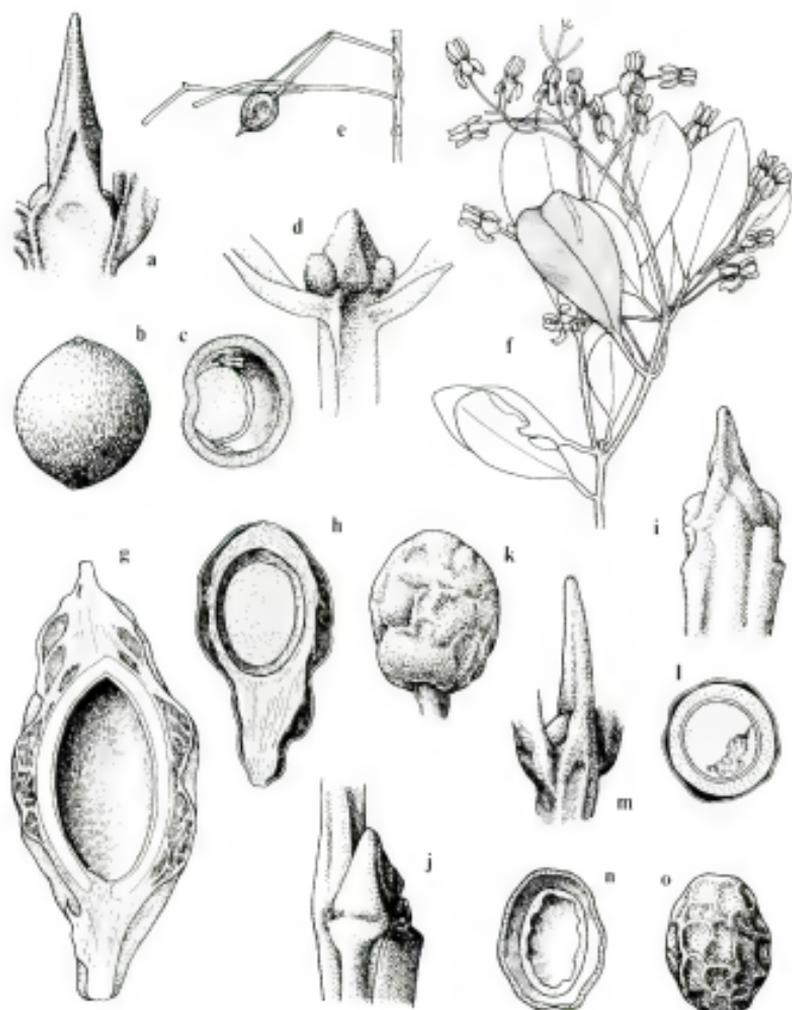


FIGURE 28. a-c, *Calophyllum celebicum* (Cel./II-213). a, terminal bud, $\times 3$. b, c, fruit, $\times 1$: b, from outside; c, transverse section. d-f, *C. ceriferum*. d, f, *Pollane 6172*: d, terminal bud, $\times 6$; f, habit, $\times 0.5$. e, *Robinson 1748*, young infructescence, $\times 0.5$. g, h, *C. macrocarpum*, fruit, longitudinal section, $\times 0.5$: g, *FRI 10926*; h, *S 15898*. i, *C. calcicola* (*Kostermans 14022*), terminal bud, $\times 6$. j-l, *C. havilandii* (*SAN 17449*). j, terminal bud, $\times 6$. k, l, fruit, $\times 1$: k, from outside; l, transverse section. m-o, *C. sundaicum*. m, *SFN 34807*, terminal bud, $\times 3$. n, o, *SFN 26047*, fruit, $\times 1$: n, longitudinal section; o, from outside.

DISTRIBUTION. Sulawesi (MAP 26).

ADDITIONAL SPECIMENS SEEN. **Celebes.** SULAWESI: Ond. Malili, Oesoe, 200 m., *Cel./II-211* (A, BO, L), *Cel./II-212* (A, BO), 300 m., *Cel./II-214* (BO, L), *Cel./II-431* coll. *Reppie* (BO, K, L), 30 m., *bb 32471* (BO, L), Kawatta, *Cel./II-431* coll. *Waturandang* (BO), nabij la Rana, *bb 1821, 1822, 1827* (all BO); Manado, Kolonedale, Pompangeo gebergte, *bb 30150* (BO, L, SING).

ECOLOGY. Forest, 30-300 m. alt. Flowering (specimens in bud) December and January; fruiting in January.

LOCAL USE. Latex produced from the stem is used for torches.

Calophyllum celebicum can be recognized by its dark-drying, strongly four-angled twigs; its coriaceous, more or less oblong lamina with depressed midrib and well-marked band of marginal thickening; and its very thin-walled stone that is almost invisible in the mature fruit. The epithet *celebicum* is taken from an old name for Sulawesi, Celebes.

Calophyllum celebicum is superficially similar to *C. sclerophyllum*, but in addition to the characters mentioned above, *C. celebicum* has pedicels that are strongly incrassate in fruit, hairs of a different type (cf. FIGURES 22, r-t, and 25, g-i), and spongy mesophyll tissue in the lamina that is not lignified as it characteristically is in *C. sclerophyllum* (Vesque, 1893; pers. obs.). The hair structure and thickened leaf margin of *C. celebicum* suggest a closer relationship to *C. teysmannii* var. *inophylloide*, but the midrib, pedicel, and fruit characters mentioned above clearly separate the two.

The specimen *bb 30150* has a more delicate appearance than do the others, but, like them, has a lamina with a prominent, thickened margin.

81. *Calophyllum sclerophyllum* Vesque, *Epharמושis* 2: t. 33. 1889, in C. DC. *Monogr. Phanerog.* 8: 587. 1893; Merr. *Bibl. Enum. Born. Pl.* 394. 1921; Masamune, *Enum. Phanerog. Born.* 476. 1942; Heyne, *Nutt. Pl. Indonesië.* ed. 3. 1: 1085. 1950 ("an *C. sclerophyllum* Vesque?"); M. R. Henderson & Wyatt-Smith, *Gard. Bull. Singapore* 15: 324. 1956; J. Anderson, *Gard. Bull. Singapore* 20: 154. 1963; Pukol & Ashton, *Checklist Brunei Trees*, 93. 1964; Ashton, *Oxford Forest Mem.* 25: pl. 32. 1964; Smythies, *Common Sarawak Trees*, 64. pl. 22. 1965; Kochummen, *Malayan Forest Rec.* ed. 2. 17: 214. 1965; T. C. Whitmore, *Tree Fl. Malaya* 2: 191. 1973; J. Anderson, *Trees Peat Swamp Sarawak*, 88. 1973; Corner, *Gard. Bull. Singapore Suppl.* 1: 105. 1978. TYPE: Sarawak, Kuching, Nov. 1886, *Beccari PB 2705* (holotype, ♀; isotypes, ♂, K, M).

C. rhizophorum Boerl. & Koord. in *Koord.-Schum. Syst. Verzeich.* 2: 39. 1910; J. Anderson, *Trees Peat Swamp Sarawak*, fig. 26C. 1973. TYPE: Sumatra, bei Biwak Soengei Gati, 25 m., 11 March 1891, *Koorders 10333* (holotype, ♂).

C. subauridum Wyatt-Smith, *Malayan Forest Rec.* 17: 113. 1952. *Nomen.* *Calophyllum* sp. prob. *inophyllum* forma, Keith, *N. Borneo Forest Rec.* ed. 2. 2: 314. 1952.

Tree 7.5-36 meters tall, d.b.h. to 76 cm.; trunk with numerous branching stilt roots to 3.5 m. tall, sometimes with knee roots; outer bark pale gray and pink with lines of lenticels, becoming brown, with rather shallow fissures, scaling, the inner surface brown to blackish; under bark pale red to brownish straw; inner bark red to red-brown; latex yellow or pale yellow, clear, very sticky, "pleasantly scented" (*KEP 76078*); sapwood orange-red; heartwood red-brown, hard.

Twigs flattened, 2.3-5.5 mm. across, rounded to sharply 4-angled, drying blackish (rarely mid-brown), glabrous or transiently subfarinose; axillary innovations lacking basal scars; internodes (0.5-)1-5 cm. long; uppermost pair of axillary buds rounded, to 1(-2) mm. long, spreading; terminal bud plump, 3-9 mm. long, with furfureaceous, grayish indumentum (hairs, *FIGURE 25, g-i*), underdeveloped internode to 3(-7) mm. long. Petiole 0.7-2.5 cm. long, broadly and shallowly concave above, convex below, drying black, glabrous or almost so; lamina obovate to elliptic or oblong, 5.7-21 by 2.5-9.5 cm., rounded to retuse at apex, acute to cuneate at base, or broadly rounded toward base, at base short-attenuate, at most distantly undulate and slightly to strongly recurved at margin, coriaceous, drying amber to olivaceous above, amber to olivaceous or sabelline below, glabrous or sparsely transiently farinose on midrib below, the midrib above usually narrowing rather abruptly near base, \pm sunken to slightly raised, adjacent lamina often raised, 0.1-0.4 (-0.5) mm. wide at midpoint, below strongly raised, striate to \pm angled, the venation \pm apparent on both surfaces, raised, (5 or) 6 to 10 veins/5 mm., angle of divergence 55-80°. Inflorescences from foliate axils along twig, with 7 to 11 flowers, unbranched, the axis 2-8 cm. long, puberulent (only near base), lowest internode 1-6(-15) mm. long; bracts unknown; pedicels 1.5-4.2 cm. long, puberulent to glabrous. Flower (?)hermaphroditic; tepals 8, the outer pair ovate to suborbicular, 4.5-7.5 by 4-7 mm., sometimes puberulent on back, the next pair suboblong, 7-12 by 5-8.5 mm., the inner ones oblong to elliptic, 6-9.5(-12) by 3-4.5(-5.5) mm.; stamens (45 to) 85 to 150, the filaments to 4.5 mm. long, the anthers oblong, 1.6-2.5 mm. long, retuse to strongly retuse at apex; ovary 2-2.5 mm. long, the style to 3 mm. long, the stigma peltate, ca. 2 mm. across, 3-lobed. Fruit ovoid to ellipsoid or spherical, 2.4-3 by 1.9-3 cm., apiculate or not (rarely acute) at apex, drying brown, finely wrinkled or striate; outer layer not detaching cleanly from stone, 1-3 mm. thick, compact, rather hard; stone ellipsoid to spherical, to 2.5 cm. long and across, rounded at apex, the walls less than 0.2 mm. thick, smooth, unmarked; spongy layer thin; cotyledons of dried embryo separating easily.

DISTRIBUTION. Malay Peninsula (mostly on the eastern coast) to Borneo, excluding Java (*MAP 27*).

SELECTED SPECIMENS SEEN. **Malaya.** KEDAH: Tasek Gelugor F.R., *KEP 9839* (KEP). PERAK: Dindings, State Land Sg. Gelam, 29 m., *KEP 69429* (KEP); Chikus F.R., *KEP 31043* (?) (KEP). KELANTAN: 59th mile, Kuala Trengganu-Khota Bharu Road, *FRI 2529* (K, KEP, SAR, SING). TRENGGANU: Bukit Bauk F.R., 90 m., *KEP 76078* (KEP); State Land Jerengau, *KEP 81115* (KEP).

PAHANG: Gunong Lesong F. R., Rompin, *KEP 80963* (K, KEP); Sungei Tabing, Kuantan, *KEP 31611* (K, KEP); Perah, Rompin, *KEP 2735* (K, KEP); Pentas Liman, Ulu Rompin, *KEP 2743* (K, KEP, SING); Pekan, 30 m., *KEP 65697* (KEP); Genting Batu (Anak Endau), *KEP 31602* (KEP); Memtelong Ulu Sungei Endau, *KEP 17293* (KEP). JOHORE: Mawai, *SFN 34728* (K, KEP, SING); Jemaluang F.R., 30 m., *KEP 71891* (BO, K, KEP, SING); G. Arong F.R., 15 m., *KEP 76279* (KEP); Sungei Semandan, *Corner s. n.*, 16 June 1934 (KEP, SING); Sungei Sedili, *Corner s. n.*, 29 July 1932 (KEP, SING); Panti F.R., 6 m., *Stevens et al. 114* (A). **Sumatra & adjacent islands.** RIAU: Lingga, Nanggoc, 8 m., *bb 5619* (BO); Indrag. Bovenlanden, Kuala Belilas, 60 m., *bb 27576* (BO, K, L, NY, SING); P. Gelang, *bb 29134* (BO, BRI); Keritang, 5 m., *bb 28677* (BO, SING). DIAMBI: Simpang, 45 m., *bb 12876* (BO). SELATAN: Banjoeasin, en Koeboestrecken, 5-20 m., *5 E 1 P 649* (A, B, BM, BO, BRI, L, NY, P, SING). BANGKA: B[e]linjoe, *Grashoff 34* (BO, L); Bikang, *bb 15106* (BO, L). BELITUNG: Tandj. Pandan, Bantan, 30 m., *bb 8391* (BO). **Borneo.** SARAWAK. 1st Division: near Kuching, *Haviland & Hose 3346* (A, BM, BO, K, SAR, UC); Setapok F.R., *S 16169* (L, SAR, SING); Lundu, *S 9774* (BO, K, L, SING); G. Pueh F.R., *S 6249* (SAR, SING). 2nd Division: Betong, Sempadi F.R., *S 12884* (SAR). 3rd Division: Sibu, Daro F.R., *FA 136* coll. *Anderson* (SAR). BRUNEI: Bendaram, *FMS 30397* (K, KEP). SABAH. Beaufort: Kampong Nuparan, 1.5 m., *A 1714* (K, KEP, L); Kimanis Forest DIST., *A 1401* (BO, CANB, K, KEP, SING); Bongawan F.R., *A 398* (A, K, KEP, SING). KALIMANTAN. Timur: Salimbatoc, S. Roemah, 25 m., *bb 11228* (BO); W. Koetei, Moejoep, 40 m., *bb 16730* (A, BO); Kembang Djangoet, *bb 15684* (BO, L). Tengah: Sampit, 3 m., *bb 32410* (BO, L), Kuala Kuajan, 20 m., *Bostermans 8020* (A, BO, CANB, K, KEP, L, LAE, NSW, P, SING); Beneden Djak, Toewanan Is., 6 m., *bb 9444* (BO). Barat: Poeloe Madjang, *Teysmann, HB 8041* (BO, FL, L); Koeboepadi, 5 m., *bb 6365* (BO); Ambawang, 0 m., *bb 13713* (BO).

ECOLOGY. Freshwater peat swamps or seasonally inundated forest, rarely on sandy soil (*A 398*, Sabah); to 60(-150) m. alt. On Malay Peninsula and in Sumatra, flowering September to November, fruiting February and March. In Borneo flowering January, March, July, October, and November; fruiting February and March.

Circular, crateriform galls occur in rows on the petiole (*bb 9444*) and along the underside of the midrib (*bb 15106*).

GERMINATION AND YOUNG PLANT. The radicle probably breaks through the stone to one side of the base. The seedling has a single pair of leaves, ranging from 11 by 7 cm. (*KEP 31043*) to 5 by 3 cm. (*Stevens 86*). Subsequent leaves produced are alternate, with the stem being notably zigzag (*5 E 1 P 404*, at BO); the terminal bud is functional. It is not known when the transition to opposite leaves takes place, but a young plant almost certainly of this species ca. 1 m. tall and still with alternate leaves was seen in the Setapok Forest Reserve, near Kuching, Sarawak.

LOCAL NAMES AND USE. "Bintangor jangkang" (Malaya), "boenoet djankar" (Bangka), "bintangor jankar" (Sarawak), "penaga djanka" (Kalimantan). The wood is hard and heavy and is used in general construction; since it is not attacked by insects, it is durable.

Although there is considerable variation in leaf, flower, and inflorescence size in the specimens of *Calophyllum sclerophyllum* cited above, they all agree in their coriaceous, rather coarsely veined leaf blades that dry olivaceous; rather short, grayish terminal buds; and stout twigs. The plant often (?always) has stilt roots and usually grows in freshwater swamps (see Ashton, *loc. cit.*, for a good photograph of the stilt roots). Despite the variation in flower size, there are only a moderate number of stamens, and the anthers are large and are often strongly retuse. The fruits are quite large and have a well-developed, compact, and rather hard outer layer and a stone with thin walls. The specific epithet *sclerophyllum* refers to the stiff, coriaceous leaf blades.

Specimens of *Calophyllum sclerophyllum* from Borneo, including the type, have glabrous flowers and inflorescences (except for the fringe of short hairs on the edges of the tepals and the slight puberulence at the base of the inflorescence), while specimens from elsewhere have puberulent indumentum on the inflorescence axis, the pedicels, and the backs of the outer tepals. However, *Kostermans 8020*, from Kalimantan, has slight puberulence at the base of the outer tepals and on the adjacent pedicel. Specimens from Sumatra and Borneo usually have spots on the lower surface of the lamina; these are visible in the field as well. Specimens from Malaya are not usually spotted.

The report of *Calophyllum sclerophyllum* from Papuaia (Stevens, 1974a, as *C. rhizophorum*, based on *Pleyte 762* (A, BO, BRI, K, L, SING)) is incorrect. *Pleyte 762* lacks the lignified spongy mesophyll characteristic of *C. sclerophyllum* (see also Vesque, 1889, *loc. cit.*; 1893, *loc. cit.*). I have not seen any other specimens matching *Pleyte 762*.

The type specimen of *Calophyllum rhizophorum*, which lacks flowers and fruits, is a good match with other specimens of *C. sclerophyllum*, although the twigs have dried somewhat lighter brown than is usual.

82. *Calophyllum havilandii* P. F. Stevens, sp. nov.

FIGURE 28, j-1.

C. rhizophorum auct., non Boerl. & Koord.; Pukul & Ashton, Checklist Brunei Trees, 93, 1964; Smythies, Common Sarawak Trees, 61, 1965; J. Anderson, Trees Peat Swamp Sarawak, 87, 1973, *excl. icon.*

A *Calophyllum sclerophyllum*, quo ut videtur simile est, in gemma terminali basibus petiolorum inclusa (in *C. sclerophyllum* haud incluso), lamina vena submarginali provisa (haud provisa), inflorescentia internodia basali 3-7.5 cm. longa (usque ad 1.5 cm. longa), et fructus rugoso (laevi), differt.

Tree 18-27 meters tall; trunk without buttresses; outer bark yellowish brown, chocolate brown, or pale black, fissured, in large trees with scales; inner bark red, slightly lamellate; latex yellow or pale yellow, clear or opaque, sticky.

Twigs slightly flattened, 1.8-4 mm. across, 4-angled, drying blackish brown, transiently sparsely puberulent; axillary innovations lacking basal scars; internodes 1-3.5(-11) cm. long; the uppermost pair of axillary buds rounded, to 0.5 mm. long, inconspicuous; terminal bud conical, 2-4 mm. long, with

subadpressed, brown indumentum (hairs, FIGURE 25, j), underdeveloped internode absent. Petiole 1-1.6 cm. long, shallowly concave to flat above and convex below, glabrous, drying black; lamina obovate to suboblong, 5.4-14.5 by 3.3-7 cm., slightly retuse at apex, cuneate to broadly rounded and ultimately short-attenuate at base, not undulate and not recurved to slightly so at margin, marginal thickening ca. 0.6 mm. wide, coriaceous, drying amber above and sepia below, transiently sparsely puberulent on midrib below, the midrib above gradually narrowed from base, \pm flat at first, becoming slightly raised, 0.2-0.4 mm. wide at midpoint, below raised, striate, the venation subapparent on both surfaces, raised, 4 to 7 veins/5 mm., angle of divergence ca. 60°. Inflorescences from foliate axils along twigs, with 5 to 9 flowers, unbranched, the axis 7-14.5 cm. long, glabrous, lowest internode 3-7.5 cm. long; bracts elliptic, to 4.5 mm. long, deciduous; pedicels 1.8-4 cm. long, glabrous. Flower (?)hermaphroditic; tepals 4, the outer pair ovate to elliptic, 7-9.5 by 4.5-6 mm., the inner pair obovate, ca. 13 by 8 mm.; stamens 175 to 200, the filaments to 7 mm. long, the anthers oblong, 1.7-2 mm. long, shallowly retuse at apex; ovary ca. 2.2 mm. long, the style ca. 5.5 mm. long, the stigma petalate, ca. 2 mm. across, 3- or 4-radiate. Fruit ellipsoid, ca. 2.1 by 1.7 cm., rounded at apex, drying brown, rather distantly and deeply wrinkled; outer layer detaching cleanly from stone, ca. 2 mm. thick, compact except for air spaces developing under skin; stone ellipsoid, ca. 1.5 by 1.15 cm., rounded at apex, the walls ca. 0.15 mm. thick, smooth, unmarked; spongy layer at first thick.

TYPE: Sarawak [1st Division], near Kuching, 24 Nov. 1894, *Haviland & Hose* = 3345 (holotype, GH; isotypes, BO, P, W).

DISTRIBUTION. Northwestern Borneo (MAP 30).

ADDITIONAL SPECIMENS SEEN. **Borneo.** SARAWAK. 1st Division: near Kuching, *Haviland & Hose* 3345 (BM, K, L, SAR, UC), near G. Siol, *Omar* 372 (K, SING); Stapok F.R., 15 m., *Stevens et al.* 149 (A). 3rd Division: Sungei Tutus Logging Camp, Btg [Batang] Igan, *S* 30557 (SAR); Sibul, Loba Kabang South Protected Forest, *KEP* 79328 (KEP, SAR), *S* 654 coll. *Anderson*, 13 Jan. 1954 (KEP, SAR, SING); Merurong Plateau, 762 m., *S* 18706 (SAR); Lassi, 1100 m., *S* 756 coll. *Sulhi*, 27 Feb. 1954 (SAR); Sungei Assan, *S* 30569 (SAR). 5th Division: Kayangeran F.R., *S* 2843 (SAR). **BRUNEI:** Kuala Belait, Babas State Land, 6 m., *SAN* 17449 (A, BO, K, KEP, L, P, SING). **SABAH:** Sipitang: Mengalong F. R., 3-7.5 m., *SAN* 22316 (SAN, SING).

ECOLOGY. Peat swamps, low alt.; once in kerangas forest, 762 m. alt.; once in swamp, 1100 m. alt. Flowering in November; submature fruit in April.

GERMINATION AND YOUNG PLANT. Young plants are little branched, with the first branch 1.5-3.5 meters above the ground. The terminal bud is functional, and the plant is erect. (*Stevens et al.* 149.)

LOCAL USE. The wood is used for planks.

Calophyllum havilandii superficially resembles *C. sclerophyllum*, with which it has been confused. However, there are numerous differences between the two, and they are probably not closely related. Dried specimens of *C. havilandii* are darker in color than those of *C. sclerophyllum*. In older leaves of *C. havilandii* there is a clear submarginal vein; the leaf blade and the marginal thickening are thinner than in *C. sclerophyllum*, and the vascular bundle embedded in the thickening is farther away from the margin—thus the position of the bundle is not obscured by the thickening. *Calophyllum havilandii* appears to lack a hypodermis and to have very tall epidermal cells with thickened anticlinal walls. However, these "cells" can be seen under high magnification to be divided by unthickened periclinal walls, while the hypodermis of *C. sclerophyllum* is two-layered, with all walls subequally thickened. In addition, *C. havilandii* lacks the thickened spongy mesophyll of *C. sclerophyllum* (see also Vesque, 1889, 1893). The basal internode of the inflorescence axis in *C. havilandii* is characteristically long; that of *C. sclerophyllum* is less than 1.4 cm. Finally, there are important differences in the fruit: *C. havilandii* lacks the strong outer layer of *C. sclerophyllum*, and air spaces develop under the skin of the dried fruit, making it deeply wrinkled. This contrasts with the darker, smooth fruit of *C. sclerophyllum*. Although young plants of the two species are not well known, those of *C. havilandii* are robust and have opposite leaves, while those of *C. sclerophyllum* are weaker and have alternate leaves. Stilt roots have not been reported for *C. havilandii*, although they are usually (perhaps always) present in *C. sclerophyllum*.

The specific epithet commemorates G. D. Haviland.

83. *Calophyllum macrocarpum* Hooker f. Fl. Brit. India 1: 273. 1874; King, Jour. Asiatic Soc. Bengal, II. 59: 179. 1890; Vesque in C. DC. Monogr. Phanerog. 8: 603. 1893; Ridley, Jour. Straits Branch Roy. Asiatic Soc. 33: 48. 1900, Fl. Malay Penin. 1: 187. 1922; M. R. Henderson, Gard. Bull. Straits Settl. 4: 224. 1928; M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 317. 1956; Kochummen, Malayan Forest Rec. ed. 2. 17: 218. 1965; I. H. Burkill, Dict. Econ. Prod. Malay Penin. ed. 2. 1: 416. 1966; Meijer, Bot. Bull. Herb. Forest Dept. Sabah 7: 16. 1967; T. C. Whitmore, Tree Fl. Malaya 2: 187. 1973; H. Keng, Gard. Bull. Singapore 28: 244. 1976; Corner, Gard. Bull. Singapore Suppl. 1: 104. 1978. TYPE: Malaya, Malacca, 30 July 1867, *Malngay 1728* (*Kew dist. 174*) (lectotype, κ). FIGURE 28, g, h.

C. horstii Boerl. Catal. Horto Bogor. 2: 79. 1901; Merr. Bibl. Enum. Bornean Pl. 393. 1921; Masamune, Enum. Phanerog. Born. 475. 1942. TYPE: JAVA [seed from Borneo], 20 May 1898, cult. hort. Bogor. sub numero VI C 39 (lectotype, BO).

Calysaccion horstii Teijsm. & Binn. Catal. Horto Bogor. 205. 1866. *Nomen*.

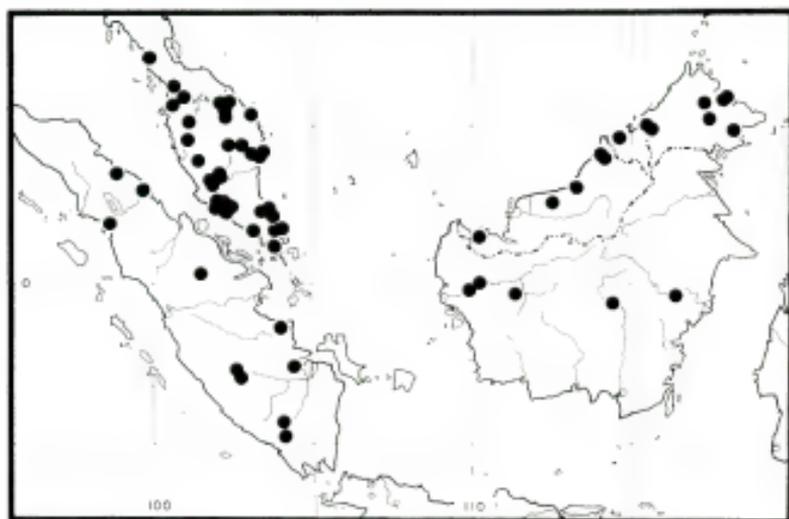
Tree 8–45(–?60) meters tall, d. b. h. to 77 cm.; trunk usually without buttresses (small buttresses present); outer bark yellowish brown at first, becoming dark brown to blackish, with boat-shaped fissures (scaling on ridges), the

inner surface mid-brown to blackish and orange mottled; under bark reddish; inner bark red; latex orange, clear (becoming cloudy later), or gummy, pinkish (*SAN 51223*); sapwood light brown; heartwood dark brown, hard.

Twigs slightly flattened, 2.5-5 mm. across, sharply 4-angled, drying [brown] dark brown or blackish, with transient, sparse, brown hairs to 0.5 mm. long; axillary innovations lacking or with up to two pairs of basal scars; internodes 0.5-2.5(-5) cm. long; uppermost pair of axillary buds rounded, less than 1 mm. long, inconspicuous; terminal bud plump, [1.8-]3.5-5.5(-9) cm. long, with brown, short, tomentose indumentum (hairs, FIGURES 27, q, r; 29, a, b), underdeveloped internode not apparent. Petiole (1.3-)2.5-5.3 cm. long, flat to shallowly concave above, convex below, glabrous, drying black [to brown]; lamina oblong to elliptic (rarely ovate to obovate), 8-25(-35) by 2.3-8.5(-9.2) cm., usually shortly and bluntly acuminate (rarely acute) at apex, acute (cuneate) at base, slightly recurved or not and barely undulate at margin, coriaceous, drying bay to umber above and umber to sepia below, glabrous or sparsely tomentose on midrib below, the midrib above gradually narrowed from base, raised or not (surrounding lamina raised), 0.2-0.8 mm. wide at midpoint, below raised, rounded to striate, the venation above and below usually apparent, raised [sometimes much reticulated and joining submarginal vein], (4 or) 5 to 10 (to 13) veins/5 mm., angle of divergence (50-)65-80°. Inflorescences from foliate axils, with (3 to) 7 to 15 flowers, unbranched or with occasional 3-flowered branches up to 5 mm. long, the axis 1.2-4.5 [-7] cm. long, \pm densely brown-tomentose toward base, glabrous above or not, lowest internode 0.2-1.2 cm. long; bracts unknown; pedicels [0.4-]1-3.2 cm. long, very short-tomentose to glabrous. Flower (?)hermaphroditic; tepals 8 (rarely 10), the outer pair broadly ovate, 9-13 by 7.5-11 mm., glabrous or densely puberulent on outer (and inner) surface, the inner ones ovate to elliptic or lingulate, 11-15 by 2.5-8 mm., two outer usually with band of indumentum down back; stamens 230 to 340, the filaments to 6 mm. long, connate for up to 1.2 mm., the anthers oblong, 1-2.1 mm. long, \pm retuse at apex; ovary 1.8-2.3 mm. long, the style 3.5-6 mm. long, the stigma peltate, 1.3-1.5 mm. across, 3- (to 5-)radiate. Fruit ellipsoid, 8-12.7 by 4.5-6 cm., acute at apex, drying dark brown, irregularly and coarsely wrinkled and regularly and finely longitudinally striate; outer layer not detaching cleanly from stone, 3-8 mm. thick, not compact, with large air spaces developing, very fibrous; stone ellipsoid, 3.7-6.7 by 2.2-3.4 cm., rounded at apex, borne in center of fruit, with fibrous zone 2-2.5 cm. long between stone and base of fruit, the walls ca. 0.4 mm. or 1.6-3.5 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Southern Thailand and Malaya to Borneo, excluding Java (MAP 28).

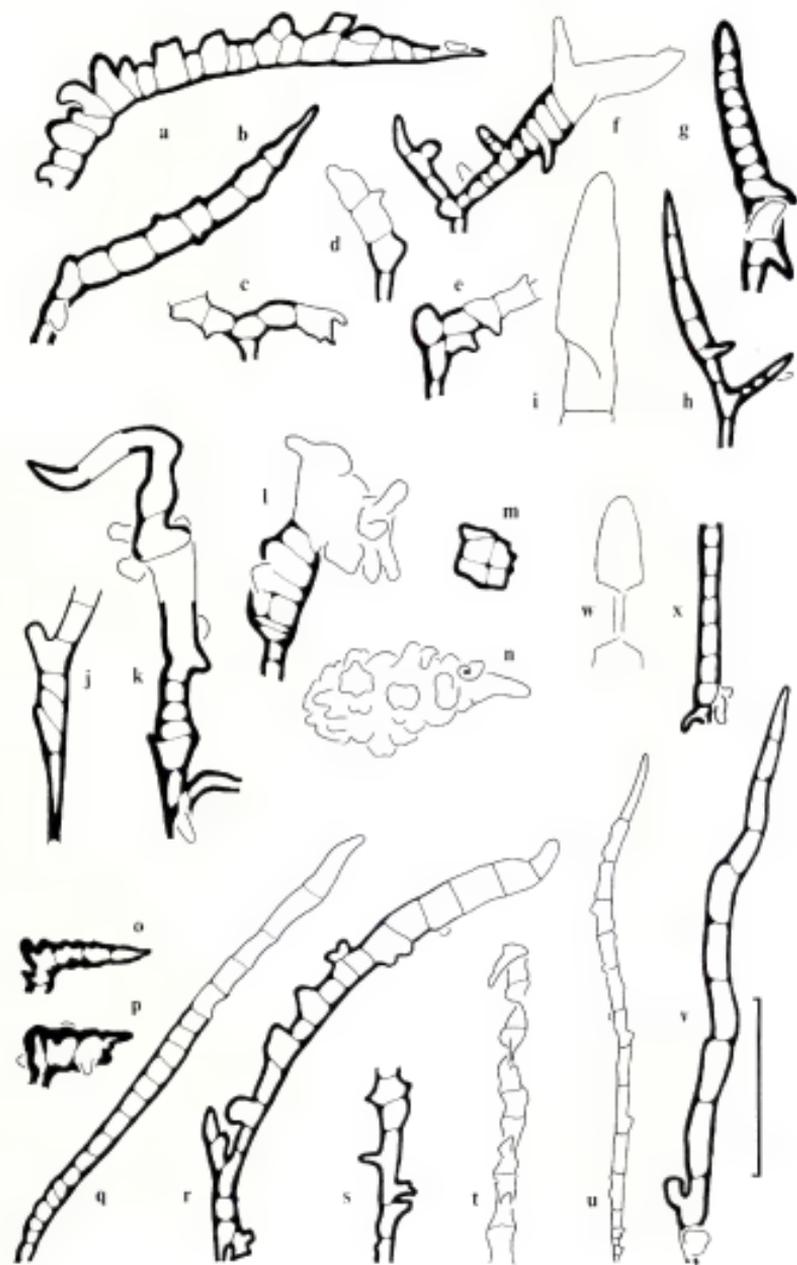
SELECTED SPECIMENS SEEN. **Thailand:** Peninsula, Trang, Khao Chong, *Phusom-saeng & Smitinand 240* (AAU, BKF, C, E, L, P). **Malaya.** KEDAH: Sik Dalam, *KEP 73822* (KEP); Perangin F.R., *KEP 79282* (KEP); Jeriang, Kuala Muda, 60 m., *KEP 73829* (KEP); Kokmoi F.R., *KEP 47869* (KEP). PERAK: Slim Hills F.R., 605 m., *FRI 708* (K, KEP); Pernam R., 60-90 m., *King's collector 8851*



MAP 28. Distribution of *Calophyllum macrocarpum* in Malaysia.

(K): Lenggong, Ulu Luat, *KEP 10368* (KEP); Parit, *KEP 39466* (KEP). SELANGOR: Bukit Lagong F.R., *KEP 94619* (K, KEP); Ulu Selangor, Batang Kali F.R., *KEP 64219* (KEP); Rantau Panjang F.R., *KEP 28915* (KEP); Ulu Langat, *KEP 63602* (KEP); Sungai Buloh F.R., *KEP 43627* (KEP); Ayer Itam F.R., *KEP 53685* (KEP); Public Gardens, Kuala Lumpur, *KEP 1185* (KEP). NEGERI SEMBILAN: Bukit Tinggi, *Ridley s.n.*, 20 Dec. 1920 (K); Sungai Menyala, *KEP 43664* (KEP); Seremban, Port Dickson, *KEP 70472* (KEP); Sertis F.R. quarters, Kuala Pilah, *KEP 94057* (K, KEP). MALACCA: Bukit Sedanan F.R., *KEP 18278* (KEP). KELANTAN: Kemahang North F.R., 30 m., *KEP 65184* (KEP); Machang, Ulu Sat., 365 m., *KEP 118263* (KEP); Sungai Lebir, 2.4 km. S. of Kuala Terengganu, *KEP 115987* (A, K, KEP, SAR, SING); Ulu Sungai Aring, near Kuala Tapah, *FRI 7165* (A, K, KEP, SAR, SING); Olak Jeram, Sungai Rek, 90 m., *KEP 65164* (KEP); Chabang Tongkit F.R., 210 m., *KEP 79208* (KEP). TRENGGANU: Kuala

FIGURE 29. Hairs (from terminal bud, unless otherwise noted). a, b, *Calophyllum macrocarpum*: a, *S 15898*; b, *122 E 1 P 788*. c-e, *C. sundaicum* (*bb 18386*), apical cells usually expanded and thin walled. f-i, *C. costulatum* (*Kadim & Noor 371*): i, terminal cell of hair from pedicel. j-l, *C. biflorum*, apical cells often notably birefringent: j, *S 15241*; k, *SFN 39532*; l, *SAN 83235*. m, *C. mukunense* (*Kostermans 7525*), axillary bud, hair from above. n, *C. subsessile* (*King's collector 6877*), surface view. o-q, s-u, *C. venulosum* var. *venulosum*. o, *Williams 2339*; p, *bb 2974*; q, *Forbes 3069*. s-u, *S 26260*: s, base of hair ca. 690 μ m. long; t, apex of hair ca. 750 μ m. long. r, v-x, *C. pentapetalum*. r, v, var. *cumingii*: r, *BS 27148*; v, *Merrill 609*. w, x, var. *pentapetalum* (*Species Blancoanae 969*), apex and base of hair ca. 860 μ m. long. Scale = 120 μ m. (in n, scale = 60 μ m., in u = 240 μ m.).



Trengganu, *KEP 76078* (KEP). PAHANG: Baloh F.R., *KEP 3139* (KEP, SING); Kuantan, Bukit Berserah F.R., *KEP 65678* (KEP); Kemasul F.R., *KEP 10667* (K, KEP, SING); G. Tapis, 792 m., *FRI 10926* (K, KEP, SAR, SING); Rotan Tunggul Reserve, *KEP 28497* (KEP); Bukit Kajang, 240 m., *KEP 40529* (KEP); Kiri State Land, *KEP 40338* (KEP); Kuala Tahan, King George Vth Park, *KEP 84969* (KEP); Jeriang, Enggang F.R., *KEP 55732* (KEP); Taman Negara Permatang Terusek, 150 m., *FRI 4711* (KEP, SING); Bentong, Clough F.R., *KEP 78708* (KEP). JOHORE: Sungai Kayu, Mawai-Jemaluang Road, *SFN 32240* (SING); above Danau, Sungai Sedili, *SFN 37108* (SING); Mersing, Endau, *KEP 70122* (BO, KEP, SING); G. Panti F.R., 150 m., *KEP 92446* (KEP); Banang F.R., *KEP 79563* (KEP); Kota Tinggi, *Ridley 15446* (BM, K, SING); Bukit Tana Abang, *Lake & Kelsall 4054* (K, SING). **Singapore:** Changi, *Goodenough s.n.*, 26 June 1889 (SING); Botanic Gardens, Lawn C, *SFN 34522* (cult.) (BO, K, KEP, SING). **Sumatra.** RIAU: upper Riau, Pakanbaru, Tenajan R., low alt., *Soepadmo 87* (B, BO, C, E, L, LAE, SING). DJAMBI: Simpang, 45 m., *bb 13114* (BO). SELATAN: Banjoecasin, Koeboestrecken, 15 m., *122 E 1 P 788* (A, K, L); Boeschproefstation, Lematang Ilir, G. Megang, 75 m., *122 E 3 P T 277* (B, BO, BRI, NY, P, SING); Rawas, 100 m., *Grashoff 1044* (BO, L); Moera Doea, Mahanggin, 566 m., *bb 9247* (BO); Bigu Lelok, 150 m., *Forbes 3252* (A, BM); Lematang Oeloe, Loeboek Betoeng, 400 m., *TB 662* (BO); Moesi Ilir, 9 m., *TB 1102* (BO); Lais, Talang Banal, 250 m., *bb 8802* (BO). UTARA: Sibolga, Baroes, Koeboen (M. Tapoes), 0 m., *bb 31026* (A, BO); Bangoean Perba, 660 m., *bb 8659* (BO); Asahan, Sempang Toba, 50 m., *bb 10435* (BO). **Borneo.** SARAWAK. 1st Division: Kuching, 3rd Mile, Matang Road, *Omar 360* (K, SING). 3rd Division: Ulu Arip, Balingian, *Ashton 6003* (A). 4th Division: Bintulu, Nyabau F.R., *S 15898* (A, BO, K, SAN, SAR, SING), 50 m., *Hou 340* (A) (A, C, K). BRUNEI: Andalau F.R., *S 21579* (K, L, SAN, SAR, SING), 30 m., *Ashton s.n.*, July 1959 (B) (SAR). SARAH. Sipitang: Ulu Mendalong, 9.5 km. SSE. of Malaman, 533 m., *SAN 16764* (BO, BRI, KEP, L, SING); Bukit Sambantongan, 30 m., *SAN 27972* (KEP, SAN, SAR). Labuk & Sugut: Bontu Trail, Telupid, 60 m., *SAN 59310* (SAN); SE. Bukit Tangkunan, Mile 85 Labuk Road, *SAN 53543* (SAN). Sandakan: Sepilok F.R., *SAN 39395* (SAN); SW. of Karamuak, Tongkabit, Bukit Mantus, *SAN 51223* (SAN). Lahad Datu: Kennedy Bay, 210 m., *SAN 34804* (SAN). KALIMANTAN. Timur: W. Koetai, bij Lahoem, 10 m., *Enderit 1834* (BO, K, L). Tengah: Poeroek Tjahoe, Tahodjan, 150 m., *bb 21160* (BO, L). Barat: Melawi, B. Watas Emang nabij Kg. Betoeng, 175 m., *bb 26852* (BO, L, MO); Sanggau, Semrangakai, 100 m., *bb 7022* (BO); Soengei Kapoeas, *bb 2030* (BO). Java. BARAT: Bogor (cult.), *VI C 42* (BO), *VI C 115* (BO).

ECOLOGY. Mixed dipterocarp forest, often by streams (Henderson & Wyatt-Smith, *loc. cit.*), also colline forest on ridges, poor lowland forest on acid, sandy soil, and forest on periodically inundated ground; to 792 m. alt. Flowering January, April to August, and November (flower scented); fruiting December, January, and July to September. At least outer layer of fruit appears edible: "orange sap at cambium pericarp of fruit may be eaten" (*FRI 7156*); "fruit green, edible and with a sweet somewhat fibrous flesh" (*S 21579*). In Malaya, fruit eaten by squirrels (*FRI 12284*); Ridley (1930) suggested that they are dispersed by rivers.

YOUNG PLANT. Leaves of young plants are 15-40 by 1.6-6 cm. (Sarawak).

LOCAL NAMES AND USES. *Calophyllum macrocarpum* is usually called "bintangor bunut" in Malaya, and variants of "bunut" ("boenoet," "boeroe") have been recorded from Kalimantan. The wood is hard and is used to build houses and make furniture.

Calophyllum macrocarpum is an easily recognized species, with its black-drying, strongly angled twigs; its long, slender, black-drying petioles, its strongly angled inflorescence axis; and its very large, ellipsoid fruits with a very fibrous outer layer. In Sabah at least, fallen leaves are not quite so readily identified, since the characteristic petiole decays rapidly. *Calophyllum macrocarpum* has the largest fruits in the genus, so its specific epithet is appropriate.

There is considerable variation within *Calophyllum macrocarpum*. Specimens from Thailand and the Malay Peninsula have very thick-walled stones and a moderately fibrous outer layer (FIGURE 28, g). In at least parts of Borneo the stone walls in ripe fruits are only ca. 0.4 mm. thick, and the outer layer is markedly fibrous (FIGURE 28, h). Specimens with the two fruit types are similar vegetatively, and more collections with flowers and ripe fruits are needed to assess the taxonomic significance of the different fruit types. Specimens with a thin stone wall may belong to a taxon close to the *C. pyriforme* complex.

Three specimens from the 4th Division of Sarawak and adjacent Brunei ("a" in the list above) differ from the rest in a number of characters: size of parts, indumentum, and (most obviously) the brown color of the dried twigs and petioles (the characters in which they differ are enclosed in brackets in the description above). One of these specimens (*Hou* 340) has flowers, but the others are sterile; fruits are not known. In characters such as tomentose terminal buds, strongly angled stem, and long-petiolate, coriaceous leaves, the specimens agree with *Calophyllum macrocarpum*, where they are included for the present. However, formal recognition may be necessary when the variation within *C. macrocarpum* is better understood.

Henderson and Wyatt-Smith (*loc. cit.*) considered the record of *Calophyllum macrocarpum* from Singapore (Changi, *Goodenough s.n.*) to be doubtful.

The sheet of *Maingay* 1728 at Kew, collected on July 30, 1867, is designated the lectotype of *Calophyllum macrocarpum*. There is also a sheet under the same number at Kew that was collected on August 3, 1866.

Calophyllum horstii agrees in all respects with *C. macrocarpum*; the large fruits that characterize *C. macrocarpum* were mentioned in the protolog. *Calophyllum horstii* is lectotypified on a sheet at Bogor under the number VI C 39; the specimen has fruits. The other specimen cited in the protolog, VI C 42, bears flowers. In the herbarium at Kew there is a specimen labeled *C. horstii* sent by Binnendijk, who initially thought that it might be *C. lowii* (Kew, *Supplementary Foreign Letters 1865-1900*, Volume 218). The local name is given as "benoet" or "bunut," and an excellent drawing of the fruit is attached to the sheet. Van der Horst (Assistant Resident in Sambas, West Kalimantan), after whom the species was later named, seems to have sent the fruit to Binnendijk.

84. *Calophyllum ferrugineum* Ridley, Jour. Straits Branch Roy. Asiatic Soc. **54**: 17. 1910. TYPE: Singapore, Rogin, 1900, *Ridley 10842* (lectotype, SING; isolectotypes, BO, K, P).

Tree 5-30 meters tall, d.b.h. to 48 cm.; trunk without buttresses or spurs; outer bark usually grayish brown to yellow- or green-brown, mottled, with irregular pustules or boat-shaped fissures (rarely blackish and scaly), hoop marked or not, the inner surface brown to blackish (rarely red or yellowish brown) (mottled); under bark red; inner bark reddish; latex usually clear yellow (white or colorless), sticky; sound of soap powder bubbles when cut (*Liew 143*).

Twigs flattened, 1-3 mm. across, obscurely to strongly 4-angled, drying brown (pruinose when young), \pm persistently tomentose; axillary innovations lacking basal scars; internodes (1-)2-7.5 cm. long; uppermost pair of axillary buds rounded, to 1.5 mm. long, erect to spreading; terminal bud plump to stoutly conical, 2.5-7 mm. long, with brown, tomentose to short-tomentose (rarely subcrustaceous) indumentum (hairs, FIGURE 27, j-p), underdeveloped internode to 3(-4.5) mm. long. Petiole 0.8-1.5 cm. long, broadly and often shallowly concave above, convex below, persistently tomentose below or not; lamina oblong to elliptic, (3-)4-12(-15) by 1.1-5(-8) cm., retuse to shortly and bluntly acuminate at apex, acute at base, \pm undulate and slightly to strongly recurved at margin, coriaceous, drying amber to brick or pale vinaceous-gray above, cinnamon to livid vinaceous below, puberulent and soon glabrescent to subpersistently tomentose on midrib above and below, the midrib above narrowed fairly quickly near base, raised, strongly sulcate at first, adjacent blade obscurely raised, 0.15-0.25 mm. wide at midpoint, below strongly raised, angled to striate, the venation subobscure above, latex canals as prominent as veins, subapparent below, raised, (10 to) 12 to 21 (to 26) veins/5 mm., angle of divergence 50-80°. Inflorescences from foliate axils, with 3 to 13 flowers, usually unbranched (flabellate and/or with 3-flowered branches to 2 cm. long), the axis (1.4-)2-8 cm. long, \pm tomentose, especially toward base, lowest internode (0.2-)1-5 cm. long; bracts ovate, to 3.5 mm. long, tomentose beneath, deciduous; pedicels 0.5-2 cm. long, glabrous, slender, \pm incrassate in fruit. Flower (?)hermaphroditic; tepals 4 (rarely 8), the outer pair ovate, 4-6.5 by 3-4 mm., the inner pair obovate-elliptic, 5-7.5 by 4.2-6 mm.; stamens 60 to 140, the filaments to 4.5 mm. long, the anthers oblong, 0.8-1.5 mm. long, slightly retuse at apex; ovary 1-1.8 mm. long, the style 3-4 mm. long, the stigma peltate, 0.6-1.1 mm. across, 3-lobed. Fruit ovoid to ellipsoid, 1.6-2.6 by 1.2-1.6 cm., acute to truncate at apex, drying \pm cinnamon, sharply wrinkled; outer layer detaching cleanly from stone, 1-1.5 mm. thick, compact, inner surface \pm shining and striate; stone ovoid to ellipsoid, 1.3-1.7 by 0.8-1.5 cm., rounded to apiculate at apex, the walls 0.1-0.2 mm. thick, smooth, unmarked; spongy layer thin.

Key to the Varieties of *Calophyllum ferrugineum*

1. Terminal bud 2.5-4 mm. long; twigs usually not strongly 4-angled; lamina shortly and bluntly acuminate (rarely retuse) at apex.
 84b. var. *oblongifolium*.

1. Terminal bud 3.5-7 mm. long; twigs strongly 4-angled; lamina usually retuse to rounded (obtusely pointed) at apex.
2. Lamina slightly recurved at margin, with (10 to) 12 to 19 veins/5 mm.; inflorescence neither branched nor flabellate. 84a. var. *ferrugineum*.
2. Lamina strongly recurved at margin, with (13 to) 15 to 21 veins/5 mm.; inflorescence often branched and/or flabellate. 84c. var. *orientale*.

84a. *Calophyllum ferrugineum* Ridley var. *ferrugineum*

C. ferrugineum Ridley; Ridley, Fl. Malay Penin. 1: 184. 1922; M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 328. 1956; Kochummen, Malayan Forest Rec. ed. 2. 17: 219. 1965; T. C. Whitmore, Fl. Malay Penin. 2: 180. 1973; H. Keng, Gard. Bull. Singapore 28: 244. 1976.

C. retusum Wall. ex Choisy, Descr. Guttif. Inde, 41. 1849, Mém. Soc. Phys. Hist. Nat. Genève 12: 421. 1851, *quoad descr. et spec. cit.*; Wall. Catal. 4846. 1831, *nomen*; Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 265. 1862; T. Anderson in Hooker f. Fl. Brit. India 1: 272. 1874, *pro parte*; King, Jour. Asiatic Soc. Bengal, II. 59: 176. 1890, *pro parte*; Vesque in C. DC. Monogr. Phanerog. 8: 578. 1893, *pro minore parte*; Ridley, Jour. Straits Branch Roy. Asiatic Soc. 33: 47. 1900, Fl. Malay Penin. 1: 184. 1922; Maheshwari, Bull. Bot. Survey India 2: pl. 21. 1960.

Tree 7.5-22 meters tall, d.b.h. to 43 cm.

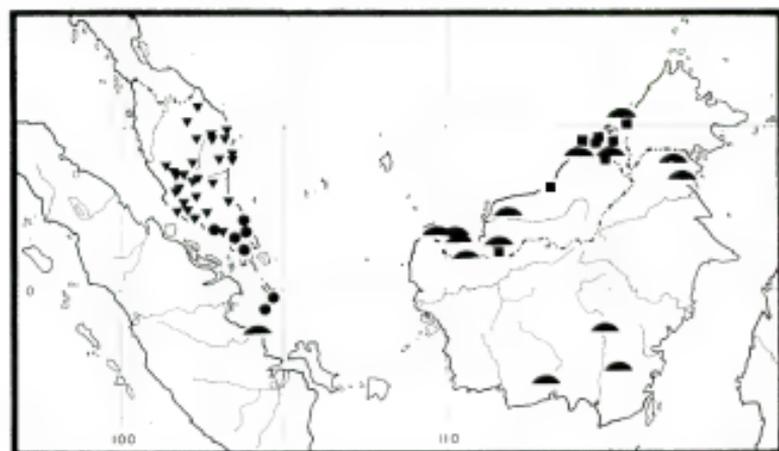
Twigs 2-3 mm. across, strongly 4-angled; terminal bud (3.5-4.5-7 mm. long. Lamina elliptic to oblong, retuse to obtusely and obscurely pointed at apex, the midrib on lower surface often \pm persistently tomentose, lacking impressed margins, the veins (10 to) 12 to 19/5 mm., angle of divergence 65-75°. Inflorescences unbranched, lowest internode tomentose; pedicels slightly incrassate. Stamens ca. 70. Fruit acute to rounded at apex.

DISTRIBUTION. Southern Malay Peninsula, Singapore, Lingga Archipelago (MAP 29).

SELECTED SPECIMENS SEEN. **Malaya.** JOHORE: Gunong Panti F.R., 427 m., *FRI 1705* (K, KEP, SAN, SING); Mersing, Tenggara F.R., 60 m., *KEP 105163* (K, KEP, SING); Panchor, *KEP 62815* (KEP); G. Pulau, 195 m., *Stevens et al. 100* (A). **Singapore:** Bukit Timah F.R., *SFN 35797* (A, K, KEP, LAE, SING); Botanic Gardens, *Ridley 4799* (BM, SING); Tanjung Gul, *SFN 39641* (E, K, P, SING); Changi, *Ridley 5747* (SING). **Sumatra and adjacent islands.** RIAU: Lingga, Daik, 100 m., *bb 11560* (BO); P. Singkep, Soengei Boeloeh, 20 m., *bb 3946* (BO). **Java.** BARAT: cult. in Hort. Bogor. sub numero *VI C 24a* (BO, K).

ECOLOGY. Lowland or colline mixed dipterocarp forest, in Johore sometimes in seasonally inundated forest; to 425 m. alt. Flowering November and December; fruiting December, January, and April (fruit greenish).

Anthony (1974) reported a midge gall (genus perhaps undescribed; Cecidomyiinae - Cecidomyiidi) that caused the edge of the leaf blade to fold abaxially and thus to form a cylinder ca. 1.5 cm. long. Other midge galls, hemispheric swellings ca. 5 mm. in diameter usually on the abaxial side of the leaf (these



MAP 29. Distribution of *Calophyllum ferrugineum* var. *ferrugineum* (circles), *C. ferrugineum* var. *oblongifolium* (triangles), *C. ferrugineum* var. *orientale* (squares), and *C. hosei* (half-circles) in Malasia.

sometimes becoming confluent, and fused in rows), also occurred on the stem, petiole, and midrib. Another gall, a swelling on both faces of the lamina elongated parallel to the midrib, was also described (Anthony, *loc. cit.*).

GERMINATION AND YOUNG PLANT. The radicle probably breaks through the stone to one side of the base. The seedling has two pairs of leaves separated by an internode less than 5 mm. long. Internodes produced during subsequent growth are longer, the young plant is erect, and the terminal bud is functional. (Stevens *et al.* 99, 110.)

84b. *Calophyllum ferrugineum* Ridley var. *oblongifolium* (T. Anderson) P. F. Stevens, *comb. nov.*

C. pulcherrimum Wall. ex Choisy var. *oblongifolium* T. Anderson in Hooker f. Fl. Brit. India 1: 272. 1874; *C. oblongifolium* (T. Anderson) Ridley, Jour. Straits Branch Roy. Asiatic Soc. 82: 170. 1920, Fl. Malay Penin. 1: 184. 1922. TYPE: Malaya, Malacca, 26 Sept., *Maingay 1066* [*Kew dist. 173*] (holotype, K; isotypes, A, K, L, P).

C. nerifolium Ridley, Jour. Straits Branch Roy. Asiatic Soc. 82: 170. 1920, Fl. Malay Penin. 1: 188. 1922; M. R. Henderson, Gard. Bull. Straits Settl. 4: 224. 1928; *C. ferrugineum* Ridley var. *nerifolium* (Ridley) M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 329. 1956; Kochummen, Malayan Forest Rec. ed. 2. 17: 221. 1965; T. C. Whitmore, Tree Fl. Malaya 2: 180. 1973. TYPE: Malaya, Malacca, Mt. Ophir, 10 Dec. 1892, *Ridley 3223* (holotype, SING; isotype, K).

C. ?kunstleri auct., non King; Burkill & Haniff, Gard. Bull. Straits Settl.

6: 173. 1930; Burkill, Dict. Econ. Prod. Malay Penin. ed. 2. 1: 416. 1966.

Calophyllum sp. Ridley, Jour. Straits Branch Roy. Asiatic Soc. 35: 8. 1901.

Tree 5-30 meters tall, d.b.h. to 48 cm.

Twig 1-2 mm. across, \pm obscurely 4-angled; terminal bud 2.5-4 mm. long. Lamina elliptic (rarely suboblong), shortly and bluntly acuminate to obtuse (rounded to retuse) at apex, the midrib on both surfaces usually soon glabrescent (rarely subsersistently puberulo-tomentose—e.g., *FRI 14317*), often with impressed margins on lower surface, the veins 11 to 17 (to 26)/5 mm., angle of divergence 50-75°. Inflorescences neither branched nor flabellate, lowest internode short-tomentose; pedicels slightly incrassate. Stamens 60 to 100. Fruit acute (rarely rounded) at apex.

DISTRIBUTION. Central and northeastern Malay Peninsula (MAP 29).

SELECTED SPECIMENS SEEN. **Malaya.** PERAK: Ulu Slim, 120-180 m., *King's collector 10885* (BM, FI, K, L, P); Ulu Bubong, 240-270 m., *King's collector 10929* (BM, BO, FI, G, K, L, US); Behrang F.R., *FRI 1784* (K, KEP, SING). SELANGOR: Sungei Buloh F.R., *KEP 2264* (K, SING); Bukit Lagong F.R., 270 m., *KEP 93374* (A, BO, K, KEP, SING); 18th mile, Pahang Road, 455 m., *FRI 14317* (A, K, KEP, SAN, SING); Gading F.R., Rawang, 549 m., *KEP 94378* (A, KEP); 22½ miles, Kuala Selangor, *KEP 66201* (KEP); Semangkok F.R., 457 m., *KEP 76195* (KEP); Klang Gates, 90 m., *KEP 66609* (KEP); Ulu Gombak F.R., 549 m., *KEP 93291* (BO, KEP, SING); Bukit Lanjan, *Loh s.n.*, 9 Oct. 1972 (KEP). NEGRi SEMBILAN: G. Angsi, 762 m., *SFN 11655* (A, BO, K, SING); Tampin, *SFN 1379* (BM, BO, K, KEP, SING); Sungei Menyala F.R., *KEP 18503* (KEP); Seremban, Cape Rachado, 120 m., *KEP 70330* (K, KEP); Jelebu, 305 m., *KEP 104916* (K, KEP); Berembun F.R., near Bukit Tangga, *KEP 104862* (K, KEP); Nilai Jindaram Estate, 30 m., *Shah 64* (SING). MALACCA: sine loco, *Alvins 983* (SING). KELANTAN: G. Stong, 838 m., *FRI 10307* (KEP); Ulu Sat F.R., *FRI 2545* (K, KEP, SAR, SING); Sungei Tekal, Gua Ninek, *SFN 19743* (A, BO, SING). TRENGGANU: Bukit Bauk F.R., 270 m., *FRI 2594* (A, K, KEP, SAR, SING); G. Padang Exped., Ulu Brang, 549 m., *FRI 12781* (A, K, KEP, SAN, SING); Kemaman State Land, *KEP 94939* (KEP, SAN, SING); Jerengau F.R., 180 m., *KEP 78561* (KEP); Jambu Bongkok F.R., 6 m., *KEP 77994* (KEP); Mandi Angin, N. of Sungei Loh near Kuala Datok, 427 m., *FRI 12014* (K, KEP); Ulu Dungun, near Sungei Bebir, 270 m., *FRI 9613* (KEP). PAHANG: Ulu Sungei Mentila, Chini, *KEP 2714* (K); Kuantan, Sempedan, 6 m., *KEP 76115* (A, K, KEP, SING); Berserah F.R., 120 m., *KEP 65699* (A, KEP, SING); G. Benom Game Reserve, Ulu Krau, 518 m., *KEP 100102* (A, K, KEP, SING); Ulu Sungei Tekak, 396 m., *KEP 84975* (KEP); Rompin, *KEP 2714* (KEP); G. Tapis, 518 m., *FRI 10037* (KEP); Baloh F.R., *KEP 40213* (KEP); Taman Negara, Lata Bakoh, 240 m., *FRI 23433* (KEP); Kemasul F.R., 75 m., *KEP 78668* (KEP); Temerloh, 180 m., *KEP 77965* (KEP); Bentong, *SFN 16731* (SING). JOHORE: Muar, Banang F.R., *KEP 74110* (KEP).

ECOLOGY. Common in mixed dipterocarp forests on well-drained ridges or hillsides, (6-)100-762 m. alt. Flowering February, May, June, and September (most) to December; fruiting October to May (most in February), June, and July (fruit green, although those of *FRI 20155* reportedly ripen plum color; pericarp eaten by musang (civet cats)).

GERMINATION AND YOUNG PLANT. Details are the same as for *Calophyllum ferrugineum* var. *ferrugineum*. (Stevens et al. 120, FRI 20155.)

LOCAL NAMES AND USES. "Pancar belukan"—boiled and the decoction drunk during the first three days after childbirth (Pahang, SFN 16731). The wood is used for masts and house-building, and the bark is used in making walls for native homes (Malacca).

The epithet *oblongifolium* ("oblong leaf") is inappropriate for this variety, which has elliptic leaf blades, although *Maingay 1066* itself has more or less oblong blades.

84c. *Calophyllum ferrugineum* Ridley var. *orientale* P. F. Stevens, var. nov.

C. ferrugineum Ridley; Pukul & Ashton, Checklist Brunei Trees, 93. 1964; Smythies, Common Sarawak Trees, 59. pl. 19. 1965; Meijer, Bot. Bull. Herb. Forest Dept. Sabah 7: 15. 1967.

A varietatibus aliis *Calophylli ferruginei* in venatione saepe densiore et inflorescentiis ramosis vel flabellatis differt.

Tree 9–28 meters tall, d.b.h. to 30 cm.

Twigs 2–2.5 mm. across, 4-angled; terminal bud 3.5–7 mm. long. Lamina oblong to subobovate, retuse (rarely obtuse) at apex, ± persistently tomentose on midrib on both surfaces, the midrib on lower surface lacking impressed margins, the veins (13 to) 15 to 21/5 mm., angle of divergence 75–80°. Inflorescences often branched or flabellate, lowest internode persistently tomentose; pedicels strongly incrassate in fruit. Stamens 120 to 140. Fruit rounded to truncate at apex.

TYPE: Brunei, Telamba, 29 Oct. 1959, BRUN 5696 coll. Ashton (holotype, L; isotypes, BO, K, KEP, SAR, SING).

DISTRIBUTION. Northwestern Borneo (MAP 29).

ADDITIONAL SPECIMENS SEEN. **Borneo.** SARAWAK. 2nd Division: Simanggang, Bukit Manta, 305 m., S 6519 (BO, K, L, SAR, SING). 4th Division: Baram, Limbang Road, 30 m., S 1500 (KEP, SAR, SING); Tutoh, Melinau, 180 m., S 18705 (SAR); Bintulu, Tinggi, S 953 coll. Kerta, 24 Nov. 1953 (KEP, SAR, SING). 5th Division: Limbang, Sagan Rouge, 427 m., S 1104 (SAR). BRUNEI: Telamba, BRUN 5697 (BO, K, KEP, L, SAR, SING); Badas F.R., 15 m., S 18707 (SAR); Ulu Sugei, 30–60 m., S 1003 (K, L). SANDAKAN. Beaufort: Bukit Sunggau, Weston, SAN 55655 (L, SAN).

ECOLOGY. Locally common on podzolized soil and in kerangas vegetation, sometimes codominant (S 1104, with species of *Casuarina* Adanson and *Dacrydium* Solander); to 427 m. alt. Flowering January, June, July, and October; fruiting in October (fruit white).

The epithet *orientale* ("eastern") was coined because this variety grows to the east of the other two.

Calophyllum ferrugineum can be recognized by its tomentose indumentum; its leaf blades, in which the venation on the upper surface appears to be twice as dense as on the lower; and its inflorescences, which have a long (usually 1–5 cm.) basal internode. The flowers have four tepals. The fruits are often ellipsoid and dry wrinkled; the outer layer detaches cleanly from the stone and is shiny on the inner surface. The epithet *ferrugineum* refers to the rust-colored indumentum that is prominent on the buds, the twigs, and the base of the inflorescence.

The ranking of the various infraspecific taxa of—and those related to—*Calophyllum ferrugineum* has been difficult, although the limits of the taxa themselves are fairly clear. All have medium-sized, moderately densely to densely veined leaves, flowers with (usually) four tepals, and fruits that dry wrinkled, with the outer layer detaching cleanly from the stone and shiny and more or less striate on the inner surface. Some of the taxa have wide geographic ranges yet show little variation within this range, although field characters within *C. biflorum* and *C. ferrugineum* var. *oblongifolium* seem to be somewhat more variable. The species in the group have been recognized on a combination of characters of venation type, inflorescence type, and indumentum distribution; thus, *C. ferrugineum* has venation that appears to be twice as dense on the upper surface of the leaf blade as on the lower (the only species in the group with this character), tomentose indumentum (*C. costulatum* approaches this indumentum type), and an inflorescence with the lowest internode very long (as in *C. costulatum*; less so in *C. biflorum*).

The differences separating the varieties of *Calophyllum ferrugineum* from each another and also from the related species *C. sundaicum*, *C. biflorum*, and *C. costulatum* are listed in TABLE 13. Sterile specimens of *C. ferrugineum* var. *oblongifolium* have been confused with those of *C. xymingtonianum*, but can be separated by the differences given in TABLE 6.

The three varieties of *Calophyllum ferrugineum* occupy geographically different areas (MAP 29). *Calophyllum sundaicum*, which always or nearly always grows in swampy forest, and *C. ferrugineum* var. *ferrugineum* were found growing together with a variant of *C. costulatum* in the Panti Forest Reserve, South Johore. *Calophyllum ferrugineum* var. *ferrugineum* was found growing with *C. biflorum* on Gunong Pulai, in southern Johore.

The specimens of *Calophyllum ferrugineum* from Malaya and Singapore can be placed in their respective varieties, *ferrugineum* and *oblongifolium*, with little difficulty, although *FRI 14317* (var. *oblongifolium*) has the leaf shape of var. *ferrugineum*. Some of the specimens of *C. ferrugineum* var. *ferrugineum* from Johore have somewhat shorter internodes than the specimens from Singapore, and *KEP 105163* has fruits that are rounded at the apex. Bark characters in the group seem to be fairly variable. The latex of *C. ferrugineum* var. *ferrugineum* is yellow, while that of var. *oblongifolium* is usually white. However, latex in specimens of *C. ferrugineum* var. *oblongifolium* (e.g., the numerous specimens collected in Gunong Stong, Kelantan) is sometimes recorded as yellow; in *FRI 10307* (also Gunong Stong) it is

TABLE 13. Variation of some characters in

	<i>C. biflorum</i> Malaya-Singapore	<i>C. biflorum</i> Borneo	<i>C. ferrugineum</i> var. <i>ferrugineum</i>
TERMINAL BUD LENGTH (mm.)	2.5-3.5	3.5-9.5	(3.5-)4.5-7
INDUMENTUM	Short-tomentose	Tomentose (subrustaceous)	Tomentose
HAIRS WITH LARGE, VERY THICK-WALLED, BIREFRINGENT APICAL CELLS	+ -	+ -	-
TWIG 4-ANGLED	Obscurely	Strongly to slightly	Strongly
LAMINA SHAPE	Oblong (elliptic/ obovate)	Basically oblong	Elliptic to oblong
APEX	Retuse to obtuse	Retuse to obtuse	Retuse to subobtuse
VENATION DENSITY (veins/5 mm.)	8 to 12	(8 to) 9 to 15 (to 18)	(10 to) 12 to 19
LATEX CANALS PROMINENT ON UPPER SURFACE MARGIN	-	-	+
RECURVED	-	-	- ±
UNDULATE	-(+)	Slightly	±
FLOWERS USUALLY IN FOURS ALONG INFLORESCENCE AXIS	-	-	-
INDUMENTUM			
PEDICELS	-	-	-
BACKS OF OUTER TEPALS	-	-	-
STAMEN NUMBER	?	60 to 225	Ca. 70
ANTHER LENGTH (mm.)	?	Ca. 1.2	Ca. 1.3
FRUIT			
SHAPE	Short-ellipsoid, apex ± rounded	Short-ellipsoid, apex ± truncate	Long-ellipsoid, apex pointed
SURFACE (when dry)	Coarsely wrinkled	Coarsely wrinkled	Coarsely wrinkled
LATEX COLOR (in trunk)	White	White (clear yellow)	Yellow, clear (rarely colorless)

the *Calophyllum ferrugineum* complex.

<i>C. ferrugineum</i> var. <i>oblongifolium</i>	<i>C. ferrugineum</i> var. <i>orientale</i>	<i>C. sundaicum</i>	<i>C. costulatum</i>
2.5-4 ± Tomentose (rarely subcrustaceous)	3.5-7 Tomentose	5-10 Short-tomentose to subcrustaceous	3.5-5.5 Tomentose
-	+(-)	-	-
Obscurely	Strongly	Moderately	Strongly to slightly
Basically elliptic	Basically oblong	Elliptic to oblong	Elliptic to oblong
Obtuse to subacuminate	± Retuse	Retuse (rounded to subobtuse)	Retuse
11 to 17 +	(13 to) 15 to 21 +	13 to 18 -	10 to 16 -
- -± -	+ Rather to strongly -	- - -(+)	-, slightly -, slightly +
-	-	-, farinose	Tomentose
-	-	-, sparse-farinose	Tomentose
60 to 100	120 to 140	100 to 170	210 to 260
0.8-1.4	0.9-1.5	1.2-2	0.35-0.5
Long-ellipsoid, apex pointed	Short-ellipsoid, apex ± truncate	Short-ellipsoid, apex rounded	Spherical, apex rounded
Coarsely wrinkled	Coarsely wrinkled	Coarsely wrinkled	Finely wrinkled
White or yellow, clear	Yellow	Yellow, clear	Yellow, almost clear

reported to be aromatic. Little is known about the bark of *C. ferrugineum* var. *orientale*; the latex appears to be at least sometimes yellow, and the bark is sometimes blackish and scaly. The hairs of *C. ferrugineum* var. *orientale* have notably thick-walled and birefringent apical cells; the apical cell walls in the other varieties are often thin, or moderately thick and slightly birefringent (FIGURE 27, o, p).

Nomenclatural Confusion in the *Calophyllum* *ferrugineum* Group

There has been much confusion as to the correct names for taxa in the *Calophyllum ferrugineum* group. When Choisy described *C. retusum*, he included *C. burmannii* Wight in its synonymy, hence *C. retusum* Wall. ex Choisy is an illegitimate (superfluous) name now referable to *C. burmannii* (= *C. calaba* var. *bracteatum*). Choisy's description of *C. retusum* seems to be based at least in part on Wallich *dist.* 4846, the only specimen he cited under *C. retusum* and to which Wallich had earlier given the manuscript name *retusum*. Planchon and Triana (1862) removed *C. burmannii* from the synonymy of *C. retusum*, basing the latter on Wallich *dist.* 4846 and giving an excellent description of the species. Unfortunately, they were nomenclaturally incorrect in doing this; their species is referred to below as "*C. retusum*."

Unaccountably, Anderson (1874) totally confused the taxa. He included both *Calophyllum amoenum* and *C. pisiferum* in the synonymy of "*C. retusum*," although the description that he gave seems to be based predominantly on *C. pisiferum*. He gave no reasons for doing this, although he may have been influenced by Planchon and Triana's removal of *C. retusum* β [var.] *parvifolium* to synonymy under *C. amoenum* forma β . (*Calophyllum amoenum* is properly a synonym of *C. polyanthum*. The correct name for the "*C. amoenum*" of authors mentioned here is *C. calaba* var. *bracteatum*.) "*Calophyllum amoenum*," *C. pisiferum*, and "*C. retusum*" are unrelated and very distinct species. Pierre (1885) and subsequent workers in the mainland Southeast Asia area have used the name *C. retusum* for what is properly called *C. pisiferum*. Vesque (1889) figured specimens of *C. pisiferum* as "*C. retusum*"; later (1893), and apparently on Anderson's suggestion, he restored "*C. amoenum*," with *C. pisiferum* as a synonym: "c'est sur la foi de M. T. Anderson que j'avais confondu le *C. retusum* avec le *C. amoenum*." However, he cited Helfer 881 ("*C. amoenum*") under "*C. retusum*" and appears to have based his anatomical description of "*C. retusum*" on that specimen. His morphological description of "*C. retusum*," which does not particularly emphasize the prominent indumentum and describes the inflorescence as being only 12-18 mm. long and five- to seven-flowered, reads somewhat like the description of yet another species, *C. sundaicum* (see below).

King (1890) included only *Calophyllum pisiferum* in the synonymy of "*C. retusum*," so when Ridley (1922) removed and correctly circumscribed *C. pisiferum*, he automatically did the same for "*C. retusum*," citing specimens collected by Wallich and Cantley. Ridley also described *C. ferrugineum*, which

he distinguished from "*C. retusum*" by its slightly larger and oblong (rather than obovate) lamina and its considerably larger inflorescence. A duplicate of *Wallich dist. 4846* at Kew has somewhat smaller inflorescences and terminal bud than are common in "*C. retusum*," but in indumentum distribution and type it is similar to other specimens referred to *C. ferrugineum*; the two taxa are the same, and the correct name for the combined taxon is *C. ferrugineum*.

Perhaps following Vesque (see above) and misled by the appearance of *Wallich dist. 4846*, authors working on the flora of the Malay Peninsula have recently used the name "*Calophyllum retusum*" for the taxon described below as *C. sundaicum*. *Calophyllum sundaicum* has a shorter inflorescence and less conspicuous indumentum than are found in *C. ferrugineum*, and the venation on the upper surface of the leaf blade is the same density as that on the lower.

The synonymy given above for *Calophyllum ferrugineum* and its varieties presents no problems. The name *oblongifolium* must replace the more appropriate *neriifolium* for the most northerly variant of *C. ferrugineum*. The name *C. ferrugineum* itself is here lectotypified by the sheet of *Ridley 10842* at Singapore; *Ridley (loc. cit.)* also cited *Ridley 4799*.

85. *Calophyllum sundaicum* P. F. Stevens, sp. nov.

FIGURE 28, m-o.

C. retusum auct., non Wall. ex Choisy; M. R. Henderson & Wyatt-Smith, *Gard. Bull. Singapore* 15: 331. *pl. 15*. 1956; J. Anderson, *Gard. Bull. Singapore* 20: 154. 1963; Kochummen, *Malayan Forest Rec. ed. 2*. 17: 218. 1965; Smythies, *Common Sarawak Trees*, 61. 1965, excl. spec. cit.; T. C. Whitmore, *Tree Fl. Malaya* 2: 188. 1973; H. Keng, *Gard. Bull. Singapore* 28: 255. 1976; Corner, *Gard. Bull. Singapore Suppl. 1*: 104. 1978.

A speciebus aliis *Calophylli* in foliis mediocris ellipticis vel oblongis apice plerumque retusis in siccitate marginibus planis nervis lateralibus densis (11 usque ad 18 per 5 mm.), et fructu ellipsoideo strato exteriori rugoso e putamine munde secedenti pagina interiore nitida plus minusve striata, differt.

Tree 22-28 meters tall, d.b.h. to 65 cm.; trunk without buttresses (with loop roots); outer bark brown to yellowish, shallowly and closely fissured, or with lenticels in lines, or cracked, the inner surface dark brown to black; under bark orange-brown to dark straw; inner bark pale to dark red; latex yellow, clear, very sticky.

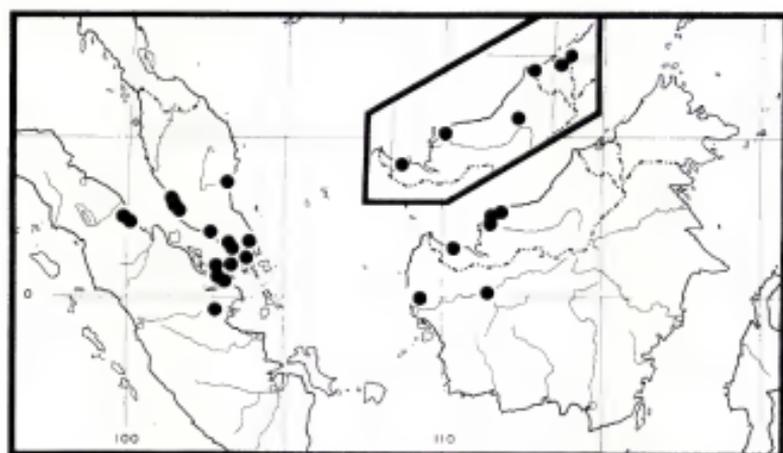
Twigs flattened, (1.5)-2-3 mm. across, 4-angled, drying dark brown to blackish, brown-puberulent when young; axillary innovations lacking basal scars; internodes 0.7-4 cm. long; uppermost pair of axillary buds subrounded, to 3 mm. long, erect; terminal bud plump, 5-10 mm. long, with brown to grayish, puberulent to subtomentose indumentum (hairs, FIGURE 29, c-e), underdeveloped internode to 3 mm. long. Petiole 0.8-2 cm. long, concave to V-shaped above and convex below, \pm puberulent when young; lamina elliptic to oblong, (3.2)-4.5-10(-14.5) by 2.5-5.5 cm., \pm retuse (rounded to subacute) at apex, cuneate to rounded at base, not undulate to slightly so

and recurved at margin, coriaceous, drying bay to castaneous or dark brick above and \pm umber below, puberulent on midrib on both surfaces, the midrib above usually narrowing near base, \pm depressed at first, becoming raised, or raised from base, 0.15–0.3 mm. wide at midpoint, below raised, striate to subangled (edges depressed), the venation subobscure on both surfaces, slightly raised, 11 to 18 veins/5 mm., angle of divergence (50–)70–80°. Inflorescences from foliate axils (rarely terminal—*bb* 4951), with 7 to 11 flowers, unbranched, terminal flowers tending to be 5 together, others in fours, the axis 0.9–2.2(–4) cm. long, puberulent toward base, lowest internode (0.15–) 0.4–1.8 cm. long; bracts ovate, 1.5–2.7 mm. long, not persistent; pedicels ca. 10 mm. long, glabrous to puberulent. Flower (?)hermaphroditic; tepals 4, the outer pair ovate, ca. 6 by 4 mm., rather fleshy, the inner pair \pm obovate, 7–7.5 by 4.5–6 mm.; stamens 100 to 170, the filaments to 4 mm. long, the anthers oblong, 1.2–2 mm. long, retuse at apex; ovary ca. 1.5 mm. long, the style ca. 3.2 mm. long, the stigma peltate, 1.2–1.6 mm. across, 3-lobed. Fruit ellipsoid, 1.5–2.1 by 1–1.4 cm., rounded at apex, drying brown, pruinose, wrinkled; outer layer detaching cleanly from stone, 0.5–1.3 mm. thick, compact, inner surface shining and striate; stone ellipsoid, 1.3–1.8 by 1–1.2 cm., rounded at apex, the walls 0.15–0.2 mm. thick, smooth, unmarked; spongy layer thin.

TYPE: Singapore, Seletar Forest, behind Nee Soon vegetable gardens, 16 June 1951, *SFN* 39252 coll. *Sinclair* (holotype, SING; isotypes, K, KEP, L).

DISTRIBUTION. Southern Malay Peninsula to western Borneo, excluding Java (MAP 30).

SELECTED SPECIMENS SEEN. **Malaya.** SELANGOR: Sungai Tinggi, Kuala Selangor, *SFN* 34087 (A, K, KEP, L, LAE, SING); Klang, Telok F.R., *KEP* 23230 (K, SING); Selatan, *KEP* 96602 (KEP); Kuala Langat, *KEP* 53951 (KEP); Olar Simpit, *KEP* 43692 (KEP). PAHANG: Pekan, State Land, Batu 2 Jalan Kuantan, *KEP* 69601 (KEP); Menchali F.R., *KEP* 67623 (KEP); Kuantan, Pekan–Ninen road, *KEP* 77956 (KEP). JOHORE: Pontian, Api–Api, *KEP* 75603 (BO, K, KEP, L, SING); Pengkalan Raja, *SFN* 36637 (SING); Pontian Besar, *KEP* 70261 (KEP); Kiri Mudek [Sungei Benut], *KEP* 73053 (KEP); Ayer Hitam, *KEP* 70206 (KEP, SING); 8th Mile, Kota Tinggi–Mawai road, *SFN* 29050 (BO, K, KEP, SING); 14 miles Muar–Pt. Sulong road, *KEP* 74107 (KEP). **Singapore:** Jurong, *SFN* 26047 (A, K, KEP, L, LAE, SING); 11½ miles Mandai Road, *SFN* 40268 (A, SING); Botanic Gardens, *SGN* 1633 (?cult.) (SING). **Sumatra and adjacent islands.** RIAU: Karimoen, Telok Sabuk, 1 m., *bb* 5309 (BO), Pangka, 10 m., *bb* 7360 (BO), Tandjong Poendoer, 15 m., *bb* 6306 (BO); Indragirische Bovenlanden, P. Gelang, 4 m., *bb* 29116 (A, BO, K, L, NY, SING); Bengkalis, Poeloe Rangsang, Panglong 222, 3 m., *Beguïn* 505 (BO, L), Telok Oekis, 3 m., *bb* 12853 (BO), P. Mendal, Keloemang, *bb* 12473 (BO); Selatpandjang, Kampar–mondong, 5 m., *bb* 22059 (BO, L); Laboeran Batoe, Laboeran Bilik, 5–10 m., *bb* 4951 (BO); Soengei Ranah, 5–10 m., *Prianier* 286 (BO). UTARA: Bila, 40 m., *Lörzing* 14227 (BO). **Borneo.** SARAWAK. 1st Division: Setapok F.R., 30 m., *S* 4817 (K, L, SAR, SING); Unjam F.R., 0 m., *S* 14464 (SAR). 3rd Division: Daro F.R., *Sl* 126 coll. *Anderson*, Sept. 1953 (SAR); Loba Kabang South Protected Forest, *KEP* 79329 (SAR); Pulau Burit, Sungei Kelepu, 3 m., *S* 8039 (?) (SAR). 4th



MAP 30. Distribution of *Calophyllum sundaicum* in Malaysia. Inset: *C. havilandii*.

Division: Miri, Sungei Dalan F.R., 10 m., *S 1422* (KEP, SAR). KALIMANTAN. Barat: Soemban, 10 m., *bb 18386* (A, BO, L); Batoe Lajang, 4 m., *bb 9675* (?) (BO).

ECOLOGY. Locally common in peat swamps, to 40 m. alt. In Sarawak sometimes in kerangas forest (*S 1422*). Flowering June and September to December; fruiting March and May (fruit greenish).

GERMINATION AND YOUNG PLANT. The radicle probably breaks through the stone to one side of the base. The seedling has two pairs of leaves separated by an internode ca. 5 mm. (-1 cm.) long. Subsequently produced internodes are longer, the terminal bud is functional, and the young plant is erect. (*Stevens et al. 41.*)

Calophyllum sundaicum can be recognized by its puberulent indumentum and by its medium-sized, elliptic to oblong leaf blades that are rounded to retuse at the apex, that have rather dense venation above and below, and that have almost flat margins even when dry. The inflorescence axis is fairly short, and the flowers have four tepals and tend to be in groups of four. The fruit is sharply wrinkled, with the outer layer detaching cleanly from the stone; the inner surface of the outer layer is shiny. The places where *C. sundaicum* grows, although now separated by water, were once part of Sundaland, hence the specific epithet.

The characters that separate *Calophyllum sundaicum* from related species are summarized in TABLE 13. The nomenclatural problems surrounding the name *C. retusum*, which has been used for this taxon, are discussed under *C. ferrugineum*.

The inflorescence of *Calophyllum sundaicum* is characteristically short and congested, with the axis less than 2.5 cm. and the lowest internode often less than 1 cm. However, in specimens such as *KEP 75603* (Malaya), and *Si 126* and *S 4817* (Sarawak), the inflorescences are longer and more like those characteristic of *C. ferrugineum*, the basal internode being more than 1 cm. long.

In the herbarium of the Botanic Gardens, Singapore, there is a specimen of *Calophyllum sundaicum* that may have been collected in Malacca. The specimen bears the number "463" and has a local name written in Arabic ("kayo bintangor batu"); the writing is similar to that on some specimens of *C. pisiferum*, also probably collected in Malacca.

86. *Calophyllum costulatum* M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 344, pl. 26. 1956; T. C. Whitmore, Tree Fl. Malaya 2: 173. 1973; H. Keng, Gard. Bull. Singapore 38: 244. 1976. TYPE: Malaya, Johore, Tanjong Bunga, June 1894, *Ridley 6332* (holotype, SING; isotypes, BM, W).

Tree 5-30 meters tall, d.b.h. to 18 cm.; trunk without buttresses or spurs; outer bark brown to yellowish brown, with vertical rows of flat to pustular lenticels, hoop marked, the inner surface yellow to bright orange; under bark dull reddish; inner bark pale red to pink; latex yellow, slightly opaque or (?)clear, very sticky.

Twigs flattened, 2-3 mm. across, 4-angled, drying blackish to yellowish when young, when older yellowish, \pm persistently (pale) brown-tomentose; axillary innovations lacking basal scars; internodes 0.5-3.5 cm. long, lowest internode of axillary innovation often notably longer than others, uppermost pair of axillary buds rounded, 2-2.5 mm. long, erect; terminal bud plump, 3.5-5.5 mm. long, with brown, tomentose indumentum (hairs, FIGURE 29, f-i), underdeveloped internode 1-2.5 mm. long. Petiole 2.5-6.5 mm. long, broadly and rather deeply concave above, convex below, \pm persistently short-tomentose; lamina elliptic to oblong, 2.4-7(-11) by 1.6-3.1(-4.2) cm., retuse at apex, broadly rounded at base, not undulate to slightly so and recurved at margin, coriaceous, drying umber to sepia above (margins much paler) and fulvous to sabelline below, \pm persistently tomentose on midrib below and often above and on margins, the midrib above narrowing quickly or rather quickly near base, raised, 0.12-2 mm. wide at midpoint, below strongly raised, striate to rounded, venation apparent above, apparent to subobscure below, raised, 10 to 16 veins/5 mm., angle of divergence 70-80°. Inflorescences from foliate axils (very rarely terminal), with 5 to 11 flowers, terminal flowers often in fives and sevens, others in fours, unbranched, the axis 3.8-9.5 cm. long, tomentose, lowest internode 1.7-5.2 cm. long; bracts unknown; pedicels 1-1.7 cm. long, tomentose. Flower (?)hermaphroditic; tepals 4, the outer pair suborbicular, ca. 4 mm. long and across, backs tomentose-canescens, the inner ones broadly obovate to elliptic, 6-7 by ca. 6 mm.; stamens 210 to 260, the filaments to 4.2 mm. long, the anthers broadly elliptic, 0.35-0.5 mm. long, retuse at apex; ovary ca. 1.2 mm. long, the

style ca. 3.5 mm. long, the stigma peltate, ca. 0.8 mm. across, 2-lobed. Fruit spherical, ca. 1.4 cm. long and across, rounded at apex, drying brown, closely wrinkled; outer layer detaching cleanly from stone, ca. 1.4 mm. thick, compact, striate on inner surface; stone spherical, ca. 1.05 cm. long and across, rounded at apex, the walls ca. 0.25 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Malaya and Singapore (MAP 36).

ADDITIONAL SPECIMENS SEEN. **Malaya.** PERAK: G. Besout F.R., Slim R., 90 m., *FRI 1767* (K, KEP, L, SAN, SING). JOHORE: Kpg. Hubong, Endau, *Kadim & Noor 371* (A, L, LAE, SING); Panti F.R., Kota Tinggi, 564 m., *KEP 94367* (K, KEP, L); G. Arong F. R., 15 m., *Stevens et al. 84* (?) (A). **Singapore:** Bukit Timah, *Langlassé 123* (G, P).

ECOLOGY. Swamps, flat land, or hillsides, primary and secondary forest; 15-564 m. alt. Flowering June to August (flower scented); fruiting in December (fruit green).

Calophyllum costulatum can be recognized by the dense, often whitish, tomentose indumentum on the twig, terminal bud, midrib, inflorescence axis, pedicels, and outer pair of tepals; the oblong-elliptic, usually more or less flat-drying leaf blades with short petioles and clear venation; the flowers with four tepals and small anthers; and the spherical fruits. The specific epithet *costulatum*, the diminutive of *costa* (midrib), refers to the narrow midrib on the upper surface of the lamina.

Calophyllum costulatum is clearly related to the *C. ferrugineum* complex; the characters by which it differs are given in TABLE 13. At least sometimes *C. costulatum* has a discolored, pale leaf margin like *C. biflorum*. In the long, lowest internode of the inflorescence, it is like *C. ferrugineum*, and in general fruit structure it agrees with all the members of the complex, although the dried fruit is more finely wrinkled than it is in the other taxa. The hairs of *C. costulatum* are slightly birefringent, and the apical cells, although often very large, are unthickened and empty (hence the whitish color of the indumentum); they are perhaps most similar to the hairs of *C. ferrugineum* vars. *ferrugineum* and *oblongifolium*.

The lamina of *Stevens et al. 84* dried similar to that of *Calophyllum biflorum*, and the scars of the flowers on the infructescence do not appear to be in fours; it is included in *C. costulatum* only with hesitation. A more problematic specimen is *Soepadmo 53* (Sumatra, Upper Riau, Pekanbaru, Tonajan River, in swamp; A, B, NO, C, L, NY, SING), which has the very coriaceous lamina and the indumentum distribution of *C. costulatum*, but the lamina is cuneate to acute at the base, the venation is obscure on both surfaces, and the midrib on the lower surface is coarsely striate. There does not seem to be any tendency for the scars of the flowers on the infructescence to be in fours. Both specimens have hairs like those of more typical specimens.

On some duplicates of *Ridley 6332*, the collection date is given as May 7. Whether this is an error or not is unknown.

87. *Calophyllum biflorum* M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 349. pl. 29. 1956; Kochummen, Malayan Forest Res. ed. 2. 17: 217. 1965; T. C. Whitmore, Tree Fl. Malaya 2: 176. 1973; H. Keng, Gard. Bull. Singapore 28: 244. 1976. Type: Malaya, Johore, Gunung Arong Forest Reserve, 18 Nov. 1948, KEP 35963 coll. *bin Talib* (holotype, KEP; isotype, K).

C. retusum auct., non Wall. ex Choisy; Smythies, Common Sarawak Trees, 61. 1965, *quoad spec. cit.*

C. inophylloide King var. *singaporense* auct., non M. R. Henderson & Wyatt-Smith; Smythies, Common Sarawak Trees, 61. pl. 20. 1965, *et quoad spec. cit.*

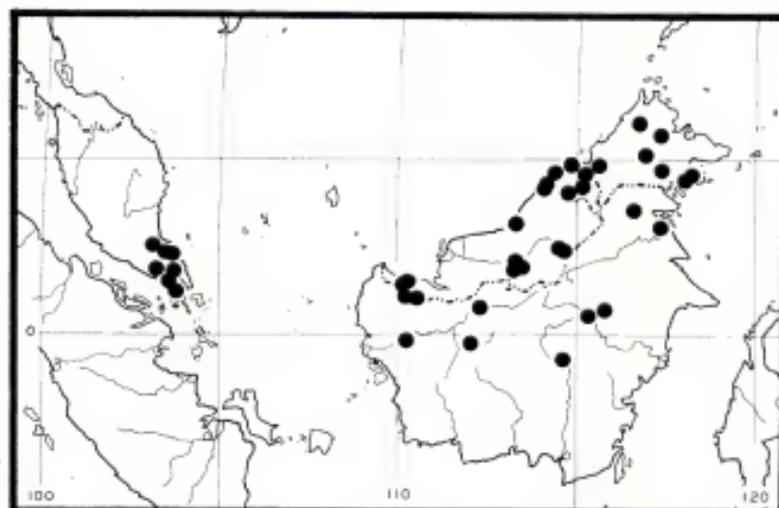
Tree 6–36 meters tall, d.b.h. to 95 cm.; trunk without buttresses (very rarely with spurs); outer bark yellowish and brownish mottled, with distant, shallow, boat-shaped fissures or lines of lenticels and with areas of darker, rougher bark, or brownish, sometimes scaly, often hoop marked, the inner surface mottled orange and dirty brown, to deep brown; under bark reddish; inner bark red, laminated; latex white, often curdy, \pm sticky (yellow, clear or opaque).

Twigs flattened, 1.2–3(–3.5) mm. across, \pm 4-angled, or rounded, drying (rarely pale) brown or dark brown, transiently farinose to subsersistently tomentose; axillary innovations lacking basal scars; internodes 1–6.5(–7.5) cm. long; uppermost pair of axillary buds \pm rounded, 0.5–3 mm. long, erect; terminal bud plump to conical, 2.5–9.5 cm. long, usually with brown, tomentose (subcrustaceous, grayish) indumentum (hairs, FIGURE 29, j–l), underdeveloped internode to 3(–7) mm. long. Petiole 0.5–1.8 cm. long, broadly concave above, convex below, glabrescent or subsersistently tomentose; lamina oblong to subelliptic or obovate, 3.5–12.5 by 1.7–4.5 cm., retuse to rounded (rarely subacute) at apex, acute to cuneate at base, slightly to strongly and distantly undulate and barely recurved at margin, coriaceous to very coriaceous, drying grayish sepia to cinnamon above and hazel to sabelline below, with subsistent, brown, farinose to tomentose indumentum on midrib on both surfaces, or soon glabrescent, the midrib above usually narrowing rather quickly near or gradually from base, raised, 0.15–0.35 mm. wide at midpoint, below raised, striate, the venation apparent (rarely subobscure) above and below, \pm raised, 7 to 15 (to 18) veins/5 mm., angle of divergence 55–75°. Inflorescences from foliate axils near ends of twigs, with 5 to 21 flowers, sometimes flabellate, and/or with 3-flowered branches to 1.5 cm. long, the axis 0.8–6.5 cm. long, \pm tomentose on lowest internode, lowest internode (0.2–)0.6–3.2 cm. long; bracts narrowly ovate or elliptic, 2–3 mm. long, deciduous; pedicels 0.8–3.2 cm. long, glabrous, pronouncedly incrassate in fruit or not. Flower (?)hermaphroditic; tepals 4, glabrous, the outer pair ovate to broadly elliptic, 4.5–6 by 3–4.5 mm., the inner pair obovate, ca. 8 by 4 mm.; stamens 60 to 225, the filaments to 3 mm. long, the anthers oblong, ca. 1.2 mm. long, retuse at apex; ovary 1.5–2 mm. long, the style ca. 2.5 mm. long, the stigma peltate, ca. 0.5 mm. across, obscurely 3-radiate. Fruit ellipsoid to spherical or ovoid, 1.1–2.3 by 1.1–2.2 cm., truncate to rounded at apex, drying brownish, sharply

wrinkled (obscurely striate); outer layer detaching cleanly from stone, 0.5-3 mm. thick, \pm compact, air spaces sometimes developing, the inner surface striate, dull or shiny; stone subspherical to ellipsoid or ovoid, 1-1.8 by 0.8-1.35 cm., rounded to obtusely pointed at apex, the walls 0.1-0.3(-0.65) mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Southern Malay Peninsula, Singapore, Borneo (MAP 31).

SELECTED SPECIMENS SEEN. **Malaya.** JOHORE: Mersing, 30 m., *KEP 76288* (A, BO, K, KEP, SING, US), Endau Road, 30 m., *KEP 76281* (A, K, KEP, SING), Ulu Endau, near summit of Bukit Kendek, 396 m., *KEP 105019* (robust) (A, K, KEP, SING); Kluang, Renggam F.R., 427 m., *KEP 98951* (A, K, KEP, SAN, SING); Kluang F.R., Bukit Jelakoi, 210 m., *KEP 76296* (K, KEP, SING); Kota Tinggi, Panti F.R., 90 m., *KEP 73055* (K, KEP, SING); G. Arong F.R., 45 m., *KEP 94883* (KEP). **Singapore:** Sungei Hantu, opposite P. Serimbun, 0 m., *SFN 39532* (A, E, K, KEP, SING); "Woodlands," *Albero s.n.*, March 1866 (FI). **Borneo.** SARAWAK. 1st Division: Semengoh F.R., *Omar 387* (K, SING); Bako Natl. Park, along Lintang Path, *S 24865* (K, L, SAR); Sempadi F.R., *S 6147* (SAR); Matang W. ridge, 305 m., *S 15241* (A, BO, K, L, SAN, SAR, SING); Serian, G. Penrissen, *S 16303* (A, BO, K, L, SAN, SAR, SING); Sabal Tapang, 150 m., *Stevens et al. 177* (A). 3rd Division: Kapit, Yong, Ulu Bediri, 750 m., *S 36381* (SAR), Ulu Sungei Kapit, Bukit Goran, 750 m., *S 36187* (SAR), ridge between Sungei Balang and Sg. Balleh, 518 m., *S 28260* (A, L, SAR, SING); Usun Apau Plateau, R. Jalan, 965 m., *S 3802* (SAR, SING), between R. Biak and Sut, 721 m., *S 2938* (SAR, SING, US). 4th Division: Miri, Sungei Miri, *S 12944* (BO, K, L, SAN, SAR, SING); Baram, Ulu Melinau, 180 m., *S 1049* coll. *Brunig*, Aug. 1958 (SAR); Bintulu, Nyabau F.R., *S 14487* (K, L, SAN, SAR, SING); Bukit Lambir,



MAP 31. Distribution of *Calophyllum biflorum* in Malasia.

366 m., *S* 26780 (A, E, K, SAR, SING). 5th Division: Trusan, Bukit Tudal, 975 m., *S* 8742 (SAR); Lawas, Morigau Range, 1067 m., *S* 18704 (SAR). BRUNEI: Berakas F.R., 15 m., *S* 7811 (A, BO, K, KEP, L, SAR, SING); R. Ingei, 30 m., *BRUN* 131 (A, K, KEP, L, SING); Kuala Belait, *S* 1944 (SAR); Andalau F.R., *BRUN* 251 (BO, K, KEP, L, SAR). SABAH: Sipitang: W. side of G. Lumaku, 16 km. SSE. of Malaman, 1372 m., *SAN* 16718 (?) (BRI, KEP, L, SAN, SING). Ranau: Poring turnoff, 640 m., *Stevens et al.* 558 (A). Labuk & Sugut: Bukit Tangkunan, 180 m., *SAN* 61260 (SAN). Tawau: Tawau R. F.R., 50 m., *SAN* 19449 (L), below summit Mt. Lucia, 1067 m., *SAN* 22691 (BO, KEP, SAN, SAR); Mt. Wullersdorf, 610 m., *SAN* 61428 (SAN); Brassey Range, 770 m., *Stevens et al.* 477 (A). Kinabatangan: Bukit Tingka, 365 m., *SAN* 23268 (?) (KEP); Lamag, S. side of G. Lotung Inarat, 1524 m., *SAN* 83235 (?) (A). KALIMANTAN. Timur: Bulungan, Sg. Sebakis region, *Kostermans* 9247 (BO, K, L, P); Ti-doengsche Landen, 16 m., *bb* 18276 (A, BO, L); Salimbatoo, Sungei Pingping, 150 m., *bb* 11178 (BO); W. Koetai, Mt. Palimasan near Tabang on Belajan R., 800 m., *Kostermans* 12959 (BO, L); Keloempang, 50 m., *bb* 16939 (A, BO, L); Boven Mahakam, Taliba (G. Leng, Bov. Pari), 600 m., *bb* 26586 (BISH, BO, K, L, NY, P, SING). Tengah: Beneden Dajak, Tewai Baroe, 40 m., *bb* 8170 (BO); Poeroktjahoe, Mahoendjoeg, 25 m., *bb* 21247 (?) (A, BO). Barat: foet van G. Kenepai, *Hallier* 1633 (A, BO, BRI, K, L, SING); Melawi Tjatit, B. Kemoenting, 225 m., *bb* 29651 (?) (BO, L, SING); Meliau, Dawak, 50 m., *bb* 12401 (BO).

ECOLOGY. Usually in well-drained mixed dipterocarp forest, to 1067(-1372) m. alt. In Borneo frequently in kerangas vegetation, once in peat swamp (*S* 12944, Sarawak); also in soil derived from ultramafic rock. Flowering May, October, and November; fruiting January to March, May, June, and October (fruit pale green).

GERMINATION AND YOUNG PLANT. The radicle almost certainly breaks the stone to one side of the base. The seedling has two pairs of leaves separated by an internode less than 1 cm. long. Subsequently produced internodes are successively longer, the terminal bud is functional, and the young plant is erect. The leaves of the seedling are 1.1-1.9 cm. wide, and successively produced ones are notably narrower (initially only 0.6-1.3 cm.). Axillary innovations of the young plant may have basal scars. (*KEP* 76296; *Stevens et al.* 50, 134A, 255, 406A.)

LOCAL USES. The wood is used to make planks (Kuching). The latex of *S* 3802 (3rd Division, Sarawak) was noted as being poisonous, but there may have been confusion between this plant and a member of the Anacardiaceae (the local name of *S* 3802 is given as "betaho").

Calophyllum biflorum can be recognized by its usually oblong lamina that has a retuse to subacute apex and venation of equal density on both sides; it often dries with the margin a paler color than the rest of the blade. Its flowers have four tepals, and its fruits are broadly wrinkled when dry. The outer layer of the fruit detaches cleanly from the stone, and the inner surface of the outer layer is striate and usually shiny. Indumentum, other than on the terminal bud, the very base of the inflorescence, and the young parts

of the plant, is usually inconspicuous. The specific epithet *biflorum* means "two flowered"; Henderson and Wyatt-Smith incorrectly thought that this species had two-flowered inflorescences.¹⁵

There is considerable variation within *Calophyllum biflorum* in Borneo, even in a single locality. On Gunong Matang (near Kuching, Sarawak) at least two forms of the species grow together (*Stevens et al.* 234, a very coriaceous-leaved form, and *Stevens et al.* 237, with less coriaceous leaves—more like the Malayan form). Some specimens from Borneo have yellow latex: *Stevens et al.* 134, from near Kuching, had yellow latex, yet is very close vegetatively to the Malayan form; some of the specimens from the 3rd Division of Sarawak are also reported to have yellow latex. Some Bornean specimens may lack the paler leaf margin otherwise common in the species, and brown outer bark seems to be notably more common in Borneo than in Malaya. In Johore trees of *C. biflorum* often have broad bands or patches of brown, scaly bark from which latex has exuded and dried a more or less pellucid greenish white color; this may be caused by damage to the trunk. I did not observe this phenomenon in trees of *C. biflorum* from Sarawak and Sabah, although there was black dammar at the base of the trunk of *Stevens et al.* 128 (Sarawak). Branched inflorescences are not present in Malayan specimens of *C. biflorum*, although they appear to occur quite commonly in Sarawak and Brunei, and at least sometimes in Sabah (*SAN* 83235). Most Bornean specimens have leaf blades that are more coriaceous and terminal buds that are longer than those of the Malayan specimens. However, the difference is not absolute; *KEP 105019* (Malaya) is very similar to many Bornean specimens.

Despite this considerable variation, it would be imprudent to recognize infraspecific taxa in *Calophyllum biflorum*. The pattern of variation in Borneo is not well understood; not only do distinct forms seem to grow in close proximity (Gunong Matang, Sarawak: see above), but the knowledge of variation in individual characters is imperfect. Thus, in Borneo inflorescence type is known only from a few specimens, and despite the abundance of *C. biflorum* in Johore, Malaya, flowers have still not been collected there. Although there is considerable variation in hair type (FIGURE 29, j-l), the hairs are similar on some Bornean and Malayan specimens.

The specimens cited above from the 3rd Division of Sarawak are included in *Calophyllum biflorum* only with hesitation. Some specimens have large fruits and/or leaf blades that are more or less acute at the apex, and the margin of the leaf does not dry notably discolored. The striate inner surface of the outer layer of the fruit is dull rather than shiny. *S 26780* (4th Division, Sarawak) also has subspherical fruits, the outer layer of which has a dull inner face; this specimen was taken from a large tree reported to have had

¹⁵The inflorescence of *Calophyllum biflorum* was originally described as being few flowered, while in the key given by Henderson and Wyatt-Smith (*op. cit.*, p. 301) it was called two flowered. However, both the young inflorescences and the infructescences of the material that Henderson and Wyatt-Smith had at hand have or had five to seven flowers.

thick, low buttresses—an unusual condition in the species.

Calophyllum biflorum is most closely related to *C. ferrugineum* and its relatives; for the differences separating these taxa, see TABLE 13. Sterile specimens of *C. biflorum* from Borneo, especially from the Semengoh Forest Reserve, near Kuching, Sarawak, can be confused with *C. teysmannii* var. *inophylloide*. The latter taxon has a more or less obovate (rather than oblong) lamina frequently with a clearly thickened margin; although the margin of *C. biflorum* is often discolored, the veins are not obscured by thickening as they are in *C. teysmannii* var. *inophylloide*. *Calophyllum teysmannii* var. *inophylloide* apparently always has yellow latex, and the trunk often has spurs and/or stilt roots; the latex of *C. biflorum* is often white, and spurs and stilt roots are very uncommon. *SAN 83235* (Sabah) at least superficially approaches *C. canum*: its leaf blades are more or less pointed at the apex and its latex is reported to be "white yellow."

88. *Calophyllum hosei* Ridley, Kew Bull. 1938: 120. 1938; Masamune, Enum. Phanerog. Born. 475. 1942; J. Anderson, Trees Peat Swamp Sarawak, 86. pl. 27B. 1973. TYPE: Sarawak [4th Division], Baram District, Jan. 1895, *Hose 146* (holotype, K; isotypes, BM, L, SING).

Calophyllum fragrans Ridley, Kew Bull. 1938: 120. 1938, *paratype excepto*; Masamune, Enum. Phanerog. Born. 475. 1942. TYPE: Sarawak, 2 miles [3 km.] from Kuching, 10 Dec. 1894, *Haviland & Hose 3355* (holotype, K; isotypes, A, BM, BO, L, P, SAR, UC, W).

Tree 7.5–18(–36) meters tall, d.b.h. to 45 cm.; trunk without buttresses, small knee roots with prominent, corky lenticels reported (Anderson, *loc. cit.*); outer bark grayish to brown and yellow, often mottled, with lines of lenticels, often hoop marked, the inner surface dark brown; under bark orange-brown; inner bark red; latex yellow (white), opaque to clear, sticky (watery).

Twigs flattened, 1.5–2.5 mm. across, rounded (4-angled), drying blackish brown, glabrous even when young; axillary innovations with pair of basal scars and another pair ca. 1.5 mm. from base; internodes 1–4 cm. long; uppermost pair of axillary buds rounded, ca. 1 mm. long, spreading; terminal bud plump, 1.8–4 mm. long, with short, adpressed, grayish brown indumentum (hairs, FIGURE 25, p, q; some also moruloid), underdeveloped internode 1–4 mm. long. Petiole (0.5–)0.8–1.3 cm. long, broadly concave above, convex below, glabrous; lamina oblong to elliptic, (3–)4–9.5 by (1.7–)2.2–5 cm., retuse (acute-subacuminate) at apex, acute [cuneate] at base, not undulate or shallowly and distantly so and slightly recurved at margin, coriaceous to very coriaceous, drying umber to sabelline-olivaceous above and umber to fulvous-olivaceous below, glabrous, the midrib above gradually narrowed from base, \pm raised, center sulcate at first, 0.2–0.4(–0.6) mm. wide at midpoint, sometimes disappearing below apex, below raised, striate [very prominent, rounded], the venation above subobscure, below subobscure to subapparent, slightly raised, (9 to) 11 to 17 (to 22) veins/5 mm., angle of divergence 70–80°. Inflorescences from foliate axils near ends of twigs, with 7 to 13

flowers, unbranched, the axis 4–8 cm. long, glabrous, lowest internode to 0.3(–2.2) cm. long, ultimate internode often much shorter than penultimate, or terminal flowers 5 together; bracts not seen, probably quite large; pedicels 1–3 cm. long, glabrous, to 2 mm. across at apex in fruit. Flower (?)hermaphroditic; tepals 4, the outer pair suborbicular, 4.5–6(–7) by 4.5–6 mm., deeply concave, thick, the inner pair obovate to broadly elliptic, (5.5–)8–11 by (5–)6.5–9 mm., thinner, less concave or not; stamens 10 to 240 [to 370 to 420], the filaments to 5 mm. long, connate for up to ca. 1.5 mm., the anthers oblong, 0.9–1.5 mm. long, shallowly [to deeply] retuse at apex; ovary 1.3–1.7 mm. long, the style 3–3.7 mm. long, the stigma peltate, 0.7–0.9[–1.8] mm. across, 2- or 3-radiate. Fruit ovoid to ellipsoid, ca. 1.9 by 1.2 cm., apiculate, drying vinaceous-brown, smooth to shallowly wrinkled; outer layer detaching cleanly from stone, 1–1.2 mm. thick, compact; stone ellipsoid, ca. 1.6 by 1 cm., \pm rounded at apex, the walls ca. 0.2 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Southeastern Sumatra, Borneo (not in the northeast) (MAP 29).

SELECTED SPECIMENS SEEN. **Sumatra.** DJAMBI: Sampit, 45 m., *bb 13128* (BO). **Borneo.** SARAWAK. 1st Division: Bako Natl. Park, T. Pandan Kechil, 0–30 m., *Carrick & Enoch 135* (KLU, SAR); Setapok F.R., 30 m., *S 8934* (BO, K, L, SAR, SING); Sirak Mangrove F.R., *FA 1126* coll. *Browne*, 24 Nov. 1951 (SAR); G. Pueh F.R., *S 6298* (SAR). 2nd Division: Botong Distr., Tj. Keranji, 9 m., *S 15969* (A, K, SAR, SING). 3rd Division: near Sibul, *Anderson & Ding Hou 475* (A, BO, C, K, L, SAR, SING). 4th Division: Marudi F.R., 9–15 m., *S 9971* (SAR). BRUNEI: "Forest Reserve," *FA 602* coll. *Igan*, 29 March 1935 (KEP). SABAH. Beaufort: Lupak area, 3 m., *SAN 15861* (KEP, SAN; SAR); Lumak, 24 m., *SAN 50914* (SAN); Bukit Siungau, 30 m., *SAN 80634* (K). KALIMANTAN. TIMUR: Tidoengsche Landen, Sepoetoeik, *bb 17832* (?) (BO, L); Pembiliangan, 8 m., *bb 18141* (A, BO). Selatan: Amoentai, Tanupekan, Rantau Kodjang, 10 m., *bb 7784* (BO); Bulungan, Sebakis R. region, *Kostermans 9304* (BO, L, SING). Tengah: Sampit, Lei Pemoelian, *bb 2085* (BO, L); Moera Tewe, Moera Montalat, *bb 9997* (BO). Barat: Soengei Landak, *Teysmann, HB 11381* (BO, FI, K, L).

ECOLOGY. In freshwater peat swamps, less commonly in kerangas forest; 3–30 m. alt. Flowering November to January and July to September; fruiting in February.

Calophyllum hosei can readily be distinguished from other species of the genus by its small terminal bud generally borne on a pronounced underdeveloped internode, by the almost complete absence of hairs except on the terminal bud, by the scars at the base of the axillary innovations, and by the usually short basal internode of the inflorescence coupled with the often much-shortened terminal internode. The fruit is smooth, even when almost mature. The specific epithet commemorates the well-known collector, C. Hose.

The leaves of the saplings of *Calophyllum hosei* are ovate, acuminate at the apex, and up to 16 by 7 cm.

Calophyllum hosei is perhaps superficially similar to *C. ferrugineum* and its relatives. However, the characters given above readily separate the two: *C. ferrugineum* and its relatives have a longer terminal bud, much more obvious indumentum, axillary innovations without basal scars, and wrinkled fruits.

In several respects the type specimen of *Calophyllum hosei* (characters enclosed in brackets in the description) differs from the others. It also has a somewhat more coriaceous lamina that is cuneate at the base and has a very prominent, rounded midrib on the lower surface. It is a good match with *S* 8943 (in bud), which was collected from kerangas forest. However, since all specimens cited agree in the other characters noted above, and there are intermediates in the other characters, only one taxon is recognized.

In the original description of *Calophyllum fragrans*, Ridley cited *Haviland 1812*, in addition to the type, *Haviland & Hose 3355*. However, Ridley annotated the former specimen at Kew as being the type, as a note by H. K. Airy Shaw on the specimen indicates that it almost certainly should be. Although the description of the leaves and the position of the inflorescences of *C. fragrans* perhaps agree better with *Haviland 1812*, and O. Stapf's earlier identification of the species as "*C. near retusum*," which Ridley mentions, is on this specimen, the length of the inflorescence and the field notes were apparently taken from *Haviland & Hose 3355*. Hence, Ridley seems to have based his description on both specimens, and his typification as given in the *Kew Bulletin* is followed. *Haviland 1812* is here included in *C. andersonii*.

89. *Calophyllum cordato-oblongum* Thwaites, Enum. Pl. Zeyl. 407. 1864; Bedd. Fl. Sylvat. 3: xxii. 1871; T. Anderson in Hooker f. Fl. Brit. India 1: 275. 1874; Vesque, Epharמוש 2: *tt.* 13, 14. 1889; Trimen, Handb. Fl. Ceylon 1: 103. 1893; Vesque in C. DC. Monogr. Phanerog. 8: 562. 1893; Alston in Trimen, Handb. Fl. Ceylon (Suppl.) 6: 21. 1931. TYPE: Ceylon [Sri Lanka], Hinidoon Patoo, Sept. 1863, CP 3823 (isotypes, BM, G, GH, K, L, MEL, NY, P, W).

Tree ca. 20 meters tall, d. b. h. to 40 cm.; trunk apparently without buttresses; outer bark brown to dark red-brown, (shallowly) fissured, the strips 2-3 cm. wide; inner bark red.

Twigs flattened, 2.2-4.5 mm. across, 4-angled, with raised lines decurrent from middle of petiole, drying dark brown, somewhat yellowish when older, sparsely brown-tomentose when young; axillary innovations apparently lacking basal scars; internodes 2-9(-13) cm. long; uppermost pair of axillary buds rounded to pointed, ca. 1.5(-4.5) mm. long, \pm erect; terminal bud plump, 0.9-1.3 cm. long, with brown, tomentose indumentum (hairs, FIGURE 25, k, t), underdeveloped internode to 1 mm. long. Petiole 3-7 mm. long, concave above, convex below, subsersistently puberulent below or not; lamina oblong to elliptic-oblong, 8-17(-25.5) by 4-7(-11.5) cm., rounded at apex, cordate at base, usually rather distantly undulate and slightly recurved at margin, coriaceous, drying sepia above and cinnamon-sepia below, subsersistently dark brown-puberulent on midrib below, the midrib above abruptly narrowed

at base, depressed for up to half length of leaf, becoming raised, 0.2-0.4 mm. wide at midpoint, below raised, angled, striate toward base, the venation above subobscure to subapparent, below \pm apparent, raised, (3 or) 4 to 9 veins/5 mm., angle of divergence 60-70°. Inflorescences terminal and from adjacent foliate axils, with 7 to 15 flowers, often flabellate, with 3-flowered branches to 2.5 cm. long, the axis (2-)6-10 cm. long, subsersistently sparsely to densely tomentose, lowest internode (0.5-)1-4 cm. long; bracts unknown; pedicels 0.5-1.3 cm. long, persistently tomentose. Flower (?)hermaphroditic; tepals (6 to) 8, the outer pair orbicular to broadly ovate, 5-7 by 7-9 mm., deeply concave, tomentose on back, the inner ones obovate to narrowly elliptic, 1.2-1.5 by 0.5-1.1 cm., outer two sometimes with few hairs toward base on back; stamens ca. 235, the filaments to 7.5 mm. long, the anthers oblong, 0.8-1.5 mm. long, rounded at apex; ovary 2.5-3 mm. long, the style 7-8.5 mm. long, the stigma peltate, ca. 1.5 mm. across, \pm 3-radiate. Fruit subspherical, 1.7-2.2 by 1.5-2 cm., rounded at apex, drying brown, smooth; outer layer not detaching cleanly from stone, 1.5-2 mm. thick, compact, with few fibers; stone subspherical, to 1.9 cm. long and across, rounded at apex, the walls less than 0.1 mm. thick, smooth, (?)unmarked; spongy layer thin.

DISTRIBUTION. Southwestern Sri Lanka (MAP 8).

SELECTED SPECIMENS SEEN. **Sri Lanka:** Kanneliya forest near Hiniduma, *Kos-termans* 24771 (A, E, US); Galle Distr., Beriliya forest near Elpitiya, *Kos-termans s.n.*, Aug. 1974 (K).

ECOLOGY. Apparently rather uncommon, in rain forest, low elev. Flowering in September; fruiting in May.

Calophyllum cordato-oblongum is a distinctive species that can readily be distinguished from the other taxa with cordate lamina bases by its terminal inflorescences with rather persistent, tomentose indumentum; its usually eight-tepaled flowers; and its fruits, which have stones with walls less than 0.1 mm. thick. The epithet refers to the leaf shape: more or less oblong, and cordate at the base.

Although Anderson (*loc. cit.*) described the flowers as having eight petals (i.e., presumably a total of twelve tepals), neither Vesque (1893, *loc. cit.*) nor I have found flowers with more than eight tepals. The surface of the fruit appears to be coarsely furfuraceous, but this is probably caused by damage.

The relationships of *Calophyllum cordato-oblongum* are unclear; its hairs are reminiscent of those of *C. bracteatum*, but the species are otherwise quite dissimilar.

90. ***Calophyllum venulosum*** Zoll. Syst. Verzeich. 2: 149, 150. 1854. TYPE: Java, ex montosis Seribu, *Zollinger 993, pro parte* (holotype, ν).

Tree 4-45 meters tall, d.b.h. to 80 cm.; trunk without buttresses (shortly spurred); outer bark grayish to pale brown, yellowish when young (dark

brown when older), usually cracked and flaking, newly exposed bark darker in color (deeply fissured) (rarely hoop marked), the inner surface dull brown to yellowish (mottled darker); under bark dull straw to reddish, mottled or not; inner bark dark red or pale brown to pink; latex clear (becoming opaque) yellow (brown-yellow or orange-yellow), sticky; sapwood cream; heartwood reddish.

Twigs flattened, 1.5–4.5 mm. across, 6-angled (very strongly flattened and 2-angled) (with transverse raised lines at nodes), drying yellowish or whitish, transiently brown-subfarinose to subsersistently tomentose, hairs to 0.8 mm. long; axillary innovations lacking basal scars; internodes (0.5–)1–10 cm. long; uppermost pair of axillary buds rounded to pointed, to 3.5 mm. long, spreading; terminal bud plump, 3–13 mm. long, with adpressed grayish to spreading brown-tomentose indumentum (hairs, FIGURE 29, o–q, s–u), underdeveloped internode to 3 mm. long. Petiole 1–6 (apparently to 25) mm. long, concave above, convex below, sometimes subsersistently tomentose below; lamina elliptic, ovate, or suboblong to obovate, 3.7–23.5 by 1.2–11.5 cm., acute to rounded (subacuminate) at apex, cordate to auriculate or minutely rounded (narrowly decurrent) at base, deeply and rather distantly undulate but not recurved at margin, the whole lamina \pm concave, thinly coriaceous to coriaceous, drying bay or honey to brown above and bay or umber to ochraceous below, usually subsersistently farinose and tomentose on midrib below (also above), the midrib above \pm abruptly narrowed at or near base, at first level or slightly depressed, becoming raised, 0.1–0.4(–0.6) mm. wide at midpoint, below raised, \pm angled, the venation above subobscure to apparent, below apparent, raised, sometimes clearly branched, 4 to 10 veins/5 mm., angle of divergence 60–80°. Inflorescences from foliate axils (rarely terminal), sometimes two together, with (1 to) 5 (to 11) flowers, very rarely flabellate, unbranched, the axis to 0.5–3.5 cm. long, puberulent to short-tomentose toward base, lowest internode to 0.3–1.7 cm. long; bracts ovate to elliptic, 2.5–5.5 mm. long, caducous; pedicels 0.6–3 cm. long, glabrous, slender, to 4.5 cm. by 2.5(–5) mm. in fruit. Flower (?) hermaphroditic; tepals 4 (very rarely 8), the outer pair ovate, 4–7 by 3.7–5 mm., the inner pair obovate, 7–13 by 4.5–10 mm.; stamens 85 to 205, the filaments to 7 mm. long, connate for up to 0.7 mm., the anthers oblong, 1–1.6(–2.1) mm. long, rounded to subretuse at apex; ovary 1.5–3 mm. long, the style 3–5 mm. long, the stigma peltate, 0.7–1.3 mm. across, \pm 3-lobed. Fruit usually subspherical, 1.2–2 by 1.1–2 cm. (rarely ellipsoid, ca. 2.6 by 2.1 cm.), minutely apiculate, drying dull brown, smooth; outer layer detaching cleanly from stone, 1–4 mm. thick, compact; stone often subobovoid, 0.95–1.25(–1.5) by 0.9–1.1 cm., rounded at apex, the walls 0.1–0.4 mm. thick, smooth, usually with triradiate or biradiate marking at apex; spongy layer thin.

Key to the Varieties of *Calophyllum venulosum*

1. Petiole 1–6 mm. long, clearly distinct from lamina; terminal bud 3–13 mm. long. 90a. var. *venulosum*.
1. Petiole apparently (0.8–)1–2.5 cm. long, not clearly distinct from lamina; terminal bud 3–5 mm. long. 90b. var. *tenuivenium*.

90a. *Calophyllum venulosum* Miq. var. *venulosum*

- C. venulosum* Miq.; Walp. Ann. Syst. Bot. 4: 366. 1857; Miq. Fl. Indiae Batavae 1(2): 511. 1858; Choisy, Pl. Javan. 9. 1858; Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 279. 1862; Vesque, Epharמושis 2: ff. 23, 24. 1889, in C. DC. Monogr. Phanerog. 8: 575. 1893; Koord. & Valetton, Meded. s' Lands Plant. 61(Bijd. Booms. Java 9): 379. 1903; Koord.-Schum. Syst. Verzeich. I(Fam. 187): 6. 1912; Koord. Exkurs. Java 2: 617. 1912; Merr. Bibl. Enum. Bornean Pl. 394. 1921; Heyne, Nutt. Pl. Indonesië. ed. 3. 1: 1086. 1950; Backer & Bakh. f. Fl. Java 1: 385. 1963.
- C. javanicum* Miq. Pl. Jungh. 3: 292. 1854; Walp. Ann. Bot. Syst. 4: 367. 1857; Miq. Fl. Indiae Batavae 1(2): 510. 1858; Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 294. 1862; Keith, N. Borneo Forest Rec. ed. 2. 2: 315. 1952 ("*C. sp. ex aff. javanicum*"); Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 318. 1956, *pro parte*; Kochummen, Malayan Forest Rec. ed. 2. 17: 214. 1965, *pro parte*; Meijer, Bot. Bull. Herb. Forest Dept. Sabah 7: 15. 1967; T. C. Whitmore, Tree Fl. Malaya 2: 187. 1973, *pro parte*. TYPE: Java, m. Gunong-Saribu, *van Gesker s.n.* (holotype, v).
- C. auriculatum* Merr. Philip. Jour. Sci. C. 4: 291. 1909, Enum. Philip. Fl. Pl. 3: 78. 1923. TYPE: Philippine Islands, Mindanao, Zamboanga, Sax River, 500 feet [150 m.], 20 Feb. 1905, *Williams 2339* (isotypes, A, K, NY (several), US).
- C. ijzermannii* Boerl. & Koord. in Koord.-Schum. Syst. Verzeich 2: 39. 1911. TYPE: Sumatra [Tapanoeli], Tapos, 20 Feb. 1891, *Koorders 10331* (holotype, BO).
- C. pulcherrimum* auct., non Wall. ex Choisy; Baker f. Jour. Bot. London 62(Suppl.): 8. 1924.
- C. griffithii* auct., non. T. Anderson; Baker f. *ibid.*

Tree 4-45 meters tall, d.b.h. to 80 cm.

Terminal bud 3-13 mm. long. Petiole 1-6 mm. long; lamina elliptic, ovate, or suboblong to subobovate, 3.7-23.5 by 1.2-11.5 cm., usually cordate or auriculate (rarely acute) at base.

DISTRIBUTION. Malay Peninsula (somewhat doubtful) and Sumatra to the Philippines (MAP 32).

SELECTED SPECIMENS SEEN (letters refer to discussion in text). **Malaya.** PERAK: Kroh F.R., 30 m., *KEP 71909* (KEP). PAHANG: Kemasul F.R., *KEP 78679* (KEP). JOHORE: Bukit Hantu F.R., 60 m., *KEP 79170* (KEP); Pontian, *KEP 70251* (KEP, SING). **Sumatra.** SELATAN: Tandjong-Ning, R. Moesoe-oeloe, 1524-1829 m., *Forbes 2756* (A) (BM, L, MO, SING); Mengkoelem [Mengkulem], 457 m., *Forbes 3069* (A) (A, BM, FI, GH); Rawas, *Grashoff 1122* (C) (BO, L); Moesi Veloe, *Endert 27* (leaf base rounded to acute, ?C) (BO); ond. afd. Redjang, bij Loeboek Bindjai marga Sindang Blibi, 150 m., *bb 3022* (A) (A, BO, L). Loeboek Blingbing, 600 m., *bb 7903* (A) (BO). BARAT: Pajakombo, Deloe Air, 1000 m., *Sjamsjoeddin 26* (BO); Sidjoendjoeng, Moearo, 200 m., *bb 2974* (C) (A, BO, L); Padang Lawas, 390 m., *bb 6633* (BO). UTARA: Angkola en Sapirook, Panobasan, 500 m., *bb 26114* (BO, L, MO, SING); Nandsiling c. a., Djoeloe, 1000 m., *bb 6180* (BO); Sibolangit, cult. (seed from Sibajak at 1200 m.), 500 m., *Lörzing 11684* (BO); Langkat, Halaban Keden, 20 m., *bb 8486* (C) (BO).

Borneo. SARAWAK. 1st Division: Mattang, *Beccari PB 1988* (c) (fl, k); Kuching, Semengoh F.R., *S 26260* (c) (A, K, L, SAN, SAR, SING); Sabal Tapang, 120 m., *Stevens*, sight record. 3rd Division: R. Biak (R. Luar), 586 m., *S 2974* (c) (L, SAR, SING, US). 4th Division: Mt. Murud, upper Baram, *Moulton 99* (c) (SING). SABAH. Sipitang: Ulu Mendalong, ca. 10 km. SSE. of Malaman, 533 m., *SAN 16763* (c) (BO, BRI, KEP, L, SING). Beaufort: Pangl, 8 km. WNW. of Tenom, 270 m., *SAN 15112* (c) (A, BO, BRI, K, KEP, L, SING). Kota Belud: Mt. Templer F.R., slope of Mt. Madalon, 610 m., *SAN 76223* (?f) (A, SAN, SAR, SING); Tuburan, 305 m., *SAN 3337* (c) (BO, K). Tenom: Rayoh F.R., *SAN 41445* (c) (K, KEP, L, SAN, SAR). Tambunan: Trusmadi F.R., 1524 m., *SAN 31444* (L, SAN). Lahad Datu: Ulu Sungei Segama, 500 m., *Stevens*, sight record. Tawau: Kalabakan, 10 acre plot, Luasong, 15 m., *SAN 59783* (c) (SAN); Brassey Range, 600 m., *Stevens et al. 462* (c) (A). KALIMANTAN. TIMUR: Salimbatoe, S. Pingping, 150 m., *bb 11171* (BO); Kabiran, S. Bengaloen, 100 m., *bb 11707* (BO); W. Koetai, no. 36, near L. Petah, 500 m., *Ender 3103* (e) (A, BO, K), no. 24, L. Iboet, 150 m., *Ender 4787* (e) (A, BO, K, L); Mt. Maranga on Tundjung Plateau, 200 m., *Kostermans 12250* (f) (BO, CANB, K, L, NY, P, SING); C. Kutei, Belajan R., G. Kelopok near Tabang, 250 m., *Kostermans 10578* (f) (BO, L); peak of Balikpapan, Beoul, 600 m., *Kostermans 7290* (f) (BO); E. Kutei, Sg. Menubar region, 5 m., *Kostermans 5034* (b) (A, BO, K, L, SING); Sangkulirang Distr., Sg. Mandu region, 150 m., *Kostermans 13312* (b) (BO, K, L). Selatan: path from Djaro Dam to Mt. Serempaka, ca. 20 km. NE. of Muara Uja, 680 m., *de Vogel 1071* (f) (L). Barat: Melawi Oeloe, Soengei Semangka, 450 m., *bb 29056* (BO, K, L, NY, SING); Soeka Lanting, *Hallier 160* (?b) (BO). **Philippine Islands.** MINDANAO. Lanao: Kalambugan, *FB 30236*(d)(UC); Lake Lanao, Camp Keithley, *Clemens 1019*(d)(f, c). Zamboanga: Sax R., 150 m., *Williams 2339* (d) (A, K, NY, US). BASILAN: Isabela de Basilan, *Ebalo 884* (d) (A, BISH, E, MO, NY). **Java.** BARAT: Batavia, Pasir Tjihideung, W. v. Leuwiliang en Buitenzorg, 600 m., *Dakkus 180* (between a and b) (BO, L); Bantam, G. Pangisisan (G. Karang), Tjamara, 10-200 m., *Koorders 2884* (a) (BO); Tjoecendar, bij Pondok Poelosari (G. Karang), 1050 m., *Koorders 5712* (a) (BO); Baya [Bajah], *Hasskarl s.n.* (a) (L, P); cult. in Hort. Bogor. sub numero *VI C 135* (between a and b) (BO, K, L, P, US).

ECOLOGY. Usually in well-drained mixed dipterocarp forest, (5-)200-610 (-1524) m. alt. Sometimes in marshes (*Kostermans 5034*; 5 m. alt.), quite frequently along streams. Flowering January, February, May, July, and September; fruiting January to May, and August to November (fruit yellowish to brownish, acid in taste (*Kostermans 10581*)).

There are spherical galls ca. 1 mm. across on and near the midrib on both surfaces of the leaf on *Dakkus 180*; these are caused by midges (Docters van Leeuwen-Reijnvaan & Docters van Leeuwen, 1926). Raised pustules occur near the margin and the midrib on the lower surface of the leaf in *Koorders 10331*.

GERMINATION AND YOUNG PLANT. The seed germinates by breaking the stone to one side of the base (*SAN 16763*). A single seedling seen had a pair of reduced leaves and a pair of expanded leaves (de Vogel, 1980, *pl. 15*). Initially the young plant grows slowly, with internodes less than 3 cm. long and only one pair of leaves being produced per flush; after the plant reaches

ca. 40 cm. in height, growth is more rapid. The plant is erect, and the terminal bud is functional.

LOCAL USE. In Java (Bantam) the wood is used for oars (Heyne, *op. cit.*).

90b. *Calophyllum venulosum* Zoll. var. *tenuivenium* (M. R. Henderson & Wyatt-Smith) P. F. Stevens, comb. et stat. nov.

C. tenuivenium M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 311, pl. 7, 1956; T. C. Whitmore, Tree Fl. Malaya 2: 193, 1973; Corner, Gard. Bull. Singapore Suppl. 1: 105, 1978. TYPE: Malaya, Johore, 8th mile Kota Tinggi-Mawai road, 18 Feb. 1937, SFN 32274 coll. Corner (holotype, SING; isotypes, A, BO, K, KEP, LAE, NY, P, SING).

Tree ca. 20 meters tall, d.b.h. ca. 30 cm.

Terminal bud 3–5 mm. long. Petiole apparently (0.8–)1–2.5 cm. long; lamina elliptic, (2.6–)6–10 by (0.8–)2–4.5 cm., attenuate at base.

DISTRIBUTION. Known only from southern Malaya (Johore).

SELECTED SPECIMENS SEEN. **Malaya.** JOHORE: Panti F.R., 5 m., Stevens *et al.* 115 (A); G. Sumalayang, 305 m., Chin 602 (KLU).

ECOLOGY. Seasonally inundated or colline forest, 5–305 m. alt. Flowering in February; flower scented.

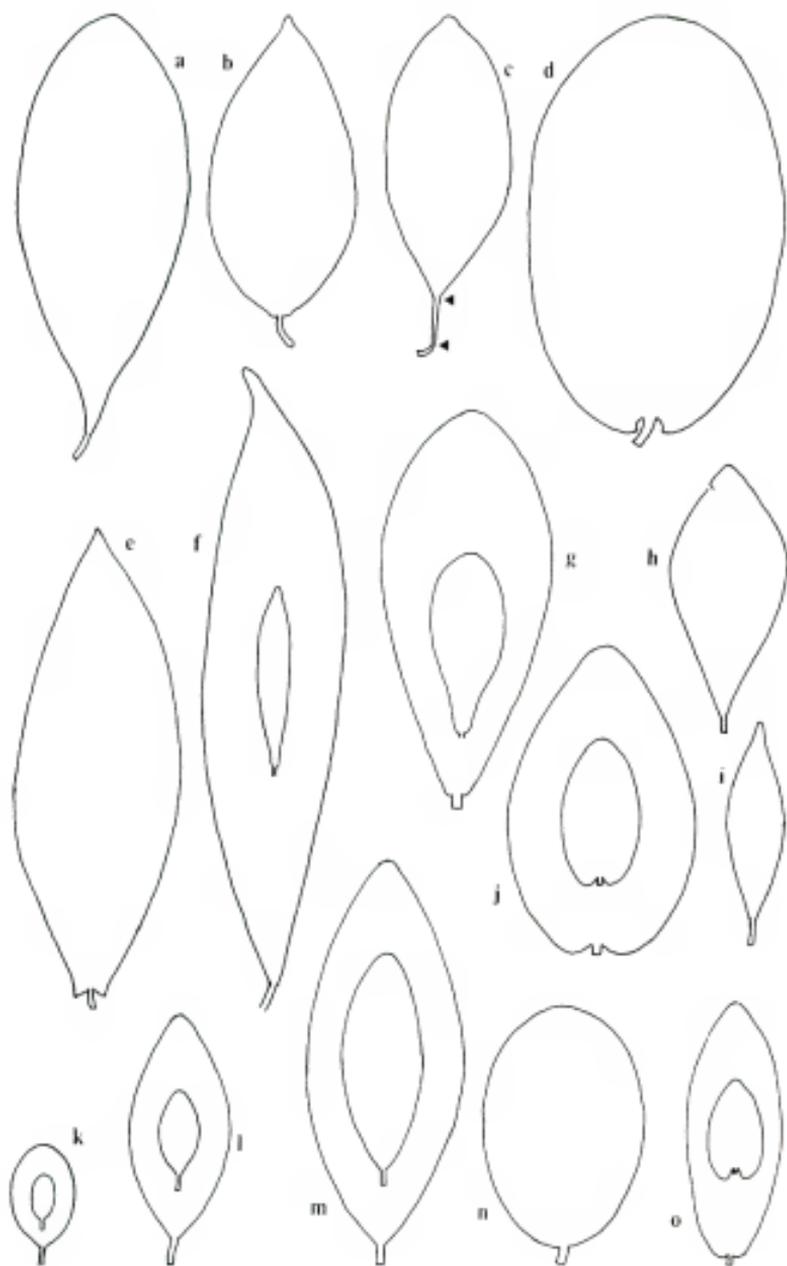
GERMINATION AND YOUNG PLANT. Growth of the young plant is initially slow, with the internodes of plants 20 cm. tall being less than 1(–2) cm. long; growth is erect, and the terminal bud is functional. The stems very soon become yellowish. (Stevens *et al.* 116.)

The epithet *tenuivenium* emphasizes the fine, but distinct and distant, venation on the type specimen.

Calophyllum venulosum is usually readily recognizable, despite the variation in its vegetative characters. The twigs dry yellowish white and usually have six raised lines. The leaves often vary considerably in size on a single specimen (FIGURE 30, g); the petiole is short; and the blade is usually cordate to minutely auriculate at the base, often has rather distant venation, and frequently dries bicolored—a dark or grayish brown above and often a somewhat orange-brown below. The inflorescence usually has fewer than seven flowers, and the flowers generally have four tepals. The fruit is characteristic—smooth when dry and with a rather thick outer layer that detaches cleanly from the smooth stone; the stone is nearly always triradiately marked. The epithet *venulosum* refers to the venation, which is often notably apparent and prominent in this species.

Rank of *Calophyllum tenuivenium*

Calophyllum tenuivenium and *C. venulosum* are similar in all characters except for the apparently long-petiolate leaves of the former: Henderson & Wyatt-Smith (*loc. cit.*) mentioned the petiole of *C. tenuivenium* as usually



being 1-2 cm. long. When dry the petiole is transversely rugulose for ca. the basal 4 mm. only; the remainder dries longitudinally striate. In *C. venulosum* the short petiole dries transversely rugulose, while the midrib on the lower surface of the lamina dries more or less striate. This suggests that the lamina of *C. tenuivenium* is in fact very narrowly attenuate, with the petiole proper being ca. the basal 4 mm. Very young plants of *C. tenuivenium* (Stevens *et al.* 116, collected under an adult tree) have leaves with a short (2.5 mm.) petiole; the lamina is gradually narrowed toward the base and is shortly and abruptly rounded at the very base (FIGURE 30, f). The tree under which these young plants were growing had the "long petioles" normal for *C. tenuivenium*, and it is presumed that in successively produced leaves the lamina becomes more and more strongly narrowed toward the base and is eventually not developed there.

There is a tendency for the base of the lamina to be cuneate or acute in other specimens of *Calophyllum venulosum*, although leaves with blades that are minutely auriculate at the base also occur on these specimens. This tendency is shown by some specimens collected by Forbes from Sumatra (FIGURE 30, a, b), by *Grashoff 1122* and *Endert 27* (also from Sumatra), by specimens that are otherwise a good match with the type specimen of *C. ijzermannii* (see below), and by specimens collected by Endert (e.g., *Endert 3451*) from West Koetei, Kalimantan. However, in none of these specimens is the petiole more than 7 mm. long, and the petiole and the lamina are always quite clearly separated.

Thus, it seems best to reduce *Calophyllum tenuivenium* to varietal rank under *C. venulosum*. Not only are the leaves of the young plants of *C. tenuivenium* similar to those of *C. venulosum*, but the slow growth of the young plant and the rather distinctive appearance of the bark of the mature tree of *C. tenuivenium* are both similar to those of *C. venulosum* seen in Sabah and Sarawak. Young plants of *Calophyllum venulosum* var. *tenuivenium* have leaves with blades that are acuminate at the apex and up to 15.6 by 5.4 cm.

Variation within *Calophyllum venulosum*
var. *venulosum*

The type specimens of *Calophyllum javanicum* and of *C. venulosum* are similar and are like a number of specimens from Java and Sumatra (denoted by "a" in the list of specimens examined). The lamina is small to medium sized (less than 14 by 4 cm.), and thin and acute to more or less rounded

FIGURE 30. Variation in leaf; extent of variation in some collections shown by smaller outlines inside larger ones. a-g, *Calophyllum venulosum*. a, b, d, e, g, var. *venulosum*: a, b, *Forbes 3189*; d, *S 26277*; e, *van Gesker s.n.*; g, *SAN 15112* (leaves from same shoot). c, f, var. *tenuivenium*: c, *SFN 32274*, arrows mark extent of narrowly attenuate lamina; f, *Stevens et al. 116* (from very young plant). h-o, *C. pentapetalum*. h, i, k-n, var. *cumingii*: h, i, *BS 26928*; k, *BS 43260*; l, *BS 44802*; m, n, *BS 30206*. j, o, var. *pentapetalum*: j, *Santos 6178*; o, *Cuming 1212*. All $\times 0.67$.

at the apex. The petiole is noticeable (3 mm. or more long), and the terminal bud is small (generally less than 5 mm. long). Field characters are scanty for specimens assigned to this group.

A somewhat ill-defined group of specimens from Java and southern Kalimantan ("b" in the list) have leaf blades that tend to dry greenish and subnitid. The apex of the lamina is acuminate, and the short petiole is obscured by the cordate base. In Kalimantan such specimens have been collected from trees 4-28 meters tall.

The form that is most common in Borneo, and which also occurs in Sumatra ("c" in the list), has well-developed, tomentose indumentum on the vegetative parts; the terminal bud is 6-11 mm. long; the twigs are stout (2-4.5 mm. across); the lamina tends to be large, although it is notably variable in size ((3.3-6-23.5 by (2-)3-11.5 cm.); and the base of the lamina is usually clearly cordate or auriculate. Such specimens have been collected from trees 27-42 meters in height.

Specimens from the Philippine Islands ("d" in the list) are similar to those in group c above. However, the indumentum is not well developed except on the terminal bud, where it may be tomentose (e.g., *Ebala* 884) or short and adpressed (e.g., *Williams* 2339). The inflorescence is sometimes rather congested. *Calophyllum auriculatum* was described from a specimen of this type. Specimens have been collected from trees 5-18 meters tall.

Some specimens from Sumatra and southern Kalimantan ("e" in the list) have moderate-sized to large leaves and terminal buds. The lamina is subcoriaceous and dries almost chestnut brown and nitid on the upper surface; the venation density is in the upper range of that given for the species. The type specimen of *C. ijzermannii* is a large-leaved specimen of this type. In both Sumatra and Kalimantan there are apparently independent tendencies for the base of the lamina to become more or less cuneate or acute. Specimens in group e have been taken from trees 12-30 meters tall.

The final group of specimens ("f" in the list), known only from Kalimantan, also have a subcoriaceous, rather densely veined lamina, but it does not dry dark brown and nitid. The terminal bud is ca. 5 mm. long, and the plant does not have very well-developed indumentum. One specimen (*Kostermans* 10581) has mostly ellipsoid fruits up to 2.6 by 2.1 cm.

The specimens from Malaya cited above are included here with hesitation. All are sterile. The specimens from Johore have stout twigs, large leaves, and rather short indumentum on the terminal bud, and are perhaps intermediate between *Calophyllum venulosum* var. *venulosum* group d and *C. subsessile* (q.v.). The specimens from Perak and Pahang have a rather small (4.6-10.6 by 1.6-3.6 cm.) lamina, and their indumentum is well developed; their latex is reported to be yellow or milky yellow. At first sight the latter group of specimens is very distinctive, but more collections of *C. venulosum* and its relatives from the entire Malay Peninsula are needed to assess the significance of the variation discussed above, as well as the status of *C. subsessile*.

Specimens taken from a tree once cultivated at the Botanic Gardens at

Bogor under the number VI C 133 are atypical in several respects (see also *Calophyllum subsessile*). The inflorescence has up to eleven flowers and is sometimes branched, the flowers have eight tepals, the fruits dry rather deeply and sharply wrinkled, and the stone lacks triradiate markings.

91. *Calophyllum grandiflorum* J. J. Sm. Bull. Jard. Bot. Buitenzorg, III. I: 396. *tt.* 45, 46. 1920; Backer & Bakh. f. Fl. Java I: 385. 1965. TYPE: Java, Soekaboemi, G. Tjimerang, ca. 700 m., Jan. 1914, *ten Oever s.n.* (lectotype, 80; isolectotype, 1).

Tree 15–28 meters tall, d.b.h. to 60 cm.; trunk without buttresses or spurs; outer bark yellowish brown and smooth at first, becoming mid-brown, with vertical lines of lenticellary welts, scaling, scales small, the inner surface yellow-straw; under bark reddish; inner bark dark red; latex opaque yellow, slightly sticky.

Twigs flattened, 3–6 mm. across, \pm 4-angled when young and with prominent raised lines decurrent from each petiole, 2-angled when older (with obscure transverse raised lines at nodes), drying brown (yellowish), glabrous or almost so; axillary innovations lacking basal scars; internodes 4–10 cm. long; uppermost pair of axillary buds acute, up to 7 mm. long, spreading; terminal bud narrowly conical, 1.2–2.2 cm. long, with grayish or brownish, subcrustose indumentum (hairs, FIGURE 25, r), underdeveloped internode to 2 mm. long. Petiole 2–5 mm. long, concave above, angled below, glabrous or puberulent; lamina oblong to elliptic or lingulate, 15–36 by 6–10 cm., acute at apex, cordate at base, undulate and slightly recurved at margin, coriaceous, drying amber to sabelline above and cinnamon to sabelline below, glabrous or with sparse hairs on midrib below when young, the midrib above narrowing quickly near base, \pm depressed in bottom 3–5(–7) cm., becoming sharply raised, 0.5–0.8 mm. wide at midpoint, below prominent, angled, the venation above and below subapparent to subobscure, raised, 4 to 9 veins/5 mm., angle of divergence 70–85°. Inflorescences from axils of topmost or adjacent leaves, with 3 to 11 flowers, often flabellate (with 3-flowered branches to 3 cm. long), the axis 3–12 cm. long, \pm glabrous, lowest internode (1)–3–7.5 cm. long; bracts reported to be foliaceous, up to 9.25 by 5.2 cm.; pedicels 3–7.5 cm. long, glabrous, in fruit to 3 mm. thick. Flower (?)hermaphroditic; tepals 8, sometimes glabrous, the outer pair reflexed at anthesis, \pm orbicular, ca. 11.5 mm. long and across, the inner ones obovate to elliptic, 1.7–2 by 1–1.4 cm.; stamens 320 to 370, the filaments to 8 mm. long, the anthers oblong, 1.5–2.5 mm. long, rounded to retuse at apex; ovary ca. 3.5 mm. long, the style 9–12 mm. long, the stigma peltate, 1.5–2.5 mm. across, 3-radiate. Fruit \pm spherical to ellipsoid, ca. 2 by 1.5 cm., apiculate, with stipe ca. 2.5 by 4 mm., scars of tepals and androecium prominent, drying yellow-brown, finally dark brown, strongly and sharply wrinkled, furfuraceous; outer layer detaching cleanly from stone, ca. 2 mm. thick, compact; stone spherical to ellipsoid, ca. 1.6 by 1.3 cm., rounded at apex, the walls ca. 0.3 mm. thick, smooth, with 2 to 4 pale longitudinal stripes from apex; spongy layer thin.

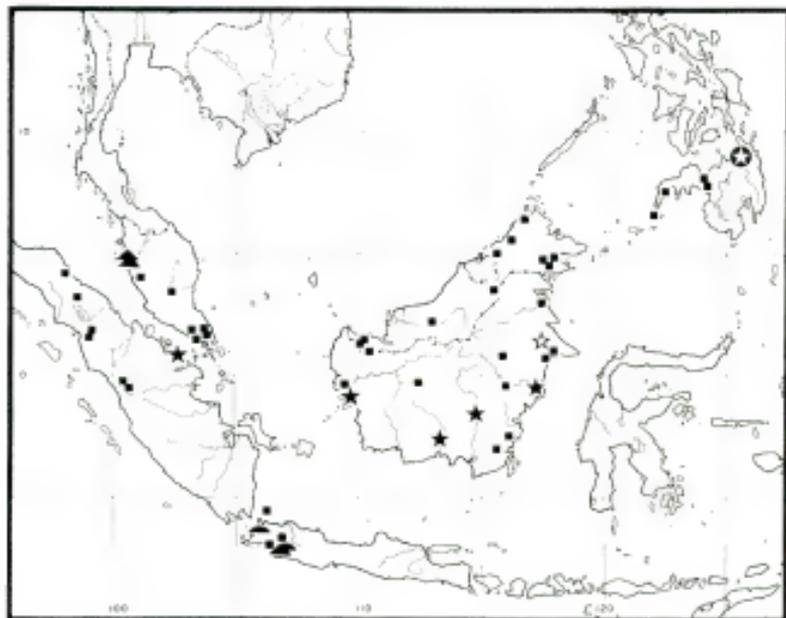
DISTRIBUTION. Western Java (MAP 32).

SELECTED SPECIMENS SEEN. **JAVA. BARAT:** Lengkong, estate Tjisamporawangum, 600 m., *Kostermans* 23822 (A, AAU, BO, CANB, G, K, L, P), Bodjong Lopang, *Backer* 16990 (BO, L); Bantam, G. Tompok, bij Pasaoeran, 300-400 m., *Backer* 7328 (BO).

ECOLOGY. Locally common in colline forest, 300-700 m. alt. Flowering February, September, October, and November (flower scented); fruiting in January (fruit yellowish brown when ripe).

GERMINATION AND YOUNG PLANT. The radicle breaks the stone wall immediately to one side of the base of the stone. The seedling has a single pair of leaves. Subsequent growth is slow, with the internodes less than 3 cm. long until the plant reaches 20-30 cm. in height; after that the internodes produced are up to 20 cm. long. The terminal bud is functional. (*Stevens et al.* 723.)

Calophyllum grandiflorum is one of the most easily recognized species of *Calophyllum*: its large leaf blade is cordate at the base and has relatively distant venation, its terminal bud is long and thin, and its inflorescence has



MAP 32. Distribution of *Calophyllum venulosum* var. *venulosum* (squares), *C. subsessile* (triangles), *C. grandiflorum* (half-circles), *C. mukunense* (solid stars), *C. calcicola* (open star), and *Calophyllum* sp. 95 (star in solid circle) in Malesia.

a long basal internode and large flowers (up to 5 cm. across when fully opened—hence the appropriate specific epithet). The stipitate, strongly wrinkled fruit is also striking.

Calophyllum grandiflorum is related to *C. venulosum*; the morphology and bark of the two species are similar, and both have young plants that grow only slowly at first. However, the characteristics mentioned above readily distinguish the two species.

The specimen *ten Oever s.n.* (collected in January, 1914) at Bogor herbarium is made the lectotype of *Calophyllum grandiflorum*. The locality data for this collection are those given on the label; they are slightly different from those given by J. J. Smith (*loc. cit.*). The other specimen that Smith cited, *Backer 7328*, is sterile.

92. *Calophyllum subsessile* King in Ridley, Ann. Bot. Gard. Calcutta 5: 142. *pl. 171*. 1896; Ridley, Fl. Malay Penin. 1: 187. 1922; I. H. Burkill & M. R. Henderson, Gard. Bull. Straits Settl. 3: 347. 1925. SYNTYPES: Malaya, Perak, Larut, less than 100 feet [30 m.], Nov. 1884, *King's collector* [*Kunstler*] 6877 (BM, K, L, P), less than 100 feet [30 m.], Feb. 1885, *King's collector* [*Kunstler*] 7311 (K).

C. javanicum auct., non Miq.; M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 318. 1956, *pro parte*; Kochummen, Malayan Forest Rec. ed. 2. 17: 214. 1965, *pro parte*; T. C. Whitmore, Tree Fl. Malaya 2: 187. 1973, *pro parte*.

Tree to 24 meters tall, d.b.h. to 90 cm.; trunk without buttresses, but knee roots reported; outer bark golden, yellow, green, and brown [mottled], with long, irregular fissures, roughly scaly; under surface yellow; inner bark pale pink, clearly laminated; latex clear golden, sticky.

Twigs slightly flattened, 2–3.5 mm. across, with 6 prominently raised lines, drying \pm shiny, whitish yellow, initially sparsely brown-puberulent; axillary innovations apparently lacking basal scars; internodes 1.5–4 cm. long; uppermost pair of axillary buds rounded, ca. 1 mm. long, inconspicuous; terminal bud plump, 4–6 mm. long, with grayish brown, farinose-puberulent indumentum (hairs, *FIGURE 29, n*), underdeveloped internode absent. Petiole 2–3 mm. long, shallowly concave above, \pm angled below, glabrous; lamina elliptic to oblong, 6.8–14 by 3.7–6 cm., rounded at apex, cordate at base, slightly undulate and not recurved or slightly so at margin, coriaceous, drying amber above and below, glabrous, the midrib above rather quickly narrowed near base, depressed in bottom quarter, becoming raised, 0.2–0.5 mm. wide at midpoint, below raised, angled, the venation above subobscure, below \pm apparent, raised, 5 to 8 veins/5 mm., angle of divergence 65–75°. Inflorescences terminal and axillary, with 5 to 13 flowers (flabellate and/or with 3-flowered branches to 1.7 cm. long), the axis 5.5–7 cm. or more long, slightly puberulent toward base or not, lowest internode 2–4 cm. long; bracts subelliptic, ca. 5 mm. long, not persistent; pedicels to 1.3 cm. long, glabrous. Flower bud only seen, (?)hermaphroditic; tepals 8, the outer pair suborbicular, to 5 by 4.5 mm.; stamens 155 to 165, the anthers oblong, 1.2–1.7 mm. long, rounded

to subtetuse at apex; ovary ca. 1 mm. long, the style ca. 1.5 mm. long, the stigma peltate, ca. 0.7 mm. across, 3-lobed. Fruit spherical, ca. 2.5 cm. long and across, rounded at apex, drying brown, with broad, rounded wrinkles; outer layer detaching cleanly from stone, ca. 2 mm. thick, compact; stone broadly obovoid, ca. 2.1 by 1.9 cm., rounded at apex, the walls ca. 0.4 mm. thick, smooth, with triradiate marking at apex; (?)spongy layer thin.

DISTRIBUTION. The Malay Peninsula, known only from Perak (MAP 32).

ADDITIONAL SPECIMEN SEEN. **Malaya.** PERAK: Gelong Raya, 41st mile Bruas-Lumut road, KEP 43570 (KEP).

ECOLOGY. Lowland freshwater swamps or seasonally inundated forests. Flowering in November; fruiting in February.

Calophyllum subsessile is closely related to *C. venulosum*, and like that species, it has leaf blades that are more or less rounded at the base and fruits with a thick, compact outer layer that detaches cleanly from the stone; the stone has a triradiate marking at the apex. It can be distinguished from *C. venulosum* by its whitish-drying terminal bud, its more coriaceous leaf blades, its longer inflorescences that are sometimes terminal and branched and that have more numerous flowers, its flowers, which have eight tepals, and its larger fruits (spherical fruits of *C. venulosum* are less than 2 cm. long). The almost sessile leaves presumably suggested the epithet *subsessile*.

Calophyllum subsessile is provisionally maintained as a distinct species, since the only specimens of *C. venulosum* that have flowers with eight tepals and inflorescences approaching those of *C. subsessile* in size are cultivated specimens from Bogor (VI C 133), which in other characters are unlike *C. subsessile*. The field notes of KEP 43570 report knee roots; although these have not been observed in *C. venulosum*, infraspecific variation in the presence or absence of knee roots is quite common in *Calophyllum*. The distribution of *C. subsessile* in Malaya (MAP 32) is not unexpected for a species with eastern affinities (Keng, 1970).

Saplings of *Calophyllum subsessile* have leaf blades up to 24.5 by 6.5 cm.; the midrib on the upper surface of the blade is raised for its entire length.

The fruits of *Calophyllum subsessile* were reported by King (*loc. cit.*) to be minutely pubescent; they are in fact glabrous.

93. *Calophyllum mukunense* P. F. Stevens, sp. nov.

A speciebus aliis Calophylli quibus laminis basibus cordatis et fructibus putaminibus signatis habent in inflorescentiis terminalibus et axillaribus (hvis cum internodiis basalibus usque ad 2 mm. longis), floribus cum 8 tepalis, et fructu strato exteriore tenui circa 0.5 mm. crasso, differt.

Tree 18–26 meters tall, d.b.h. to 50 cm.; outer bark yellowish, exfoliating irregularly, the scales elongated, thin, 1 mm. thick; inner bark pink; latex yellow (*Kostermans 7725*).

Twigs strongly flattened, 3.2–5 mm. across, rounded to obscurely 4-angled,

drying yellowish, shiny, glabrous at maturity; axillary innovations apparently lacking basal scars; internodes 1-4.5 cm. long; uppermost pair of axillary buds rounded, to 1 mm. long, inconspicuous, sometimes glabrous; terminal bud broadly conical, 3.5-4.5 mm. long, with brown, crustaceous to subappressed indumentum (hairs, FIGURE 29, m; also moruloid), underdeveloped internode to 2.5 mm. long. Petiole 4-8 mm. long, broadly and shallowly concave above and convex below, glabrous; lamina elliptic to suboblong, 6.3-23.3 by 2.6-7.3 cm., acute to subacuminate (rarely rounded) at apex, cordate to rounded at base, strongly and distantly undulate and slightly recurved at margin, coriaceous, drying shiny, ochraceous to umber above and umber below, glabrous, the midrib above gradually narrowed from base, depressed, (0.25-0.5-1.1 mm. wide at midpoint, below raised, becoming flat to slightly raised, angled (striate or rounded toward base), the venation usually subobscure above and subapparent below, raised to flat, 4 to 6 veins/5 mm., angle of divergence 65-80°. Inflorescences terminal and from adjacent foliate axils, with scars of 11 to 17 flowers, unbranched (rarely with 3-flowered branches to 4 cm. long), the axis 3.5-7.5 cm. long, stout, puberulent at base, lowest internode in axillary inflorescences to 2 mm. long; bracts not known; pedicels 1.3-3 cm. long, glabrous, slender, in fruit to 5.5 cm. by 4 mm. Flower not known. Fruit ellipsoid to spherical, 1.8-2 by 1.4-1.8 cm., rounded at apex, drying grayish brown, strongly wrinkled; outer layer detaching cleanly from stone, ca. 0.5 mm. thick, compact, inner surface shiny; stone subspherical, 1.3-1.7 by 1.2-1.4 cm., rounded at apex, the walls ca. 0.2 mm. thick, smooth, with 3 longitudinal stripes from apex; spongy layer thin.

TYPE: Borneo [Kalimantan], Sg. [Sungei] Mukun near Sangasanga (Samarinda), 5 m., 3 Aug. 1952, *Kostermans 7725* (holotype, A; isotypes, B, BO, K, L, LAE, P, SING).

DISTRIBUTION. Sumatra and southwestern Borneo (MAP 32).

ADDITIONAL SPECIMENS SEEN. **Sumatra.** RIAU: Selatpandjang, Kampar Monding, 5 m., *bb 22058* (BO). DJAMBI: Maera Pidjoean, 89 m., *bb 12831* (BO); Simpang, 45 m., *bb 13141* (BO). **Borneo.** KALIMANTAN. Tengah: Boentok, Asem, *bb 2670* (BO); Beneden Djak, Troesas, 1 m., *bb 9872* (BO); Sampit, Sei Kereng Bindjai, Selongau, 3 m., *bb 7939* (BO). Barat: Koeboepadi, 5 m., *bb 6364* (BO).

ECOLOGY. At least periodically flooded forest, 1-90 m. alt. Fruiting March (once), and August (once; submature).

Calophyllum mukunense can be recognized by its shiny, at most slightly angled twigs, its rather large leaf blades that are rounded to cordate at the base, its terminal and axillary inflorescences with at least eleven flowers, and its fruits that dry wrinkled and that have an outer layer about 0.5 mm. thick and a triradiately marked stone. The axillary inflorescences have a very short basal internode; however, there do not seem to be scars at the bases of the axillary innovations, although this must be confirmed. The epithet *mukunense* comes from the name of the river near which the type specimen was collected.

The closest relatives of *Calophyllum mukunense* are probably *C. venulosum*, *C. subsessile*, and *C. grandiflorum*, all three of which have similarly shaped leaf blades and stones with triradiate markings. However, the other characters mentioned above readily differentiate *C. mukunense* from these species. Although the pedicels of *C. venulosum* var. *venulosum* are sometimes notably incrassate in fruit (e.g., *Enderb 27*, from Sumatra), such specimens agree with *C. venulosum* in all other respects.

94. *Calophyllum calcicola* P. F. Stevens, sp. nov.

FIGURE 28, i.

A speciebus aliis Calophylli quibus laminis basibus cordatis habent in innovatione axillari saepe cicatricibus basalibus ornata, lamina mediocra coriacea vel percoriacea nitida, inflorescentiis axillaribus, floribus cum 8 tepalis, et fructu putamine haud signato, differt.

Shrub or tree to 10 meters tall, d.b.h. to 20 cm.; outer bark yellowish, rough, cracked.

Twigs slightly flattened, 1.5–2 mm. across, with 6 elevated lines, drying brown to yellow when young, later whitish, glabrous to sparsely brown-puberulent when young; axillary innovations often with basal scars; internodes 1–5 cm. long; uppermost pair of axillary buds rounded, ca. 0.4 mm. long, ± spreading, inconspicuous; terminal bud plump, 2–3 mm. long, with brown, crustaceous indumentum (hairs, FIGURE 25, s), underdeveloped internode absent. Petiole 2–4 mm. long, concave above and convex below, glabrous, drying black; lamina obovate to elliptic-oblong, 1.2–8.5 by 1–3.8 cm., rounded to retuse (rarely apiculate) at apex, auriculate to rounded at base, undulate but not recurved at margin, coriaceous to very coriaceous, drying shiny, bay above and umber below, glabrous, the midrib above abruptly narrowed near base, not obvious, flat to slightly raised, ca. 0.15 mm. wide at midpoint, below raised, striate, the venation subobscure above and apparent below, raised, 4 to 6 veins/5 mm., angle of divergence 40–70°. Inflorescences from foliate axils, with 5 flowers, unbranched, the axis (0.2–)2.5–3.5 cm. long, glabrous or sparsely puberulent at base, lowest internode 0.2–1.5 cm. long; bracts ovate, ca. 2 mm. long, deciduous; pedicels 2–2.7 cm. long, glabrous. Flower (?)hermaphroditic; tepals 8 (rarely 7), sometimes glabrous, the outer pair ovate, ca. 5.5 by 4.5 mm., the inner ones ovate to obovate, 6–8 by 4–5.5 mm.; stamens 60 to 75, the filaments to 3.7 mm. long, the anthers oblong, 1.2–1.6 mm. long, ± retuse at apex; ovary 1.5–2 mm. long, the style ca. 2.5 mm. long, the stigma peltate, ca. 0.6 mm. across, (?)lobed. Submature fruit ellipsoid, ca. 1.5 by 1–1.4 cm., ± rounded at apex, drying brown, smooth; outer layer detaching cleanly from stone, ca. 1 mm. thick, compact; stone subspherical, ca. 1.3 by 1.2 cm., almost round at apex, the walls ca. 0.8 mm. thick, smooth, unmarked; spongy layer initially thick.

TYPE: Borneo [Kalimantan], Berouw, Mt. Ilas Bungaan, 700 m., 12 Dec. 1957, *Kostermans 13837* (holotype, 1; isotypes, BO, CANB, K, LAE, P, SING).

DISTRIBUTION. Southeastern Borneo (MAP 32).

ADDITIONAL SPECIMENS SEEN. **Borneo, KALIMANTAN.** Timur: Berouw, Mt. Ilas Bunaan, 700 m., *Kostermans 13834* (BO, K, L, SING); top of Mt. Ilas Mapulu, 800 m., *Kostermans 14022* (BO, K, KEP, L, SING).

ECOLOGY. On limestone, 700–800 m. alt.; sometimes shrub pendulous on limestone walls (*Kostermans 13834*). Flowering in September.

Calophyllum calcicola can be recognized by its short terminal bud; small, very coriaceous, nitid leaf blades that are rounded to auriculate at the base; axillary, five-flowered inflorescences; flowers with eight tepals; and spherical fruits with an unmarked stone. The epithet *calcicola* means "limestone dweller," a reference to the ecological proclivities of this species.

Calophyllum calcicola is perhaps related to the widespread and variable *C. venulosum*. However, it differs in its axillary innovations that often have scars at the base (such scars are absent in *C. venulosum*), its coriaceous and nitid leaf blade, its small terminal bud, its flowers that always have seven or eight tepals (in *C. venulosum* I know of only one cultivated specimen with eight tepals), and its fruit with a thinner outer layer and an unmarked stone. In *C. venulosum* the outer layer is 1–4 mm. thick, and the stone has longitudinal markings.

95. *Calophyllum* sp.

Tree 8 meters tall, d.b.h. 10 cm.; trunk and bark unknown.

Twigs flattened, 2.5–3 mm. across, with $4 \pm$ raised lines, drying yellowish, tomentose when young; axillary innovations apparently lacking basal scars; internodes (0.3–)0.7–6 cm. long; uppermost pair of axillary buds rounded, ca. 1 mm. long, erect; terminal bud conical, 7.5–8.5 mm. long, brown-tomentose, underdeveloped internode absent. Petiole 2–3.5 mm. long, concave above, convex below, tomentose; lamina elliptic to subobovate or suboblong, 10–20 by 3.8–7.1 cm., cuneate at apex, broadly rounded to shallowly cordate at base, obscurely undulate and slightly recurved at margin, drying near sepia on both surfaces, with grayish covering above, \pm persistently tomentose over entire lower surface, the midrib above quickly narrowed at base, raised, center strongly sulcate at first, 0.35–0.4 mm. wide at midpoint, below raised, striate, the venation above and below subobscure, raised, 8 to 13 veins/5 mm., angle of divergence 75–80°. Infructescences from foliate axils, with scars of 3 to 5 flowers, unbranched, the axis 2.5–4 mm. long, glabrous when mature, lowest internode 1–2.5 mm. long; bracts unknown; pedicels 8–10 by ca. 2.5 mm., glabrous. Flower unknown. Fruit probably spherical, ca. 2 cm. long and across, minutely apiculate, drying vinaceous-brown, smooth; outer layer detaching \pm cleanly from stone, 1.5–2.5 mm. thick, compact, small air spaces under skin; stone subspherical, ca. 1.4 by 1.2 cm., rounded at apex, the walls 0.3–0.4 mm. thick, smooth, perhaps with triradiate marking at apex; spongy layer thin.

DISTRIBUTION. The Philippine Islands (MAP 32); known only from a single collection.

SPECIMEN SEEN. **Philippine Islands**. MINDANAO. AGUSAN: Butuan, San Matea Bo., Tuñgao Bo., along Ojot R., Maasin Line km. 25, 350 m., *PNH 41930* (L, *PNH*, SING).

ECOLOGY. Colline forest, 350 m. alt. Fruiting in June (fruit green).

LOCAL USE. The wood is used in construction.

Calophyllum sp. 95 can be recognized by its bluntly conical, tomentose terminal bud; its rather large, sepia-drying leaf blades that are rounded to shallowly cordate at the base and that have subobscure venation; and its spherical fruits with a thick outer layer and a rather thin-walled stone. Sparsely tomentose indumentum persists on the lower surface of the lamina.

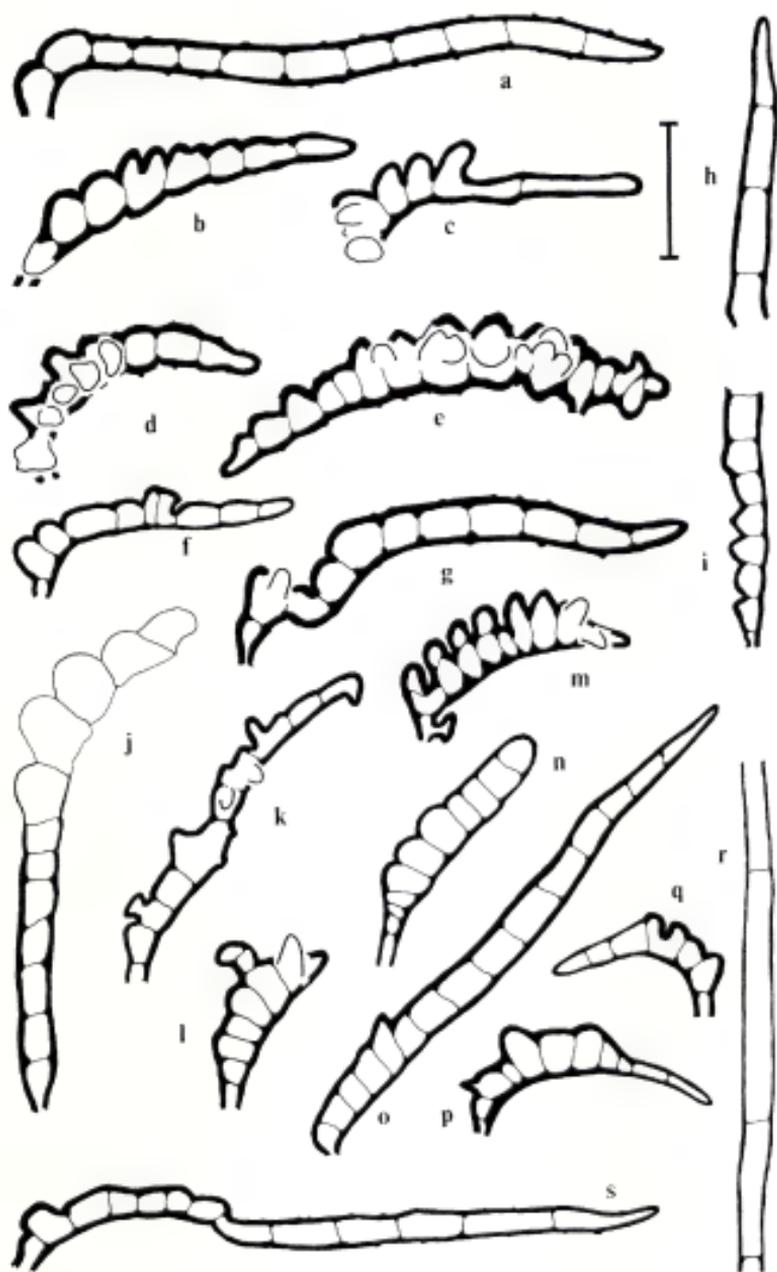
The duplicate of *PNH 41930* at Leiden appears to have furfuraceous fruits, but this is apparently the result of damage.

96. *Calophyllum pentapetalum* (Blanco) Merr. Sp. Blancoanae, 266. 1918; *Tovomita pentapetala* Blanco, Fl. Filip. 432. 1837. TYPE: Philippine Islands, Luzon, Lepanto subprovince, *Species Blancoanae 184* coll. *la Peña* (neotype, A; isoneotypes, BO, F, GH, K, L, MO, NSW, NY, P).

Shrub or tree to 7.5 meters tall; trunk and bark unknown.

Twigs not flattened to slightly so, 1–2.3 mm. across, usually strongly 4-angled when young, drying brown to blackish, initially tomentose; axillary innovations lacking basal scars; internodes 0.5–2(–4) cm. long; uppermost pair of axillary buds rounded, to 0.7 mm. long, spreading; terminal bud plump, 1–4 mm. long, with brown, \pm tomentose to subadpressed indumentum (hairs, FIGURES 29, r, v–x; 31, b, e), underdeveloped internode not apparent. Petiole 0.5–6 mm. long, concave above, convex below, subsersistently tomentose; lamina ovate to oblong or obovate, 1–9.5(–15) by (0.5–)0.9–4.5 cm., acute to rounded at apex, cordate to cuneate at base, neither undulate nor recurved at margin, coriaceous, drying sepia to hazel above and sepia to near sabelline below, \pm deciduously and sparsely puberulent to tomentose on and near midrib below, the midrib above \pm quickly narrowed at base, flat to slightly raised (surrounding lamina also raised), 0.2–0.4 mm. wide at midpoint, below slightly raised, subangled to striate, the venation above and below subobscure to subapparent, \pm raised, 8 to 13 veins/5 mm., angle of divergence (20–)40–75°. Inflorescences terminal and/or from adjacent foliate axils, with 7 to 21 flowers,

FIGURE 31. Hairs (from terminal bud). a, *Calophyllum clemensorum* (*Clemens & Clemens 40705*). b, c, *C. pentapetalum* var. *pulgarensis*: b, *Foxworthy 567*; c, *Elmer 13217*. d, e, *C. ceriferum*: d, *Robinson 1478*; e, *Poilane 6207*. f, h–k, *C. pisiferum*. f, *SFN 34747* (atypical specimen). h, i, k, *Pierre 3648*: h, i, apex and base of hair ca. 510 μ m. long; j, *Kostermans 10292*. g, *Calophyllum* sp. 98 (*SAN 21074*). l, r, *C. dispar*: l, *Achmad 1751*; r, *SFN 37715*, base of hair ca. 480 μ m. long (uncommon type). m, n, q, *C. tetrapterum* var. *tetrapterum*: m, *FRI 14014* (atypical specimen); n, *Kerr 9175*; q, *van Rossum 34*. o, p, *C. rupicola*: o, *Kostermans 22040*; p, *FRI 12526*. s, *C. lineare* (*Martin 1783*). Scale = 120 μ m.



sometimes flabellate and/or with branches to 4 cm. long and 9 flowers, the axis 3.5–12 cm. long, \pm tomentose toward base, lowest internode 1–3 cm. long; bracts ovate to elliptic, to 5 mm. long, deciduous (foliaceous, to 3.2 cm. long, subsistent); pedicels 0.7–2.1 cm. long, glabrous or with sparse hairs. Flower (?)hermaphroditic; tepals 6 to 12 (to 17), the outer pair suborbicular, 2.5–5 by 2.2–4.5(–6) mm., the next pair broadly elliptic to obovate, (4–)6–8 by (2–)4.5–6 mm., the inner ones elliptic to obovate, (4–)6–11 by (2–)3–6 mm., sometimes glabrous; stamens 40 to 145 (to 180), the filaments to 6 mm. long, the anthers suboblong, 0.65–1.8 mm. long, \pm retuse at apex; ovary 1.4–2 mm. long, the style 3–4.8 mm. long, the stigma peltate, 0.7–1.7 mm. across, \pm 3-lobed. Fruit subspherical to ovoid, 8.5–18 by 7.5–10 mm., \pm rounded at apex, drying purplish brown to gray, pruinose, smooth, sharply wrinkled when young; outer layer not detaching cleanly from stone, 0.2–0.4 mm. thick, air spaces developing, especially under skin; stone subspherical to ellipsoid, 6–12 by 5–7 mm., rounded at apex, the walls 0.1–0.3 mm. thick, smooth, unmarked; spongy layer thin.

Key to the Varieties of *Calophyllum pentapetalum*

1. Lamina cordate at base; petiole 0.5–2(–4) mm. long. 96a. var. *pentapetalum*.
1. Lamina rounded to cuneate at base; petiole at least 2 mm. long.
 2. Tepals 12 to 17; stigma at least 1 mm. across; lamina obovate to trapeziform. 96c. var. *pulgarensis*.
 2. Tepals (6 to) 8 (to 12); stigma less than 1 mm. across; lamina variable in shape, but rarely obovate or trapeziform. 96b. var. *cumingii*.

96a. *Calophyllum pentapetalum* (Blanco) Merr. var. *pentapetalum*

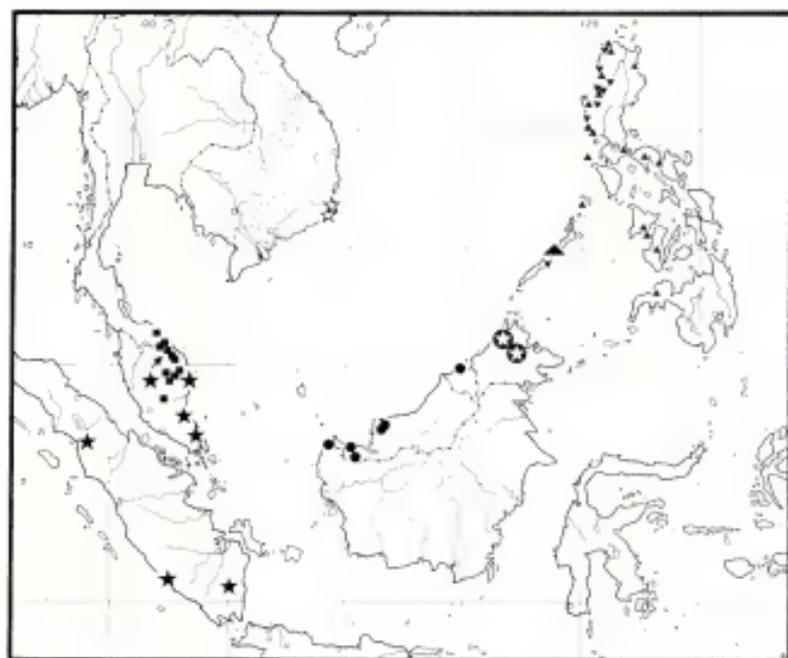
- C. pentapetalum* (Blanco) Merr.; Merr. Enum. Philip. Fl. Pl. 3: 80. 1923.
Ochrocarpus pentapetalus (Blanco) Fernand.-Vill. Novis. App. 17. 1880.
C. amplexicaule Choisy ex Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 281. 1862; Vidal, Phanerog. Cuming. Philip. 96. 1885, Rev. Pl. Vasc. Filip. 54. 1886; Vesque, Epharosis 2: t. 16. 1889, in C. DC. Monogr. Phanerog. 8: 564. 1893; Merr. Philip. Jour. Sci. C. 5: 199. 1910. Type: Philippine Islands, Luzon, Albay [properly Ilocos Norte], *Cuming 1212* (holotype, G; isotypes, BM, FI, K, MEL).

Shrub or small tree to 5 meters tall, d.b.h. to 15 cm.

Petiole 0.5–2 mm. long; lamina ovate or elliptic to oblong, 1.1–5.8(–8) by 0.9–3.3 cm., \pm cordate at base, angle of divergence of venation 60–75°. Flower with 6 to 12 tepals, outer pair 3.2–5 by 2.9–4.2 mm.; stigma 0.6–0.9 mm. across.

DISTRIBUTION. Philippine Islands: Palawan and western Luzon (MAP 33).

SELECTED SPECIMENS SEEN. **Philippine Islands.** PALAWAN: km. 112, Pinagbatuan, *PNH 91186* (L, PNH). LUZON. Ilocos Norte: sine loco, *Cuming 1841* (K). Ilocos Sur: Candon, *Clemens 18675* (BO, C, SING, UC, W). LA UNION: San Fernando, *Species Blancoanae 969* (A, BM, BO, F, GH, L, MO, NSW, NY, P, US, W). Benguet:



MAP 33. Distribution of *Calophyllum ceriferum* (open stars), *C. rupicola* (squares), *C. rupicola* variant (solid stars), *C. andersonii* (circles), *C. clemensorum* (stars in solid circles), *C. pentapetalum* var. *pulgarensis* (large triangle), *C. pentapetalum* var. *pentapetalum* (inverted small triangles), and *C. pentapetalum* var. *cumingii* (erect small triangles) in Southeast Asia-Malesia.

sine loco, *Loher 67* (κ). Pangasinan: sine loco, *FB 28413* (λ). Zambales: Santa Cruz, Barrio Dinabag, *Santos 6176* (L, US).

ECOLOGY. Dry forests, sometimes with pine; also in secondary forest and in rocky places in littoral forest; low alt. Flowering December, February, and March; fruiting November, December, and March.

96b. *Calophyllum pentapetalum* (Blanco) Merr. var. *cumingii* (Planchon & Triana) P. F. Stevens, comb. et stat. nov.

C. cumingii Planchon & Triana, *Ann. Sci. Nat. Bot.* IV, 15: 259. 1862; Vidal, *Phanerog. Cuming. Philip.* 96. 1885, *Rev. Vasc. Pl. Filip.* 54. 1886; Merr. *Enum. Philip. Fl. Pl.* 3: 78. 1923. **TYPE:** Philippine Islands, Luzon, Albay [or Zambales?], *Cuming 1077* (holotype, G; isotypes, BM, E, FI, G, K, L, MEL, NY, P, W).

C. pseudotacamahaca Planchon & Triana, *Ann. Sci. Nat. Bot.* IV, 15: 270. 1862; Vidal, *Phanerog. Cuming. Philip.* 96. 1885, *Rev. Pl. Vasc.*

Filip. 54. 1886; Vesque, *Epharmonis* 2: *tt.* 16-18. 1889, in C. DC. Monogr. Phanerog. 8: 565. 1893. TYPE: Philippine Islands, Luzon, Albay [or Zambales?], *Cuming 1047* (holotype, *o*; isotypes, BM, E, FI, G, K, L, MEL, MO, NY, P, W).

C. buxifolium Vesque, *Epharmonis* 2: *tt.* 18, 19. 1889, in C. DC. Monogr. Phanerog. 8: 538. 1893; Merr. Enum. Philip. Fl. Pl. 3: 78. 1923. TYPE: Philippine Islands, anno 1853, *Llanos s.n.* (holotype, *c*).

C. tacamahaca auct., non Willd.; Choisy, *Descr. Guttif. Inde.* 43. 1849. *Mém. Soc. Phys. Hist. Nat. Genève* 12: 423. 1851, *pro parte*.

Tree 1-7.5 meters tall, d.b.h. to 10 cm.

Petiole 2-6 mm. long; lamina elliptic to obovate, (1-)2-9.5(-15) by (0.5-)1-4.5 cm., cuneate to rounded at base, angle of divergence of venation (20-)40-70°. Flower with 8 or 9 tepals, outer pair 3.5-5.5 by 3-3.5 mm.; stigma 0.4-0.8 mm. across.

DISTRIBUTION. Philippine Islands (MAP 33).

SELECTED SPECIMENS SEEN (for explanation of letter, see discussion). **Philippine Islands.** CALAMIAN. CULIION: sine loco, *Merrill 609* (GH, K, NY, US). MINDORO: Golo, Lubang Is., *PNH 36738* (cf. a) (K, BISH, L, PNH, SING). LUZON. ILOCOS Norte: Burgos, *BS 26728* (A, K, US); Banguí, *BS 27419* (A, BO). ILOCOS Sur: Barrio Lugong, Santa Maria and vicinity, *Clemens 17096* (UC). La Union: San Fernandes, 4 m., *Sete 174* (UC). Pangasinan: So. Cabalatinawan, Sual, 450 m., *FB 30206* (E, UC). Zambales: Mt. Canaynayan, Castillejos, *BS 26838* (A, BM, BO, F, L, MO, P, UC, US); Mt. Marayep, 396 m., *BS 44802* (A, NY, UC); Subig, *Merrill 1768* (US); Sitio Apulul, Barrio Amuñgan, Iba, *Santos 6142* (L, US); Botolan, *Merrill 2592* (SING, US); Anuling, *BS 44602* (B, C, NY, UC); Mt. Tapalao, 917 m., *BS 44718* (L, NY, UC). QUEZON: Quinayangan, *Vidal 1152* (a) (FI, K, L); Gumihan, *FB 30741* (NY, SING). GUIMARAS Is.: sine loco, *FB 229* (cf. a) (BM, BO, F, K, LY, NSW, NY, SING, US). PANAY: Iloilo, *FB 25433* (A, BO, BISH). MINDANAO. Zamboanga: sine loco, *FB 25284* (A, P, US).

ECOLOGY. Habitats similar to those of var. *pentapetalum*, to 450 (rarely to 917) m. alt. Flowering November to March, and May; fruiting December to March, May, and August (ripe fruit black (*BS 44602*)).

The epithet commemorates H. Cuming, the noted collector of shells, plants, and other items of natural history.

96c. *Calophyllum pentapetalum* (Blanco) Merr. var. *pulgarensis* (Elmer) P. F. Stevens, comb. et stat. nov.

C. pulgarensis Elmer, *Leafl. Philip. Bot.* 5: 1786. 1913 ("C. *pulgarensis*"); Merr. Enum. Philip. Fl. Pl. 3: 80. 1923. TYPE: Philippine Islands, Palawan, Puerto Princesa (Mt. Pulgar), 4250 feet [1295 m.], May 1911, *Elmer 13217* (neotype, A; isoneotypes, BISH, BM, BO, E, F, FI, G, GH, K, L, LY, MO, NSW, NY, P, U, US, W).

Tree ca. 3 meters tall.

Petiole 2.5-5 mm. long; lamina obovate to trapeziform, 2.1-5.5 by 1.3-3 cm., cuneate at base, angle of divergence of venation 40-55°. Flower with 12 to 17 tepals, outer pair to 5 by 6 mm.; stigma 1.4-1.7 mm. across.

DISTRIBUTION. Philippine Islands, known only from Palawan (MAP 33).

SELECTED SPECIMEN SEEN. **Philippine Islands.** PALAWAN: sine loco, BS 567 (BO, GH, K, SING, NY, US).

ECOLOGY. Locally abundant in rocky, mossy summit scrub, 1100-1300 m. alt. Flowering in May; fruiting in December.

The epithet is taken from the name of the mountain on which the type specimen was collected.

Calophyllum pentapetalum can be recognized by its usually rather small and coriaceous leaf blades that often dry sepia-brown and nitid on the upper surface and that have moderately dense venation. The terminal bud is small, with more or less well-developed, tomentose indumentum. The inflorescences are usually terminal, and the flowers are relatively large (often more than 1 cm. across) for the size of the fruit (usually less than 1.5 cm. long). The very thin outer layer of the fruit becomes disorganized by air spaces, and the stone has thin walls. The epithet *pentapetalum* ("five-petaled") was coined because Blanco thought that the specimen he studied had five "petals."

Variation within *Calophyllum pentapetalum*

There is a great deal of variation in *Calophyllum pentapetalum*; leaf shape, in particular, varies considerably on a single individual (FIGURE 30, h-o). Despite the (at first sight) very different appearance of the extreme forms, Vesque already suspected in 1893 that the details of lamina anatomy and indumentum of the three species he recognized were so similar that specific rank would probably not be maintained; however, "il faudrait avoir le courage d'opérer la fusion et de distinguer simplement des variétés." Vesque recognized *C. pseudotacamahaca*, *C. buxifolium* (both = *C. pentapetalum* var. *cumingii*), and *C. amplexicaule* (= *C. pentapetalum* var. *pentapetalum*).

Although most specimens of *Calophyllum pentapetalum* from low altitudes in the Philippine Islands are easily placed in either var. *pentapetalum*, which has a lamina that is cordate at the base, or var. *cumingii*, which has a lamina that is cuneate at the base, there are two specimens that are more or less intermediate: BS 30047 (Luzon, Pangasinan, Mt. San Isidro) and PNH 92450 (Luzon, Laguna, Llavac). A few specimens of *C. pentapetalum* var. *cumingii* ("a" in the list above) have somewhat denser venation (10 to 13 veins/5 mm.) that diverges from the midrib at only 20-40°; the apex of the leaf is more acute than usual. In leaf shape such specimens approach the type of *C. buxifolium*. Finally, FB 27842 has long, narrow leaf blades (9-15.5 by 2.5-3.2 cm.), although in other respects it is not unusual.

Although specimens referable to *Calophyllum pentapetalum* have very small leaves and at first sight appear to represent yet another variety, *C. buxifolium* and *C. pentapetalum* var. *cumingii* are connected by intermediates. FB 26728, FB 27419, and BS 26838 form a series in leaf size: the first two (from Ilocos Norte Province, Luzon) are placed in *C. buxifolium*, while FB 26838 at the Arnold Arboretum (Zambales, Luzon) has one shoot somewhat like a comparatively large-leaved *C. buxifolium* and the other like a fairly small-leaved

C. pentapetalum var. *cumingii* (see also FIGURE 30, h-o). The type specimen of *C. buxifolium*, *Llanos s.n.*, has narrower leaves; the lamina was described as 1.6-3.2 by 0.5-1 cm., although on the type specimen at Geneva the largest leaf remaining is only 2.6 by 1 cm. It is therefore not possible to recognize a taxon based on *C. buxifolium*.

Calophyllum pentapetalum var. *pulgarensis* grows at higher altitudes than do the other varieties (ca. 1300 m. vs. usually less than 450 (rarely to 917 m.) and is known only from Mt. Pulgar, on Palawan Island; not surprisingly, its leaves are more coriaceous than those of the other two varieties. In these varieties the midrib on the lower surface of the lamina is often demarcated from the adjacent surface by a line that is absent in var. *pulgarensis*. *Calophyllum pentapetalum* var. *pulgarensis* always has numerous tepals in each flower (vs. usually only eight in the other varieties), and its stigma is very much larger. In all other details, including those of the fruit (in an envelope on the sheet of *FB 3873* at Kew), it is similar to the other two varieties.

Nomenclature and Synonymy

I follow Merrill in his interpretation of Blanco's name *Tovomita pentapetala* (Merrill, 1918, *loc. cit.*), and the duplicate of *Species Blancoanae 184* at the Arnold Arboretum is designated the neotype of the name (Blanco's description is poor).

The type specimen of *Calophyllum pseudotacamahaca*, *Cuming 1047*, has especially well-developed, leaflike bracts, but similar bracts occur in *C. pentapetalum* vars. *pentapetalum* and *cumingii* (the sheet of *Cuming 1047* at FI is exceptional in that the flowers are single and axillary). Planchon and Triana specifically excluded the fruiting shoot of *Cuming 1047* at G from their *C. pseudotacamahaca* because they thought that the small fruits on this shoot were unlikely to have come from flowers the size of those on the other shoot. However, as Vesque (1893, *loc. cit.*) suggested, the two are conspecific. (The localities for the specimens collected by Cuming are taken from Merrill, 1915.)

Cuming 1077, the type specimen of *Calophyllum cumingii*, is very similar to the type of *C. pseudotacamahaca*, although it has smaller flowers. It may be noted that if the taxon here called *C. pentapetalum* var. *cumingii* is recognized at the specific level and includes *C. pseudotacamahaca* in its circumscription, the correct name for this taxon is *C. pseudotacamahaca* rather than *C. cumingii* (cf. Merrill, 1923, *loc. cit.*). Vesque (1893, *loc. cit.*) reduced *C. cumingii* to synonymy under *C. pseudotacamahaca*.

The specimen of *Elmer 13217* at the Arnold Arboretum is designated the neotype of *Calophyllum pulgarensis*; the holotype was destroyed.

97. *Calophyllum ceriferum* Gagnep. ex P. F. Stevens FIGURE 28, d-f.

C. ceriferum Gagnep. in Humbert, Fl. Gén. Indo-Chine Suppl. 1: 272. fig. 24, 1-8. 1943; Phạm, Cây-Cỏ Miền Nam Việt-Nam. ed. 2. 2: 301. fig. 1970. *Nomen invalidum*.

A *Calophyllo pentapetalo*, quo aliter simile est, in indumento minus evoluto, internodio terminali innovationis saepe brevior quam aliis, pedicellis in fructo valde incrassatis usque ad 2.5 mm. in transversis (minus quam 1 mm. in transversis), et fructibus corrugatis strato exteriori circa 1 mm. crasso, compacto (minus quam 0.3 mm. crasso, haud compacto) et putamine parietibus circa 0.7 mm. crassis (minus quam 0.3 mm. crassis), differt.

Tree 5-12 meters tall; trunk and bark not known.

Twigs flattened, 1.2-1.6 mm. thick, 4-angled, drying blackish (with grayish, waxy covering), puberulent when young; axillary innovations lacking basal scars; internodes 0.4-3.3 cm. long, terminal internode often shorter than others; uppermost pair of axillary buds rounded, ca. 0.5 mm. long, subspreading; terminal bud plump, 1.3-2 mm. long, with short-tomentose brown or grayish subadpressed indumentum (hairs, FIGURE 31, d, e), underdeveloped internode absent. Petiole 0.25-1.3 cm. long, broadly concave above and convex below, glabrous; lamina obovate (rarely subelliptic or trapeziform), (1.6-)2.3-5.5 by (0.6-)-1-3.5 cm., obtuse to rounded (rarely subacute to retuse) at apex, cuneate to acute at base, neither undulate nor recurved at margin, coriaceous, drying amber above (color obscured by grayish covering) and below, glabrous or transiently puberulent on midrib below, the midrib above gradually narrowed from base, \pm flat, 0.1-0.25 mm. wide at midpoint, below raised, rounded, narrow, inconspicuous, the venation subapparent on both surfaces, raised, 5 to 8 (to 10) veins/5 mm., angle of divergence 30-55°. Inflorescences terminal and from adjacent foliate axils, with 7 to 15 flowers, flabellate or with 5-flowered branches to 5 cm. long, the axis 3-7 cm. long, puberulent, or with scattered hairs toward base, lowest internode (0.5-)-1.5-4 cm. long; bracts not known; pedicels 0.5-3.1 cm. long, glabrous to transiently puberulent, slender, up to 2.5 mm. thick in fruit. Flower (?) hermaphroditic; tepals 8, the outer pair ovate, 5-6 by 3.5-5 mm., the inner ones elliptic to obovate, 5.5-10 by 3.5-6 mm.; stamens 100 to 125, the filaments to 5 mm. long, the anthers oblong, 1-1.5 mm. long, subretuse at apex; ovary 1.7-2 mm. long, the style ca. 3 mm. long, the stigma peltate, ca. 1 mm. across, 3-radiate. Submature fruit spherical, ca. 1.7 cm. long and across, acute at apex when young, becoming \pm rounded, drying pale brown, closely and deeply wrinkled; outer layer not detaching cleanly from stone, ca. 1 mm. thick, compact; stone spherical, ca. 1.5 cm. long and across, rounded at apex, the walls ca. 0.7 mm. thick, smooth, not marked; spongy layer initially thick.

TYPE: Annam [Vietnam], Nhatrang, presqu'île de Nui Hon Heo, 100 m., 3 May 1925, *Poilane 6172* (holotype, B; isotypes, A, K).

DISTRIBUTION. Vietnam (MAP 33).

ADDITIONAL SPECIMENS SEEN. **Vietnam:** Nhatrang, presqu'île de Nui Hon Heo, *Poilane 6207* (P), *Poilane 6234* (B, BM, K); Nhatrang and vicinity, *C. B. Robinson 1478* (K, NY, P); Phanrang, Cana, 200 m., *Poillane 9612* (K, P), 400 m., *Poillane 12512* (B, K, P).

ECOLOGY. Tree sometimes of rather poor form, stony ground, 100-400 m.

alt. Flowering April, May, and October (flower scented); submature fruit in October.

Calophyllum ceriferum can be recognized by its short, plump terminal bud; its small, more or less obovate leaf blades with subdistant, steeply ascending venation; and its more or less obvious grayish, waxy covering on the vegetative parts of the plant. The pedicels are markedly incrassate in fruit, the flowers have eight tepals, and the submature fruit has a compact outer layer about 1 mm. thick and stone walls about 0.7 mm. thick. The epithet *ceriferum* ("wax bearing") refers to the waxy covering of the plant.

Calophyllum ceriferum is perhaps close to the variable *C. pentapetalum*, from the Philippine Islands, but can be distinguished from that species by the characters given in the diagnosis.

The specimens of *Calophyllum ceriferum* from Phanrang, as well as *Robinson 1478*, from Nhatrang, have small leaves with rather dense venation; the leaves are frequently, but not always, separated by internodes of equal length, and the bud has subadpressed, grayish indumentum. The other specimens have larger leaves with more distant venation, the terminal internode of an innovation is often markedly shorter than the others, and the terminal bud has brown, subtomentose indumentum. However, all specimens have a short, plump, terminal bud, the hairs are similar in structure, there is no absolute difference in leaf size and venation density, the inflorescences and flowers are similar, and the pedicels are long, becoming markedly incrassate in fruit. The grayish (waxy) covering of the leaf alluded to by Gagnepain (*loc. cit.*) is not always obvious, but is best developed on *Robinson 1478*.

Formal description of *Calophyllum ceriferum* is necessary since Gagnepain's description is invalid, being in French.

98. *Calophyllum* sp.

C. brachyphyllum auct., non Merr.; Meijer, Symp. Ecol. Res. Humid Trop. 347. 1965.

Tree 7.5–20 meters tall, d.b.h. to 20 cm.; trunk with rounded buttresses (*SAN 51735*); outer bark pale yellow to red-brown, thin, shallowly fissured, smooth, or scaly-flaky in oblong scales.

Twigs slightly flattened, 1–1.7 mm. across, ± strongly 4-angled, drying blackish brown, at least sometimes puberulent when young; axillary innovations lacking basal scars; internodes 0.5–4 cm. long; uppermost pair of axillary buds rounded, ca. 0.3 mm. long, erect; terminal bud narrowly conical, 1–2 mm. long, with adpressed, brown indumentum (hairs, *FIGURE 31, g*), underdeveloped internode absent. Petiole 1.5–5 mm. long, deeply concave above, convex below, glabrescent; lamina suborbicular to elliptic or obovate, 1.1–4.2 by 0.9–2.5 cm., slightly retuse to bluntly pointed at apex, cuneate to shallowly cordate at base, slightly undulate and not recurved at margin, coriaceous, drying umber to fuscous above and bay to umber below, glabrous when mature, the midrib above abruptly narrowed at base, flat to slightly raised, 0.15–0.25 mm. wide at midpoint, below raised, striate, not very conspicuous,

the venation obscure to apparent above and \pm apparent below, raised, 7 to 9 veins/5 mm., angle of divergence 40–60°. Inflorescences terminal and/or from adjacent foliate axils, with 5 to 11 flowers, unbranched, the axis 2–3.5 cm. long, sparsely brown-tomentose, especially near base, lowest internode 0.5–1.3 cm. long; bracts foliaceous (? or not), to 7 mm. long, deciduous; pedicels 4–8 mm. long, glabrous. Flower known only in bud, (?) hermaphroditic; tepals 8 (rarely 9), the outer pair suborbicular, ca. 4.5 by 4 mm.; stamens 75 to 105, the anthers oblong, ca. 1.5 mm. long, truncate to retuse at apex; ovary ca. 1 mm. long, style ca. 1.5 mm. long, stigma ca. 0.5 mm. across. Immature fruit \pm ellipsoid, ca. 8 by 5 mm.; outer layer probably ca. 0.3 mm. thick; stone walls probably very thin; spongy layer unknown.

DISTRIBUTION. Northeastern Borneo (MAP 35).

SPECIMENS SEEN. **Borneo.** SABAH. Ranau: Bukit Ampuon, 1280 m., SAN 21074 (A, CANB, K, KEP, L, LAE, SAN, SAR). Kinabatangan: Mt. Tavai, Karamuak, 610 m., SAN 51735 (A, SAN). Lahad Datu: NW. ridge of Mt. Silam, 19 km. WSW. of Lahad Datu, 762 m., SAN 15045 (A, BO, BRI, KEP, L, SING), 853 m., SAN 75168 (SAN).

ECOLOGY. Hillsides and ridges, in soil derived from ultramafic rock; 610–1280 m. alt. Flowering March and July.

Calophyllum sp. 98 is very similar to small-leaved specimens of *C. pentapetalum* var. *buxifolium*, differing mainly in its more narrowly conical terminal buds and in the characteristically dark-drying (umber to fuscous) upper lamina surface. The lowest internode of the axillary innovation is often notably longer than the others. All specimens were collected at moderate elevations in areas of ultramafic rock, and this may in part be responsible for their rather distinctive facies. However, it is best to segregate them as a distinct, but unnamed, taxon close to *C. pentapetalum*, at least until fruits are known.

Calophyllum sp. 98 can be readily distinguished from *C. brachyphyllum* by its less coriaceous leaves with less dense venation, and by its larger, often terminal inflorescences. The two taxa are not immediately related.

Although *Calophyllum* sp. 98 shows considerable variation in lamina shape, the extremes (suborbicular blade subcordate at the base vs. obovate blade cuneate at the base) are connected by intermediates.

99. *Calophyllum clemensorum* P. F. Stevens, sp. nov. FIGURE 32, c, d.

C. rotundifolium auct., non Ridley; Meijer, Symp. Ecol. Res. Humid Trop. 347. 1965.

A speciebus aliis Calophylli in lamina basi cordata, venulis lateralibus manifestis, inflorescentia terminali, floribus saepe cum 12 tepalis, et fructu parvo circa 1.1 cm. longo strato exteriori compacto circa 0.2–0.3 mm. crasso e putamine munde secedens, differt.

Shrub to tree 3.9–15 meters tall, d.b.h. to 30 cm.; bark not known.

Twigs flattened, 2–2.5 mm. across, usually strongly 4-angled, drying dark brown, sparsely and transiently puberulent; axillary innovations usually with basal scars; internodes 1.5–3 cm. long; the upper pair of axillary buds rounded, to 0.7 mm. long, \pm spreading; terminal bud conical, 2–2.5 mm. long, with grayish indumentum (hairs, FIGURE 31, a), underdeveloped internode to 1 mm. long. Petiole 1–3 mm. long, narrowly concave above and convex below, glabrescent; lamina orbicular to lingulate, (1.7–)2.7–7.3 by (1.5–)2.4–6.3 cm., obtuse to retuse at apex, cordate at base, slightly undulate and somewhat recurved at margin, coriaceous, drying umber to sepia on both surfaces, glabrous at maturity, the midrib above \pm quickly narrowed near base, flat to slightly raised, 0.15–0.3 mm. wide at midpoint, below raised, slightly striate, the venation \pm apparent on both surfaces, raised, 7 to 12 veins/5 mm., angle of divergence 65–75°. Inflorescences terminal (also from adjacent foliate axils), with 9 to 25 flowers (flabellate and/or with branches to 3.5 cm. long and with 7 flowers), the axis 3–4.5 cm. long, glabrous or sparsely puberulent toward base, lowest internode 0.6–1.2(–2) cm. long; bracts oblong to ovate, 2.5–4 mm. long, or foliaceous, to 1.5 cm. long, subsistent; pedicels 0.5–1.5 cm. long, sometimes sparsely puberulent when young. Flower (?) hermaphroditic; tepals (11 or) 12 (or 13) [8 or 9 in *SAN 17252*], the outer pair broadly ovate, 4–6 by 3.7–5 mm., the inner ones obovate to elliptic, 6.5–12.5 by 2.5–6 mm., sometimes glabrous; stamens 110 to 195, the filaments to 4.5 mm. long, the anthers oblong, (0.9–)1.3–1.8 mm. long, retuse at apex; ovary 1.2–1.7 mm. long, the style ca. 3 mm. long, the stigma subpeltate, ca. 0.7 mm. across. Submature fruit ellipsoid, ca. 1.1 by 1 cm., rounded at apex, drying vinaceous-brown, sharply wrinkled; outer layer detaching cleanly from stone, 0.2–0.4 mm. thick, compact; stone ellipsoid, ca. 10 by 8 mm., rounded at apex, the walls ca. 0.2 mm. thick, smooth, unmarked; spongy layer (?) thin.

TYPE: North Borneo [Sabah], Penibukan, 5000 feet [1524 m.], 11 Nov. 1933, *J. & M. S. Clemens 50316* (holotype, A; isotypes, G, K, MICH, NY, UC).

DISTRIBUTION. Northeastern Borneo (MAP 33).

ADDITIONAL SPECIMENS SEEN. **Borneo.** SABAH. Ranau: Mt. Kinabalu, Penibukan, head of Dahobong R., 1524 m., *Clemens 40705* (A, G, K, NY, UC), 1524 m., *Clemens 30984* (BO), 1219–1524 m., *Clemens 31428* (BO); W. Marai Parai, 1219 m., *Clemens 35038* (BO, NY); Pentaturan Basin, 2134 m., *Clemens s.n.*, 27 July 1933 (BO). Kinabatangan: G. Tonsuon, 975 m., *SAN 17252* (?) (A, BO, KEP).

ECOLOGY. Lower montane rain forest, 975–2135 m. alt.; near Mt. Kinabalu on sometimes dry ridges. Flowering February, May, July, and October; submature fruit in April.

In *Clemens 35038* the stem is much swollen in places, apparently being galled, and is up to 1 cm. across. This swelling may also occur on the midrib of the lamina, which then becomes woody.

Calophyllum clemensorum can readily be distinguished from the other Malasian species of *Calophyllum* with a cordate-based lamina by its strongly

four-angled twigs, distinct venation, terminal inflorescence, flowers usually with more than eight tepals, and ellipsoid fruits with a thin, compact outer layer that detaches easily from the thin-walled stone. This species is named after the collectors and missionaries J. and M. S. Clemens (for an excellent photograph of the couple, see Fl. Males. I(1): 109, 1950).

Although the leaves of *Calophyllum clemensorum* are superficially like those of *C. rotundifolium* (see Meijer, *loc. cit.*; E. D. Merrill also identified Clemens's specimens as *C. rotundifolium*), that species has more profusely branched, only slightly angled twigs, leaves with the midrib below more or less depressed and not very distinct, and a terminal inflorescence consisting of only one or two flowers. The flowers of *C. rotundifolium* are larger than those of *C. clemensorum* and have very thick outer tepals.

Calophyllum clemensorum is superficially similar to *C. vergens* (*C. thwaitesii* Planchon & Triana 'β'), from the mountains of Sri Lanka. However, the latter species has axillary inflorescences, flowers with only eight tepals, a somewhat longer terminal bud, and much larger fruits with a thicker outer layer.

SAN 17252 is the only specimen of *Calophyllum clemensorum* that has eight (or nine) tepals, and it also has a thicker lamina than the others. It is a poor specimen, however, and further collections from Gunong Tonsuon may show that it belongs to the variable *C. teysmannii* complex.

The above description of the fruit is based on detached fruits on the sheets of Clemens 35038.

100. *Calophyllum tetrapterum* Miq. Pl. Jungh. 291. 1854. Type: Sumatra, Angkola superior, 1000-3000 pedes [310-925 m.], *Junghuhn s.n.* (holotype, v; isotypes, 80, 1).

Shrub 1.5 meters tall or tree 3-20 meters tall, d.b.h. to 40 cm.; trunk lacking buttresses but occasionally with stilt roots; outer bark whitish to yellowish or brown, shallowly fissured or smooth (rarely brown, deeply fissured), usually hoop marked, the inner surface orange(-red) to blackish; under bark reddish or reddish and yellow mottled; inner bark reddish; latex usually clear to opaque yellow, sticky (rarely white to whitish or yellow, fluid, not sticky).

Twigs slightly flattened, 1.3-2.8(-3.5) mm. across, strongly 4-angled (to ± rounded), drying brown to blackish or yellowish, glabrous or ± sparsely and transiently brown-pubescent; axillary innovations usually lacking basal scars; internodes 0.5-5 cm. long; uppermost pair of axillary buds rounded, 0.5-1.5 mm. long, spreading; terminal bud plump, 1.5-4 mm. long, with short, adpressed, grayish, to short-tomentose, brown indumentum (hairs, FIGURE 31, m, n, q; cf. 20, i-1, and 22, k, l), underdeveloped internode 0.5-2(-3) mm. long. Petiole 0.4-1.4(-2) cm. long, ± deeply concave above, convex below, at most transiently puberulent below; lamina elliptic to obovate (oblong), (2.2-)3.5-14 by (1-)1.6-6.5 cm., acuminate or acute to rounded at apex, cuneate to acute at base, at margin sometimes with band of thickening to 1 mm. wide, or clear submarginal vein, undulate but not recurved or only slightly

so, ± coriaceous, drying umber to gray-olivaceous above, margin often paler, or color obscured by pruinose covering, and cinnamon to olivaceous below, glabrous or sparsely puberulent to subtomentose on midrib below, the midrib above gradually narrowed from base, usually sharply raised (almost level), 0.15–0.45 mm. wide at midpoint, below raised or slightly raised, somewhat striate, the venation on both surfaces usually apparent, raised, (4 or) 5 to 14 (to 17) veins/5 mm., angle of divergence (50–)65–75°. Inflorescences usually axillary (terminal), with 3 to 11 flowers, unbranched, the axis (0.3–)1–4 (–7.5) cm. long, glabrous or short-puberulent to subtomentose toward base, lowest internode 0.4–3.5 cm. long; bracts usually small and fugaceous (foliaceous, to 2 cm. long, subsistent); pedicels (0.2–)0.5–2(–3) cm. long, glabrous, usually very slender, frequently incrassate and to 2.5 mm. thick in fruit. Flower (?)hermaphroditic; tepals 4 or 8 (rarely 5 to 7, or 10), the outer pair ovate to broadly elliptic, 2.2–5 by 2–4 mm., sometimes papillate or puberulent on back near apex, the inner ones elliptic to lingulate, 3.5–8.5 by 1.5–3.5 mm.; stamens 25 to 105 (to 135), the filaments to 4.5 mm. long, the anthers suboblong, (0.4–)0.7–1.2 mm. long, shallowly retuse at apex; ovary 0.8–1.3 mm. long, the style to 3.5 mm. long, the stigma peltate, ca. 0.4 mm. across, slightly lobed. Fruit ellipsoid to spherical, 6.5–16 by 5–12 mm., apiculate or rounded at apex, drying grayish to pale brown, sharply wrinkled when young, at least sometimes smooth when mature; outer layer usually not detaching cleanly from stone, 0.25–0.5(–1.3) mm. thick, with large air spaces developing; stone spherical to ellipsoid, 5.5–11 by 5–10 mm., rounded at apex, the walls 0.1–0.2(–0.35) mm. thick, smooth, unmarked; spongy layer thin.

Key to the Varieties of *Calophyllum tetrapterum*

1. Lamina with clear submarginal vein, or submarginal band of thickening (0.2–)0.4–1 mm. wide, (4 or) 5 to 7 (to 10) veins/5 mm.; floral bracts sometimes subsistent. 100b. var. *obovale*.
1. Lamina lacking distinct submarginal vein, marginal band of thickening less than 0.4 mm. wide, usually more than 7 veins/5 mm.; floral bracts soon deciduous.
 2. Lamina with obscure venation on lower surface, 5 to 7 veins/5 mm. 100c. var. *blumutense*.
 2. Lamina with ± clear venation on lower surface, (5 to) 8 or more veins/5 mm. 100a. var. *tetrapterum*.

100a. *Calophyllum tetrapterum* Miq. var. *tetrapterum*

- C. tetrapterum* Miq.; Walp. Ann. Syst. Bot. 4: 367. 1857; Miq. Fl. Indiae Batavae 1(2): 510. 1857, *ibid.* Suppl. 3(2): 1861; Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 293. 1862; Vesque in C. DC. Monogr. Phanerog. 8: 610. 1893; H. Keng, Gard. Bull. Singapore 28: 245. 1976.
- C. bancanum* Miq. Fl. Indiae Batavae, Suppl. 1(3): 499. 1861; Kurz, Nat. Tijdschr. Nederl.-Indië 27: 192. 1864; F. Mueller in Walp. Ann. Syst. Bot. 7: 357. 1868; Scheffer, Nat. Tijdschr. Nederl.-Indië 31: 354. 1870, *ibid.* 32: 405. 1873. TYPE: Bangka, Djebus, *Teysmann, HB 3214* (holotype, u; isotypes, uo, k, l).

- C. gracile* Miq. Fl. Indiae Batavae, Suppl. 1(3): 498. 1861; F. Mueller in Walp. Ann. Syst. Bot. 7: 357. 1868; *C. pulcherrimum* Wall. ex Choisy var. *gracile* (Miq.) Boerl. Catal. Horto. Bogor. 2: 82. 1901, *excl. spec. cit.* TYPE: Sumatra, prope Paja-Kombo, *Teysmann, HB 649* (holotype, U; isotypes, BO, K (S.N.), L, MEL (S.N.)).
- C. floribundum* Hooker f. Fl. Brit. India 1: 272. 1874, *pro parte*; King, Jour. Asiatic Soc. Bengal, II. 59: 175. 1890; Ridley, Fl. Malay Penin. 1: 184. 1922; M. R. Henderson, Gard. Bull. Straits Settl. 4: 224. 1928; M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 332. *pl. 16*. 1956; Smythies, Common Sarawak Trees, 61. 1965; Kochummen, Malayan Forest Rec. ed. 2. 17: 215. 1965; I. H. Burkill, Dict. Econ. Prod. Malay Penin. ed. 2. 1: 412. 1966; T. C. Whitmore, Tree Fl. Malaya 2: 180. 1973; Corner, Gard. Bull. Singapore, Suppl. 1: 104. 1878. TYPE: Malaya, Malacca, 1 Jan. 1867, *Maingay 1660 (Kew dist. 170)* (lectotype, K).
- C. praineanum* King, Jour. Asiatic Soc. Bengal, II. 59: 175. 1890; Vesque in C. DC. Monogr. Phanerog. 8: 550. 1893; Ridley, Fl. Malay Penin. 1: 183. 1922. SYNTYPES: Malaya, Perak, Larut, less than 100 feet [30 m.], Dec. 1883, *King's collector [Kunstler] 5366* (BM, FI, G, K, P, UC), 800-1000 feet [240-305 m.], Feb. 1885, *King's collector [Kunstler] 7243* (BM, FI, K, P).
- C. venustum* King, Jour. Asiatic Soc. Bengal, II. 59: 180. 1890; Vesque in C. DC. Monogr. Phanerog. 8: 549. 1893; Ridley, Fl. Malay Penin. 1: 186. 1922. TYPE: Malaya, Perak, Larut, 300-350 feet [90-105 m.], July 1885, *King's collector [Kunstler] 7763* (isotypes, FI, G, K).
- C. foetidum* Ridley, Jour. Straits Branch Roy. Asiatic Soc. 54: 18. 1910, *pro maxime parte*, Fl. Malay Penin. 1: 186. 1922, *pro parte*. TYPE: Singapore, Gardens Jungle, anno 1904, *Ridley 11958* (lectotype, SING; isolectotypes, BM, K).
- C. lanceola* Ridley, Jour. Straits Branch Roy. Asiatic Soc. 82: 170. 1920, Fl. Malay Penin. 1: 182. 1922. TYPE: Malaya, Kedah, Kedah Peak, 4000 feet [1219 m.], *Ridley 5751* (holotype, SING).
- C. rupicola* Ridley var. *elatum* T. C. Whitmore, Gard. Bull. Singapore 26: 270. 1970, *pro minore parte*, Tree Fl. Malaya 2: 169. 1973, *pro minore parte*. TYPE: Malaya, Kelantan, Ulu Sat F.R., 180 m., 2 Feb. 1970, *FRI 2538* coll. *Kochummen* (holotype, KEP; isotypes, K, L, SING).
- C. pulcherrimum* auct., non Wall. ex Choisy; T. Anderson in Hooker f. Fl. Brit. India 1: 271. 1874, *pro parte*; Pierre, Fl. Forest. Cochinch. 1: *pl. 104A*. 1885, *pro parte*; Vesque, Epharמוש 2: *t. 21*. 1889, in C. DC. Monogr. Phanerog. 8: 570. 1893, *pro parte*; Curtis, Jour. Straits Branch Roy. Asiatic Soc. 25: 78. 1894; Pitard in Lecomte, Fl. Gén. Indo-Chine I(4): 321. 1910; Ridley, Fl. Malay Penin. 1: 182. 1922, *pro parte*; I. H. Burkill & M. R. Henderson, Gard. Bull. Straits Settl. 3: 347. 1925; Craib, Fl. Siam. Enum. 1: 121. 1931; Gagnep. in Humbert, Fl. Gén. Indo-Chine, Suppl. 1: 274. 1943; Pham & Nguyễn, Cây-Cỏ Miền Nam Việt-Nam, 179. 1960; Pham, Cây-Cỏ Miền Nam Việt-Nam. ed. 2. 2: 301. *fig. 1970, pro parte*.
- C. amoenum* auct., non Wall. ex Choisy; Vesque in C. DC. Monogr. Phanerog. 8: 576. 1893, *quoad King 548*.
- C. griffithii* auct., non T. Anderson; Baker f. Jour. Bot. London 62(Suppl.): 8. 1924.
- C. dryobalanoides* auct., non Pierre; Craib, Fl. Siam. Enum. 1: 120. 1931;

Gagnep. in Humbert, Fl. Gén. Indo-Chine, Suppl. 1: 274. 1943, *pro parte*.
C. globuliferum Ridley, Kew Bull. 1938: 121. 1938, *typo excluso*.
Calophyllum sp. Craib in Schmidt, Bot. Tidsskr. 32: 328. 1915.

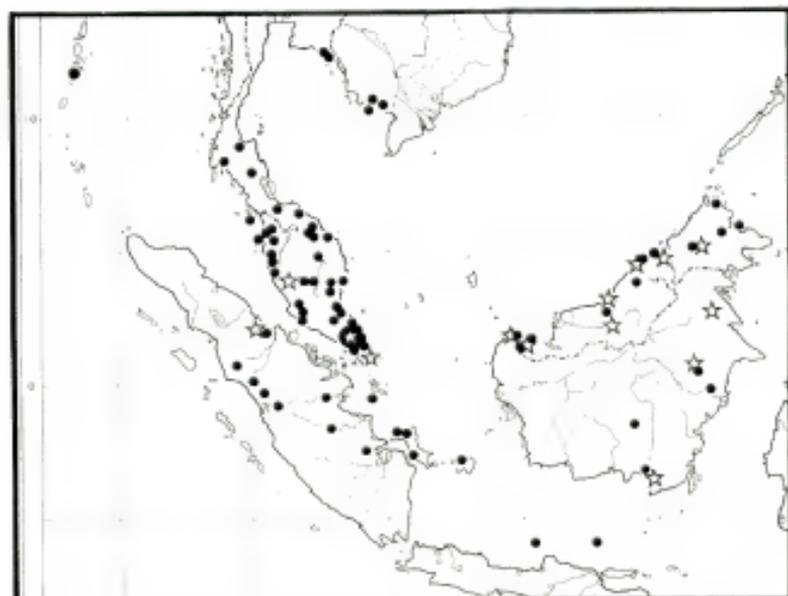
Tree 6-30 meters tall, d.b.h. to 38 cm.; outer bark closely fissured; latex clear to opaque yellow (rarely white to whitish (SAN 22940, 71512)), sticky.

Twigs slightly flattened, usually strongly 4-angled; axillary innovations nearly always lacking basal scars. Lamina elliptic to obovate (rarely suboblong), 3.7-13.5 by 1.6-5.2 cm., usually acuminate (acute) at apex, usually notably pale at margin, marginal thickening less than 0.4 mm. wide, thinly coriaceous, the venation \pm clear above and below, (5 to) 8 to 14 (to 17) veins/5 mm. Inflorescences axillary; bracts very fugaceous, usually lost even in very young inflorescences.

DISTRIBUTION. Cambodia to Borneo, excluding mainland Java (MAP 34).

SELECTED SPECIMENS SEEN ("e" denotes atypical specimens—see notes at end).

Vietnam: Phu Quoc, *Pierre* 3645 (p), near Hatien, *Poilane* 876 (k, p). **Cambodia:** Kampot, Mt. Bokor, 1000 m., *Smitinand & Abbe* 6511 (k). **Thailand:** Krat, Kookrap, 700 m., *Kerr* 17772 (sm, k), Kao Saming, *Put* 567 (k); Kaw Koh Chang, Klong Munse, *Schmidt* 528 (c, k); Klong Majum, *Schmidt* 603A (c, k), Klawng Non Si, 50 m., *Kerr* 9175 (A, C, E, K, L, P); Krabi, Ao Luk, 50



MAP 34. Distribution of *Calophyllum tetrapterum* var. *tetrapterum* (circles), *C. tetrapterum* var. *blumutense* (star in solid circle), and *C. tetrapterum* var. *obovale* (stars) in Southeast Asia-Malesia.

m., *Kerr 18567* (A, BM, C, K, P); Terutas, Satul, 5 m., *Kerr 14213* (BM, C, K, L, P); Huey Tonpong, Bandom, *FDS 874* (BKF, K); Songkla, Sadao, Khao Le, *Premrasmi 183* (KEP); Tanto, *Nim 41* (BKF); Pen [insula], Narathiwat, Waeng, *Nitrasirak 206* (?) (BKF). **Andaman and Nicobar Islands.** S. ANDAMAN: Tusonobad, *King's collectors s.n.*, 23 Jan. 1893 (BO, K, P, U). MALAYA. KEDAH: Kedah peak, 792 m., *KEP 94422* (A, BO, K, KEP, NY, SING); Bukit Enggang F.R., 427 m., *FRI 13730* (e) (A, K, SAN, SING); Sik catchment area, *FRI 16289* (e) (A, KEP, SAR); Langkawi, G. Raya, *Corner s.n.*, 15 Nov. 1941 (SING); Bukit Sawak F.R., *KEP 66442* (KEP); Sungei Batu Asap, 150 m., *Ridley 15540* (BM, K, SING); Perangin F.R., *KEP 79283* (SING); Kuala Muda, Gurun, Jerai F.R., *KEP 17925* (SING); Bukit Malut, *KEP 7683* (SING). PINANG: Muku head, 150-240 m., *Curtis 418* (?e) (K, SING); Pulau Penang, above waterfall garden, *SFN 3368* (BM, SING); Penang Hill, 762 m., *FRI 20525* (KEP); Pantai Acheh F.R., *KEP 72565* (KEP). PERAK: Larut, 150-240 m., *King's collector 3378* (K, P); Lumut F.R., 120 m., *FRI 977* (?e) (A, K, KEP, SAN, SING); Taiping Hill, *J. W. Anderson 114* (SING); Batu Undan F.R., 305 m., *KEP 54223* (KEP). SELANGOR: Ulu Gombak F.R., *FRI 2213* (A, K, SAN, SING); 22 mile Ginting Simpah, *KEP 12854* (SING); Bukit Lagong F.R., *KEP 80646* (KEP). NEGERI SEMBILAN: Kuala Pilah, Serting F.R., *KEP 62955* (A, K, KEP, SING); Senaling Inas F.R., *KEP 62882* (KEP); Pedas, G. Angsi F.R., 457 m., *FRI 14620* (KEP, SAR, SING). MALACCA: Pulau Besar, *Stone 9034* (BISH, G, KLU, MO); Pulo Pesar, *Griffith, Kew dist. 877* (BO, E, G, K, P); Bukit Bruang, 0 m., *Derry 393* (BM, K, SING); Bukit Sandanan, 0 m., *Derry 514* (K, SING). KELANTAN: Sungei Anak Ketil, S. of G. Rabong, 305 m., *FRI 20705* (KEP, SAN); Kemansul F.R., *KEP 99583* (e) (KEP); Ulu Sat F.R., Machang, *KEP 100143* (A, K, KEP, SING); Pasir Mas, Gual Periok, *KEP 66804* (KEP); Ulu Temiang F.R., Gua Musang, *KEP 104284* (A, K, KEP, SAN, SING); G. Rabong, 610 m., *FRI 20617* (KEP); Kuala Krai, Sungei Durian F.R., *KEP 104728* (K, KEP, SING); Kemahang F.R., 18 m., *KEP 93588* (KEP). TRENGGANU: along Sungei Pelong, *FRI 14841* (K, KEP, SAR, SING); Jerangau F.R., 180 m., *KEP 78562* (KEP); Dungun, Ulu Chukai F.R., *KEP 100059* (KEP); 40th mile Jerteh Road, Sungei Tong, *FRI 2521* (K, KEP, SAR, SING); path to G. Tebu, Jabi, 610 m., *Shah et al. 3306* (SING). PAHANG: Menchali F.R., *KEP 94898* (A, KEP, SAN, SAR, SING); Aur F.R., *FRI 3646* (A, KEP, SING); Ulu Sungei Kelui, 610 m., *FRI 10956* (e) (A, K, KEP, SING); Ulu Sungei Anak Endau, 396 m., *FRI 8174* (A, K, KEP, SAR, SING); Kerdau, *KEP 29997* (KEP); Rotan Tunggul F.R., *KEP 23389* (K, KEP, SING); Lepar Hill F.R., 150 m., *FRI 9186* (e) (KEP); Baloh F.R., *KEP 66646* (KEP); Ulu Perah, *KEP 11212* (KEP); Kuantan, Sungei Sawah Chini, *KEP 2712* (?e) (K, KEP, SING); Ginting Highlands, 915 m., *Stone 7443* (BISH, KLU); Bukit Simpul, *KEP 15638* (SING); Kemasul F.R., 45 m., *KEP 78741* (KEP). JOHORE: Mawai, *SFN 34748* (A, BO, K, KEP, SING); Labis F.R., G. Besar Massif, *FRI 14014* (?e) (A, K, KEP, SAN, SING); G. Panti Timor, 478 m., *FRI 7770* (KEP, SING); Johore Coast, Tg. Penawar, 15 m., *FRI 7629* (A, K, KEP, SING); Kangka Sedili Kechil, *SFN 28599* (K, KEP, SING); Jemaluan F.R., *KEP 73463* (KEP); Lenggong F.R., *KEP 72652* (KEP); G. Arong F.R., 30 m., *KEP 71312* (KEP). **Singapore:** Bukit Timah F.R., *SFN 38848* (A, BO, LAE, SING); Botanic Gardens jungle, *SFN 36255* (A, BO, K, KEP, LAE, P, SING); Changi, *Goodenough 1958* (SING); Jurong, *Corner s.n.*, 14 Jan. 1932 (SING); SW. side of Seletar Reservoir, upper Mandai, *SFN 40014* (SING); N. side of MacRitchie Reservoir, *Sinclair 5372* (SING). **Sumatra and adjacent islands.** RIAU: Lingga Arch., Pulau Singkep, *bb 2714* (BO); Koeantan, Tjerenti, 50 m., *bb 25239* (?) (BO, L). DIAMBI: Moera Tembesie, Soengei Roean, 15 m., *bb 9250* (e)

(BO). SELATAN: Koeboestrecken, 10-20 m., *Endert 256* (BO, L). BARAT: Loeobek Sikaping, Tandjong Boengo, 370 m., *bb 6512* (e) (BO); Sidjoengdjoeng, Moeara, 596 m., *bb 6057* (BO). UTARA: Laboehan Batoe, Kota Pinang, Langga Pajoeng, *si Toroes 3354* (A, NY, US). BANGKA: G. Permisian, Soengei Selan, 450 m., *Binnemeyer 2046* (BO, L); G. Maras, Soengei Liat, 500 m., *bb 1954* (BO, L); Gadoeng, 20 m., *bb 10579* (?) (BO). BELITUNG: Tandjong Pandan, Bantan, 20 m., *bb 7376* (BO). BORNEO. SARAWAK. 1st Division: Semengoh Arboretum, 15 m., *S 5361* (BO, K, KEP, L, P, SAN, SAR, SING); Lundu, G. Pueh, 160 m., *S 13724* (A, BO, K, L, SAN, SAR, SING); G. Gading, 760 m., *S 13325* (?) (A, BO, SAN, SAR, SING); G. Santubong E., 762 m., *S 13695* (K, L, SAN, SAR, SING). 4th Division: Bukit Mentagei, Bok-Tisam Marudi, 610 m., *S 23286* (A, K, KEP, SAN, SAR, SING); Bukit Mersing, Anap, 400 m., *S 21926* (A, BO, K, SAN, SAR, SING). BRUNEI: Berakas F.R., 60 m., *S 7820* (A, BO, K, KEP, NY, SAR, SING); Andalau F.R., 15 m., *SAN 17529* (A, BO, K, KEP, SING); Kuala Belait, *S 1945* (SAR). SABAH. Kudat: Lokapas, Bengkoka, 72 m., *SAN 1827* (A, BO, K, US). Keningau: Sook plain, mile 1½ Tulid road, *SAN 55615* (SAN). Labuk & Sugut: base of Bukit Mesasau, 180 m., *SAN 25429* (BO, K, KEP, L, SAN, SAR); Telupid, mile 87, 120 m., *SAN 71474* (SAN). Sandakan: Leila F.R., *A 2712* (A, K, KEP, KLU, SING, US); Sepilok F.R., 120 m., *A 3880* (A, K, KEP, SAN, SING); Sungei Kapur, *SAN 22940* (SAN, SAR); Batu Sapi, Mt. Walker, *SAN 61592* (SAN). KALIMANTAN. Timur: Central Kutei, Belajan R., *Kostermans 10254* (A, BO, K, LAE, P, SING); E. Kutei, *Kostermans 7248* (A, B, BO, CANB, G, K, LAE, P, SING). Selatan: Bukit Besae, 305 m., *Motley 304* (K). Tengah: Beneden Dajak, 40 m., *bb 8159* (BO). Java and adjacent islands. BAWEAN IS.: Mt. Besar, 400 m., *Buwalda 3224* (BO, L). KARIMOENDJAWA: Japara, 150 m., *Ja 1705* (BO).

ECOLOGY. Usually in well-drained mixed dipterocarp forest; often common on sandy, acid soil (eastern Sabah); sometimes on highly leached, giant podzols (elsewhere in Borneo); in swamp forest (Malaya) (Corner, *loc. cit.*, as *C. floribundum*; *FRI 2521*, *Sinclair 7763*); on ultramafic rock (Borneo); in evergreen forests (Thailand); to 975 m. alt. On mainland SE. Asia flowering mostly December to February, rarely in March, April, July, August, and November; data from the rest of Malesia scanty, but flowering perhaps more scattered. Flower scented, sometimes fetid ("very foetid, [smelling] of garlic when decaying"—*SFN 33143*). Fruiting February to May, rarely at other times; fruit yellowish or bluish green, eaten by iban patong (*SFN 28599*, Johore).

One atypical specimen has bilabiate galls (*FRI 14014*, Johore).

GERMINATION AND YOUNG PLANT. The radicle breaks through the stone to one side of the base. The seedling has two pairs of leaves separated by well-developed internodes over 1 cm. long. Subsequently produced internodes are longer, the terminal bud is functional, and growth is erect. (*Stevens et al. 121*; *Stone 9034*.)

100b. *Calophyllum tetrapterum* Miq. var. *obovale* (Miq.) P. F. Stevens, comb. et stat. nov.

C. obovale Miq. Fl. Indiae Batavae, Suppl. 1(3): 498. 1861; F. Mueller in Walp. Ann. Syst. Bot. 7: 357. 1868; Vesque in C. DC. Monogr. Phanerog.

- 8: 606. 1893. TYPE: Sumatra, ad littoram Siboga, *Teysmann, HB 644* (holotype, U; isotypes, BO, K, L, MEL, P).
- C. griffithii* T. Anderson in Hooker f. Fl. Brit. India 1: 273. 1874; King, Jour. Asiatic Soc. Bengal, II. 59: 179. 1890; Vesque in C. DC. Monogr. Phanerog. 8: 602. 1893; Ridley, Fl. Malay Penin. 1: 187. 1922, *pro parte*; M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 312. 1956; T. C. Whitmore, Tree Fl. Malaya 2: 168. 1973. TYPE: Malaya, Malacca, *Griffith, Kew dist. 882* (holotype, K; isotypes (sometimes *s.n.*), BO, E, GH, L, M, P).
- C. globuliferum* Ridley, Kew Bull. 1938: 121. 1938, *paratype excepto*; Masamune, Enum. Phanerog. Born. 475. 1942. TYPE: Dutch SE. Borneo [Kalimantan], Bangarmassing, *Motley 618* (holotype, K).
- C. elegans* auct., non Ridley; Keith, N. Borneo Forest Rec. ed. 2. 2: 313. 1952.

Tree 3–20(–27) meters tall, d.b.h. to 20 cm.; outer bark smooth or rather distantly fissured; latex clear yellow, fluid, becoming opaque when rubbed.

Twigs flattened, usually not strongly angled; axillary innovations sometimes with basal scars. Lamina obovate (rarely elliptic to oblong), (2.2–)3.7–9.5(–14) by (1–)2–5(–6.5) cm., rounded to shortly and bluntly acuminate at apex, usually notably pale at margin, marginal thickening (0.2–)0.4–1 mm. wide, rarely with clear submarginal vein ca. 0.7 mm. from margin, thinly coriaceous to coriaceous, the venation ± clear on both surfaces, (4 or) 5 to 8 (to 10) veins/5 mm. Inflorescences sometimes terminal; bracts sometimes foliaceous, up to 2 cm. long, subsistent.

DISTRIBUTION. The Malay Peninsula, Sumatra, and Borneo; scattered (MAP 34).

SELECTED SPECIMENS SEEN. **Malaya.** PERAK: G. Besut, *Soepadmo s.n.*, 28 Nov. 1973 (BISH, KLU). **Sumatra and adjacent islands.** RIAU: Rieuw Arch., P. Bintan, S. Poelei, 30 m., *Bünnemeyer 6335* (BO, L). UTARA: Laboehan Batoe, Kota Pinang, Kaloebi, Goenoeng Si Papan, *si Toroes 3471* (A, US), Langa Pajoeng, *si Toroes 3409* (intermediate) (A, K, L, NY, US), *si Mandi Angin, si Toroes 3983* (intermediate) (A, US). **Borneo.** SARAWAK. 1st Division: Bukit Jebong, Bau, S 25605 (A, K, KEP, L, SAN, SAR, SING); G. Pueh, Sematan, 628 m., S 34475 (A, SAN, SAR). BRUNEI: Anduki F.R., *KEP 37144* (K, KEP); Bukit Puau, 12 m., *Ashton s.n.*, July 1959 (SAR); Temburong, Bukit Patoi, 281 m., *SAN 17132* (A, BO, K, KEP, L, SAN, SING); Berakas F.R., 30 m., S 4926 (intermediate) (SAR). SABAH. Sipitang: Mile 5, Menggalong F.R., *SAN 21806* (A, K, SAN). Beaufort: Weston, Siangan F.R., 69 m., *SAN 78166* (SAN). Papar: Kimanis, 24 m., *SAN 41411* (K, L, SAN). Keningau: Sook, mile 2 1/2 Tulid road, 917 m., *SAN 49521* (SAN). KALIMANTAN. Timur: W. Kutei, Mt. Palimasin near Tabang on Belajan R., 700 m., *Kostermans 12899* (BO, K, L); Boelongen, Sungei Binai, *Rutten 20* (BO, U). Selatan: G. Pamatton, *Korthals s.n.* (L). Barat: between Mt. Klam and S. Djemela, *Hallier 2526* (A, BO, K, L, SING).

ECOLOGY. Primary or sometimes secondary mixed dipterocarp forest, in Sarawak sometimes on limestone; 12–917 m. alt. Flowering March, April, and June (flower scented); fruiting April, June, and October (fruit reddish yellow, pedicel red (*Kostermans 12899*)).

GERMINATION AND YOUNG PLANT. The seedling has two or three pairs of scale leaves and two pairs of expanded leaves, all separated by well-developed internodes. The young plant is erect, the terminal bud is functional, and the internodes are well developed. (Two plants only: *Stevens et al. 219A.*)

The epithet *obovale* refers to the leaf shape of the type specimen.

100c. *Calophyllum tetrapterum* Miq. var. *blumutense* (M. R. Henderson & Wyatt-Smith) P. F. Stevens, comb. et stat. nov.

C. blumutense M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 343, pl. 22. 1956; T. C. Whitmore, Tree Fl. Malaya 2: 171. 1973. TYPE: Malaya, Johore, Gunong Blumut, 3300 feet [1006 m.], 23 March 1923, *KEP 5880* coll. *Yeob* (holotype, SING; isotypes, K, SING).

Shrub 1.5 meters to tree 12 meters tall; bark unknown.

Twigs flattened, not strongly angled; axillary innovations lacking basal scars. Lamina elliptic (rarely suboblong), 5.5–11.3 by 2–4.3 cm., acute to subacuminate at apex, pale at margin, marginal thickening 0.2–0.35 mm. wide, coriaceous, the venation clear above, obscure below, the latex canals impressed (*G. Blumut*), 5 to 7 veins/5 mm. Inflorescences very rarely terminal; bracts not seen, (?)small, fugaceous.

DISTRIBUTION. Malay Peninsula, Johore (MAP 34).

SELECTED SPECIMENS SEEN. **Malaya.** JOHORE: *G. Blumut*, 762 m., *KEP 98052* (K, KEP); *G. Panti*, 488 m., *SFN 18098* (BO, K, SING).

ECOLOGY. Shrub or small tree of colline or lower montane rain forest, 488–1006 m. alt. Flowering February and March; fruiting in May.

The name of the mountain on which the type specimen was collected suggested the epithet *blumutense*.

Calophyllum tetrapterum is usually an easily recognizable species. It is characterized by its short terminal bud, its often strongly four-angled and soon glabrescent twigs, and its rather small, more or less chartaceous lamina with clear venation, a sharply raised midrib narrowing gradually from the base, and a pale-drying margin. The base of the dried lamina is minutely truncate where it joins the deeply concave petiole. The inflorescences and pedicels are usually slender, although the latter may become thickened in fruit; the more or less spherical fruits often dry grayish or pale brownish and sharply wrinkled. The epithet *tetrapterum* ("four winged") is appropriate, since many specimens have strongly four-angled twigs.

Intraspecific Variation

Henderson and Wyatt-Smith adopted a wide view of this species (see *loc. cit.*, *Calophyllum floribundum*). I have taken a yet wider view but with the recognition of three varieties. However, much work must be done to sort out the variation within the species as here delimited, as well as to clarify the relationships between *C. tetrapterum*, *C. rupicola*, and *C. pisiferum*.

The type specimen of *Calophyllum tetrapterum*, Junghuhn s.n., differs from many others assigned to var. *tetrapterum*. The indumentum on the inflorescence axis and tepals in particular is relatively well developed (in some other specimens the outer tepals are more or less papillate on the back); the inflorescence axis is only 3-6 mm. long; and the rather large leaves lack a pale-drying margin. In foliar characters other specimens from Sumatra (such as *Forbes 3220a*), as well as some from Malaya, agree with the type.

Although there are a few specimens intermediate between *Calophyllum tetrapterum* vars. *obovale* and *tetrapterum* (cited under the former), the two are usually readily distinguishable by the characters given in the key above. There may also be differences in the field characters, although this needs to be confirmed. A tree of *C. tetrapterum* var. *obovale* on Bukit Jebong, near Kuching, Sarawak, had fluid latex that became opaque when rubbed, and venation that was visible on the upper surface of the lamina but invisible on the lower, the reverse of the usual case. There are also possible differences in the seedlings (see above).

S 34475 is a very robust specimen of *Calophyllum tetrapterum* var. *obovale* with twigs up to 3.5 mm. across and notably short terminal internodes. *Kostermans 12899*, from Kalimantan, is a very small-leaved specimen referred to var. *obovale* with some hesitation: it has a terminal bud 1.5-2 mm. long, coriaceous, obovate leaf blades 2.2-5.7 by 1-2.4 cm., and fruits only 7 by 6 mm. borne on red pedicels. *KEP 48612* is an unlocalized specimen probably from Malaya that may belong here; *C. tetrapterum* var. *obovale* is less distinct in Malaya than elsewhere in its range.

The taxon *Calophyllum tetrapterum* var. *blumutense* is a very local variant, and specimens from the two mountains from which it is known differ somewhat. The latex canals on the lower lamina surface of the Gunong Panti specimen are not impressed, while those of the Gunong Blumut specimens are. When Henderson and Wyatt-Smith described *C. blumutense*, they noted that it was similar to *C. floribundum* (= *C. tetrapterum* var. *tetrapterum*) but thought that it could be distinguished by the more distant venation of the lamina. However, specimens from the Malay Peninsula (e.g., *KEP 100143, 104284*) otherwise clearly assignable to *C. tetrapterum* var. *tetrapterum* have comparably distant venation. Henderson and Wyatt-Smith also described the fruits of *C. blumutense* as smooth, while those of *C. floribundum* were described as wrinkled. However, the fruits of the former are ripe, and there is a tendency in *C. tetrapterum* for ripe fruits to be smooth, with large air spaces disorganizing the outer layer and occupying most of the space between the stone and the skin (see also under *C. foetidum*, below).

There are a number of specimens of *Calophyllum tetrapterum* var. *tetrapterum* from the Malay Peninsula and Sumatra (cited as "e" in the list above) that are somewhat different from the others. They have a shorter, more congested inflorescence usually less than 2 cm. long, and the flowers are small. The lamina often dries darker brown on the upper surface; the margin does not dry notably paler; the venation is rather dense, with (8 to) 11 to 13 (to 15) veins/5 mm.; and the midrib on the upper surface of the leaf, although narrowing gradually from the base, is relatively little raised. The

fruit is spherical and is smooth when mature; the young fruit is at least sometimes prominently apiculate. The type specimen of *C. rupicola* var. *elatum* is a specimen of this type. In some characters (leaf color, venation density, flower, and inflorescence) these atypical specimens of *C. tetrapterum* var. *tetrapterum* approach *C. calaba* var. *bracteatum*. Yet other collections, notably some from Kelantan (e.g., *KEP 104284*, *FRI 20705*), have fruits like those mentioned above. More studies are needed to clarify the significance of this variation, and it would be premature to give these specimens formal recognition.

Synonyms and Nomenclature

As mentioned above, the type specimen of *Calophyllum tetrapterum* differs somewhat from many of the specimens assigned to var. *tetrapterum*. Miquel (1854, *loc. cit.*) described the pedicels as sometimes being four together, although they are in pairs, separated by an internode. Miquel's description may have led Planchon and Triana (*loc. cit.*) to compare *C. tetrapterum* with *C. spectabile* (= *C. soulattri*), a very different species that often has four flowers at a node.

The type specimens of most of the names reduced to synonymy under *Calophyllum tetrapterum* var. *tetrapterum* are nearly all close matches with the common form of the variety. The specimens cited under *C. floribundum* in the original description, *Maingay*, *Kew dist.* 170, 172, and ?171, belong to three species. *Maingay*, *Kew dist.* 170 agrees with the original description and has a lamina with a notably pale margin (probably the thickened margin mentioned in the description); it is a reasonable lectotype for *C. floribundum*. *Maingay*, *Kew dist.* 171 belongs to *C. pulcherrimum*, and *Kew dist.* 172 is a specimen of *C. dioscurii*. The adjacent number *Kew dist.* 169 is a mixture of *C. tetrapterum* and *C. pulcherrimum*. For notes on the confusion between these last two species, which are very distinct, see the discussion after *C. pulcherrimum*.

The type specimen of *Calophyllum venustum*, *King's collector 7763*, has the broader leaf marginal thickening that is common in *C. tetrapterum* var. *tetrapterum*, and the lamina tends to be rounded at the apex. In both of these characters, *C. venustum* tends toward *C. tetrapterum* var. *obovale*.

The sheet of *Ridley 11958* at Singapore is designated the lectotype of *Calophyllum foetidum*; the field label notes that the flowers were small, one of the characters that Ridley used in distinguishing this species. However, *Ridley 11958* has rather short inflorescences, although Ridley thought that *C. foetidum* could also be distinguished by its long inflorescences. Ridley cited a number of his specimens collected in Singapore, as well as unspecified collections of Derry from Bukit Bruang, Malacca, in the protologue. *Derry 393* is in flower; *Derry 1103* is in fruit, (*Derry 514*, cited by Henderson & Wyatt-Smith (*loc. cit.*) as being from Bukit Bruang, is in fact from Bukit Sandanan.) Fruiting specimens referable to *C. foetidum* have a completely smooth, brittle outer layer, but it does not seem possible to recognize a taxon based on this character (see also above under *C. tetrapterum* var. *blumutense*).

The type specimen of *Calophyllum rupicola* var. *elatum* is probably to be referred to *C. tetrapterum* var. *tetrapterum*, although it is a somewhat atypical specimen (see above).

The type specimens of *Calophyllum obovale* and *C. globuliferum* are very similar, and both also have terminal inflorescences. However, *C. griffithii* is reduced to synonymy under *C. tetrapterum* var. *obovale* with some hesitation. The key character used to separate this species was the presence of a submarginal vein (although this is obscured by the submarginal thickening in most specimens of *C. tetrapterum* var. *obovale* and is thus not obvious, it is sometimes visible). Ridley (1922, *loc. cit.*) noted that *C. griffithii* was common on the riverbanks in Pinang, Malacca, Johore, and Singapore; I am not sure to what species he was referring, although it may have been *C. tetrapterum* *sensu lato*.

101. *Calophyllum rupicola* Ridley, Trans. Linn. Soc. Bot. II. 3: 278. 1893 ("C. rupicolum"), Fl. Malay Penin. 1: 182. 1922; M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 346. 1956; T. C. Whitmore, Tree Fl. Malaya 2: 168. 1973. Type: Malaya, Pahang, Tahan River, anno 1891, Ridley 2636 (holotype, SING; isotypes, BM, K).

C. rupicola Ridley var. *elatum* T. C. Whitmore, Gard. Bull. Singapore 26: 270. 1973, *pro parte, typo haud incluso*, Tree Fl. Malaya 2: 168. 1973, *pro parte*.

Shrub or tree 0.6–6 meters tall; bark unknown; latex yellow to cream.

Twigs slightly flattened, 0.5–2(–3.5) mm. across, strongly 4-angled, drying brown, ± puberulent when young; axillary innovations usually lacking basal scars; internodes 0.5–3.5 cm. long; uppermost pair of axillary buds rounded, to 1 mm. long, spreading, not very conspicuous; terminal bud plump, 1.2–4.5 mm. long, with short, grayish to brownish, adpressed indumentum (hairs, FIGURE 31, o, p), underdeveloped internode to 2.5 mm. long. Petiole 2–4(–8) mm. long, concave above, convex below, glabrescent; lamina elliptic to elliptico-oblong (rarely oblong), (1.9–)3–9(–16) by (0.35–)0.75–3(–4.7) cm., acute to acuminate at apex, narrowly cuneate at base, rather broadly and distantly undulate but slightly recurved at margin, coriaceous to thinly coriaceous, drying dark brick color to umber above and umber to fulvous below, ± persistently puberulent on midrib above and below (on entire lower surface), the midrib above narrowing gradually from base, raised, 0.15–0.25 (–0.3) mm. wide at midpoint, below raised, striate, the venation apparent to subobscure above, usually subobscure below, raised, latex canals often impressed, (6 to) 12 to 15 veins/5 mm., angle of divergence 50–60(–80)°. Inflorescences from foliate axils, with (1 to) 3 to 9 flowers, unbranched, the axis 0.25–1(–2.2) cm. long, strongly angled, puberulent, lowest internode 2–5(–7) mm. long, upper internodes if present often very short; bracts ovate, ca. 1.8 mm. long, densely puberulent below; pedicels 1.5–7 mm. long, puberulent to glabrous, strongly angled even in fruit. Flower (?) hermaphroditic; tepals 4 or 6, the outer pair ovate, 2.7–3 by ca. 2.2 mm., with strip of puberulence down back, the inner ones elliptico-oblong, 4–5 by 1.5–2.6 mm.;

stamens ca. 50, the filaments to 3 mm. long, the anthers subelliptic to oblong, 0.4–1 mm. long, \pm rounded at apex; ovary 1.2–1.6 mm. long, style 2–2.7 mm. long, stigma unknown. Fruit ellipsoid to subspherical, 0.8–1.2 cm. by 0.6–0.95 mm., usually strongly apiculate, drying brown, wrinkled when immature, later smooth; outer layer not detaching cleanly from stone, very thin, obscured by large air spaces developed; stone spherical to ellipsoid, 7–10.5 by 6–8.5 mm., rounded at apex, the walls ca. 0.15 mm. thick, smooth, unmarked; (?)spongy layer.

DISTRIBUTION. Northeastern Malaya and Peninsular Thailand; a form in eastern Malaya and scattered in Sumatra (MAP 33).

SELECTED SPECIMENS SEEN (all specimens of the variant seen cited). **Thailand:** Peninsula, Narathiwat, Waeng, *Sangkhachand et al. 1067* (BKF, L). **Malaya.** KELANTAN: Kuala Rek, *SFN 10175* (A, SING); Chan[n]ing Woods, *Ridley s.n.*, 30 Jan. 1917 (var.) (K); Bukit Baka, Machang, 457 m., *Shah & Shukor 3163* (SING); Ulu Sat F.R., 210 m., *FRI 2951* (K, KEP, SING); G. Stong, 762 m., *FRI 12416* (K, KEP); Mak Meh Nak, *KEP 37975* (SING). TRENGGANU: Mandi Angin, S. Loh near Kuala Datok, 30 m., *FRI 8952* (K, KEP, L); Ulu Telamong, Bukit Rambai F.R., *FRI 11401* (var.) (KEP, L, SAN, SING); Bukit Bauk F.R., *KEP 76091* (?) (A, SING); Sungei Trengganu, near Jeram Galong, *FRI 8350* (A, K, KEP, L, SAR, SING); compartment 90, Gunong Tebu F.R., 150 m., *FRI 2513* (KEP, L, SAR, SING); Ulu Brang, near Kuala Lallang, 90 m., *FRI 12526* (A, K, KEP, L, SING); PAJANG: between Sungei Puteh and Teku Taman Negara, *Soepadmo 865* (A, BO, K, KEP); near Kuala Tahan, Jeram Panjang, *Shah & Noor 2039* (A, C, CANB, KEP, L, SING); Poko Kamancheng, *Ridley s.n.*, NOV. 1920 (K); Taman Negara, Sungei Tahan, *Shah & Shukor 2670* (C, KEP, SING); G. Tahan, *Wong & Wyatt-Smith 22* (KEP); Sungei Tembeling, 90 m., *Stone 10889* (KLU); between Kuala Tahan and Kuala Trengganu, 100–200 m., *Chin 1318* (K, KLU, L); Tahan woods, Kuala Teku, 120 m., *FRI 4762* (K, KEP, L, SING); Rompin, *KEP 15461* (var.) (KEP); Lesong F.R., *Ahmad & Shukor 448* (var.) (C, KEP, SING); Bukit Cheras, ca. 180 m., *Henderson s.n.*, 22 Oct. 1931 (var.) (SING); Bukit Goh F.R., *KEP 3132* (var.) (SING). JOHORE: G. Blumut, Upper Camp, 549 m., *FRI 8824* (var.) (A, KEP, L, SAR, SING); Sungei Kayu Ara, Mawai-Jemaluang Road, *Corner s.n.*, 9 Feb. 1935 (var.) (SING); Panti F.R., 6 m., *Stevens et al. 104* (var.) (A), *104A* (var.) (A). **Sumatra.** SELATAN: Toelang Bawang nabij Talung Batoe, 30 m., *Idenburg 44* (var.) (BO); Moeko2, Lalang Loeas, 50 m., *bb 23555* (var.) (BO, L, MO). UTARA: Padang Sidempuan, near village Grunggan, 150 m., *Kostermans 22040* (var.) (A, L).

ECOLOGY. Usually rheophyte growing on banks of rivers and streams, hence liable to be inundated. Normally shrub less than 2.5 m. tall, but *FRI 8350* apparently taken from tree 8 m. tall with trunk initially creeping along ground. Sometimes in forest away from streams—then small tree (e.g., *FRI 2516*). Variant typically tree (see below). 30–762 m. alt., the variant 6–550 m. alt. Flowering January, April, May, July, August, and November; fruiting January, February, April, and June to October (ripe fruit yellowish or orange).

The typical form of *Calophyllum rupicola* can be characterized by its often rather small, (narrowly) elliptic, subcoriaceous lamina that dries grayish brown above and golden brown below, with the latex canals on both surfaces often

impressed. The buds along the twigs are often markedly supra-axillary. Its inflorescence is short and congested, with the upper internodes often shorter than the lowest one; both the inflorescence axis and the short pedicels are strongly angled. The small fruits are apiculate, sometimes markedly so, and are reported to be yellow to orange when ripe. The epithet *rupicola*, "rock-dweller," emphasizes the fact that this species is usually found growing among rocks by rivers and streams.

When *Calophyllum rupicola* grows away from streams, it looks rather different from the typical rheophytic form of the species; it is larger in all its parts and has a broader leaf blade. However, the two extremes are connected by intermediates. Scars at the bases of the innovations are found in the smaller, profusely branched rheophytic forms. Some of the specimens cited as *C. rupicola* var. *elatum* by Whitmore (*loc. cit.*; *FRI* 2513, 2516) belong to the forest form (see also the discussion after *C. tetrapterum*).

Sangkha Chand et al. 1067, from Peninsular Thailand, has stout twigs and large leaves (the upper limits of the measurements given) and was taken from a tree 10 meters tall. In such characters as inflorescence and color and venation of the dried leaf, it agrees with the typical form of *Calophyllum rupicola*. *KEP* 76091 was included in *C. rupicola* variety by Henderson and Wyatt-Smith (*loc. cit.*). It is retained in *C. rupicola* with hesitation: the specimen is superficially like *C. dasypodum* but differs in hair type and leaf. The thick outer layer of the immature fruit also invites comparison with *C. dispar*.

The specimens cited above as "var." are perhaps merely an extreme form of the forest-dwelling *Calophyllum rupicola*. They have not been included in the description above and can be characterized as follows.

Shrub 0.5 meters (*Kostermans* 22040) to tree 6(-18) meters tall; inner surface of outer bark brick orange; latex opaque, pale yellow, only tardily becoming sticky. Petiole tending to dry dark brown, contrasting with paler brown twig; lamina elliptic-oblong, (3.5-)7-16.5 by (1.1-)3.2-5 cm., sharply acuminate, acumen (0.3-)0.5-1 cm. long, thinly coriaceous, margin closely and strongly undulate, angle of divergence of venation 65-80°.

In other characters these specimens seem close to *Calophyllum rupicola*: the latex canals of the lamina tend to dry impressed, the inflorescence axis and the short pedicels are strongly angled, and—according to field notes on *Kostermans* 22040—the fruit is yellow. The variant of *C. rupicola* grows with *C. tetrapterum* in the Panti Forest Reserve, Johore (*C. rupicola*—*Stevens et al.* 105, 105A; *C. tetrapterum*—*Stevens et al.* 104), and the two are clearly different taxa. The inner surface of the outer bark of *Calophyllum rupicola* variant was brick orange in color and the latex opaque, pale yellow, and fluid; the margin of the lamina was undulate; and the very young plant was arched, with the stem initially plagiotropic. These bark characters are at most unusual in *C. tetrapterum* (the inner surface of the outer bark of *C. tetrapterum* in the Panti F.R. was brownish, and the latex was clear yellow and sticky). I have never seen *C. tetrapterum* with undulate margins to the leaf blades, nor have I seen young plants growing other than erect. Clearly, it will be of considerable interest to study germination and the young plant of *C. rupicola* *sensu stricto*.

Calophyllum rupicola is apparently related to *C. pisiferum*, which in Thailand (although apparently not in Malaya) is also sometimes a rheophyte, and to the variable *C. tetrapterum*. *Calophyllum pisiferum* has stouter twigs, better-developed indumentum, and leaf blades that are less sharply pointed at the apex and that dry browner. *Calophyllum tetrapterum* is usually quite different from *C. rupicola*, having broader leaf blades with clearer, more distant venation and a margin that dries paler than the rest of the blade; the blade itself rarely dries golden brown below, and the latex canals are usually \pm invisible. The inflorescence and pedicels are longer and are not so clearly angled. However, a few specimens referable to *C. tetrapterum* at least superficially approach *C. rupicola*. *FRI 10956* (610 m., SE. Pahang) is like *C. rupicola* in inflorescence type, flower size, and—to a certain extent—color of the dried leaf; it was taken from a tree 15 meters tall. *FRI 13630* (425 m., Kedah) is perhaps like *C. rupicola* in fruit type, although in other respects it is not similar.

Careful field observations of the *Calophyllum rupicola*-*C. pisiferum*-*C. tetrapterum* group as a whole in Malaya and Thailand are needed to assess the significance of all the variation discussed.

102. ***Calophyllum pisiferum*** Planchon & Triana, Ann. Sci. Nat. Bot. IV, 15: 294. 1862; Ridley, Fl. Malay Penin. 1: 184. 1922; M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 345. 1956; T. C. Whitmore, Tree Fl. Malaya 2: 172. 1973. TYPE: Malaya, Malacca, Nov. 1837, *Gaudichaud 86* (lectotype, σ ; isolectotype, ν). FIGURE 32, k, l.
- C. retusum* Wall. ex Choisy var. *cambodgense* Pitard in Lecomte, Fl. Gén. Indo-Chine I(4): 321. 1910; Gagnep. in Humbert, Fl. Gén. Indo-Chine Suppl. 1: 275. 1943 (incl. *C. sangkai*); Pham, Cây-Cỏ Miền Nam Việt-Nam. ed. 2, 2: 303. 1970. TYPE: Cambodge, Dom-Phaong, *Hahn 86* (holotype, ν).
- C. retusum* Wall. ex Choisy var. *cochinchinense* Pitard in Lecomte, Fl. Gén. Indo-Chine I(4): 321. 1910; Gagnep. in Humbert, Fl. Gén. Indo-Chine Suppl. 1: 275. 1943; Pham & Nguyễn, Cây-Cỏ Miền Nam Việt-Nam, 179. *bang 62bis D*. 1960; Pham, Cây-Cỏ Miền Nam Việt-Nam. ed. 2, 2: 303. *fig.* 1970. TYPE: Cochinchine [Vietnam], Ti Tinh, *Thorel 1395* (lectotype, ν ; isolectotypes, η , κ).
- C. sangkai* Craib, Kew Bull. 1925: 18. 1925, Fl. Siam. Enum. 1: 122. 1931. TYPE: Siam [Thailand], Surin, Sangka, ca. 300 m., 4 Jan. 1924, *Kerr 8283* (holotype, κ ; isotype, ν).
- C. motleyi* Ridley, Kew Bull. 1938: 122. 1938; Masamune, Enum. Phanerog. Born. 476. 1942. TYPE: Dutch SE. Borneo [Kalimantan], Bangarmassing, *Motley 865* (holotype, κ).
- C. retusum* auct., non Wall. ex Choisy; T. Anderson in Hooker f. Fl. Brit. India 1: 272. 1874, *pro parte*; Pierre, Fl. Forest. Cochinch. 1: *pl. 102*. 1885; Vesque, Epharosis 2: *t. 25*. 1889; King, Jour. Asiatic Soc. Bengal, II, 50: 176. 1890, *pro majore parte*.
- C. amoenum* auct., non Wall. ex Choisy; Vesque in C. DC. Monogr. Phanerog. 8: 576. 1893, *pro parte*.
- C. rupicola* Ridley variety; M. R. Henderson & Wyatt-Smith, Gard. Bull.

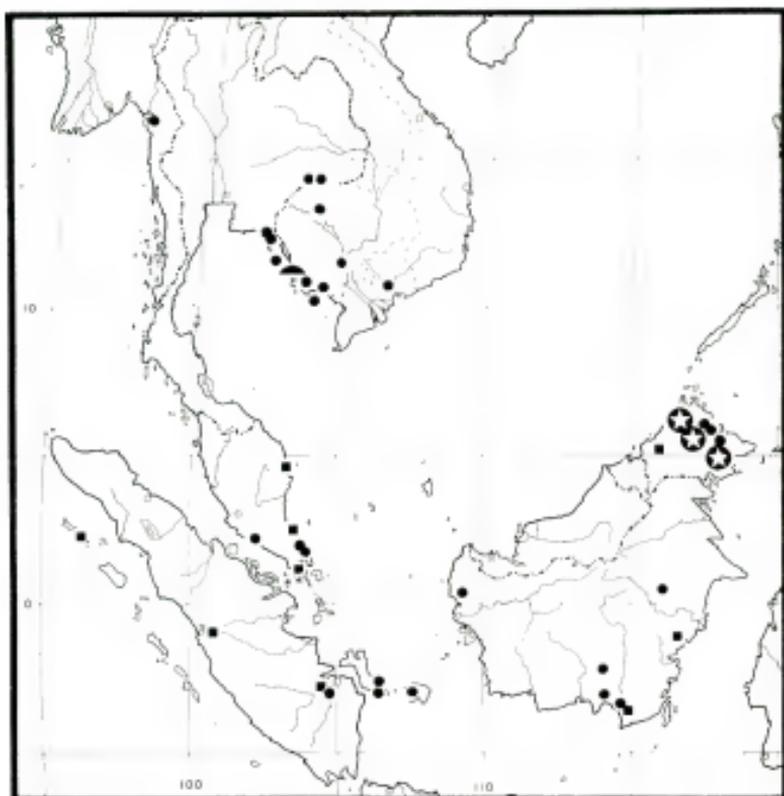
Singapore 15: 347. pl. 27. 1956, *pro parte*.

C. rupicola Ridley var. *elatum* T. C. Whitmore; Corner, Gard. Bull. Singapore Suppl. 1: 104. 1978, *pro parte*.

Shrub 0.1 meter to tree 30 meters tall, d.b.h. to 60 cm.; trunk without buttresses, knee roots sometimes present; outer bark yellowish and brownish mottled, or pale yellow, hoop marked or not, somewhat cracked longitudinally or lenticellate, the inner surface dirty greenish and dull straw mottled; under bark dark red; inner bark dark red; latex opaque yellow, sticky (pale yellow—*SAN 51649*; bright yellow—*Motley 865*); sapwood dirty white or pale ochre; heartwood red and beautifully marked, or light brown.

Twigs slightly to strongly flattened, 1.5–2.5 mm. across, sharply 4-angled, drying grayish brown to blackish, shortly and usually persistently tomentose; axillary innovations lacking basal scars or not; internodes 0.3–3 cm. long; uppermost pair of axillary buds rounded, less than 0.7 mm. long, \pm spreading, inconspicuous; terminal bud plump, 2–4.5 mm. long, with adpressed to spreading, brown indumentum (hairs, FIGURE 31, f, h–k), underdeveloped internode absent. Petiole 2.5–5 mm. long, deeply concave above, convex below, subsersistently short-tomentose, especially below; lamina ovate to oblong or (narrowly) elliptic, (1.9–)3–7.5(–9.5) by (0.9–)1.6–3.2(–4) cm., rounded to acute at apex, broadly rounded (shallowly cordate) to narrowly cuneate at base, almost flat to distantly undulate and at most slightly recurved at margin, thinly coriaceous to coriaceous, drying sepia to olivaceous above and umber to sabelline below, subsersistently puberulent on midrib above and especially below (soon glabrescent), the midrib above rather narrow at base, further narrowing gradually, sharply raised (\pm depressed at first), 0.15–0.35 mm. wide at midpoint, below raised, striate or rounded, the venation on both surfaces \pm apparent, raised, latex canals sometimes impressed, (3 to) 5 to 8 (to 11) veins/5 mm., angle of divergence 55–75°. Inflorescences from (de)foliate axils along stem, with 5 to 15 flowers, unbranched, the axis (0.2–)1–3.5 cm. long, short-tomentose at base, otherwise \pm puberulent, lowest internode to 5(–10) mm. long, next internode often shorter than those at end of inflorescence; bracts ovate to subelliptic, 2.2–3 by 0.8–1.5 mm., deciduous; pedicels 0.3–1.3(–1.8) cm. long, glabrous or almost so, slender and 4-alate. Flower (?) hermaphroditic; tepals 4, the outer pair broadly elliptic to ovate, 3.5–5 by 1.5–3 mm., sometimes with short hairs on back near apex, the inner ones elliptic to obovate, 5–6 by 2–4(–5) mm.; stamens 30 to 70, the filaments to 3.5 mm. long, the anthers elliptic, 0.4–0.6 mm. long, (sub)retuse at apex; ovary 1.2–1.3 mm. long, the style 2.5–3.5 mm. long, the stigma expanded, 0.3–0.4 mm. across. Fruit spherical to ellipsoid, 6–9 by 5.5–7 mm., sharply apiculate, drying sharply wrinkled, smooth when quite ripe, brown; outer layer not detaching cleanly from stone, ca. 0.2–0.5 mm. thick, air spaces developing; stone spherical to ellipsoid, 5.5–8 by 5–6 mm., rounded at apex, the walls less than 0.1 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Southern Vietnam to Borneo, scattered, excluding Java (MAP 35).



MAP 35. Distribution of *Calophyllum pisiferum* (circles), *C. dispar* (squares), *C. lineare* (half-circle), and *Calophyllum* sp. 98 (stars in solid circles) in Southeast Asia-Malesia.

SELECTED SPECIMENS SEEN. **Burma:** Martaban, *Griffith s.n.* (BM, C, FI, G, GH, M, P). **Vietnam:** flumen Saigon prope Beu Chuc, *Pierre 3648* (P); Phu Thoc, Sinus Siamica, *Pierre 3648* (P); Cai Cong, *Thorel 1395* (P). **Cambodia:** Koh Kong, presqu'île Smach, *Vidal 5000* (L, P); près de Thmar Banf, 400 m., *Martin 1495* (P); route de Srê Ambel, *Martin 1017* (P); Kampot, cascade Tuk Sap, *Martin 1133* (P); Pnomh Penh, *Béjaud 458* (K, P); Kg. Thom, Kg. Loai, *Béjaud 215* (P); Siem Reap, Phnom Kulen, 250 m., *Martin 1298* (P). **Thailand:** Chantaburi, Makam, Ban-ang, *Chit 161* (BKF); E. of Makam, 100 m., *Sorensen et al. 464* (C); Krat, Kao Saming, *Kerr 9435* (BM, C, K, L, P); Kao Kuap, 700 m., *Kerr 17774* (A, BM, C, L, P); SE. Ko Kut, *Charoenphol et al. 5097* (AAU); Trat, Kaw Kut, 20 m., *Smitinand 5723* (BKF). **Malaya.** MALACCA: sine loco, *Griffith s.n.* (coll. *Lemann*) (BM, BO, G, GH, K, L, MO, P). JOHORE: Mawai, "low" alt., *SFN 34706* (?) (BO, LAE, SING), *SFN 34747* (?) (A, L, SING); Kangka Sedili Ketchil, *Corner s.n.*, 17 June 1934 (?) (SING). **Sumatra and adjacent islands.**

SELATAN: Meranjat, Sebetan, *Teysmann*, HB 3451 (BO). BANGKA: Lobok Besar, 5 m., bb 34028 (L, SING); Rias, 10 m., bb 15401 (BO, L). BELITUNG: Tandjong Pandan, *Teysmann s.n.* (BO). BORNEO. SABAH. Labuk & Sugut: Sungei Mangkanyoh, N. of Klagan R., SAN 51649 (SAN); Lower Sugut, SAN 27622 (SAN). Sandakan: Ulu Dusun F.R., 2 m., *Stevens et al.* 354 (A). Kinabatangan: opposite Gabang Camp, SAN 23096 (A, KEP, SAN, SAR, SING). KALIMANTAN. TIMUR: Central Kutei, Belajan R., near Long Bleh, *Kostermans* 10292 (A, BO, G, K, LAE, SING). Selatan: km. 14 Bandjarmassin en Martapoera, Toelong Redjo, *Polak* 419 (BO); d. Kambat, *Korthals s.n.* (L); Tabanio, Tanah Laut, *Civiel Bestuur s.n.* (BO); Kaiteng, Sungei Sekunyir, Kumai, *Anderson (1975) 1* (BO). Tengah: Djoeking Koempai (Koelo Kapaeos), bb 2180 (BO); Beneden Dajak, Mangkoe-top, bb 2957 (BO). Barat: Mandor, 50 m., *Dunselman* 101 (BO); Pontianak, sine loco, bb 16373 (BO, K, L, SING, U).

ECOLOGY. On SE. Asian mainland: shrub or small tree frequently on stream banks, usually rocky places (narrower-leaved specimens typically rheophytes), also on sandy soil; 20–700 m. alt. Flowering October and January (flower scented); fruiting November to February (ripe fruit apparently orange to light chestnut, although reported by Pierre (*loc. cit.*) to be white).

In Malesia: in peat swamps, periodically inundated flat land, or riverine forest; below 50 m. alt. Flowering November, January, and March (flower scented; corolla reported to be pink (*Anderson (1975) 1*)); fruiting March and April (fruit yellow and sour, or orange).

GERMINATION AND YOUNG PLANT. The radicle probably breaks through the stone to one side of the base. The seedling is small (less than 7 cm. tall), and has two or three pairs of leaves separated by internodes ca. 1 cm. long. During subsequent growth, the internodes produced are successively longer, the plant grows erect, and the terminal bud is functional. (*Stevens* 353, from Sabah.)

LOCAL USES. A decoction of the bark is used to cure diarrhea (Cambodia); the branches are used for house and boat poles (Thailand).

Calophyllum pisiferum can be recognized when sterile by its sharply four-angled twigs that are often persistently short-tomentose. Its rather small leaf blades vary considerably in size and sometimes also in shape on one specimen and are sepia above in older specimens; their venation is relatively distant and prominent. Internode length increases toward the top of the inflorescence axis, and the axis is usually covered with indumentum for its entire length. The pedicels are slender, and the flowers always have four tepals. The fruits are small and wrinkled and have a thin outer layer; they look rather like dried, wrinkled peas (*pisiferum* means "pea-bearing").

Calophyllum pisiferum is quite a variable species and has a disjunct distribution¹⁶ (MAP 35), especially in mainland Southeast Asia. Its delimitation has been troublesome. With only one exception, the specimens from this area were collected from shrubs or small trees less than 9 meters tall (*Smitinand* 5723 is reported to have been taken from a tree up to 30 meters tall—probably

¹⁶The single specimen from Burma, *Griffith s.n.*, may be incorrectly labeled.

an error) often growing alongside rivers. The leaf blades vary from narrowly elliptic to ovate. The Malesian specimens were taken from medium-sized to fairly large (to 30 m.) trees generally growing in wet places; variation in lamina shape is less, and the blades are usually more or less ovate. In at least some specimens from West Malesia (e.g., *bb* 36028, *Kostermans* 10292), the axillary innovations have basal scars, but such scars are uncommon in specimens from the Southeast Asian mainland (although they occur on some innovations in *Charoenphol* 5106). Nevertheless, *C. pisiferum* is broadly circumscribed because in other vegetative details, hair type, flowers, and fruit, all specimens are similar.

Calophyllum lineare is very close to *C. pisiferum* and may be merely an extremely narrow-leaved form of it. There are other, perhaps minor, differences between the taxa: *C. lineare* has slender twigs that dry grayish brown, and the stone is separated from the base of the fruit by a fibrous zone 1-2 mm. long. Such a fibrous zone is much less well developed in *C. pisiferum*. The leaf blades of *C. lineare* are more or less coriaceous, but so are those of such specimens of *C. pisiferum* as *Martin* 1133 and *Kerr* 17774. Further collections of *C. pisiferum* and *C. lineare* from Cambodia and Thailand may lead to a reduction in rank of the latter, but such a reduction is at present premature. The type (and only) specimen of *C. lineare* cannot be satisfactorily accommodated in *C. pisiferum*.

Calophyllum pisiferum is also related to *C. dispar*; for the differences between the two, see *C. dispar*. *Calophyllum rupicola* and *C. tetrapterum* are also somewhat similar to *C. pisiferum*; both these species are variable, and *C. rupicola* is also a rheophyte. The indumentum of both species is less prominent than that of *C. pisiferum*. *Calophyllum rupicola* often has denser venation, the latex canals are frequently (rather than rarely) impressed, the buds along the stem are often supra-axillary, the fruit is ovoid-elliptic, and the apex of the leaf blade is acute to acuminate. When dry the leaf is characteristically greenish-grayish brown above and golden brown below, rather than the sepia color of *C. rupicola*. The flowers and the fruits of *C. tetrapterum* are larger than those of *C. pisiferum*, and the upper internodes of the inflorescence axis are usually not markedly longer than the lower ones. The leaf blade generally dries a different color, and the margin is more or less recurved. *Nitrasirirak* 206 (probably *C. tetrapterum*, from S. Thailand) has the inflorescences of *C. pisiferum*.

The specimens from Johore cited above are included with some hesitation; they were included in an unnamed variety of *Calophyllum rupicola* by Henderson and Wyatt-Smith (*loc. cit.*; for *KEP* 76091, also placed there, see *C. rupicola*). They differ somewhat from more typical *C. pisiferum* in having puberulent indumentum only near the base of the inflorescence and a coriaceous lamina with more or less impressed latex canals. However, in other characters they agree with *C. pisiferum*, and the field notes attached to *Corner s.n.* suggest that the bark characters are similar to the trees of *C. pisiferum* seen in Sabah, although the plants are somewhat smaller (less than 10 m. tall).

The specimen of *Gaudichaud* 86 at Geneva is designated as the lectotype

of *Calophyllum pisiferum*. Planchon and Triana cited another specimen, "Griffith [*Kew dist.* 876] in herb. Planchon, ex herb. Hook.," also collected in Malacca. Of the two syntypes of *C. retusum* var. *cochinchinense* (Thorel 1395 and 1407), Thorel 1395 at Paris is designated as the syntype.

The type specimens of *Calophyllum motleyi* and *C. retusum* var. *cochinchinense* are good matches with the type of *C. pisiferum*. The type specimens of *C. retusum* var. *cambodgense* and *C. sangkai* represent a rather long-leaved variant common in the Cambodia-Thailand area.

103. *Calophyllum lineare* Kostermans, *Adansonia*, II, 13: 333. *pl.* 1, 1, 2. 1973. TYPE: Cambodia, Kah Kong, Khab Kah, 12 Feb. 1970, Martin 1783 (holotype, ♀; isotypes, L, ♀).

Shrub 1.5 meters tall; bark not known.

Twigs slightly flattened, 0.7–1 mm. across, 4-angled, drying grayish brown, subpruinose, puberulent when young; axillary innovations lacking basal scars; internodes 0.3–1.5 cm. long; uppermost pair of axillary buds rounded, ca. 0.7 mm. long, suberect; terminal bud conical, 1.8–2.4 mm. long, with short, tomentose, brown indumentum (hairs, FIGURE 31, s), underdeveloped internode absent (to 1 mm. long). Petiole 2–2.5 mm. long, concave above and convex below, glabrous when mature; lamina narrowly elliptic, 1.8–6 by 0.18–0.6 cm., cuneate to rounded at apex, narrowly cuneate at base, not undulate but slightly recurved at margin, coriaceous, drying amber to sepia above and below, glabrous when mature, the midrib above narrowing gradually from base, flat to slightly raised, 0.08–0.14 mm. wide at midpoint, below raised, ± rounded, the venation above and below subapparent, slightly raised, 7 to 11 veins/5 mm., angle of divergence 45–50°. Infructescences from foliate axils, with scars of 3 to 7 flowers, unbranched, the axis 0.8–2 mm. long, sparsely tomentose toward base, lowest internode 3–7 mm. long; bracts unknown, their scars sometimes 2 mm. below pedicel they subtend; pedicels 1–1.5 cm. long, glabrous. Flower unknown; tepals probably 4 (from scars). Fruit broadly ovoid, 8–10 by ca. 7 mm., apiculate, drying russet, smooth, when submature obovoid and sharply wrinkled; outer layer not detaching cleanly from stone, ca. 0.3 mm. thick, disorganized by air spaces; stone ellipsoid, ca. 8 by 6.3 mm., rounded at apex, with fibrous zone ca. 2 mm. long at base, the walls ca. 0.1 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Cambodia (MAP 35); known only from the type locality.

ECOLOGY. Rheophyte with narrow leaves, among rocks at edge of river. Fruiting in February; fruit orange.

LOCAL USE. The fruit is used as bait for fish.

Calophyllum lineare can be recognized by its narrowly elliptic, coriaceous leaf blades, short terminal bud, and small fruits borne on slender pedicels. The specific epithet *lineare* alludes to the shape of the leaf blades.

Calophyllum lineare is closely related to *C. pisiferum*; for the differences

between the two species, see *C. pisiferum*. It also shows a superficial similarity to the more or less linear-leaved specimens of *C. nodosum* from Brunei. However, *C. nodosum* has a shorter terminal bud with much less conspicuous indumentum, axillary innovations with basal scars, and a midrib impressed on the lower surface of the lamina but raised and continuous with the leaf surface on the upper.

Kostermans (*loc. cit.*) noted that the lamina of *Calophyllum lineare* was densely and finely marked by pores on both surfaces. I have seen pores (stomata) only on the lower surface.

104. *Calophyllum dispar* P. F. Stevens, sp. nov.

FIGURE 32, m-o.

C. molle auct., non King; H. Keng, Gard. Bull. Singapore 28: 244. 1976; Corner, Gard. Bull. Singapore Suppl. 1: 104. 1978.

A *Calophyllum pisifero*, quo aliter simile est, in gemma terminali (3.5-)4.5-7 mm. longa (versus 2-4.5 mm. longa), lamina 6-15 cm. longa et 1.8-5 cm. lata (versus (1.9-)3-7.5(-9.5) cm. longa et (0.9-)1.6-3.2(-4) cm. lata), et fructu strato exteriori (0.5-)1-1.5 mm. crasso (versus 0.2-0.5 mm. crasso), differt.

Tree 15-18 meters tall, d.b.h. to 30 cm.; trunk without buttresses; outer bark yellowish to grayish, smooth or with diamond-shaped fissures; inner bark pinkish to brown; latex yellow or yellowish.

Twigs slightly flattened, 1.5-3 mm. across, 4-angled (with 4 additional raised lines), drying blackish, subsersistently brown-tomentose or gray-brown-puberulent; axillary innovations sometimes with basal or subbasal scars; internodes 0.5-3.5 cm. long; uppermost pair of axillary buds rounded, ca. 1 mm. long, suberect, inconspicuous; terminal bud plump, (3.5-)4.5-7 cm. long, with brown, tomentose to subappressed indumentum (hairs, FIGURE 31, l, r), underdeveloped internode absent. Petiole 4-6 mm. long, broadly and deeply concave above and convex below, transiently to subsersistently puberulent to tomentose; lamina elliptic to ovate, 6-15 by 1.8-5 cm., obtuse to short-acuminate at apex, cuneate to broadly rounded at base, strongly and closely undulate but at most slightly recurved at margin, coriaceous, drying bay to umber above, often with grayish covering, and brick to umber below, transiently puberulent to persistently tomentose on midrib below (scattered hairs over entire surface), the midrib above gradually to rather quickly narrowed, raised, 0.2-0.3 mm. wide at midpoint, below raised, striate (rarely angled), the venation apparent on both surfaces, raised, 5 to 9 (to 11) veins/5 mm., angle of divergence (65-)75-80°. Inflorescences from foliate axils along twigs, with 7 to 21 flowers, unbranched (rarely with 3-flowered branches ca. 3 mm. long), the axis 0.7-5.2 cm. long, puberulent to subtomentose (glabrous toward apex), lowest internode 2-4 mm. long; bracts subovate, to 6 mm. long, deciduous; pedicels 3-6 mm. long, glabrous or almost so, in fruit to 10 mm. long, usually obviously incrassate, to 2 mm. across. Flower (?)hermaphroditic; tepals 4, sometimes glabrous, narrowly ovate, 3-4 by 1.5-2 mm., outer pair sometimes tomentose, inner pair sometimes with tuft of hairs at apex; ovary ca. 1 mm. long, the style 2.2-2.5 mm. long, the stigma

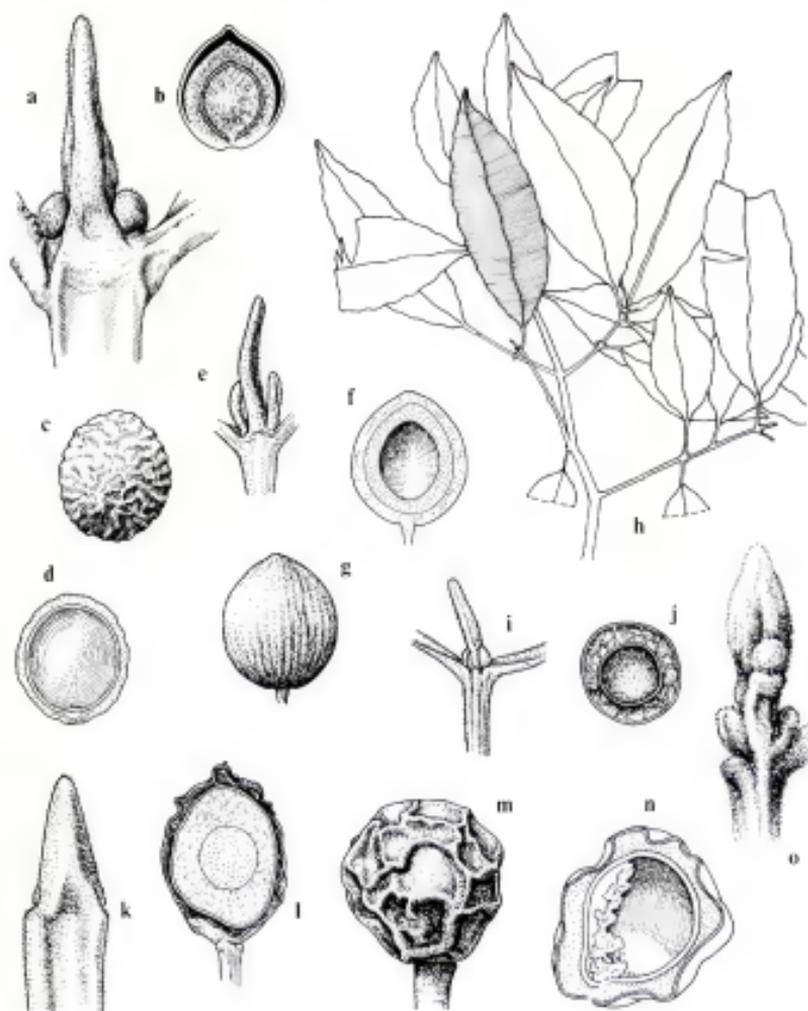


FIGURE 32. a, b, *Calophyllum incumbens*: a, *Kostermans 12813*, terminal bud, $\times 6$; b, *BRUN 327*, fruit, longitudinal section, $\times 1.5$. c, d, *C. clemensorum* (*Clemens 35038*), fruit, $\times 1.5$: c, from outside; d, longitudinal section. e-g, *C. banyengii* (*Stevens et al. 296*): e, terminal bud, $\times 3$; f, g, fruit, $\times 1$: f, longitudinal section; g, from outside. h-j, *C. dioscurii*: h, *FRI 19292*, habit, $\times 0.5$; i, *FRI 19292*, terminal bud, $\times 3$; j, *FRI 6773*, fruit, longitudinal section, $\times 1$. k, l, *C. pisiferum* (*Griffith s.n.*): k, terminal bud, $\times 6$; l, fruit, longitudinal section, $\times 3$. m-o, *C. dispar* (*SFN 37715*): m, n, fruit, $\times 3$: m, from outside; n, longitudinal section. o, terminal bud, $\times 3$.

peltate, ca. 0.6 mm. across, obscurely radiate. Fruit spherical to broadly ellipsoid, 7-10 by 7-9 mm., apiculate, drying pruinose-brown, strongly wrinkled; outer layer not detaching cleanly from stone, (0.5-)1-1.5 mm. thick, at first compact, air spaces developing under skin; stone spherical, 4.5-7.5 by 4.5-7 mm., rounded at apex, the walls 0.1-0.2 mm. thick, smooth, unmarked; spongy layer thin.

TYPE: Singapore, Mandai Road, 29 July 1940, *SFN 37715* coll. *Kiah* (holotype, A; isotypes, BM, BO, KEP, SING).

DISTRIBUTION. Malaya to Borneo, scattered, excluding Java (MAP 35).

ADDITIONAL SPECIMENS SEEN. **Malaya.** TRENGGANU: 55 m. [88 km.] S. Kuantan toward K. Trengganu, *Phytochem. Survey Malaya 505* (L, SING). PAHANG: Rompin, Bukit Serdang State Land, *KEP 29864* (KEP). Singapore. W. end of Seletar Reservoir, upper Mandai, *SFN 39698* (BO, E, K, SING), *Sinclair 7727* (L), 15 m., *Stevens et al. 716* (A). **Sumatra and adjacent islands.** SELATAN: Lematang Ilir, 75 m., *T 3 P 894* (*T[horenaar]* 894) (BO, L, LAE, P), *T 3 P 859* (*T[horenaar]* 859) (BO). BARAT: Solok, Loeboek Soelasik, 1150 m., *bb 6544* (BO). ATJEH: Is. Simaloer, Landschap Tapah (Defajan), *Achmad 1483* (BO, L), *1664* (BO, L), *1751* (BO, L). **Borneo.** SABAH: Keningau: Mile 23 $\frac{1}{2}$, Tulid Road, Sook Plain, *SAN 55545* (SAN). KALIMANTAN. TIMUR: peak of Balikpapan, G. Beratus, 700 m., *Kostermans 7592* (A, BO, K, L, LAE, P, SING). SELATAN: Bandjermasin, *Dachlan 20b* (BO). Sine loco (?Sumatra), *Buwalda 6751* (BO, K, L).

ECOLOGY. In swamp forest (*SFN 37715*); on sandy, blackish soil (*SAN 55545*); on sandstone (*Kostermans 7592*); 15-1150 m. alt. Flowering July, October, and November; fruiting February, July, August, and November.

Calophyllum dispar can be recognized by its plump, usually tomentose terminal bud; its slightly flattened, strongly angled, and often tomentose twigs; and its medium-sized lamina with a short petiole and with the venation on both surfaces clear and relatively distant. The inflorescence axis is strongly four-angled, and the flowers have four tepals. The ripe fruits are small (1 cm. or less long) with the outer layer relatively very thick ((0.5-)1-1.5 mm.). The epithet *dispar* was chosen to emphasize the disparity in size between the medium-sized leaf blades and the small fruits.

The closest relative of *Calophyllum dispar* is *C. pisiferum*, the two species being separable by the characters given in the diagnosis. Both *C. pisiferum* (at least in Malesia) and *C. dispar* (at least in Singapore) may grow in swamp forest, and apart from the characters given above, the two are very similar. More collections of both species in Malesia are needed to understand the relationship between them—it is possible that the two taxa are only varietally distinct.

Of the specimens of *Calophyllum dispar* cited above, those from Malaya (Trengganu), Singapore, and Borneo have similar tomentose indumentum on twigs, midrib of the lamina (often a few hairs persist on the lower surface of the lamina), and at least the lower part of the inflorescence axis. Specimens from Sumatra and Malaya (Pahang) have less well-developed, more or less

puberulent indumentum, and there is also a tendency for the midrib to narrow more gradually from the base of the blade. Variation in hair type is considerable (FIGURE 31, l, r); some hairs in the tomentose form have only a few cells, yet are similar in size to the more common hairs with many more cells.

SFN 37715 was included in *Calophyllum molle* by Henderson and Wyatt-Smith (1956) and subsequent authors, albeit with considerable hesitation. Although the distribution of indumentum on the vegetative parts of *C. molle* and *C. dispar* is similar, they differ in many other characters (the ovary of *C. molle* is densely pubescent, the leaf blade has much closer venation, and the fruits are very much larger). *Calophyllum molle* and *C. dispar* are not at all closely related taxa.

105. *Calophyllum incumbens* P. F. Stevens, sp. nov.

FIGURE 32, a, b.

A speciebus aliis Calophylli in lamina (per)coriacea elliptica-obovata margine plerumque valde undulata in siccitate saepe supra olivacea infra mellea-cinamomea, inflorescentiis axillaribus indumento subpuberulo praeditis, floribus cum 8 tepalis paribus exterioribus dorsalibus puberulis, et fructu strato exteriori plerumque 1-1.8 mm. crasso, differt.

Tree 12-30 meters tall, sometimes leaning, d.b.h. to 23 cm.; trunk ridged or with spur roots; outer bark yellowish, gray to brown, or orange, yellow, gray, and fawn mottled, (slightly) fissured; inner bark orange- to red-brown; latex yellow, clear, sticky.

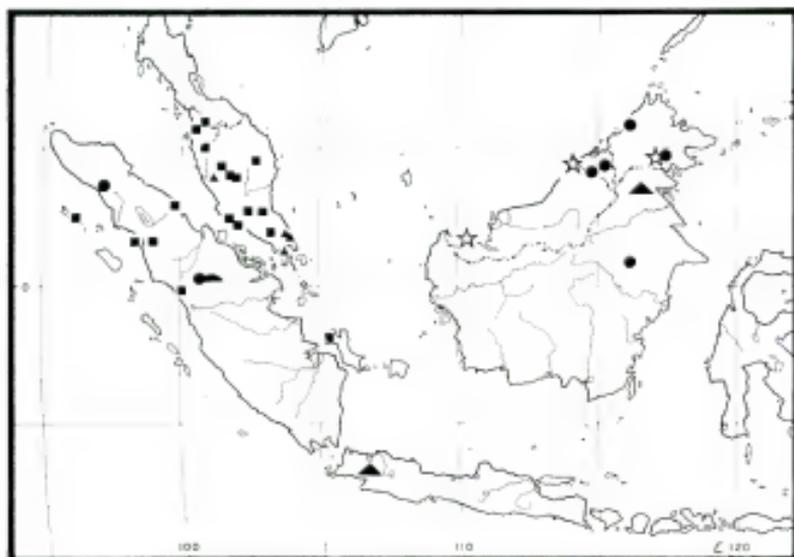
Twigs slightly flattened, 1.5-3.2 mm. across, 4-angled, drying dark brown, transiently farinose-puberulent; axillary innovations lacking basal scars or with single pair near base; internodes (0.5-)1.5-5 cm. long; uppermost pair of axillary buds rounded, 1-1.8 mm. long, spreading; terminal bud plump, 3.6-6.5 mm. long, with brown, puberulent to subfurfuraceous indumentum (hairs, FIGURE 34, a, b; cf. 22, k, l), underdeveloped internode (absent to) 2-3.5 mm. long. Petiole 0.5-1.5 cm. long, broadly and deeply concave above and convex below, puberulent when young; lamina elliptic to obovate, (4.4-)5.5-16.5 by (1.6-)2.8-6 cm., shortly acuminate to acute at apex, cuneate to attenuate at base, strongly undulate and slightly recurved at margin, coriaceous to very coriaceous, drying olivaceous to sepia above and cinnamon to near honey below, farinose-puberulent on midrib below when young, the midrib above gradually narrowed from base, raised to almost flat, 0.15-0.4 mm. wide at midpoint, below raised, slightly striate, the venation apparent above and obscure to subapparent below, raised, latex canals above sometimes slightly impressed, 7 to 17 veins/5 mm., angle of divergence 65-80°. Inflorescences from foliate axils, with 5 to 9 flowers, unbranched, the axis 0.8-4.2 cm. long, puberulent, lowest internode 2-8 mm. long; bracts not known; pedicels (0.3-)0.6-2.2 cm. long, puberulent, usually thickened in fruit, to 2 mm. thick. Flower (?)hermaphroditic; tepals (4 to) 8, the outer pair elliptic to ovate, 4-5 by 3-4 mm., farinose-puberulent on back, especially at base, the next pair broadly ovate to elliptic, 6-7 by 3.5-5.5 mm., the inner ones elliptic to lingulate, (4-)5.5-8 by (0.7-)1.5-3.5 mm.; stamens 115 to (?)250, the filaments to 4.5 mm. long, connate for up to 1.3 mm., the anthers suboblong,

0.6–1.1 mm. long, retuse at apex; ovary 1.5–2 mm. long, the style ca. 3.5 mm. long, the stigma peltate, ca. 0.8 mm. across, (?)2-radiate. Fruit ellipsoid to ovoid, 1.7–2 by 1.4–1.6 cm., apiculate, drying grayish brown, smooth, vinaceous-brown and smooth when young, strongly wrinkled when submature; outer layer detaching \pm cleanly from stone, (?0.5–)1–1.8 mm. thick, compact except for air spaces developing under skin; stone ellipsoid to subspherical, 0.9–1.35 by 0.7–1.3 cm., rounded at apex, the walls 0.15–0.6 mm. thick, smooth, unmarked; spongy layer (?)thin.

TYPE: Borneo [Kalimantan], West Kutei, Mt. Palimasan near Tabang on Belajan River, 70 m., 9 Nov. 1956, *Kostermans 12813* (holotype, l; isotypes, BO, CANB, K, KEP, L, NY, P, SING).

DISTRIBUTION. Sumatra and Borneo (MAP 36).

ADDITIONAL SPECIMENS SEEN. **Sumatra.** BARAT: Bangkinang, Pedadit, 250 m., *bb 23017* (BO, L). ATJEH: G. Leuser Nature Reserve, G. Bandahara, ca. 25 km. NNW. of Kutatjane, 1100 m., *Wilde & Wilde-Duyfjes 12974* (KEP, L). **Borneo.** BRUNEI: Bukit Suang, ulu Batu Apoi, 610 m., *BRUN 327* (BO, BRI, KEP, L, SAR, SING); R. Ingei-ulu R. Belait watershed, 57 m., *BRUN 158* (BO, BRI, KEP, L, SAR, SING). SABAH: Penampang: Sun Suran Trail, 320 m., *SAN 37777* (SAN). KENINGAU: Mile 5 Rashna Road, Nabawan, *SAN 83875* (A). TAWAU:



MAP 36. Distribution of *Calophyllum dioscurii* (squares, localized specimens; large triangles, incompletely localized specimens), *C. costulatum* (small triangles), *C. aff. costulatum* (half-circle), *C. banyengii* (stars), and *C. incumbens* (circles) in Malesia.

Brassey Range, 770 m., *Stevens et al.* 480 (A). KALIMANTAN, TIMUR: W. Kutei, Mt. Palimasan near Tabang on Belajan R., 600 m., *Kostermans 13037* (BO, CANB, K, KEP, L, NY, P, SING).

ECOLOGY. Usually in colline forest, (57–)320–1100 m. alt. In Kalimantan, locally abundant in *Agathis* forest on sandy, acid, waterlogged soil; in Penampang, Sabah, in primary (sic) forest on steep hillside with much lapotang (*Gleichenia linearis* C. B. Clarke); in Tawau, small tree on ridge with several other species of *Calophyllum*. Flowering June and December; submature fruit August and September (fruit white (*Kostermans 13037*) or greenish (*SAN 83875*)).

Calophyllum incumbens is a rather variable species that nevertheless can readily be recognized by its somewhat short, plump terminal bud and its elliptic-obovate, often very coriaceous and rigid leaf blades that are strongly undulate at the margins and that often dry bicolored (olive above and honey to cinnamon below). The inflorescence axis, pedicels, and at least the bases of the backs of the outer pair of tepals are covered by farinose-puberulent indumentum. The pedicels have become much thickened in four of the five collections that have fruits, and the outer layer of the fruit is (?0.5–)1–1.8 mm. thick. The type specimen was described as coming from a slender, leaning tree—hence the specific epithet (from *incumbo*, "to lean").

Calophyllum incumbens is superficially similar to *C. depressinervosum*: the leaves of the two species dry a similar color, but in *C. incumbens* the venation on the upper surface of the lamina is raised rather than more or less depressed, the axillary innovations lack basal scars, the inflorescence axis is puberulent rather than glabrous, and the outer layer of the fruit is much thicker. *Calophyllum incumbens* is similar to *C. rupicola* in color of the dried specimens and in indumentum distribution, but it is not a rheophyte, the leaves are larger and often thicker, the flowers have eight tepals, and the fruits are larger and have a much thicker outer layer.

The two specimens collected by *Kostermans* from Kalimantan are the most robust and have thicker leaf blades than the others. The specimens from Sabah are somewhat less robust and are intermediate between the specimens from Kalimantan and those from Brunei and Sumatra. Only two specimens with flowers are known, *Wilde & Wilde-Duyffes 12974* and *SAN 37777*; the latter specimen has more stamens and smaller anthers. *Wilde & Wilde-Duyffes 12974* has vinaceous-brown immature fruits with an outer layer perhaps only 0.5 mm. thick; ripe fruits from Sumatra are needed to confirm the occurrence of the species there.

FB 10650, a sterile specimen from the Philippines, dries a similar color to specimens of *Calophyllum incumbens*, but it has branched hairs and probably belongs to the *C. blancoi* complex, which characteristically has hairs of this type.

Immature fruits of *Calophyllum incumbens* are smooth and dry vinaceous-brown. When submature they are wrinkled, but when mature they become smooth again, with air spaces just under the brittle skin.

106. *Calophyllum dioscurii* P. F. Stevens, sp. nov.

FIGURE 32, h-j.

C. floribundum Hooker f. Fl. Brit. India 1: 272. 1874, quoad *Maingay*,
Kew dist. 172.

Calophyllum sp. 1. H. Burkill & Haniff, Gard. Bull. Straits Sett. 6: 174.
1930; *Calophyllum* sp. 45, M. R. Henderson & Wyatt-Smith, Gard. Bull.
Singapore 15: 351. pl. 31. 1956; T. C. Whitmore, Tree Fl. Malaya 2:
195. 1973.

A speciebus aliis *Calophylli* in ramulo in siccitate albescenti et petiolo nigrescenti, lamina 3-9(-10.1) cm. longa apice valde acuminata nervis laterali-bus (sub)densis elevatis, et fructu mediocri strato exteriori 1-1.8 mm. crasso, differt.

Tree 15-33 meters tall, d.b.h. to 55 cm.; trunk probably unbuttressed; outer bark grayish yellow, gray, or brown, smooth, with few lenticels, or fissured, sometimes with large, thin scales; inner bark dark brown; latex yellow or dark red (*FRI 20070*), clear.

Twigs slightly flattened, 1.2-1.6 mm. across, obscurely 4-angled, drying whitish to pale yellowish, transiently puberulent; axillary innovations lacking basal scars; internodes 0.5-3(-6.5) cm. long; uppermost pair of axillary buds \pm acute, to 1.5 mm. long, erect; terminal bud plump to conical, 2.5-5.5 mm. long, with reddish brown, puberulent indumentum (hairs, FIGURE 34, c-g; cf. 34, a), underdeveloped internode absent. Petiole 3.5-6 mm. long, slender, broadly concave above and convex below, glabrescent, drying black; lamina elliptic to ovate (rarely suboblong), 3-9(-10.1) by 1.2-3.4 cm., acuminate (caudate) at apex, cuneate (rarely acute) at base, strongly undulate but not recurved at margin, coriaceous, drying olivaceous to bay above [sometimes shiny] and olivaceous to sepia below, subsersistently puberulent to farinose on midrib below (also above), the midrib above gradually narrowed from base, raised (depressed at first), 0.15-0.25(-0.4) mm. wide at midpoint, below raised, \pm rounded, the venation apparent on both surfaces, raised, [7 to] 12 to 20 (to 28) veins/5 mm., angle of divergence (55-)70-80°. Inflorescences from foliate axils, with 5 to 7 flowers, unbranched, the axis 4-9 mm. long, puberulent, lowest internode 0.5-3 mm. long; bracts not known; pedicels 4.5-6 mm. long, subsersistently puberulent, in fruit to 2 mm. thick. Flowers known only when old, (?)hermaphroditic; tepals (?)4; stamens (?)numerous, the filaments to 3 mm. long, the anthers oblong-elliptic, ca. 0.5 mm. long, retuse at apex; ovary 1-1.3 mm. long, the style ca. 2 mm. long, the stigma subpelate, ca. 0.4 mm. across. Fruit spherical, 1.2-1.6 by 1.2-1.5 cm., rounded to apiculate at apex, drying pale pruinose-brown, deeply wrinkled when young, \pm smooth when older; outer layer not detaching cleanly from stone, 1-1.8 mm. thick, compact when young, large air spaces developing when older; stone spherical to ellipsoid, 0.9-1.1 by ca. 0.9 cm., rounded at apex, the walls 0.3-0.5 mm. thick, smooth, unmarked; spongy layer thin.

TYPE: Malaya, Kedah, Ulu Muda F.R., 1000 feet [305 m.], 23 June 1969, *FRI 11719* coll. *Bray* (holotype, A; isotypes, K, KEP, L, SAR, SING).

DISTRIBUTION. Malay Peninsula, Sumatra, perhaps also in Java and eastern Borneo (MAP 36).

ADDITIONAL SPECIMENS SEEN. **Malaya.** KEDAH: Ulu Mudah F.R., 457 m., *FRI* 6773 (A, K, KEP, L, SAR), 120 m., *FRI* 11763 (K, KEP, L); Bigia Enggang F.R., 75 m., *KEP* 73776 (KEP); Sungkap F.R., *KEP* 59624 (KEP). PERAK: Bintang Hijan F.R., *KEP* 39154 (K). NEGERI SEMBILAN: Port Dickson, Sungai Menyala F.R., *FRI* 103 (KEP), 45 m., *KEP* 64079 (KEP), 30 m., *KEP* 66585 (KEP, SING); Pasoh F.R., anon. s.n., 27 Aug. 1974 (KEP). MALACCA: sine loco, *Maingay* 1644 (*Kew dist.* 172) (K). PAHANG: Ulu Bertram at Kuala Mensum, 549 m., *FRI* 20070 (K, KEP, SAR); Lesong F.R., near Sungai Jekatih, "low hill," *FRI* 15995 (A, K, KEP); King George Vth Natl. Park, 180 m., *KEP* 71956 (KEP); Kuala Lompat, 45 m., *Chivers DCL* 45 (KEP), 406 (KEP); Gali, Raub, *SFN* 16220 (SING). JOHORE: Kluang, *SFN* 9424 (SING). **Sumatra and adjacent islands.** BARAT: Ond. afd. Oud Agam, Sipisang, 660 m., *bb* 2872 (BO, L). UTARA: Angkola en Sapirook Panobasan, Dk. Poehoetan Lajan, 600 m., *bb* 31537 (A, BO, NY, SING); Sibolga, Laboean Talang, P. Poenei (P. Morsala), 260 m., *bb* 19292 (A, BO, L); Is. Morsala, Bukit Muara Talang, 40 m., *Kostermans' collector* 24 (A, BO, K, L). ATJEH: Simaloer, *Achmad* 391 (?) (BO), 517 (?) (BO, L, U); 601 (?) (BO, L, U); Asahan, Simpang Toba, 10 m., *bb* 8442 (BO). BANGKA: prope Djeboes, *Teysmann, HB* 3222 (?) (BO). **Borneo.** KALIMANTAN. TIMUR: Boeloengan, Kabiran, S. Simendoeroet, 200 m., *bb* 11760 (BO). JAVA. BARAT: Passier Toegoe, Kikoehkoeran, *Hasskarl* 392 (L).

ECOLOGY. Usually in colline mixed dipterocarp forest, 10-660 m. alt. Flowering in January; fruiting November (?ripe), January, February, April, and June (fruit green, finely mottled with yellow, or "bronzed" (*FRI* 20070); reported to be eaten by siamang (*Chivers DCL* 406; Chivers, 1974)).

LOCAL USES. In Pahang, Malaya, it is used as a medicine: "Sidauwai puteh [used] after child[birth] with a decoction of the root" (*SFN* 16220). In Bangka the bast is used in atap thatching (as a tie?).

Calophyllum dioscurii is a distinctive species that is easily recognized, even when sterile, by its small, prominently acuminate leaf blades that dry pale brownish green and have very dense, fine venation, and by its pale-drying twigs that contrast strongly with the dark-drying petioles. In addition, the internodes tend to be rather short (usually less than 3 cm.); the pedicels are short; and air spaces develop in the outer layer of the fruit. The epithet is taken from Dioscuri, the name given to Castor and Pollux, inseparable twins of classical mythology, in commemoration of the work of M. R. Henderson and J. Wyatt-Smith on the genus.

Henderson and Wyatt-Smith (*loc. cit.*) compared this species with *Calophyllum gracillimum*. However, in that species the venation is obscure, the indumentum is much better developed, and there are hairs on the anthers; in fruit the two are not similar. They also thought that *C. floribundum* (= *C. tetrapterum* var. *tetrapterum*) was close to *C. dioscurii*. However, there are numerous differences in vegetative and fruit characters (venation density, twig color and type, thickness of the outer and woody layers of the fruit), and the two species are not closely related.

The specimens cited above that were collected from Simaloer, Sumatra, differ from the others in having a thicker lamina that is acute to acuminate at the apex, dries more or less brown, and has less dense venation; they also have stouter petioles. The characters in which they differ from the other specimens are enclosed in brackets in the above description. *Hasskarl* 302, from Java, is a sterile specimen, perhaps collected from a young tree; it has a lamina up to 12 by 3.1 cm.

107. *Calophyllum banyengii* P. F. Stevens, sp. nov.

A speciebus aliis *Calophylli* in ramulo tenui 0.8-1.2 mm. in transverso in siccitate flavido, petiolo tenui in siccitate nigrescenti, lamina chartacea mediocra valde acuminata (lamina 4.8-10.5 cm. longa acumine 1-1.5 cm. longo) margine valde undulata, fructu late ovoideo putamine tenuissimo (minus quam 0.1 mm. crasso), differt.

Tree 8-12 meters tall, d.b.h. to 10 cm.; trunk without buttresses; outer bark yellowish, smooth, the inner surface straw brown; under bark reddish; inner bark pale red; latex yellow, (?)clear, sparse, sticky.

Twigs flattened, 0.8-1.2 mm. across, rounded or with 4 raised lines, drying yellowish to pale brown, subpersistently brown-farinose; axillary innovations lacking basal scars (with pair of scars ca. 5 mm. from base); internodes 1-7 cm. long; uppermost pair of axillary buds subacute, to 3 mm. long, erect; terminal bud narrowly conical, 3.5-4(-5.5) mm. long, with \pm appressed, brown indumentum (hairs, FIGURE 34, h-j; cf. 34, c), underdeveloped internode absent (to 4 mm. long). Petiole 0.7-1.8 cm. long, \pm deeply concave above and convex below, subglabrous, drying blackish; lamina elliptic-oblong, 4.8-10.5 by 2.2-3.9 cm., acuminate at apex, acumen slender and to 1.5 cm. long, acute at base, strongly and closely undulate and slightly recurved at margin, thinly coriaceous, drying dark olivaceous-buff above and olivaceous below, subpersistently farinose on midrib above, the midrib above gradually narrowed from already narrow base, raised, 0.1-0.15 mm. wide at midpoint, below raised, striate to obscurely angled, the venation subobscure on both surfaces, slightly raised, latex canals impressed below, 8 to 14 veins/5 mm., angle of divergence 70-75°. Inflorescences from foliate axils along twigs, with 3 to 7 flowers, unbranched, the axis (0.1-0.6-2 cm. long, puberulent, lowest internode (1-4-7 mm. long; bracts subovate, to 3 mm. long, deciduous (subpersistent); pedicels (2-5-12 mm. long, sparsely puberulent. Flower known only in bud, (?)hermaphroditic; tepals (?6 or) 8, the outer pair ovate, 1.6-3 by 1.4-2.2 mm., \pm puberulent on back, the inner ones persisting at the base of fruit, obovate, ca. 5 by 2.3 mm.; stamens 140 to 175, the filaments to 4.5 mm. long, the anthers oblong, ca. 0.6 mm. long, subretuse at apex. Submature fruit broadly ellipsoid to ovoid, ca. 1.2 by 1 cm., drying pruinose-brown, obscurely striate; outer layer not detaching cleanly from stone, ca. 0.8 mm. thick, compact; stone subspherical, ca. 1 by 0.85 cm., rounded at apex, the walls less than 0.1 mm. thick, smooth, (?)unmarked; spongy layer at first thick.

TYPE: Sarawak, 1st Division, Gunong Santubong, 54 m., 20 Dec. 1975, *Stevens et al.* 296 (holotype, A; isotype, SAR).

DISTRIBUTION. Northern Borneo, scattered (MAP 36).

ADDITIONAL SPECIMENS SEEN: **Borneo.** SARAWAK. 4th Division: Miri, proposed Lambir Natl. Park, S 25074 (A, L, SAN, SAR, SING). SABAH. Kinabatangan: Brassey Range, 660 m., *Stevens et al.* 578 (?) (A).

ECOLOGY. On Gunong Santubong, in lowland dipterocarp forest, ca. 54 m. alt. Well-developed flower buds and submature fruits in December.

Calophyllum banyengii can be recognized by its slender, yellowish-drying twigs; its slender, blackish-drying petioles; and its medium-sized lamina with a strongly acuminate apex and closely undulate margins. Its flowers have about eight tepals, and its ovoid fruits have a rather thin, but compact, outer layer and a very thin-walled stone. The epithet commemorates Banyeng ap Nudong, who found the tree from which the type collection was made beside the much-traveled track up Gunong Santubong.

Calophyllum banyengii is at least superficially similar to *C. dioscurii*: the terminal buds of the species are similar, as are the yellowish-drying twigs and the acuminate leaves. However, *C. dioscurii* has smaller, more coriaceous leaf blades that are more shortly and less abruptly acuminate, stouter twigs, and shorter petioles. The fruits are smaller, large air spaces develop in the outer layer, and the stone has a perfectly distinct wall ca. 0.2 mm. thick.

In some flowers of *Calophyllum banyengii* the outermost pair of tepals appears to be markedly smaller than the next pair. These outermost tepals are separated from the others by a short length of pedicel and appear to be bracts that lack axillary flowers.

Stevens et al. 478, from the Brassey Range in Sabah, is similar to the specimens from Sarawak except that the lamina is narrower (up to 11.8 by 3.1 cm.) and is gradually acuminate at the apex, and the petiole is at least 6 mm. long. There is a tendency for the veins on the upper surface of the lamina to be impressed. However, the fresh leaf had a notably undulate margin, as did the individual from which the type specimen was taken.

108. *Calophyllum novoguineense* Kanehira & Hatusima, Bot. Mag. Tokyo **56**: 562, fig. 3, 1942; P. F. Stevens, Austral. Jour. Bot. **22**: 409, 1974. TYPE: Dutch New Guinea [Irian Jaya], Boemi, 40 km. inward of Nabire, 300 m., 10 March 1940, *Kanehira & Hatusima 12701* (isotypes, A, BO).

C. warensense Kanehira & Hatusima, Bot. Mag. Tokyo **56**: 564, fig. 5, 1942; P. F. Stevens, Austral. Jour. Bot. **22**: 409, 1974. TYPE: Dutch New Guinea [Irian Jaya], Waren, 96 km. south of Manokwari, 2 m., 23 March 1940, *Kanehira & Hatusima 13708* (isotypes, A, BO).

Tree 15–20 meters tall, d.b.h. to 20 cm.; outer bark yellow-brown, smooth except for fine vertical cracks, the inner surface dull straw-brown; under bark red to deep red; inner bark red; latex cloudy, not sticky, white or

becoming white when rubbed (details from Papuan specimens).

Twigs slightly flattened, 0.4–1.2 mm. across, 4-angled, drying brown (yellowish when old), with sparse, \pm adpressed hairs when young; axillary innovations lacking basal scars; internodes (0.2–)0.5–2 cm. long; uppermost pair of axillary buds rounded, 0.7–1.2 mm. long, suberect; terminal bud subconical, 1–2 mm. long, with brown, adpressed to spreading, puberulent indumentum (hairs, FIGURE 34, t, u; cf. 34, l), underdeveloped internode to 1 mm. long. Petiole 1–4 mm. long, broadly concave above, convex below, \pm glabrescent; lamina elliptic to subcuneiform or subobovate, 0.6–5 by 0.35–3 cm., subacute to rounded at apex, cuneate at base, somewhat undulate and recurved at margin, entire lamina often \pm boat shaped, coriaceous, drying brown-vinaceous to umber above and umber to sabelline-sepia below, with subadpressed to erect hairs on midrib below (on entire lower surface), the midrib above narrowing gradually from base, \pm raised, (0.07–)0.15–0.3 mm. wide at midpoint, sometimes disappearing up to 5 mm. below apex, below only slightly raised, striate, the venation above subobscure, below apparent, raised, 5 to 9 (to 11) veins/5 mm., angle of divergence 50–70°. Inflorescences from foliate axils, with 3 to 7 flowers, unbranched, the axis 0.2–2.5 cm. long, pubescent, especially toward base, sometimes glabrous above, lowest internode (2–)4–7 mm. long; bracts elliptic, ca. 1.5 mm. long, caducous; pedicels 3–15 mm. long, glabrous or sparsely pubescent. Flower (?)hermaphroditic; tepals 4, glabrous or almost so, the outer pair suborbicular to ovate-elliptic, 2.5–3.2 by 2–2.5 mm., the inner pair subelliptic, 2–3.5 by 1.5–2.5 mm.; stamens 20 to 35, the filaments to 2 mm. long, the anthers elliptic to oblong, 0.4–1.5 mm. long, retuse at apex; ovary 0.4–1 mm. long, the style ca. 1 mm. long, the stigma peltate, 0.3–0.5 mm. across, \pm 3-radiate. Fruit spherical, 5–7 by 4.5–6 mm., apiculate, drying brown, \pm wrinkled; outer layer not detaching cleanly from stone, 0.3–0.5 mm. thick, becoming disorganized by air spaces; stone spherical to ellipsoid, 3.5–6.5 by 3–5.5 mm., rounded at apex, the walls less than 0.1 mm. thick, smooth, (?)unmarked; spongy layer thin.

DISTRIBUTION. Western New Guinea (MAP 45).

ADDITIONAL SPECIMENS SEEN. **Papuasía.** IRIAN JAYA. Fakfak: Genofa, 750 m., *bb* 22569 (A, B, BO, L, SING). Djajapura: Cycloop Mts., Ifar, 400 m., *van Royen & Sleumer 6592* (K, L). PAPUA NEW GUINEA. Western: Kiunga Airstrip, 25 m., *NGF 18302* (A, CANB, E, K, LAE, M, MO, SING), 20 km. from Kiunga on Rumginae road, 30 m., *Stevens et al. 919* (A).

ECOLOGY. Varied habitats: *NGF 18302* at edge of lowland freshwater swamp; *Stevens et al. 919* in well-drained lowland forest; *Kanehira & Hatusima 13708* in dry thicket by seashore; *Kanehira & Hatusima 12701* in colline, *Agathis*-dominated forest; *bb* 22569 on chalk; 2–750 m. alt. Flowering March, April, and August; fruiting April, August (submature), and September.

YOUNG PLANT. Young plants ca. 30 cm. tall have short (less than 1 cm.) internodes and narrowly elliptic leaf blades; the terminal bud is functional, and growth is erect. Innovations from the terminal bud lacked basal scars, while innovations from axillary buds had them. (Observations made on numerous plants beneath the tree from which *Stevens et al. 919* was collected.)

TABLE 14. Differences between western Papuan species of the *Calophyllum novoguineense* complex.

	<i>C. novoguineense</i>	<i>C. bicolor</i>	<i>C. caudatum</i>	<i>C. undulatum</i>	<i>C. bifurcatum</i>	<i>C. parvifolium</i>
TWIG THICKNESS (mm.)	0.4-1.2	1.5-2.5	0.7-1	Ca. 1	1-1.4	0.7-1.2
TERMINAL BUD						
LENGTH (mm.)	1-2	4-7	2-3	1.5-3	3-5.5	1.8-3
FUNCTIONAL	+	+	+	+	(?)-	+
LAMINA						
LENGTH (cm.)	0.6-5	(2-)4-8(-13)	3.7-5.5	5.3-10.5	(4-)8-15	2.5-4
APEX SHAPE	Subacute- rounded	Acute- acuminate	Acuminate- caudate	Long- acuminate	Long- acuminate	Acute (rounded)
BASE SHAPE	Acute	Rounded- acute	Cuneate	Acute	Rounded	Cordate
MARGIN CLOSELY						
UNDULATE	-	-	-	+	+	-
DRYING STRONGLY						
BICOLORED	-	+	-	-	-	-
HAIRS PERSISTING ON						
LOWER SURFACE	-(+)	+(-)	-	-	-	-
MIDRIB SURROUNDED BY						
RAISED LAMINA	-	-	-	+	-	-
VEINS/5 mm.	5 to 9 (to 11)	4 to 9	11 to 14	(7 to) 9 to 16	6 to 8	4 to 7
FOLIACEOUS BRACTS						
PERSISTENT	-	-	+	+ -	-	-
PEDICEL LENGTH (cm.)	0.3-1.5	0.35-1.6	0.4-0.9(-1.2)	0.35-0.9	1.1-1.8	2.2-3.5

Calophyllum novoguineense can be characterized by its strongly four-angled twigs, its small terminal bud, and its lamina less than 5 cm. long that is at most subacute at the apex and that dries notably darker brown above than below. The flowers have four tepals and few anthers; the fruits are small. The type specimen was collected from New Guinea; hence the epithet.

Calophyllum novoguineense is a member of a complex of largely allopatric taxa occurring from the Moluccas to Fiji. All members have similar hairs, characterized by having at most a single rounded, basal branch and a notably rough surface (see FIGURES 34, k-u; 35, a); the leaves and fruits are generally small (the latter are larger in *C. confusum*). The flowers, where known, have few stamens and usually only four tepals. Species limits in the taxa centered on New Guinea (*C. novoguineense*, *C. bicolor*, *C. parvifolium*, and *C. caudatum*) are not very clear, but characters by which they can be distinguished are listed in TABLE 14.

Calophyllum novoguineense is closest to *C. bicolor*, which also frequently has hairs on the lower surface of the lamina; in both species, walls of the spongy mesophyll are lignified (for *C. bicolor*, see Stevens, 1974 (as *C. caudatum*); for *C. novoguineense*, specimens cited). *Calophyllum novoguineense* is superficially similar to *C. pisiferum*, but that species has much more robust twigs, larger leaf blades and inflorescences, very different hairs, and flowers with smaller anthers.

The type specimen of *Calophyllum warensense* and *van Royen & Sleumer 6592* both have longer inflorescence axes and anthers about three times as long as those of other specimens; however, pollen from the anthers of the type specimens of *C. warensense* and *C. novoguineense* was of similar size and became colored in cotton blue, so was presumably fertile. All the specimens cited have fairly similar leaves and twigs, although there is some variation in the size, shape, and texture of the lamina: the leaf blades of *van Royen & Sleumer 6592* are somewhat larger and more coriaceous than those of the others, and they dry almost flat; those of *Stevens et al. 919* are smaller but otherwise rather similar.

There is no difference in venation density between *Kanehira & Hatusima 12701* and *13708*, although *Kanehira* and *Hatusima (loc. cit.)* thought that there was. The indumentum of the type specimens of *Calophyllum warensense* and *C. novoguineense* is suberect (that of the other specimens is subadpressed), and apart from inflorescence size, the two can hardly be differentiated. Therefore, I have no hesitation in reducing the name *C. warensense* to synonymy.

109. *Calophyllum bicolor* P. F. Stevens, sp. nov.

FIGURE 33, a, f.

C. caudatum auct., non *Kanehira & Hatusima*; P. F. Stevens, Austral. Jour. Bot. 22: 362. 1974.

A speciebus aliis *Calophylli* in indumento tomentoso persistenti in ramulis, pagina inferiore laminae, axi inflorescentiae et pedicellis praedito, lamina ovata parva vel mediocra in siccitate bicolori margine leviter undulata haud vel leviter recurvata, et fructu strato exteriori circa 0.2 mm. crasso lacunis evolutentibus, differt.



FIGURE 33. a, f, *Calophyllum bicolor* (Pullen 7484): a, habit, $\times 0.5$; f, fruit, transverse section, $\times 3$. b, c, *C. bifurcatum* (Aet & Idjan 410): b, terminal bud, $\times 3$; c, habit, $\times 0.5$. d, *C. archipelagi* (Kostermans & Wirawan 921), terminal bud, $\times 3$. e, *C. undulatum* (Kuswata & Soepadmo 261), terminal bud, $\times 6$.

Tree 17-30 meters tall, d.b.h. to 48 cm.; trunk without buttresses; outer bark yellowish to yellowish gray, or gray and brown mottled, smooth when young, becoming fissured and scaly, the inner surface dark straw to straw; under bark brownish red; inner bark pale red to pink; latex yellow, brown, perhaps colorless, clear (rarely milky), sticky.

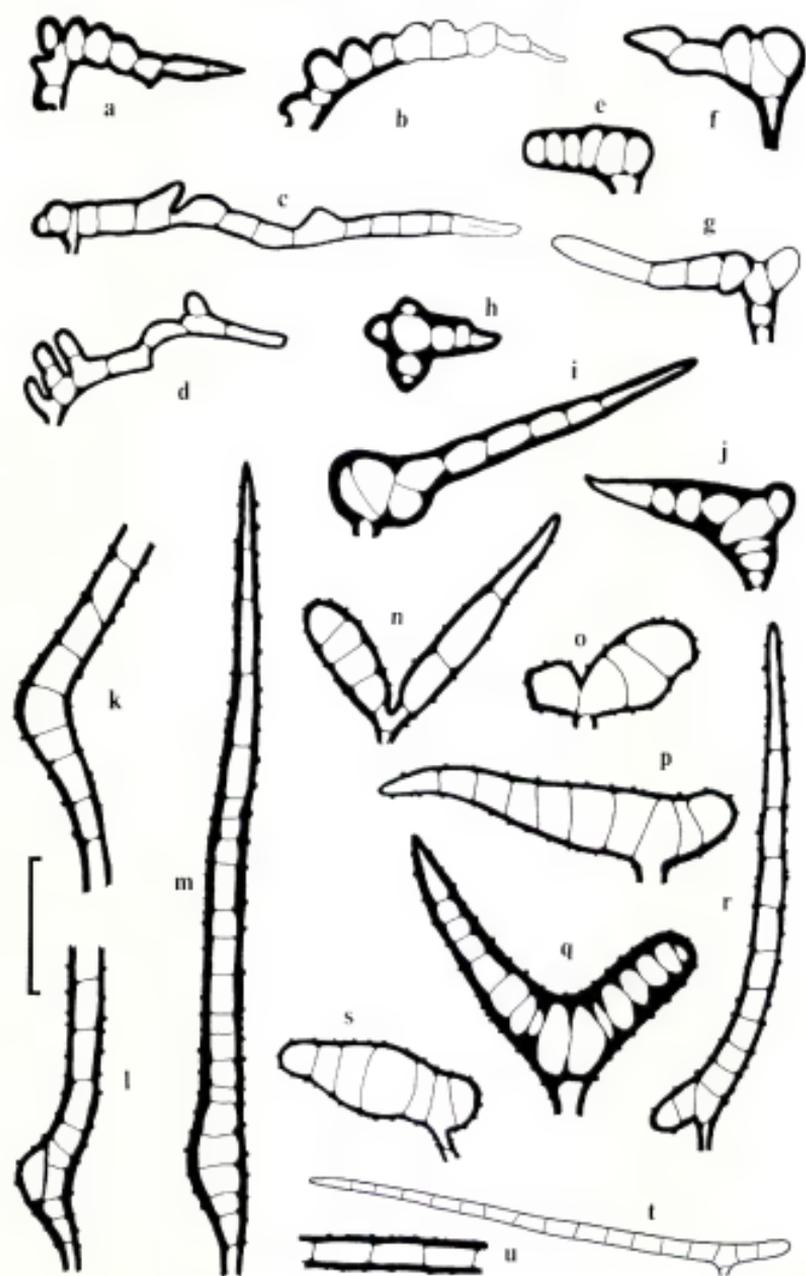
Twigs slightly flattened, 1.5–2.5 mm. across, slightly 4-angled to rounded, drying brown to dark brown, yellowish brown when older, often persistently brown-tomentose to pubescent; axillary innovations lacking basal scars; internodes 1–2(–4) cm. long; uppermost pair of axillary buds rounded, 0.5–1.5 mm. long, suberect; terminal bud plump, 4–7 mm. long, with brown-tomentose indumentum (hairs, FIGURE 34, k, l), underdeveloped internode to 2.5 mm. long. Petiole 2–7 mm. long, \pm concave above and convex below, subsersistently tomentose; lamina ovate to elliptic, (2–)4–8(–13) by (1–)1.5–3(–4) cm., acute to acuminate at apex, rounded or truncate to cuneate at base, slightly undulate and not recurved or slightly so at margin, coriaceous, drying hazel, vinaceous-brown, or olivaceous to sabelline above and honey to near sabelline below, pubescent-tomentose on midrib on both surfaces and sparsely over entire lower surface, the midrib above generally gradually narrowed from base, raised (flat at base), 0.2–0.4 mm. wide at midpoint, below raised, striate, the venation \pm obscure above and apparent below, raised, 4 to 9 veins/5 mm., angle of divergence 50–65°. Inflorescences from foliate (rarely defoliate) axils along twigs, with 3 to 5 flowers, unbranched, the axis 0.3–1.6 cm. long, pubescent-tomentose, lowest internode 3–5(–10) mm. long; bracts not known; pedicels 0.35–1.6 cm. long, pubescent to subtomentose. Flower (?) hermaphroditic; tepals 4, subelliptic, to 4 by 2.8 mm.; stamens ca. 40, the filaments to 2.5 mm. long, the anthers 0.7–1 mm. long, rounded at apex; ovary 1.2–1.5 mm. long, the style ca. 2 mm. long, the stigma peltate, ca. 1.1 mm. across, 3-radiate. Fruit ovoid to ellipsoid, 7–11 by 5–9 mm., apiculate, drying brown, \pm smooth to slightly wrinkled; outer layer not detaching cleanly from stone, ca. 0.2 mm. thick, with large air spaces developing; stone ovoid-ellipsoid, 6–9 by 4.5–7.5 mm., rounded at apex, the walls less than 0.2 mm. thick, smooth, unmarked; spongy layer thin.

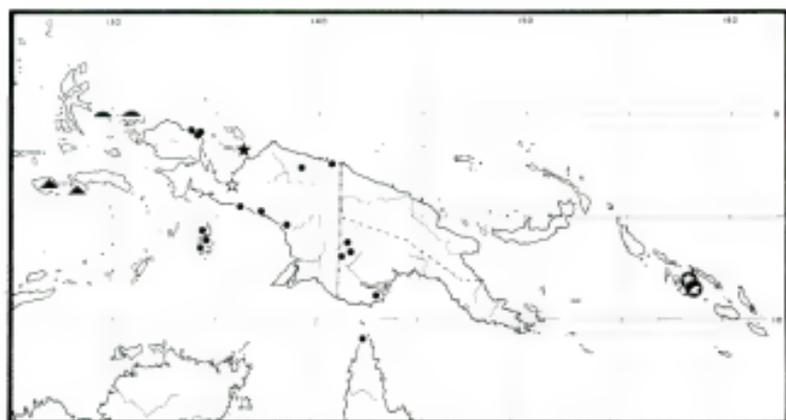
TYPE: Papua New Guinea, Western District, Oriomo Creek, mouth of Yakup Creek, 40 miles [64 km.] from the sea, 45 feet [13.5 m.], 23 Sept. 1963, NGF 17746 coll. Womersley (holotype, A; isotypes, CANB, E, K, L, LAE, NSW).

DISTRIBUTION: Western New Guinea, the Aru Islands, and Australia (Queensland) (MAP 37).

ADDITIONAL SPECIMENS SEEN. **Papuasias**. IRIAN JAYA. AET: P. Kobfoot, Dosinamalo, 20 m., bb 25283 (K, L, NY, SING); P. Trangan, 30 m., bb 25463 (L, NY, SING), Buwalda 5425 (K, L); [P. Wokam] Giabu-leŕngan, Beccari, PP

FIGURE 34. Hairs (from terminal bud, unless otherwise noted). a, b, *Calophyllum incumbens* (Kostermans 13037). c–g, *C. dioscurii*: c, d, FRI 11719; e, Achmad 601; f, g, bb 2872. h–j, *C. banyengii* (Stevens et al. 296): h, from above; i, from lateral bud. k, l, *C. bicolor*: k, Pullen 7484, base of hair ca. 590 μ m. long; l, NGF 17746, base of hair ca. 480 μ m. long. m, q, *C. leucocarpum* (A. C. Smith 6820). n, *C. confusum* (BSIP 424). o, p, s, *C. bifurcatum* (Aet & Idjan 410). r, *C. caudatum* (Kanehira & Hatusima 12030). t, u, *C. novoguineense* (NGF 18302): u, part of hair. Scale = 60 μ m. (in t, scale = 120 μ m.).





MAP 37. Distribution of *Calophyllum undulatum* (triangles), *C. parvifolium* (half-circles), *C. bicolor* (circles), *C. caudatum* (open star), *C. bifurcatum* (solid star), and *C. confusum* (stars in solid circles) in Papuaasia.

1137-1137C (FI). Vogelkop: Manokwari, *BW 1786* (CANB, L); Sidai (± 50 km. W. of Manokwari), 5-20 m., *BW 6761* (A, BO, CANB, L, LAE), *BW 6763* (CANB, L, LAE), 10 m., *BW 6929* (L); Beri Creek, near Andai, SW. of Manokwari, 80 m., *BW 11953* (L, LAE). Djajapura: distr. Jafi, Singgi, 250 m., *BW 2855* (CANB, L); Hollandia ("Noordwijk"), 5 m., *BW 2888* (CANB, L, LAE); Bodem R., 60 km. SE. from Sarmi, 75 m., *BW 5878* (CANB, L, LAE). Mimika: Najaja (Oeta), *bb 32849* (*Exp. Lundquist 130*) (BO, L), 3 m., *Aët* (*Exp. Lundquist*) 340 (BO, L); Moejoe, ca. 55 km. N. from Mindiptana, 100 m., *BW 6482* (CANB, L, LAE); Otakwa, 0 m., *bb 22087* (BO); Lorentz R., *bb 22109* (BO). PAPUA NEW GUINEA. Western: Kiunga, 25 m., *NGF 18367* (A, CANB, E, L, LAE, M, MO, SING), 24 m., *LAE 51789* (A, CANB, E, K, LAE), *Stevens et al. 889* (A), 915 (A); Kaim R., Lake Murray area, 15 m., *Pullen 7484* (A, CANB, K, L, LAE); near Boset Lagoon, Middle Fly R., 30 m., *Pullen 7385* (A, CANB, K, L, LAE). AUSTRALIA. QUEENSLAND: Cape York Peninsula, Bamaga, *Webb & Tracey 8027* (NSW).

ECOLOGY. Seasonally inundated or well-drained rainforest, 3-100(-250) m. alt. In southern Western Province, in *Melaleuca* forest, or forest with *Melaleuca* and *Acacia*; sometimes in secondary forest. Flowering March, June, and August; fruiting February, May, June, September, and October (ripe fruit deep blue to black).

Calophyllum bicolor is a distinctive species recognizable by the puberulotomentose indumentum that persists on the twigs, lower surface of the lamina, inflorescence axis, and pedicels, and by its small to medium-sized, ovate or sometimes elliptic lamina that commonly dries hazel-brown-vinaceous-olivaceous on the upper surface and honey-sabelline on the lower. The flowers have four tepals that are glabrous on the back, and the fruit has a thin

outer layer and a thin-walled stone. The epithet *bicolor* ("two colors") was chosen because of the different colors of the upper and lower surfaces of the dried leaf.

Calophyllum bicolor can readily be distinguished from *C. caudatum*, with which I had earlier confused it; for the differences between them, see TABLE 14. *Calophyllum bicolor* is perhaps most similar to *C. novoguineense*. Both species apparently grow in the Kiunga area, and careful studies are needed to see if they can be distinguished on bark and/or seedling and young plant differences.

110. *Calophyllum caudatum* Kanehira & Hatusima, Bot. Mag. Tokyo 56: 561. fig. 2. 1942. TYPE: Dutch New Guinea [Irian Jaya], Dalman, 40 km. in from Nabire, 400 m., 1 May 1940, Kanehira & Hatusima 12030 (isotypes, A, 80).

Tree ca. 5 meters tall; trunk and bark not known.

Twigs slightly flattened, 0.7-1 mm. across, obscurely 4-angled at first, soon becoming rounded, drying brown, sparsely pubescent when young, glabrescent; axillary innovations lacking basal scars; internodes 0.7-1.7 cm. long; uppermost pair of axillary buds rounded, ca. 0.7 mm. long, spreading; terminal bud plump, 2-3 mm. long, with subspreading, red-brown indumentum (hairs, FIGURE 34, r), underdeveloped internode absent. Petiole 3-4 mm. long, deeply concave above, convex below, pubescent; lamina narrowly ovate, 3.7-5.5 by 1-1.7 cm., acuminate to caudate at apex, cuneate at base, slightly undulate but not recurved at margin, fairly thin, coriaceous, drying sabelline or olivaceous above and umber below, sparsely pubescent when young, some hairs persisting on midrib below, the midrib above narrowing gradually from base, raised, ca. 0.2 mm. wide at midpoint, below not very prominent, slightly raised, striate, the venation obscure above, obscure to subapparent below, slightly raised below, 11 to 14 veins/5 mm., angle of divergence 55-70°. Inflorescences from foliate axils, with ca. 3 flowers, unbranched, the axis 4-9 mm. long, slender, sparsely pubescent, lowest internode 4-9 mm. long; bracts narrowly ovate, ca. 5 mm. long, persisting almost to anthesis; pedicels 0.4-0.9(-1.2) cm. long, \pm glabrous, slender. Flower known only in late bud, (?)hermaphroditic; tepals 4 or 6, glabrous, the outer pair suborbicular, ca. 2.2 mm. long; stamens 25 to 35, the filaments ca. 1 mm. long, the anthers oblong, ca. 1 mm. long, rounded to retuse at apex; ovary ca. 0.8 mm. long, style ca. 1 mm. long, stigma peltate. Fruit unknown.

DISTRIBUTION. Irian Jaya (MAP 37); known only from one collection.

ECOLOGY. Edge of *Agathis* forest, 400 m. alt. Late bud in early May.

Calophyllum caudatum can be recognized by its slender twigs, its narrowly ovate lamina 3.7-5.5 by 1-1.7 cm. with the apex acuminate to caudate and the midrib and venation both inconspicuous, and its slender, three-flowered inflorescence. The epithet is appropriate because the leaf blade is caudate at the apex.

Calophyllum caudatum appears to be related to the other small-leaved species of the genus occurring in the western part of New Guinea. The differences separating it from *C. bicolor*, with which it has been confused, are dealt with under the latter species. It differs from *C. insularum*, which has similarly shaped leaves, in having somewhat less dense and much less obvious venation; much smaller flowers with fewer, glabrous tepals and fewer, smaller anthers; and different hair structure (cf. FIGURES 34, r, and 46, a-d); the two species are not at all close.

From the figure accompanying the description of *Calophyllum caudatum*, it would appear that the bracts can be up to 1.5 cm. in length, although they were described as "bracteolis lanceolatis circ. 3 mm. longis."

111. *Calophyllum undulatum* P. F. Stevens, sp. nov.

FIGURE 33, e.

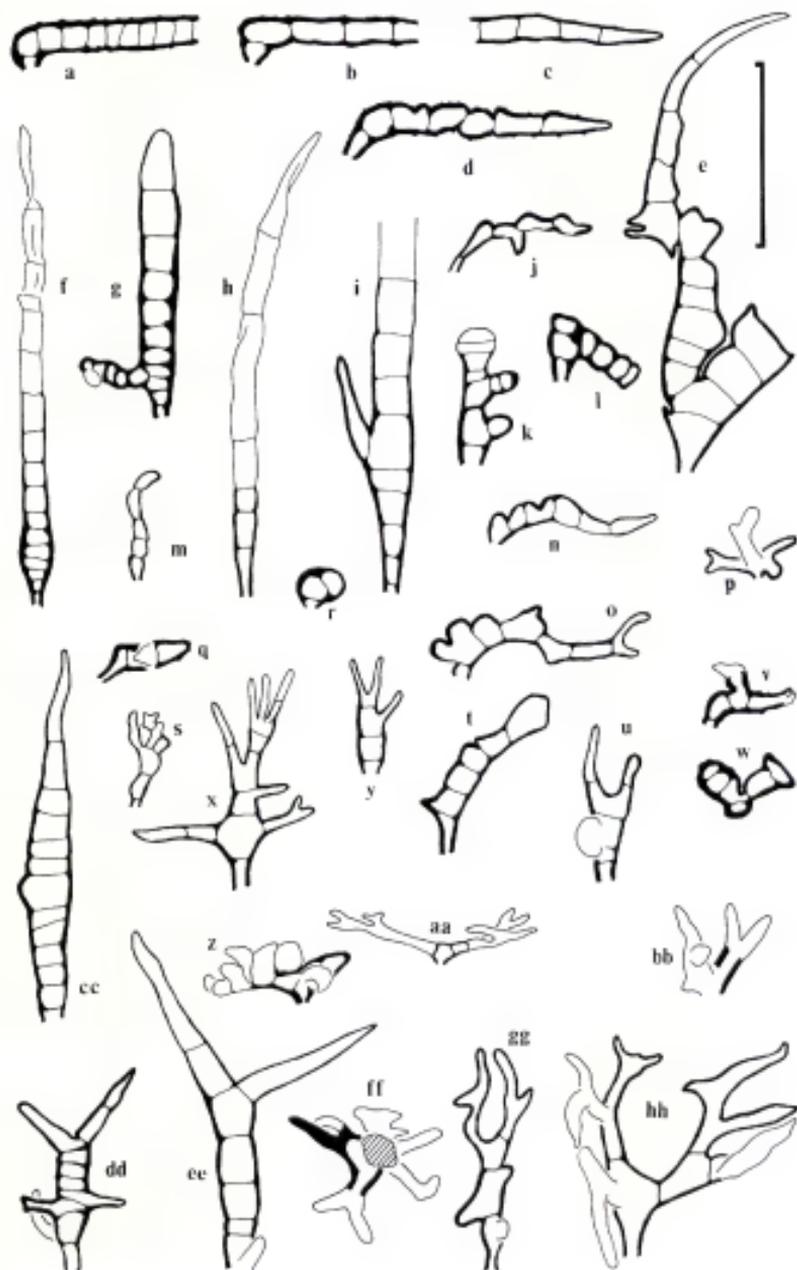
Calophyllum sp. Merr. Interp. Rumph. Herb. Amboin. 371. 1917.

A speciebus aliis Calophylli in innovationibus axillaribus cicatricibus basalibus haud ornatis, lamina (anguste) ovata margine anguste valdeque undulata costa supra elevata pagina laminae circumcinctae elevata et costa infra marginibus depressis, differt.

Tree 20-27 meters tall, d.b.h. to 33 cm.; outer bark grayish brown, thin, with slender cracks; inner bark red-brown.

Twigs slightly flattened, ca. 1 mm. across, 4-angled, drying brown, glabrous or with sparse, adpressed indumentum; axillary innovations lacking basal scars; internodes 0.7-5(-7) cm. long; uppermost pair of axillary buds \pm rounded, 0.5-1.3 mm. long, suberect; terminal bud conical, 1.5-3 mm. long, with adpressed, brown indumentum (hairs, FIGURE 35, a; cf. 34, p), underdeveloped internode absent. Petiole 3.5-7 mm. long, deeply concave above and convex below, soon glabrescent; lamina ovate to narrowly ovate, 5.3-10.5 by 1.8-3.6 cm., long-acuminate at apex, acute at base, strongly and closely undulate and at most slightly recurved at margin, coriaceous, drying shiny, amber to ferruginous above and amber below, glabrous or with sparse,

FIGURE 35. Hairs (from terminal bud, unless otherwise noted). a, *Calophyllum undulatum* (Pl. Rumph. Amboin. 483), base of hair ca. 250 μ m. long. b-d, *C. articulatum* (Kuswata & Soepadmo 219): b, c, base and apex of hair ca. 420 μ m. long; d, from axillary bud. e, *C. savannarum* (bb 30477), axillary bud. f, g, *C. vitiense* var. *amblyphyllum* (A. C. Smith 9243). h-j, m-o, *C. neo-ebudicum*: h, n, BSIP 429; i, Kajewski 2463, base of hair ca. 840 μ m. long; j, m, NGF 2873; o, A. C. Smith 6449. k, l, *C. vitiense* var. *vitiense*: k, Gillespie 2407; l, A. C. Smith 7201. p, *Calophyllum* sp. 121, *Decades Philip. Forest Fl.* 142. q-s, z, *C. cerasiferum*: q, A. C. Smith 8286; r, A. C. Smith 8553; s, A. C. Smith 8525; z, A. C. Smith 1789. t-w, *C. caledonicum*: t, Baumann-Bodenheim 16088; u, Virot 522; v, w, Virot 1340, from above. x, y, cc-ee, *C. collinum*: x, Brass & Versteegh 13576; y, dd; Stevens et al. 890; cc, ee, NGF 45057. aa, bb, ff, *C. carrii* var. *carrii*: aa, ff, Carr 15599, from peduncle; ff, from below; bb, LAE 60276, from stem. gg, hh, *C. costatum* (Hyland 8912), from stem. Scale = 120 μ m.



subadpressed indumentum \pm persisting on midrib below, the midrib above gradually narrowed from base, raised, surrounding lamina also raised, 0.15–0.25 mm. wide at midpoint, below slightly raised, margins depressed, striate, the venation subapparent, slightly raised, latex canals below impressed, (7 to) 9 to 16 veins/5 mm., angle of divergence 65–80°. Inflorescences from foliate axils, with (1 to) 3 to 5 flowers, unbranched, the axis (0.5–)0.6–1.5 cm. long, with adpressed indumentum toward base, lowest internode 3–8 mm. long; bracts at least sometimes foliaceous, to 2.7 by 1 cm., subsistent; pedicels 3.5–9 mm. long, glabrous. Flower (?)hermaphroditic; tepals 4, glabrous, the outer pair elliptic, ca. 4 by 3 mm., the inner pair subobovate, ca. 4.5 by 3 mm.; stamens ca. 40, the filaments to 2.5 mm. long, the anthers oblong, 1–1.2 mm. long, subrounded at apex; ovary ca. 0.8 mm. long, the style ca. 1.5 mm. long, the stigma subpeltate, ca. 0.3 mm. across. Fruit subspherical, 6–9 by 5–9 mm., rounded at apex, drying brown, shallowly wrinkled; outer layer not detaching cleanly from stone, 0.3–0.5 mm. thick, with large air spaces developing; stone ellipsoid, 5.4–8 by 4–6.7 mm., rounded at apex, the walls 0.1–0.2 mm. thick, smooth, (?)unmarked; spongy layer (?)thin.

TYPE: Ambon, Waai, slope of Mt. Salahatu, 200–300 m., 9 July 1959, *Kuswata & Soepadmo 261* (holotype, A; isotypes, BISH, BO (several), C, G, K, KEP, L, LAE, NSW, NY, P, SAN, SING).

DISTRIBUTION. The Moluccas (Ambon and Buru) (MAP 37).

ADDITIONAL SPECIMENS SEEN. **Moluccas.** BURU: Wai Geren Olon, 800 m., *bb 21507* (BO, L). AMBON: Hoetomoeri Road, 300 m., *Pl. Rumph. Amboin. 483* (BO, K, L, P, US); Mt. Toena, *Teysmann s.n.* (BO), *Boerlage 301* (BO); Haeosarocroe, 400 m., *bb 14292* (BO), *Salahoctoe, Rant 661* (sapling) (BO), *Boerlage 173* (BO); Alang, *Boerlage 419* (BO); sine loco, *Hombroen s.n.*, anno 1841 (P), *anon. 14614* (BO). Sine loco: *anon., MEL 62322* (MEL).

ECOLOGY. Colline forest, 200–800 m. alt. Fruiting in July (ripe fruit reported to be black).

Calophyllum undulatum is a very distinctive species with rather narrow leaf blades that dry shiny and have strongly and closely undulate margins. The midrib on the upper surface of the lamina is raised but is continuous with the immediate leaf surface (also raised), and the midrib on the lower surface has at least its edges notably impressed. The strongly undulate leaf margins suggested the specific epithet *undulatum*.

In venation density and general leaf shape, *Calophyllum undulatum* is like the poorly known *C. caudatum* (from Irian Jaya); the two species can be distinguished by the characters given in TABLE 14. The specimens of *C. undulatum* have adpressed hairs with thickened cell walls; at the base the hairs are asymmetrical. The hairs of *C. caudatum* are subspreading, they are only slightly asymmetrical at the base, and the cell walls are thin, with cuticular striations that are so prominent that the cell walls are partly obscured. However, there is almost comparable variation within *C. novoguineense*, which is also part of the same species complex.

Calophyllum undulatum is probably to be equated with the "bintangor montana tertia" of Rumphius (Herb. Amboin. 2: 217. 1741). Merrill (*loc. cit.*), in his interpretation of Rumphius's work, thought that Robinson's collection (*Pl. Rumph. Amboin. 483*) represented an undescribed species, but he was not sure because the collection lacked flowers. Rumphius described the bark as yellowish (compare the description above).

112. *Calophyllum bifurcatum* P. F. Stevens, sp. nov.

A speciebus aliis Calophylli in gemma terminali probabiliter haud fungenti, folia petiolo brevi et lamina basi rotundata apice longa sensimque acuminata, innovationibus axillaribus cicatricibus basalibus ornatis sed inflorescentiis axibus internodiis infimis bene evolutis, differt.

(?)Tree; trunk and bark unknown.

Twigs slightly flattened, 1-1.4 mm. across, 4-angled, soon becoming terete, drying brown, puberulent when young; axillary innovations with basal scars; internodes 2-4 cm. long; uppermost pair of axillary buds plump, acute at apex, 1-4(-7.5) mm. long, spreading, conspicuous; terminal bud plump, 3-5.5 mm. long, with gray-brown, scurfy indumentum (hairs, FIGURE 34, o, p, s), underdeveloped internode absent. Petiole 3-5 mm. long, narrowly concave above and convex below, soon glabrescent; lamina narrowly ovate, (4-)8-15 by (0.7-)1.9-3 cm., gradually acuminate at apex, rounded to shortly truncate at base, closely undulate and slightly recurved at margin, thinly coriaceous, drying cinnamon above and cinnamon to brick below, almost glabrous even when young, the midrib above narrowing gradually from base, raised, 0.2-0.3 mm. wide at midpoint, below raised, obscurely angled, rather narrow, the venation subobscure on both surfaces, slightly less so below, raised, 6 to 8 veins/5 mm., angle of divergence 70-80°. Infructescences from foliate axils, with scars of 3 flowers, unbranched, the axis 3-8 mm. long, sparsely puberulent toward base, lowest internode 3-8 mm. long; bracts not known; pedicels 1.1-1.8 cm. long, glabrous. Flower unknown. Immature fruit subspherical, ca. 8 by 7 mm., apiculate, drying brown, wrinkled; outer layer not detaching cleanly from stone, ca. 0.25 mm. thick, compact; stone (?)spherical, the walls ca. 0.15 mm. thick, smooth; spongy layer (?)thin.

TYPE: Nederlands Nieuwe-Guinea [Irian Jaya], Wasabari near Seroei, Jappen-Biak, 12 Aug. 1939, *Aët & Idjan* (exp. L. J. van Dijk) 410 (holotype, L).

DISTRIBUTION. Japen Island, Irian Jaya (MAP 37); collected only once.

Calophyllum bifurcatum can be recognized easily. It has a nonfunctional terminal bud and consequent profuse branching, scars at the bases of the axillary innovations, short petioles, and rather narrowly ovate leaf blades that are long-acuminate at the apex and rounded at the base. The venation is somewhat distant, and the inflorescences are axillary and have a well-developed basal internode. The often subequal branches associated with the abortion of the apex suggest the specific epithet.

Calophyllum bifurcatum is perhaps related to *C. caudatum*, but it differs in the characters listed in TABLE 14.

113. *Calophyllum parvifolium* Choisy, Mém. Soc. Phys. Hist. Nat. Paris 1: 229. 1823; Gaudich. Uranie Phys. Bot. 56. 1826; G. Don, Gen. Syst. 1: 622. 1831; Choisy, Descr. Guttif. Inde, 44. 1849, Mém. Soc. Phys. Hist. Nat. Genève 12: 424. 1851; P. F. Stevens, Austral. Jour. Bot. 22: 383. 1974; *C. microphyllum* Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 282. 1862, *nomen superfluum*; Vesque, Epharמושis 2: tt. 12, 13. 1889, in C. DC. Monogr. Phanerog. 8: 560. 1893; Lauterb. Bot. Jahrb. 58: 12. 1922. TYPE: [Waigeo Island] Rawak, *Gaudichaud s.n.* (holotype, P; isotypes, FI, G (as 34)).

C. microphyllum Scheffer, Natuurk. Tijds. Nederl.-Indië 32: 406. 1873, non Planchon & Triana (1862) nec T. Anderson in Hooker f. (1874); *C. schefferi* Vesque in C. DC. Monogr. Phanerog. 8: 609. 1893, *nomen novum*. TYPE: P. Gebeh, *Teysmann, HB 7868* (holotype, no; (?)isotype, (anon.) MEL).

(?)Tree or (?)shrub; trunk and bark unknown.

Twigs somewhat flattened, 0.7-1.2 mm. across, obscurely 4-angled, drying brown, glabrous or with subadpressed hairs when young; axillary innovations lacking basal scars; internodes 0.5-2.75 mm. long; uppermost pair of axillary buds rounded, 0.4-1 mm. long, spreading; terminal bud plump, 1.8-3 mm. long, with short, brown, subadpressed indumentum (hairs, cf. FIGURE 34, r), underdeveloped internode to 1.5 mm. long. Petiole 1.5-2 mm. long, concave above, convex below, sparsely puberulent at first; lamina ovate to broadly ovate, 2.5-4 by 1.5-3 cm., acute (rounded) at apex, cordate at base, slightly undulate and not recurved at margin, coriaceous, drying concave, umber to hazel-olivaceous above and umber to sepia below, with subsistent, short hairs on midrib below, the midrib above narrowed gradually from base, level, ca. 0.15 mm. wide at midpoint, below slightly raised, edges \pm impressed, inconspicuous, the venation obscure to subapparent above and below, raised, 4 to 7 veins/5 mm., angle of divergence 40-60°. Inflorescences from foliate axils, with 3 to 7 flowers, unbranched, the axis 1.5-4.7 cm. long, slender, sparsely puberulent toward base, lowest internode 1-2.5 cm. long; bracts unknown; pedicels 2.2-3.5 cm. long, glabrous, slender. Flower (?)hermaphroditic; tepals reported to be 8, probably 4 in flower examined, the outer ones ovate, ca. 4.5 by 3 mm., the inner ones obovate, ca. 5.5 by 3.5 mm.; stamens ca. 28, the filaments to 2.2 mm. long, the anthers oblong, 1.1-1.4 mm. long, \pm rounded at apex; ovary ca. 0.8 mm. long, style ca. 1.3 mm. long, stigma not known. Fruit (not seen) reported to be globose, barely 4 mm. long, apiculate.

DISTRIBUTION. Gebeh Island (Moluccas) and nearby Waigeo Island (MAP 37); known only from the two type specimens.

ECOLOGY. Montane forest (*Gaudichaud, loc. cit.*).

Calophyllum parvifolium is a poorly known species, characterized by its leaves with small, cordate-based blades and distant venation, and by its long, very slender, glabrous pedicels. The small leaves suggested the specific epithet.

The nomenclature of *Calophyllum parvifolium* and its synonym, *C. microphyllum* Scheffer, was discussed earlier (Stevens, *loc. cit.*). The sheet of *C. parvifolium* at Melbourne (MEL 62310) was probably collected by Teysmann (*cf.* Stevens, *loc. cit.*) and may be an isotype of *C. microphyllum*. However, neither the holotype nor the presumed isotype of *C. microphyllum* has fruits, although fruits were described in the protolog. In vegetative characters the type specimens of *C. parvifolium* and *C. microphyllum* are similar, and both have long, very slender pedicels.

Calophyllum parvifolium is probably most closely related to *C. novoguineense*, which occurs in the western half of New Guinea. *Calophyllum novoguineense* has well-developed, subsistent indumentum on its twigs, a lamina that is at most rounded at the base, and pedicels up to 15 mm. long (see also TABLE 14). The two species dry in much the same way and apparently have similar flowers, although *C. parvifolium* may have flowers with eight tepals (see description; this would be another difference between the two species).

114. *Calophyllum confusum* P. F. Stevens, Austral. Jour. Bot. 22: 363, fig. 3. 1974. TYPE: Solomon Islands, northwest New Georgia, Vaimbu River, 100 feet [30 m.], 25 March 1964, BSIP 3154 coll. Whitmore's collectors (holotype, LAE; isotypes, L, SING).

Calophyllum sp. T. C. Whitmore, Guide Forest Brit. Solomon Is. 78. 1966.

Tree 9-27 meters tall, d.b.h. to 25 cm.; outer bark greenish yellow to dark brown, becoming scaly; latex white or yellow, sticky.

Twigs flattened, 1-1.5 mm. across, 4-angled, drying blackish, sparsely brown- or grayish-brown-puberulent; axillary innovations lacking basal scars; internodes 1-4.5(-6) cm. long; uppermost pair of axillary buds pointed, to 2.8 mm. long, erect; terminal bud \pm conical, 3-6.5 mm. long, with brown, subadpressed indumentum (hairs, FIGURE 34, n; *cf.* 35, a), underdeveloped internode absent. Petiole 0.6-1.1 cm. long, concave above, convex below, slender, drying blackish, glabrous; lamina ovate to elliptic, (3.5-)4.5-8.5 by 1.2-2.6 cm., acute to subacuminate at apex, acute at base, distantly and shallowly undulate but not recurved at margin, thinly coriaceous, drying olivaceous above and sepia below, soon glabrescent or subsistently puberulent on midrib below, the midrib above gradually narrowed from base, \pm flat at first, becoming slightly raised, 0.1-0.15 mm. wide at midpoint, below slightly raised, substrate, the venation above subobscure, below subobscure to apparent, raised, latex canals clearly depressed below, 8 to 12 veins/5 mm., angle of divergence 65-75°. Infructescences from upper foliate axis, with scars of 3 (to 5) flowers, (?)unbranched, the axis 0.2-1.5 cm. long, sparsely and subsistently puberulent toward base, lowest internode 2-15 mm. long; bracts unknown; pedicels 7-11 mm. long, glabrous. Flower unknown. Fruit ovoid, 2.3-2.8 by 1.9-2.2 cm., \pm rounded at apex, drying pruinose, smooth; outer layer not detaching cleanly from stone, 2.6-4 mm. thick, compact; stone subellipsoid, 1.7-2 by 1.3-1.6 cm., rounded at apex, the walls 0.2-0.3 mm. thick, smooth, (?)unmarked; spongy layer thin.

DISTRIBUTION. The Solomon Islands, known only from the New Georgia group (MAP 37).

SPECIMENS SEEN. **Papuaia.** SOLOMON ISLANDS: see Stevens, *loc. cit.*

ECOLOGY. Well-drained, primary rain forest, 80 to at least 305 m. alt. Fruiting in March.

Calophyllum confusum can be recognized by its slender, profusely branched twigs that dry blackish, its uppermost axillary buds that are tightly appressed to the terminal bud, its rather narrowly ovate to elliptic lamina that dries dark olivaceous on the upper surface, and its relatively large (2.3–2.8 cm. long) fruit that dries smooth and has a thick, compact, outer layer and a thin-walled stone lacking a basal plug. The epithet *confusum* was coined because specimens placed in this species had previously been placed in several quite different ones.

The relationships of *Calophyllum confusum* are not clear; it may be related to *C. leucocarpum*, from the Fiji Islands, and to other species of the *C. novoguineense* complex, although all the other species in the group have much smaller fruits (less than 1.7 cm. long with an outer layer less than 1 mm. thick).

115. ***Calophyllum leucocarpum*** A. C. Smith, Jour. Arnold Arb. 31: 314. 1950; A. C. Smith & Darwin, Jour. Arnold Arb. 55: 219, figs. 1–3. 1974. TYPE: Fiji, Vanua Levu, Mathuata, Seangangga Plateau, in drainage of Korovuli River, vicinity of Natua, 100–299 m., 4 Dec. 1947, A. C. Smith 6820 (holotype, s; isotypes, k, NY, P, US).

C. neo-ebudicum auct., non Guillaumin; Parham, Pl. Fiji Is. ed. 2. 192. 1972, *pro parte*.

Slender tree 4 meters tall; trunk and bark unknown.

Twigs slightly flattened, 1–1.5 mm. across, \pm 4-angled, drying mid-brown, sparsely subsersistently tomentose; axillary innovations lacking basal scars; internodes 1–4 cm. long; uppermost pair of axillary buds pointed, 1.5–2 mm. long, \pm erect; terminal bud conical to somewhat plump, 4.5–5 mm. long, with brown, tomentose indumentum (hairs, FIGURE 34, m, q), underdeveloped internode not apparent. Petiole 0.65–1.2 cm. long, deeply concave above, convex below, \pm persistently puberulo-tomentose; lamina oblong to elliptic or subovate, 2.7–6.5 by 1–2.6 cm., acuminate at apex, acute to attenuate at base, slightly undulate and recurved at margin, thinly coriaceous, drying umber above and below, subsersistently puberulo-tomentose on midrib above and especially below, the midrib above narrowing gradually from base, strongly raised, 0.13–2 mm. wide at midpoint, below raised, 3-striate, in young leaves edges subdepressed, the venation subobscure on both surfaces, above impressed, below slightly raised, latex canals impressed, 6 to 10 veins/5 mm., angle of divergence 65–75°. Inflorescences axillary, rarely two per axil, with 3 to 5 flowers, unbranched, the axis in flower 0.1–(?)1 cm. long, short-tomentose on lowest internode, otherwise glabrous, lowest internode 1–(?)6 mm. long,

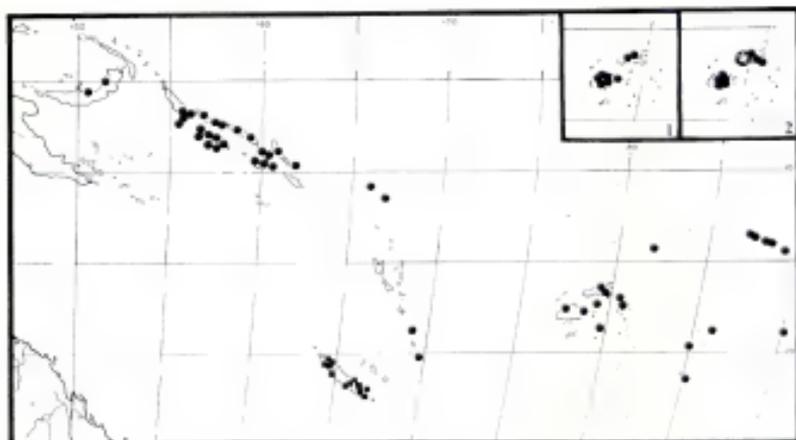
in fruit axis to 1.8 cm. long, lowest internode to 10 mm. long; bracts not known; pedicels 1-3 mm. long, glabrous, in fruit 2.5-6 mm. long. Flower (?)hermaphroditic; tepals 4, the outer pair broadly ovate-elliptic, ca. 3 by 2.6 mm., the inner ones broadly obovate, ca. 4.5 by 4.8 mm.; stamens (?)40 to 70, the filaments ca. 3 mm. long, the anthers suboblong, 0.6-0.9 mm. long, retuse at apex; ovary ca. 1.3 mm. long, the style ca. 1.2 mm. long, the stigma peltate, ca. 0.4 mm. across, (?)3-radiate. Submature fruit ellipsoid, ca. 11 by 8.5 mm., apiculate, drying vinaceous-brown, finely and irregularly striate; outer layer not detaching cleanly from stone, ca. 0.8 mm. thick, compact; stone ellipsoid, ca. 9 by 6.5 mm., apiculate, the walls ca. 0.2 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Vanua Levu, Fiji (MAP 38); known only from the type collection.

ECOLOGY. Forest patches in rolling grassland, 100-200 m. alt. Flowering and fruiting in December; submature fruit white.

Calophyllum leucocarpum can be recognized by its small leaves that dry amber and nitid and that have a prominent midrib on the upper surface; by the subsistent, more or less tomentose indumentum on its terminal bud, twig, and midrib, and on the basal part of its inflorescence; by its four-teped flowers with short styles; and by its small fruits that have a relatively thick outer layer and are white when ripe. The epithet *leucocarpum* means "white fruit"—appropriate for this species.

Calophyllum leucocarpum is superficially similar to *C. gracillimum* (from Malaya). The two species can be most readily separated by the indumentum



MAP 38. Distribution of *Calophyllum neo-ebudicum* (circles; not including doubtful records from the Celebes) and *C. caledonicum* (squares) in the western Pacific. Inset 1: *C. vitiense* var. *vitiense*. Inset 2: *C. cerasiferum* (circles) and *C. leucocarpum* (star in solid circle).

of the inflorescence and flowers; in *C. gracillimum* there are hairs on the pedicels, the backs of the tepals, and the anthers.

116. *Calophyllum articulatum* P. F. Stevens, sp. nov.

FIGURE 36, f-i.

A speciebus aliis Calophylli quibus laminis cordatis basibus habent in innovationibus basibus tumidis cum ramulis articulatis, fructu strato exteriore tenui (circa 0.6 mm. crasso), et putamine haud signato, differt.

Tree 8-25 meters tall, d.b.h. to 40 cm.; outer bark yellowish brown (grayish), cracked at first, becoming fissured; inner bark pale reddish to brown; latex clear.

Twigs flattened, 2-3.5 mm. across, obscurely 4- or 6-angled, drying pale to dark brown, subtomentose when young; axillary innovations lacking basal scars, but swollen at base; internodes (0.5-)1-3.5 cm. long; uppermost pair of axillary buds rounded, less than 1 mm. long, inconspicuous; terminal bud plump, 2.5-3 mm. long, with subtomentose, brown indumentum (hairs, FIGURE 35, b-d), underdeveloped internode absent. Petiole 2-3.5 mm. long, \pm flat above and convex below, with few subsistent hairs; lamina elliptic or obovate to subtrapeziform, 2.3-7(-11) by 0.9-3.8(-6.5) cm., \pm rounded at apex, cordate to narrowly rounded at base, broadly and distantly undulate but not recurved at margin, very coriaceous, drying chestnut above (midrib and margin notably paler) and umber below, glabrous at maturity, the midrib above gradually narrowed from base, almost flat to raised, surrounding lamina \pm raised, 0.3-0.6 mm. wide at midpoint, below slightly raised, striate, the venation subobscure above and subapparent below, raised, 4 to 7 (to 9) veins/5 mm., angle of divergence 40-55°. Infructescences from foliate axils, with scars of (75 to) 7 to 9 flowers, unbranched, the axis 2.4-6.2 cm. long, glabrous, lowest internode 1.2-3.2 cm. long; bracts not known; pedicels 0.6-1.2 cm. long, glabrous. Flower not known. Fruit ellipsoid, ca. 1.15 by 0.9 cm., apiculate when young, becoming rounded, drying pruinose-brown, smooth; outer layer not detaching cleanly from stone, ca. 0.6 mm. thick, air spaces developing beneath skin; stone ellipsoid, ca. 9 by 7.5 mm., rounded at apex, the walls ca. 0.15 mm. thick, smooth, unmarked; spongy layer thin.

TYPE: Seram (West), Waiselang, 100 m., 23 June 1959, *Kuswata & Soepadmo 219* (holotype, BO; isotypes, A, CANB, K, KEP, L, LAE, NY, P, SING).

DISTRIBUTION. The Moluccas (MAP 39).

ADDITIONAL SPECIMENS SEEN. **Moluccas**, AMBON: Waai, slope of Mt. Salahatu, 300-600 m., *Kuswata & Soepadmo 301* (BO, I); Mt. Salhoetoe, *Teysmann s.n.* (BO).

ECOLOGY. Colline forest, 100-600 m. alt. Ripe fruit reported to be blue.

Calophyllum articulatum can be readily recognized by its very coriaceous leaf blades that are rounded to cordate at the base, its partly enclosed axillary buds, and its articulations where the axillary branches join the stem. The epithet *articulatum* ("jointed") was chosen because of this last feature.

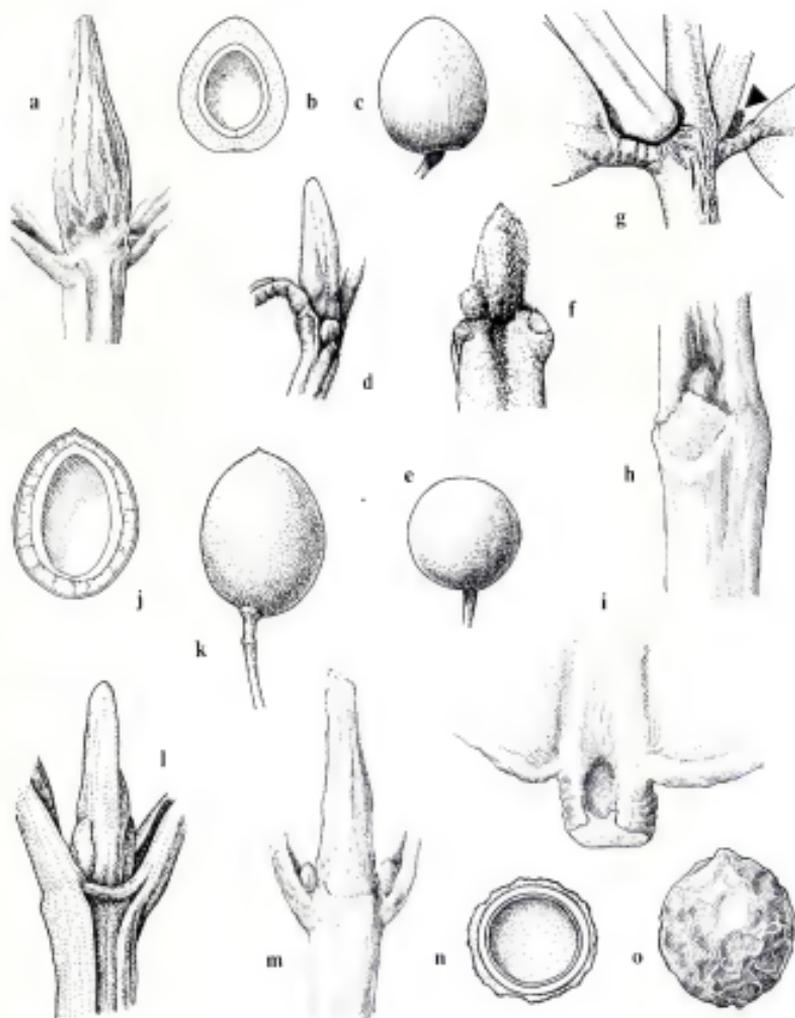
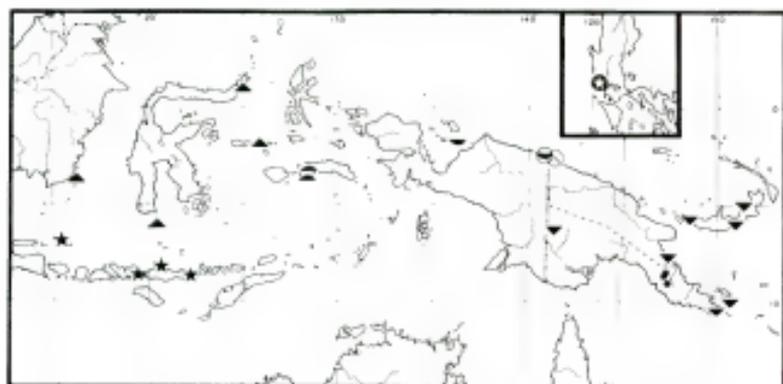


FIGURE 36. a, *Calophyllum* sp. 129 (bb 29806), terminal bud, $\times 3$. b-e, *C. collinum*. b, c, Stevens et al. 921, fruit, $\times 1$; b, longitudinal section; c, from outside. d, e, NGF 42992: d, terminal bud, $\times 3$; e, fruit, from outside, $\times 1$. f-i, *C. articulatum* (Kuswata & Soepadmo 219): f, terminal bud, $\times 6$; g, branch insertion, $\times 3$, arrow marks supernumerary axillary bud; h, axillary bud, $\times 6$; i, leaf base, $\times 6$. j-l, *C. hirastum* (Kanehira & Hatusima 13980). j, k, fruit, $\times 1.5$; j, longitudinal section; k, from outside. l, terminal bud, $\times 6$. m-o, *Calophyllum* sp. 121 (Merrill's collector 142). m, terminal bud, $\times 6$. n, o, fruit, $\times 1$; n, transverse section; o, from outside.



MAP 39. Distribution of *Calophyllum archipelagi* (stars), *Calophyllum* sp. 129 (erect triangles), *C. articulatum* (erect half-circles), *C. savannarum* (inverted half-circles), *C. laticostatum* (inverted triangles), *C. carrii* var. *carrii* (solid circles), and *C. carrii* var. *longigemmatum* (open circles) in Malaysia. Inset: *Calophyllum* sp. 121.

Calophyllum articulatum differs from both *C. venulosum* and *C. calcicola*, which may have at least superficially similar leaves, in having an inflorescence with more flowers (in both of the latter species, there are rarely more than five). The lowest internode of the inflorescence is about half the length of the entire axis and is much longer than the upper internodes (in the other two species the relationship is reversed). The swollen bases of the innovations, which then become noticeably constricted where they join higher-order branches, and the partly enclosed axillary buds, distinguish sterile material of *C. articulatum* from that of the other two species. Unlike *C. venulosum*, but like *C. calcicola*, the outer layer of the fruit is thin; however, *C. calcicola* has an inconspicuous submarginal vein that is lacking in *C. articulatum*.

The color of the dried leaf blade (especially in the type specimen), the articulations at the bases of the innovations, the partly enclosed axillary buds, and the midrib type suggest that *Calophyllum articulatum* is closely related to *C. savannarum*. However, the functional terminal bud, the cordate base of the leaf blade, and the inflorescence type of *C. articulatum* all readily distinguish the two species.

Teysmann s.n. has leaf blades that are up to 11 by 6.5 cm. and are broadly cordate at the base.

117. *Calophyllum savannarum* A. C. Smith, *Jour. Arnold Arb.* **22**: 352. 1941; P. F. Stevens, *Austral. Jour. Bot.* **22**: 394. 1974. TYPE: Netherlands New Guinea [Irian Jaya], Hollandia [Djajapura] and vicinity, 20-100 m., 29 June 1938, *Brass 8888* (holotype, *s*; isotypes, *BO*, *BRI*, *K*, *L*, *LAE*).

FIGURE 4, b-d.

Tree 10-12 meters tall, d.b.h. to 19 cm.; trunk and bark not known. Crown with hanging branches.

Twigs strongly flattened, 1-2.5 mm. across, 2-angled or rounded, drying (pale) brown, glabrous when mature; axillary innovations lacking basal scars, but swollen where joining stem; internodes 1.5-5 cm. long; uppermost pair of axillary buds rounded, less than 1 mm. long, spreading, inconspicuous (hairs, FIGURE 35, e); terminal bud not seen, apparently not functional and soon falling off, underdeveloped internode 3-7(-13) mm. long. Petiole 0.7-1.5(-2) cm. long, slightly concave above, convex below, glabrous; lamina ovate to elliptic, (5.5-7)-12.5 by (2-)2.3-4.5 cm., cuneate to bluntly acuminate at apex, acute to decurrent at base, moderately and distantly undulate and slightly recurved at margin, coriaceous, drying chestnut to sepia above, shiny, midrib and margins (veins) notably paler, and umber to sepia below, glabrous, the midrib above narrowed gradually from base, raised, continuous with surrounding blade, 0.3-0.6 mm. wide at midpoint, below slightly raised, angled, venation apparent on both surfaces, raised, 5 to 7 veins/5 mm., angle of divergence 45-60°. Inflorescences from foliate axils, with 5 to 9 flowers, unbranched, the axis 3-4 cm. long, glabrous, lowest internode (0.3-)0.5-1.5 cm. long; bracts unknown; pedicels 1.1-1.7 cm. long, glabrous, somewhat incrassate in fruit. Flower (?)hermaphroditic; tepals 4, glabrous, the outer pair broadly ovate, ca. 5.5 by 5 mm., the inner pair \pm obovate, ca. 7 by 4 mm.; stamens 50 to 70, the filaments to 3 mm. long, \pm free, the anthers oblong, 2-2.7 mm. long, retuse at apex; ovary 1.2 mm. long, the style ca. 3 mm. long, the stigma peltate, ca. 1.5 mm. across, 3- to 5-radiate. Fruit ovoid, ca. 1.4 by 1.1 cm., rounded at apex, drying grayish olive, smooth; outer layer detaching cleanly from stone, 0.8 mm. thick, compact except for air spaces developing under skin; stone ovoid-ellipsoid, 1-1.1 by 0.6-0.7 cm., apiculate or rounded at apex, the walls ca. 0.15 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Northern Irian Jaya (MAP 39).

SELECTED SPECIMENS SEEN. **Papua**. IRIAN JAYA. Geelvink Bay: Seroei, Eil. Japen, Mariatoc, 500 m., *bb* 30477 (A, SING). Djajapura: Hollandia [Djajapura], "Dok 2," *BW* 3915 (A, BO, K, L, LAE, P, SING).

ECOLOGY. Secondary forests on steep slopes; principal component of forest clumps in secondary savanna; 20-500 m. alt. Flowering in August; fruiting June and August (fruit blue).

Calophyllum savannarum is an easily recognized species, even when sterile, because of its nonfunctional terminal bud and consequent profuse branching, and its axillary shoots that are noticeably swollen at the base but lack the scars of perulae. The axillary buds, which are almost glabrous, are inconspicuous due to the way they are protected (FIGURE 4, b, c). Its leaf blades are coriaceous, dry dark brown (but with lighter-colored midrib, margins, and veins), and have rather distant, steeply ascending veins. The epithet *savannarum* ("of the savannas") reflects the habitat of this species around Djajapura.

Calophyllum savannarum is most closely related to *C. articulatum*. For the differences between the two species, see *C. articulatum*.

118. *Calophyllum vitiense* Turrill, Jour. Linn. Soc. Bot. 43: 17. 1915. TYPE: Fiji [Viti Levu, Mba], Nandarivatu, some three miles [4.8 km.] along the road to Suva, 2 Dec. 1906, *in Thurn* 297 (lectotype, κ ; isolectotype, κ).

Tree 5-30 meters tall, d.b.h. to 50 cm.; trunk without buttresses; outer bark brown, slightly fissured or flaking, exposing greenish yellow patches; latex brownish, smelling strongly of green ginger; sapwood grayish brown; heartwood deep reddish brown with dark brown lines.

Twigs slightly flattened, 1.7-4 mm. across, persistently 4-angled to 4-angled (with additional, less prominent raised lines, rarely coarsely striate), drying dark brown, farinose to subtomentose when young; axillary innovations lacking basal scars; internodes 0.5-3 cm. long; uppermost pair of axillary buds rounded, to 1.5 mm. long, \pm spreading; terminal bud plump (conical), (4.5-)-7-12 mm. long, with brown to grayish, subcrustose to short-tomentose indumentum (hairs, FIGURE 35, f, g, k, l; cf. 35, n), underdeveloped internode absent (to 3 mm. long). Petiole 0.5-3 cm. long, broadly and deeply concave above, convex below, glabrous when mature; lamina ovate to elliptic or oblong, (4-)-11-21 by (1.2-)-3-5.8 cm., shallowly retuse to acuminate at apex, acute to attenuate (rarely broadly rounded and then attenuate) at base, undulate and at most slightly recurved at margin, thinly coriaceous, drying sepia to grayish sepia above, margin and midrib paler, and umber below, sparsely farinose on midrib below when young, the midrib above gradually narrowed from base, depressed, clearly demarcated from lamina by often raised margins, 0.25-0.7 mm. wide at midpoint, center clearly sulcate, becoming raised toward apex, below raised, angled toward apex, striate toward base, the venation subobscure to apparent above and below, raised, (3 to) 5 to 9 (to 11) veins/5 mm., angle of divergence 65-80°. Inflorescences from foliate axils, with 5 to 13 (to ca. 21) flowers, unbranched, the axis (1.3-)-4-12 cm. long, sparsely brown-farinose to tomentose toward base, or subglabrous, lowest internode (0.3-)-0.7-2.2(-4.5) cm. long; bracts elliptic to ovate, 2.5-5 by 1.7-2 mm., caducous; pedicels (0.4-)-1-3.2 cm. long, glabrous or sparsely farinose. Flower (?) hermaphroditic; tepals (7 or) 8 (to 12), the outer pair broadly ovate to suborbicular, 4.5-6 by 2.8-3.5 mm., the inner ones elliptic to oblong, 7.5-12.5 by 3.5-10 mm.; stamens 275 to 340, the filaments to 5.5 mm. long, the anthers oblong to elliptic, 0.5-1 mm. long, retuse at apex; ovary 2.5-2.8 mm. long, the style 2.7-5 mm. long, the stigma peltate, 0.9-1.3 mm. across, 3- or 4-lobed. Fruit \pm ellipsoid, 2.2-3.3 by 1.8-2.2 cm., rounded at apex, drying dark Indian red, pruinose or not, \pm broadly wrinkled, the wrinkles sharp and deep in submature fruit, rounded and shallower in mature fruit; outer layer not detaching cleanly from stone, ca. 0.5(-1.5) mm. thick, \pm fibrous, with numerous air spaces; stone ellipsoid, 2-2.7 by 1.5-2 cm., rounded at apex, the walls 1-3 mm. thick, smooth, unmarked, with basal plug ca. 10 mm. across; spongy layer thin.

Key to the Varieties of *Calophyllum vitiense*

1. Terminal bud (6-)8-12 mm. long, usually with subcrustaceous indumentum; lamina acute to acuminate at apex. 118a. var. *vitiense*.
1. Terminal bud 4.5-7 mm. long, usually short-tomentose; lamina shallowly retuse to rounded (acute) at apex. 118b. var. *amblyphyllum*.

118a. *Calophyllum vitiense* Turrill var. *vitiense*

- C. vitiense* Turrill; Watkins, Dept. Agr. Jour. Agr. Fiji 31: 15. fig. 1961; Parham, Fl. Fiji Is. 134. 1964, *ibid.* ed. 2. 192. 1972; A. C. Smith & Darwin, Jour. Arnold Arb. 55: 227. figs. 9, 11. 1974, *pro majore parte*.
- C. tenuicrustosum* A. C. Smith & Darwin, Jour. Arnold Arb. 55: 236. fig. 22. 1974, *pro parte*. Type: Fiji, Viti Levu, Mba, slopes of Mt. Nairova, eastern flank of Mt. Evans range, 700-1050 m., 28 April 1948, A. C. Smith 4058 (holotype, A; isotypes, K, NY, P, US).
- C. spectabile* auct., non Willd.; A. Gray, U. S. Expl. Exped. 15(1): 218. 1854, *pro parte*, Proc. Am. Acad. 5: 315. 1862, Bonplandia 10: 34. 1862; Seem. Fl. Vit. 11. 1865; Horne, Year Fiji, 258. 1881.
- C. (?) polyanthum* auct., non Wall. ex Choisy vel *C. (?) lanceolatum* auct., non Bl.; Seem. Viti, 433. 1862.

Tree 5-30 meters tall, d.b.h. to 50 cm.

Twigs with brown, farinose to tomentellous indumentum when young; terminal bud plump, (6-)8-12 mm. long, with brown to grayish, crustaceous (rarely puberulo-tomentose) indumentum. Lamina ovate to elliptic or suboblong, (4-)11-21 by (1.2-)3-5.8 cm., acute to acuminate at apex, acute to attenuate (very rarely rounded) at base. Inflorescence axis (2.5-)5-12 cm. long, glabrous or farinose at base; pedicels (0.4-)1.7-3.2 cm. long.

DISTRIBUTION. The Fiji Islands (MAP 38).

SELECTED SPECIMENS SEEN. **Pacific Islands.** FIJI. Viti Levu, Mba: vicinity of Nandarivatu, 900 m., Gillespie 4229 (A, BO, GH, K, NY, P, US); Nausori Highlands, Mt. Evans Range, 579 m., Damani E118 (K); Nasama Creek, 457 m., C.S.I.R.O. S 1404/6 (K). Serua: Nabukavesi, 90 m., C.S.I.R.O. S 1404/4 (K); Naboutini, 150 m., C.S.I.R.O. S 1404/15 (K). Namosi: sine loco, FDA 14236 (A, CHR, K, NY). Tailevu: E. of Wainimbuka R., near Ndakuivuna, A. C. Smith 7201 (GH, K, P, US); Colo[Tholo]-i-Suva, Watkins 713 (K); Tamavua, Gillespie 2407 (BO, GH, K, NY, P, US); Kalambo, FDA 16410 (MASS); Naisinu, 150 m., Gillespie 3647 (BISH). Ovalau: Mt. Korotolotolu, W. of Thawathi, A. C. Smith 8021 (GH, K, NY, P, US); W. of Lovoni valley, ridge S. of Mt. Korolevu, A. C. Smith 7542 (GH, K, NY, P, US); E. of Lovoni valley, A. C. Smith 7269 (GH, K, NY, P, US). VANUA LEVU. Mathuata: near Lambasa, Greenwood 507 (K), Mt. Numbuloa, E. of Lambasa, A. C. Smith 6362 (A, K, US), Motuyagaikaveta, 90 m., C.S.I.R.O. S 1404/2 (K); Natidoyaga, Fl. Fiji [FDA] 12910 (K); Seaqaqa, coffee plantation, Fl. Fiji [FDA] 13935 (CHR, K, LAE). Sine loco: Howard 187 (US).

ECOLOGY. Dense or open forest, rarely in grassland; 90-1050 m. alt. Flowering August, and October to January; fruiting mostly May to August (fruit purple).

LOCAL USE. The wood is used for general construction (A. C. Smith & Darwin, *loc. cit.*).

118b. *Calophyllum vitiense* Turrill var. *amblyphyllum* (A. C. Smith & Darwin) P. F. Stevens, comb. et stat. nov.

C. amblyphyllum A. C. Smith & Darwin, Jour. Arnold Arb. 55: 232, figs. 17, 18. 1974, *pro minore parte*. TYPE: Fiji, Viti Levu, Serua, hills west of Waivunu creek, between Ngaloa and Korovou, 50-150 m., 23 Sept. 1953, A. C. Smith 9243 (holotype, US; isotypes, GH, K, NY, P).

C. tenuicrustosum A. C. Smith & Darwin, Jour. Arnold Arb. 55: 236. 1974, *pro minore parte*.

Tree 9-15 meters tall.

Twigs short-tomentose when young; terminal bud plump to conical, 4.5-7 mm. long, with short, tomentose (rarely subcrustaceous), brown indumentum, hairs to ca. 0.25 mm. long. Lamina oblong to subelliptic, (4.3-)6.5-13.6 by 2.7-4.6(-5.2) cm., minutely retuse to rounded (acute) at apex, acute at base, or toward base broadly rounded and at base short-attenuate. Inflorescence axis (1.5-)2.3-6.5 cm. long, short-tomentose toward base; pedicels 0.9-2 cm. long.

DISTRIBUTION. Fiji, Viti Levu.

ADDITIONAL SPECIMENS SEEN. FIJI, VITI LEVU. SERUA: near Taunovo Creek, E. of Wainiyambia, s.l.-50 m., A. C. Smith 9576 (GH, K, NY, P, US); Queen's road, littoral forest, FDA 7036 (BISH). RAVA: Qoyo F.R., 45 m., FDA 13764 (BISH); Goya, 30 m., Damanu E121 (K).

ECOLOGY. Forests near coast, sometimes by sea; below 50 m. alt. Flowering in November.

The epithet *amblyphyllum* means "blunt leaf," so is appropriate for this taxon.

Calophyllum vitiense is a fairly easily recognizable species, having characteristic leaf blades that dry sepia on the upper surface, with the margin and the depressed midrib brighter brown; the venation is rather distant and clear. The fruit has a thin (usually ca. 0.5 mm.) outer layer. The upper surface of the leaf blade is minutely bullate when viewed at a magnification of $\times 30$ or greater; this is most clearly visible in the younger leaves. The epithet *vitiense* is derived from a Latinized form of "Fiji."

The description of the bark is taken from Watkins (*loc. cit.*) and is probably that of *Calophyllum vitiense* var. *vitiense*.

The specimens of *Calophyllum amblyphyllum* included in *C. vitiense* have the characteristic leaf type described above; however, the majority of the specimens included in this species by Smith and Darwin (*loc. cit.*) are here placed in *C. cerasiferum* and *C. neo-ebudicum*. *Calophyllum vitiense* var. *amblyphyllum* differs from var. *vitiense* in having leaf blades that are more or less rounded at the apex, rather than acute to acuminate, and a short terminal bud that often, but not always (e.g., FDA 13764), has short, tomentose

indumentum. The specimens cited under *C. vitiense* var. *amblyphyllum* were all collected at low altitudes, while var. *vitiense* is usually a plant of colline forest.

There is substantial similarity between the large-leaved species of *Calophyllum* from Fiji and Samoa (*C. vitiense*, *C. neo-ebudicum*, *C. cerasiferum*, and perhaps also *C. inophyllum*). All have similar hairs, fruits with stones that have basal plugs, flowers with usually eight tepals, and internodes that are rather short for such large-leaved plants. *Calophyllum vitiense* has sepia-drying leaves with rather distant venation and a minutely bullate upper epidermis; *C. neo-ebudicum* has rather shiny leaves drying other than sepia and with dense venation drying a different color; *C. cerasiferum* has leaves drying dull sepia and with dense, concolorous venation. *Calophyllum inophyllum* is the only species of the group with leaves that are basically rounded at the apex, and it has rather distant venation.

Calophyllum tenuicrustosum was characterized by its flowers, which have more than eight tepals, and by its fruits, which have a thin outer layer. It was compared with *C. cerasiferum*, in part probably because Howard 195, which was included in *C. tenuicrustosum*, is *C. cerasiferum*. Although the type specimen of *C. tenuicrustosum* has a rather narrowly elliptic leaf blade, it has all the other leaf characteristics of *C. vitiense*, including the minutely bullate upper surface. The thin outer layer of the fruit is also characteristic of *C. vitiense*. The fruits of *C. tenuicrustosum* are rather small for those of *C. vitiense* (in the lowest part of the size range for the species), but as the illustration in Smith and Darwin (*loc. cit.*) shows, they are immature: they lack an embryo, and the woody layer is poorly organized. The fruits of FDA 7036 are somewhat more mature and have a basal plug.

It is not certain that *Calophyllum vitiense* grows on Vanua Levu; I have seen only the single unlocalized specimen cited above from there.

The three complementary sheets of *im Thurn* 297 at Kew were designated the lectotype of *Calophyllum vitiense* by Smith & Darwin (*loc. cit.*); Turrill also cited a sterile specimen (*Seemann* 47) in the protolog.

119. ***Calophyllum neo-ebudicum*** Guillaumin, Jour. Arnold Arb. 12: 227. 1931; St. John & A. C. Smith, Pacific Sci. 25: 326. 1971; A. C. Smith & Darwin, Jour. Arnold Arb. 55: 230, figs. 14-16. 1974. TYPE: New Hebrides, Aneityum, Anelgauhat Bay, 25 m., 4 Feb. 1929, *Kajewski* 705 (lectotype, ♀; isolectotypes, ♂, BO, BRI, NY, US).
- C. samoense* Christophersen, Bishop Mus. Bull. 128: 147, fig. 20. 1935; Yuncker, Bishop Mus. Bull. 184: 52. 1943; Parham, New Zealand Dept. Sci. Industr. Res. Inf. Ser. 85: 121. 1972; A. C. Smith & Darwin, Jour. Arnold Arb. 55: 229, figs. 12, 13. 1974. TYPE: Samoa, Savaii, Vaipouli-Manase, 100 m., 21 Sept. 1929, *Christophersen* 720 (holotype, BISH (n.v.); isotypes, ♂, US).
- C. pseudovitiense* P. F. Stevens, Austral. Jour. Bot. 22: 389, fig. 12. 1974. TYPE: Solomon Islands, Guadalcanal, Gold Ridge, 690 m., 16 Oct. 1962, *BSIP* 648 coll. *Whitmore* (holotype, LAE; isotype, SING).
- C. spectabile* auct., non Willd.; Planchon & Triana, Ann. Sci. Nat. Bot.

- IV. 15: 266. 1862, *quoad Abadie* 29; Drake, Illus. Fl. Insul. Maris Pacifici, fasc. 6. 116. 1890, *pro parte*; Drake, Fl. Polynésie Franç. 10. 1893; Hemsley, Jour. Linn. Soc. Bot. 30: 169. 1894; Reinecke, Bot. Jahrb. 25: 656. 1898; Denkschr. Akad. Wiss. Wien. Math.-Naturw. 81: 313. 1910; Lloyd & Aiken, Bull. Lloyd Libr. Bot. 4: 72. 1934; Burrows, Bishop Mus. Bull. 138: 136, 154. 1936; Yuncker, Bishop Mus. Bull. 184: 52. 1945.
- C. vitiense* auct., non Turrill; Setchell, Carnegie Inst. Wash. Publ. 431: 69. 1924; A. C. Smith, Jour. Arnold Arb. 22: 347. 1941; F. S. Walker, Forests Brit. Solomon Is. Protect. 124. 1948; T. C. Whitmore, Guide Forests Brit. Solomon Is. 78. 1966, Gard. Bull. Singapore 22: 12. 1967; Sykes, New Zealand Dept. Sci. Industr. Res. Bull. 200: 100. fig. 9. 1970; Foreman, Check List Vasc. Pl. Bougainville, 42, 86, 87. fig. 1972; A. C. Smith & Darwin, Jour. Arnold Arb. 55: 227. fig. 10. 1974, *pro parte*.
- C. (?)inophyllum* auct., non L.; Guillaumin, Jour. Arnold Arb. 12: 227. 1931.
- C. amblyphyllum* A. C. Smith & Darwin, Jour. Arnold Arb. 55: 232. fig. 19. 1974, *pro minore parte*.
- C. leptocladum* A. C. Smith & Darwin, Jour. Arnold Arb. 55: 221. 1974, *pro minore parte*.
- Calophyllum* sp. Burkill, Jour. Linn. Soc. Bot. 35: 27. 1901.

Tree 6-8 meters tall, d.b.h. to 184 cm.; trunk rarely with buttresses to 1.3 meters tall; outer bark gray to yellowish mottled at first, with brown and pinkish patches intermingled, later brown, deeply fissured, not hoop marked, the inner surface blackish; under bark reddish; inner bark reddish, fibrous; latex yellow (rarely cream), clear, but tending to become turbid, sticky. Crown pyramidal when young, becoming cauliflower shaped with age.

Twigs slightly flattened, 1.5-4 mm. across, obscurely 4-angled, drying brown to blackish, puberulent to short-tomentose when young; axillary innovations lacking basal scars; internodes 0.7-4 cm. long; uppermost pair of axillary buds rounded, to 2 mm. long, \pm erect; terminal bud plump (rarely conical), 0.4-1.5 cm. long, with grayish to ferruginous, puberulent to short-tomentose indumentum (hairs, FIGURE 35, h, j, m-o), underdeveloped internode to 4 mm. long. Petiole 0.6-3.7 cm. long, broadly concave above, convex below, often drying blackish, glabrous when mature; lamina rather narrowly ovate to elliptic (rarely suboblong), (4-)5-19.5 by 1.5-7.3 cm., acuminate (obtusate) at apex, cuneate to narrowly acute or attenuate at base, undulate but slightly or not recurved at margin, coriaceous, drying olivaceous to umber above, often nitid, margin and midrib often paler, and fulvous to near dark olive-buff below, glabrous to subsersistently puberulent on midrib below, the midrib above gradually narrowed from base, depressed, margins usually raised, becoming raised toward or above midpoint, (0.1-)0.2-0.5(-0.8) mm. across at midpoint, below raised, angled toward apex, striate toward base, the venation \pm apparent above and below, raised, latex canals \pm raised or not, 7 to 14 veins/5 mm., angle of divergence 60-80°. Inflorescences from upper foliate axils (rarely terminal), with 7 to 17 flowers, unbranched (very rarely with

3-flowered branches to 1 cm. long, or flabellate), the axis 1.5-9.2(-13) cm. long, puberulent or short-tomentose, especially toward base (glabrous above), lowest internode 0.4-3.3(-4.5) cm. long; bracts ovate, to 5 mm. long, not persistent; pedicels 0.7-2 cm. long, glabrous to puberulent. Flower (?) hermaphroditic; tepals 8 (to 12), the outer pair ovate to suborbicular, 2.5-5.5 by 2.7-4 mm., back sometimes puberulent toward base, the inner ones elliptic to obovate, 7-10 by 3.5-6 mm.; stamens 150 to 275, the filaments to 5.5 mm. long, the anthers elliptic or suboblong, 0.4-1.2 mm. long, retuse at apex; ovary 1.5-2.5(-3) mm. long, the style 2.5-3 mm. long, the stigma peltate or infundibular, 0.5-1 mm. across, 3- or 4-radiate or not. Fruit ovoid or ellipsoid to subspherical, 2.1-3.7(-4.3) by 1.5-2.8 cm., \pm rounded at apex, drying vinaceous-brown to blackish and pruinose, broadly and \pm deeply wrinkled to smooth; outer layer usually not detaching cleanly from stone, (0.5-)-1-3 mm. thick, compact, usually with air spaces developing adjacent to skin and stone (throughout); stone ovoid or ellipsoid to subspherical, (1.5-)-1.8-3.2(-4) by (1-)-1.3-2.5 cm., rounded to obtusely pointed at apex, the walls (0.7-)-1.3-2.1(-3.3) mm. thick, smooth, unmarked, with basal plug 6-10 mm. across; spongy layer thin.

DISTRIBUTION. (?) Celebes, New Britain, and Bougainville, to the New Hebrides, Fiji, Samoa, and Tonga (MAP 38).

SELECTED SPECIMENS SEEN. **Celebes.** SALAJAR: Lembang, Djampea, 245 m., *bb 2947* (?) (BO). **Papuaia and adjacent islands:** see *C. pseudovitiense*, Stevens, *loc. cit.* **Pacific Islands.** FIJI. Moala: near Maloku, 200 m., *A. C. Smith 1334* (BO, GH, K, NY, P, US). Naitamba: sine loco, *FDF L12384* (BISH). Mango: sine loco, 50-100 m., *Bryan 569* (A). Viti Levu. Mba: mountains near Lautoka, 360 m., *Greenwood 907* (A); Mt. Evans Range, 610 m., *Greenwood 1232* (US). Sine loco, *Gräffe s.n.* (NY, W). Ovalau: sine loco, *Horne 43* (K). Koro: main ridge, 300-500 m., *A. C. Smith 1047* (BO, GH, K, NY, US). Vanua Levu. Mathuata: Mt. Numbiloa, E. of Lambasa, 500-590 m., *A. C. Smith 6449* (A, K, NY, P, US). Thakaundrove: near Valeni, *FDA 15722* (?) (BISH); valley of Navonu Creek, 305 m., *Howard 104* (BISH, CHR, US). TONGA. Vava'u, sine loco, *Crosby 204* (K); Kao, *Yuncker 15883* (BM, U, US, W); 'Eua, near center of island, 240 m., *Yuncker 15326* (BISH, BM, US). **HORNE ISLANDS AND SAMOA:** see *C. samoense*, Smith & Darwin, *loc. cit.* Also, Samoa: Upolu, Vaiaberg, *Rechinger 1399* (W); bei Tiari, *Rechinger 1317* (W); bei Utumapu, *Rechinger 941* (W). NIUE: Ana, near Hakapu-Liku road, *Sykes 821A* (BISH, CHR); Huvalu Forest, *Sykes 399* (CHR). **NEW HEBRIDES:** see *C. neo-ebudicum*, Smith & Darwin, *loc. cit.*

ECOLOGY. Usually primary lowland to colline rainforest, to 825 m. alt. Often abundant, especially in Solomon Islands and New Hebrides, favoring ridges and other well-drained habitats. In New Hebrides common in Kauri (*Agathis*) forests; *Agathis* regenerates in gaps resulting from death of mature *C. neo-ebudicum* (Beveridge, 1975). Sometimes on coralline limestone in Fiji and the Horne Islands, rarely so elsewhere. Flowering in Solomon Islands February, April, May, July to December; elsewhere September to February (flower scented). Fruiting more or less year around in both areas (fruit pale green at first, turning bluish to purple-black when ripe).

Details of the establishment of *Calophyllum neo-ebudicum* on Kolombangara (the Solomon Islands) are given by Whitmore (1974, as *C. vitiense*). The fruits are well dispersed, and the seedling grows to adult size in closed forest as well as in gaps.

GERMINATION AND YOUNG PLANT. The radicle pushes out a basal plug during germination. The seedling has two (Sykes 823), three, or four pairs of leaves; when there are four pairs, some leaves are always very much reduced (1-4 mm. long) and soon fall off; the internodes are 1-2.2 cm. long. Subsequent growth is erect, the terminal bud is functional, and the internodes gradually become longer. (Sykes 823; LAE 50491.)

LOCAL NAME AND USES. "Gwarangaro" (Kwara'ae). Through much of the range of the species, the timber is used for building canoes; more locally it is used for building houses or in making spears or bowls. Hair oil is made from the flowers (Fauro Islands). In Malaita small saplings, with the outer layer of the bark removed to give bright, saffron-colored sticks, are reported to have been used in bride purchase.

Calophyllum neo-ebudicum can be recognized by its frequently dark-drying twigs and leaf stalks and by its ovate-elliptic lamina, the upper surface of which often dries somewhat nitid greenish and has a depressed midrib. The predominantly eight-lobed flowers have small anthers and a short (less than 3 mm.) style. The spherical to ovoid-ellipsoid fruits dry more or less smooth and have a rather thick outer layer and a moderately thick stone; the stone has a basal plug. Indumentum on parts of the plants other than the terminal bud is usually inconspicuous. The specific epithet is derived from a Latinization of "New Hebrides."

The single specimen cited from the Celebes, *bb* 22947, may not belong here. The specimen is sterile, and fertile material, preferably in fruit, is needed to confirm the record.

A number of specimens from throughout the range of the species have terminal inflorescences, but are not otherwise unusual. *FDA* 15722, cited by Smith and Darwin as *C. leptocladum*, has very small, coriaceous leaf blades that dry the color of those of *C. leptocladum* but have the midrib of those of *C. neo-ebudicum*; its terminal bud and infructescence are also like *C. neo-ebudicum*. In vegetative characters *BSIP* 8876 is like *C. neo-ebudicum*, but the thin, sharply wrinkled outer layer of the fruit is like that of *C. inophyllum*; fruit shape is intermediate between those of the two species. *Greenwood* 1232 has exceptionally thick-walled stones (measurements in parentheses); the specimen consists only of fallen leaves and fruit.

Calophyllum pseudovitiense and *C. neo-ebudicum* cannot be separated since they have similar leaves, inflorescences, and flowers, and the anthers of both are small.

Smith and Darwin (*loc. cit.*) separated *Calophyllum samoense* from *C. neo-ebudicum* predominantly on fruit characters. *Calophyllum neo-ebudicum* had fruits that were definitely longer than broad and a firmly fibrous mesocarp 1-4 mm. thick that did not fall away from the endocarp (their terminology)

and leave air cavities, while *C. samoense* had ovoid or subglobose fruits and a fibrous-spongy mesocarp 3.5–6 mm. thick with prominent cavities. The fruits of *C. neo-ebudicum* figured by Smith and Darwin (from *Kajewski* 399) are immature; those of *Kajewski* 953, which are submature, have cavities immediately under the skin. The fruits of *Bristol* 2248 (originally determined as *C. samoense*) have a subcompact outer layer with cavities under the skin and adjacent to the stone, although in most other fruiting specimens of *C. samoense* the cavities have invaded the entire outer layer. All these specimens have ripe or nearly ripe fruits, and the development of cavities seems to be a part of the ripening process. However, both in *C. neo-ebudicum* from the Solomon Islands (e.g., *BSIP* 79; seed possibly not developing) and in specimens placed by Smith and Darwin (*loc. cit.*) in *C. amblyphyllum*, but properly identified as *C. neo-ebudicum* (e.g., *A. C. Smith* 6449; nearly mature), the outer layer may be almost compact. Although the fruits of *C. samoense* tend to be broader than the others, this is not an absolute difference, specimens with similar fruits having been collected from the Solomon Islands (e.g., *BSIP* 6255, Ulawa Island). Of the specimens originally included in *C. amblyphyllum* but correctly placed here, *A. C. Smith* 6449 (Fiji) has fruits about 1/4 times longer than broad, while those of *Yuncker* 15583 (Tonga) are almost spherical. Fruits from Niue seem to be longer than broad (*Sykes* 821A). Specimens of all taxa discussed have stones with thick walls and a plug at the base that presumably becomes detached during germination, and the ripe fruits are reported to be (pruinose) dark purple, black, or sometimes brown. There are no vegetative differences between the specimens of the various taxa placed in synonymy, and in most details of flower and inflorescence they are also similar. However, in specimens of *C. neo-ebudicum* the anthers are 0.4–0.8 mm. long, while in those referable to *C. samoense* they are (0.5–)0.7–1.2 mm. (Anther length is known from only a single Fijian collection (*Gräffe s.n.*, from Viti Levu); the anthers are ca. 1 mm. long.) Specimens in flower have not yet been collected in Niue. Smith and Darwin (*loc. cit.*) note that *C. neo-ebudicum* and *C. samoense* were reported to have differences (unspecified) in general aspect, bark, and wood, and that *C. samoense* grew on coralline limestone, while *C. neo-ebudicum* never did. However, on Samoa itself *C. samoense* does not seem to have been collected on limestone, and it certainly grows on other rocks.

Although specimens assignable to *Calophyllum samoense* show certain differences when compared to other specimens placed in *C. neo-ebudicum*, such as somewhat longer anthers, relatively broader fruits, and twigs that more frequently dry brown, there is overlap in these characters between specimens from Samoa, Tonga, and the Horn Islands and those from the rest of the range of the species. Furthermore, the length of the anthers is not known in some parts of the range of the species (see above). It thus seems unwise to recognize any infraspecific taxa within *C. neo-ebudicum* at present.

Variation in hair type in *Calophyllum neo-ebudicum* is considerable. The variation in *BSIP* 429 alone bridges the gap between the large, erect hairs of *Kajewski* 2643 and the more normal, small, papillate, adaxially curved

hairs of most other specimens, including those that have been called *C. samoense* (FIGURE 35, h, n).

I have not seen *Abadie* 29, on which Planchon and Triana (*loc. cit.*) based their record of *Calophyllum spectabile* in the Society Islands, but it probably belongs here.

It should be noted that *Calophyllum neo-ebudicum* must be lectotypified on the sheet of *Kajewski* 705 in the Muséum d'Histoire Naturelle at Paris (cf. Smith & Darwin, *loc. cit.*). Guillaumin worked on the set of *Kajewski's* specimens deposited in the herbarium there.

120. *Calophyllum cerasiferum* Vesque, *Epharosis* 2: t. 32. 1889, in C. DC. Monogr. Phanerog. 8: 585. 1893; Parham, *Pl. Fiji Is.* ed. 2. 192. 1972; A. C. Smith & Darwin, *Jour. Arnold Arb.* 55: 235, *figs.* 20, 21. 1974. TYPE: Fiji [Viti Levu, Namosi Province], Voma Peak, 24 August 1860, *Seemann* 49 (lectotype, G; isolectotypes, BM, G, GH, K, P).

C. burmannii auct., non Wight; Seem. *Bonplandia* 9: 254. 1861, Viti, 433. 1862; Horne, *Year Fiji*, 258. 1881; Drake, *Illus. Fl. Insul. Maris Pacifici*, fasc. 6. 116. 1890.

C. burmannii Wight var. *parvifolium* auct., non Wight; Seem. *Fl. Vit.* 11. 1865.

Calophyllum sp. nov. Horne, *Year Fiji*, 258. 1881.

C. amblyphyllum A. C. Smith & Darwin, *Jour. Arnold Arb.* 55: 232. 1974, *pro parte*.

Tree 12.5–25 meters tall, d.b.h. to 60 m.; trunk (?) without buttresses; outer bark yellowish, rough to smooth, with wide vertical erodes (?fissures); inner bark red; latex yellow (*A. C. Smith* 4944), white (*A. C. Smith* 8378), or opaque (*Howard* 336).

Twigs slightly flattened, (1.7–)2.5–4.5(–7) mm. across, \pm 4-angled at first, becoming coarsely striate, with ca. 8 raised lines, drying dark brown when young, later brown and yellowish white, sparsely farinose when young; axillary innovations lacking basal scars; internodes 0.5–2.5(–3.5) cm. long; uppermost pair of axillary buds rounded, to 2 mm. long, \pm spreading; terminal bud plump, 0.5–1.6 cm. long, with subcrustose, grayish brown indumentum (hairs, FIGURE 35, q–s, z), underdeveloped internode absent. Petiole (0.5–)0.8–2(–2.8) cm. long, flat or broadly to rather narrowly concave above, convex or \pm angled below, often drying blackish, glabrous when mature; lamina elliptic to oblong, (3.2–)4.5–16 by (1.5–)2–6.8 cm. (ca. 15 by 4 cm.), shortly and rather abruptly acuminate to rounded at apex, attenuate at base, or broadly rounded toward base and attenuate at very base, undulate and slightly to strongly recurved at margin, coriaceous, drying \pm sepia above and honey to amber below, farinose on midrib below when young, the midrib above \pm abruptly narrowed near or gradually narrowing from base, subdepressed, the margins raised or not, becoming level or slightly raised, 0.15–0.5(–0.8) mm. wide at midpoint, below strongly raised, angled toward apex, striate toward base, the venation subobscure to subapparent above and below, slightly raised, (6 to) 11 to 18 veins/5 mm., angle of divergence 65–80(–85)°.

Inflorences from foliate axils, with (3 to) 5 to 9 (to 13) flowers, unbranched (rarely with 3-flowered branches up to 3.5 cm. long), the axis (1.1-)2-5.8(-10) cm. long, farinose (rarely subglabrous) when young, lowest internode 1-3 (-4.5) cm. long; bracts ovate, ca. 5 mm. long, soon deciduous; pedicels 0.4-2.3 cm. long, sparsely farinose when young. Flower (?) hermaphroditic; tepals 8 to 12, the outer pair broadly ovate to suborbicular, 4.75-7.5 by 4.5-6.5 mm., the next pair broadly ovate to oblong or elliptic, 4.5-9 by 4-7 mm., the inner ones ovate to elliptic or oblong, 6.5-11 by 2.5-7 mm.; stamens (80 to) 120 to 250, the filaments to 4.5 mm. long, connate for up to 1 mm., the anthers elliptic to suboblong, 0.3-1.4 mm. long, retuse at apex; ovary 1-2 mm. long, the style 1-2.5 mm. long, the stigma peltate to infundibular, ca. 1 mm. across, not lobed. Fruit spherical to ellipsoid, 1.8-3.2 by 1.7-2.4 cm., rounded to subacute at apex, drying vinaceous-brown to orange-cinnamon, smooth to sharply wrinkled; outer layer detaching \pm cleanly from stone, (0.8-)1-2.5 mm. thick, compact but skin often breaking off easily in ripe fruits; stone ellipsoid to subspherical, (1.6-)2.1-2.5 by 1.5-2.1 cm., \pm rounded at apex, the walls 1-1.6 mm. thick, smooth, unmarked, with basal plug to 1 cm. across; spongy layer thin.

DISTRIBUTION. Fiji Islands (MAP 38).

ADDITIONAL SPECIMENS SEEN. **Pacific Islands.** FIJI. *Sine loco*: *Horne s.n.* (GH). Viti Levu, Mba: vicinity of Nandarivatu, S. slopes of Mt. Ndelainathovu, 870-890 m., *A. C. Smith 4944* (A, K, NY, P, US), Sovutuwambu, 750-800 m., *Degener 14664* (A, K, NY), Waimoqi, 823 m., *FDF 1075* (K), Vunidawa Path, 823 m., *Vaughan 3431* (BM, K), Waimongge Creek, 610 m., *Berry 82* (MASS, US), *85* (MASS), *88* (MASS), *Damanu K88* (CHR, US). Nandronga & Navosa: S. of Mt. Victory [Tomanivi], 914 m., *FDA 14292* (BISH, K); track to Vanua Levu village, 610 m., *Berry 79* (CHR, MASS); Rairamatuku Plateau, between Nandrau and Nanga, 725-825 m., *A. C. Smith 5461* (A, K, NY, P, US). Serua: Nabukelevu, *FDA 15654* (CHR, MASS); Naboutinini, 150 m., *Damanu R22* (K), *FDF 573* (BISH); Ngaloa, 210 m., *Damanu G22* (K, NY), *FDF 574* (BISH). Namosi: hills bordering Wainavindrau Creek, near Wainimakatu, 150-250 m., *A. C. Smith 8525* (GH, K, NY, P, US), *8553* (GH, K, NY, US); hills near Navua R., 200-300 m., *Greenwood 1036* (A, K); Mt. Vakarongasiu, *Gillespie 3267* (BISH); Mt. Voma Track, 610 m., *FDA 604* (SUVA). Naitasiri: Nanubu R., Rewasau, 914 m., *Howard 308* (SUVA, US); Mendrausuthu Range, 751 m., *FDA 15463* (CHR, MASS, SUVA), *15471* (CHR, LAE); Mt. Naitarandamu, *Gillespie 3232* (GH). *Sine loco*, *Macgillivray & Milne 67* (K). Vanua Levu. Mathuata: Sasa [Tikina], *Howard 195* (MASS). Thakaandrove: Yanawai R. region, Mt. Kasi, 300-430 m., *A. C. Smith 1789* (?) (BO, GH, K, NY, P, US). Taveuni: near Crater Lake E. of Somosome, 600-900 m., *A. C. Smith 8378* (GH, K, NY, P, US); Wailotua-Wainibuka, *Howard 336* (CHR); E. of Wairiki, valley between Mt. Manuka and Mt. Koroturanga, 600-700 m., *A. C. Smith 8286* (GH, K, NY, P, US). *Sine loco*: *Milne 244* (K).

ECOLOGY. Colline and lower montane forest, on ridges and summits at higher altitudes (stunted tree in exposed conditions); 150-1250 m. alt. Flowering March, June, and November; fruiting June, and August to November (fruit reddish tinted—*A. C. Smith 8525*).

LOCAL USE. The wood is good timber and is used in construction.

Although *Calophyllum cerasiferum* is a variable species, it can be characterized by its rather plump terminal bud with more or less crustaceous, grayish brown indumentum; its twigs, which dry yellowish brown and coarsely striate; its coriaceous leaf blades, which have dense venation and dry sepia on the upper surface; and its fruits, which have a more or less compact outer layer and a thick-walled stone with a basal plug. The epithet *cerasiferum* ("bearing cherries") alludes to the dried fruits, which are about the size of large cherries.

The circumscription of *Calophyllum cerasiferum* has been somewhat troublesome. It was originally decided to recognize two taxa: one including the large-leaved and -fruited specimens, with leaf blades sometimes strongly recurved at the margins and acuminate at the apex; the other, *C. cerasiferum* sensu stricto, including the smaller-leaved and -fruited specimens with the leaf blades only slightly recurved at the margin and more or less rounded at the apex. The fruits of the former group of specimens are wrinkled, while those of the latter are smooth. However, there are all intermediates in leaf size and type: *Damanu* G22 (large, strongly revolute blades); *A. C. Smith* 8525 (large, not very revolute blades); *A. C. Smith* 5461 (smaller blades); *A. C. Smith* 4944, *FDF* 1075, *FDA* 14292, and *Berry* 79 (small leaves acute at the apex; fruit wrinkled); *Seemann* 49 (leaves obtuse, fruit \pm smooth). There is considerable variation in the width of the leaf blade in both small- and large-leaved specimens. In details of terminal bud, hair type, leaf (apart from its size and apex), and fruit (except for the surface), the specimens are all basically similar.

A. C. Smith 4944 is the only large-leaved specimen that has flowers; the flowers have eight tepals, and the filaments appear to have a yellow pigment. Of the smaller-leaved specimens, *Howard* 195, *Berry* 82, *Berry* 88, and *FDA* 15463 have flowers; all have ten to twelve tepals, and there is no pigment in the filaments. Within these latter specimens there is considerable variation in anther size: the anthers of *Berry* 88 are up to 1.5 mm. long, while those of *FDA* 15463 are only 0.3–0.5 mm.

Thus, despite the considerable variation in the group, all specimens have a basic similarity. In some characters the variation is continuous and is independent of variation in other characters; in others (notably those of the flower), there is too little material to evaluate the variation. Hence, it seems sensible to adopt broad limits for *Calophyllum cerasiferum*, at least for the time being.

Greenwood 1036, which was apparently collected from a young tree of *Calophyllum cerasiferum*, has leaves with a lamina up to ca. 22.5 by 5.5 cm. *A. C. Smith* 1789 is included in *C. cerasiferum* only with hesitation. With its broad midrib (figure in parentheses in the description above) and its rather distant venation (6 to 8 veins/5 mm.) it approaches *C. vitiense*; however, it has a coriaceous lamina with a recurved margin, and its twigs, although much stouter than those in other specimens of either species, are more similar to those of *C. cerasiferum* than to those of *C. vitiense*. Its

inflorescences are extremely robust (measurements in parentheses in the description above).

Calophyllum cerasiferum has been lectotypified on the duplicate of *Seemann 49* once in the Boissier Herbarium in Geneva and now in the general herbarium there. It seems that Vesque based his original illustration of *C. cerasiferum* on this specimen, rather than on the duplicate at Kew Herbarium. Thus, the typification of *C. cerasiferum* by Smith and Darwin (*loc. cit.*) has to be slightly emended.

121. *Calophyllum* sp.

FIGURE 36, m-o.

Tree ca. 12 meters tall; trunk and bark unknown.

Twigs slightly flattened, 1.2-2.5 mm. across, obscurely 4-angled, drying blackish, grayish- to brown-puberulent; axillary innovations lacking basal scars; internodes 0.5-2.5 cm. long; uppermost pair of axillary buds ca. 1.5 mm. long, rounded, subspreading; terminal bud plump, 5-9 mm. long, with grayish to brown, crustaceous to puberulent indumentum (hairs, FIGURE 35, p; cf. 35, o), underdeveloped internode to 2 mm. long. Petiole 0.3-1.2 cm. long, shallowly concave above, convex below, glabrescent; lamina ovate to rhombiform, 2.8-8.6 by 1.3-2.5 cm., acuminate at apex, acute to narrowly acute at base, somewhat undulate and slightly recurved at margin, coriaceous, drying \pm sepia above and sepia to sabelline below, glabrous when mature, the midrib above narrowing gradually from base, \pm level or slightly depressed, 0.3-0.4 mm. wide at midpoint, below rather inconspicuous, raised, striate, the venation above and below subobscure to apparent, raised, 10 to 15 veins/5 mm., angle of divergence 55-70°. Inflorescences from foliate axils, with 7 to 15 flowers, unbranched, the axis 1.4-3 cm. long, puberulent, lowest internode 3-7 mm. long; bracts unknown; pedicels 0.5-1 cm. long, puberulent. Flower (?) hermaphroditic; tepals 8, the outer pair broadly ovate, 4.5-5 by 3.5-4.5 mm., the next pair elliptic, 7 by 5 mm., to suborbicular, 5.3 by 6 mm., the inner ones elliptic, 6-7.5 by 3-4 mm.; stamens 120 to 145, the filaments to 4.5 mm. long, the anthers oblong, ca. 1 mm. long, retuse at apex; ovary ca. 1.5 mm. long, the style 2.5-3 mm. long, the stigma peltate, 0.6-0.8 mm. across, obscurely radiate. Fruit ellipsoid, 1.9-2.3 by 1.4-1.8 cm., persistently apiculate or not, drying vinaceous-brown, \pm wrinkled; outer layer detaching \pm cleanly from stone, ca. 1 mm. thick; stone ellipsoid, 1.3-1.8 by 1.3-1.5 cm., rounded at apex, the walls 0.4-0.9 mm. thick, ca. 2 mm. at base and ca. 0.25 mm. to one side of base, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Philippine Islands, LUZON (MAP 39).

SELECTED SPECIMENS SEEN. **Philippines.** LUZON. Bataan: Lamao R., Mt. Mariveles, *Whitford 257* (P, G, K, NY, P, US), 1017 m., *Williams 424* (GH, K, NY, US); Lamao F.R., *BS 1577* (US).

ECOLOGY. Lower montane forest, ca. 1000 m. alt. Flowering in January; fruiting March, May, July, October, and November.

Calophyllum sp. 121 can be characterized by its plump terminal bud and

its medium-sized lamina that is acute to acuminate at the apex, with the midrib on the upper surface drying reddish brown. The inflorescence is rather short, and the flowers have eight tepals. The fruit is relatively large (ca. 2 cm. long) and has a rather thin outer layer and a stone that lacks a basal plug.

Although in general appearance *Calophyllum* sp. 121 is similar to *C. neo-ebudicum*, the stone lacks the basal plug characteristic of that species; the hairs suggest a comparison with *C. whitfordii* (cf. FIGURES 35, p, and 43, q, s, y). Until *Calophyllum* sp. 121 is better known, it is premature to describe it formally.

In leaf and twig there is considerable variation among the specimens cited. *BS 1577* and *Whitford 1190* have short, rather thickly coriaceous leaf blades with rather dense venation, and stout twigs with short internodes, while *Williams 424* has longer, thinner leaf blades with more distant venation, and thinner twigs with longer internodes. There is no comparable variation in the fruit, and in all specimens the midrib on the upper surface of the lamina narrows gradually from the base and is reddish.

122. *Calophyllum caledonicum* Vieill. ex Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 291. 1862; Vesque, Epharosis 2: t. 3. 1889, in C. DC. Monogr. Phanerog. 8: 546. 1893; Guillaumin, Ann. Mus. Colon. Marseille, II. 9: 102. 1911; Baker f. Jour. Linn. Soc. Bot. 45: 273. 1921; C. T. White, Jour. Arnold Arb. 7: 95. 1926; Daniker, Mitt. Bot. Mus. Zurich 112: 271. 1933; Guillaumin, Fl. Nouv. Caléd. 217. 1948; Sarlin, Bois Forêts Nouv. Caléd. 206. pl. 91. 1954. TYPE: New Caledonia, bords des ruisseaux à Gatope, anno 1886, *Vieillard 175* (lectotype, ♀; (?)-isolectotypes, A, K, NSW).

C. montanum Vieill. ex Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 292. 1862; Vieill. Ann. Sci. Nat. Bot. IV. 16: 74. 1862; Schlechter, Bot. Jahrb. 39: 193. 1906; Guillaumin, Ann. Mus. Colon. Marseille, II. 9: 102. 1911; Sarlin, Bois Forêts Nouv. Caléd. 308. pl. 93. 1954. TYPE: New Caledonia, montagnes à Balade, *Vieillard 174* (holotype, ♀; isotypes, A, FI, G, L, P).

Tree 3-10(-720) meters tall, d.b.h. to 30 cm.; trunk without buttresses; outer bark brown to gray, fissured, thick; wood reddish.

Twigs slightly flattened, 3-4.5 mm. across, 4- (very rarely 2-)angled when young, soon becoming coarsely striate, drying brown when young, later often with yellowish patches, sparsely farinose-puberulent when young; axillary innovations lacking basal scars; internodes 0.7-3.5 cm. long; uppermost pair of axillary buds rounded, to 1.5 mm. long, suberect, inconspicuous; terminal bud plump, 0.75-1.2(-1.8) cm. long, with short-tomentose to subcrustaceous, grayish to brown indumentum (hairs, FIGURE 35, t-w), underdeveloped internode absent (to 3.5 mm. long). Petiole (0.2-0.5-1.5(-2.5) cm. long, flat to broadly concave above, convex below, glabrous when mature; lamina oblong to elliptic, 5-14.3 by 1.8-3.6(-4.5) cm., rounded (rarely acute to subacuminate) at apex, acute to broadly rounded at base, slightly undulate,

slightly or not recurved at margin, coriaceous, drying amber to olivaceous above and below, glabrescent or sparsely and subsperiscently farinose on midrib below, the midrib above narrowing rather quickly near base, broadly depressed at first, 0.2-0.6 mm. wide at midpoint, becoming raised in top $\frac{1}{3}$ of lamina, below raised, striate (rarely angled), the venation above and below apparent, raised, (6 to) 8 to 13 veins/5 mm., angle of divergence 70-85(-90)°. Inflorescences from foliate axils (very rarely terminal), with (5 to) 11 to 25 flowers, unbranched (rarely with 5-flowered branches up to 4 cm. long), the axis (3-)5-10(-21) cm. long, transiently puberulent or subglabrous, lowest internode 1.5-4(-8) cm. long; bracts narrowly ovate to elliptic, to 11 by 3 mm., not persistent; pedicels 0.7-2(-3.5) cm. long, glabrous to puberulent. Flower (?)hermaphroditic; tepals (9 to) 12 (to 16), the outer pair \pm orbicular, 4-8 by 2.7-7 mm., the inner ones elliptic to obovate, (7-)10-12.5 by (2-)3.5-7 mm., outer tepals larger and inner ones glabrous; stamens 330 to 430, the filaments to 4.5 mm. long, the anthers elliptic to suboblong, 0.7-1.1 mm. long, rounded to retuse at apex; ovary ca. 1.8 mm. long, the style 2-3 mm. long, the stigma subpeltate, ca. 0.7 mm. across. Fruit spherical to ellipsoid, 1.7-2.7 by 1.2-2.2 cm., rounded to obtuse at apex, drying \pm vinaceous-brown, smooth or broadly wrinkled; outer layer detaching cleanly from stone, 1-4.5(-10) mm. thick, compact, air spaces developing under skin or not; stone spherical to ellipsoid, 1.2-1.8 by 0.9-1.6 cm., rounded to acute at apex, the walls 0.2-1 mm. thick, smooth, unmarked, at base poorly defined semifibrous (?)plug ca. 5 mm. across; spongy layer thin.

DISTRIBUTION. New Caledonia (MAP 38).

SELECTED SPECIMENS SEEN, New Caledonia: Balade, *Viellard* 175 (G, P); sommet de Puébo, *Viellard* 174 (G, GH, K, L); Wagap, *Viellard* 173 (P); So. base of Mt. Kaala, *McKee* 7985 (CANB, K, L, P, US); vallée de Pouai (entre Ta et la Ouaine), 20-100 m., *McKee* 15618 (P); Chagrin Mine, Koumac Distr., *McKee* 7996 (A, CANB, K, L, P, US); Hienghène, *McKee* 26918 (P); Koné, Pinjen, 10 m., *McKee* 29360 (P); bords de la Oumbea, au dessus de Koè, *Balansa* 1335 (G, K, P, US); Bourail, col des Rouseilles, *Sarlin* 151 (P); Haute Boulari, flancs du Pic Buse, 500 m., *Viro* 522 (A, P); banks of Toutouta R. near junction of the Kalouéholo, 50 m., *McKee* 7732 (A, CANB, K, L, NSW); Kanala, *Viellard* 175 (NSW, NY, P); Bergen am Ngoye, 100 m., *Schlechter* 15241 (BM, E, F, G, K, L, M, NSW, P, W); am Südwestfüsse des Mt. Humboldt, *Daniker* 573 (P); Paita, *Le Rat* 82 (P); forêts de la Caricouye, 200-400 m., *Franc* 39 (A, G, NY); Noumea, *Gandoger* s.n., June 1906 (M); montagnes de St. Louis, *Pompéry* s.n., anno 1881 (P); Col de Plum, *Baumann-Bodenheim* 16088 (A); route de la montagne des Sources, 500 m., *McKee* 24840 (P); Plaine des Lacs, Mois de Mai forest, 250-350 m., *Buchholz* 1383 (A, BISH, K, P, US); Route de Yaté, *Sarlin* 165 (P); Prony, 2 m., *Balansa* 584 (BM, K, P); Baie de Sud, *Raoul* s.n. (P).

ECOLOGY. On serpentine rocks by rivers, on schists away from rivers; to 500 m. alt. Flowering November to February, and August (flower sweetly scented (like those of oranges—*Viro* 1340)); fruiting September to January (fruit blue to black, glaucous).

GERMINATION AND YOUNG PLANT. The seedling has three pairs of leaves separated by well-developed internodes at least 1 cm. long. (*McKee 24841*.)

Calophyllum caledonicum can be recognized by its plump terminal bud; stout twigs, which dry yellowish and striate when old; more or less oblong leaves that have clear venation and a depressed midrib; and flowers, which have at least nine tepals. The specific epithet comes from the Roman name for Scotland.

Calophyllum caledonicum is perhaps related to the *C. vitiense*-*C. cerasiferum* group of species; particularly in its terminal bud, twig, and flower, it is most similar to *C. cerasiferum*. However, it is not clear that *C. caledonicum* has a plug at the base of the stone like the other members of the *C. vitiense* group.

Vesque (1893, *loc. cit.*) thought that *Calophyllum inophyllum* and *C. caledonicum* were close, since both have flowers with a large number of tepals. However, *C. inophyllum* usually has only eight tepals, and it further differs from *C. caledonicum* in having a shorter terminal bud, a more or less obovate, thinner lamina, longer pedicels, and a larger fruit that differs in structure and is pale green when ripe. The two species are probably not particularly closely related (but see below).

Variation within *Calophyllum caledonicum*

Planchon and Triana noted that *Calophyllum montanum* had leaves in whorls of four, or almost in whorls, or sometimes only opposite. On some sheets bearing the same number as the lectotype of *C. caledonicum* (*Vieillard 175*; see below), the leaves are alternate. Few subsequent collections have whorled leaves. Those of *Sarlin 278* are in whorls of four, while those of *McKee 20797* and *McKee 15618* are in whorls of three. Five shoots of *McKee 20797* were seen at Paris: two of the five had opposite leaves, and three had leaves in threes; all shoots came from the same tree (*McKee, pers. comm.*). The arrangement of the leaves in whorls on one of the shoots had broken down in an older part of the shoot, with scars of alternate, opposite, and "adjacent" leaves (i.e., leaves borne two at a node, but adjacent, rather than opposite, in insertion). Although specimens with whorled leaves tend to have long petioles and blades that are more or less acuminate at the apex, there are intermediates in these characters as well. The fruits of *McKee 20797* are broadly ellipsoid, ca. 2.4 cm. long, and with a stone ca. 1.7 cm. long. The as yet immature fruits of *McKee 15618* are ovoid and ca. 2.7 cm. long, but the stone is only ca. 1.4 cm. long, the outer layer being up to 1 cm. thick—over twice as thick as is usual in the species. Although the whorled arrangement of the leaves of the specimens discussed is a remarkable character, it is unstable and does not correlate with other characters. *Calophyllum montanum* is left in synonymy under *C. caledonicum*, as was first suggested by Vesque (1893, *loc. cit.*).

Viot 511 and *522*, both sterile specimens, have the midrib on the lower surface of the lamina angled rather than striate; the young stem is strongly two- (vs. four-)angled.

Nomenclature

The sheet of *Vieillard 175* at Paris with a locality label "bords des ruisseaux à Gatope" is designated the lectotype of *Calophyllum caledonicum*. Other sheets, possibly isolectotypes, bear a label "bords d'un torrent à Gatope."

Possible Hybridization with *Calophyllum inophyllum*

Two specimens collected from the southern end of New Caledonia (Goro, *Sarlin 182* (v); Baie du Prony, *Balansa 585* (v)), are intermediate between *Calophyllum caledonicum* and *C. inophyllum*. The lamina is up to 20 by 5-8 cm. and has 5 to 8 veins/5 mm. It is more coriaceous and narrower than is usual for *C. inophyllum*, but in both venation density and midrib type it approaches that species. Both specimens are in fruit (those of *Balansa 585* are mature, the stone being filled by the embryo); the fruit is of a lighter color than is usual in *C. caledonicum*. The fruits approach those of *C. inophyllum*, although the spongy layer does not seem to be particularly thick. *Sarlin 182* has on its field label "tamanu de bord de mer," the French name for *C. inophyllum*!

123. *Calophyllum carrii* P. F. Stevens, Austral. Jour. Bot. **22**: 360. fig. 2. 1974. TYPE: Papua [Northern Province], Isuarava, 3500 feet [1530 m.], 15 Feb. 1936, *Carr 15599* (holotype, LAE; isotypes, A, CANB, K, L, NY, SING).

Tree; for details of trunk and bark, see varieties.

Twigs slightly flattened, 3.5-7 mm. across, \pm 4-angled, or with ca. 8 raised lines, becoming striate when older, drying grayish brown, puberulo-farinoso when young; axillary innovations lacking basal scars; internodes 1-3 cm. long; uppermost pair of axillary buds rounded, ca. 1.5 mm. long, suberect, inconspicuous; terminal bud plump, 1-3 cm. long, with grayish brown, crustaceous indumentum (hairs, FIGURE 35, aa, bb, ff; also submoruloid), underdeveloped internode to 3 mm. long. Petiole 1-3 cm. long, broadly concave above, convex to angled below, glabrescent; lamina obovate to suboblong, (5.5-)-7-12 by 2.9-6 cm., obtuse to shallowly retuse at apex, acute at base, undulate and recurved at margin, marginal thickening sometimes up to 1 mm. wide, coriaceous, drying sabelline above and fulvous-umber below, subsersistently puberulent to furfuraceous on midrib below, the midrib above narrowing gradually from base, depressed at first, 0.2-1.5 mm. wide at midpoint, becoming raised in top half of leaf, below raised, rounded to striate, the venation rather obscure above, \pm apparent below, raised, 7 to 13 (to 15) veins/5 mm., angle of divergence 65-75°. Inflorescences from lower foliate (rarely defoliate) axils, with 5 to 18 flowers (with 3-flowered branches to 1.2 cm. long), the axis 3.3-4.5 cm. long, farinose-puberulent, lowest internode 2-4 mm. long; bracts unknown; pedicels 0.5-1.9 cm. long, farinose-puberulent. Flower known only in bud; tepals 8 (rarely 6), the two outer broadly ovate, ca. 6.5 by 5.5 mm., sparsely farinose on back at very base; stamens 90 to 120, the anthers oblong, 0.5-1 mm. long, \pm retuse at apex; ovary ca.

1.8 mm. long, the style unknown, the stigma excentrically peltate, ca. 1.5 mm. across. Immature fruit (from var. *longigemmatum*) subspherical, ca. 1.8 cm. long, drying smooth.

Key to the Varieties of *Calophyllum carrii*

1. Twigs 3.5–4.5(–5.5) mm. across; terminal bud 1–2.2 cm. long; lamina lacking an obviously thickened margin. 123a. var. *carrii*.
 1. Twigs 4.5–7 mm. across; terminal bud 2–3 cm. long; lamina with thickened margin ca. 1 mm. wide. 123b. var. *longigemmatum*.

123a. *Calophyllum carrii* P. F. Stevens var. *carrii*

Tree ca. 35 meters tall, d.b.h. to 100 cm.; trunk with buttresses to 0.9 mm. tall; outer bark dark brown, fissured; under bark light brown; latex golden, clear.

Twigs 3.5–4.5(–5.5) mm. across, \pm 4-angled or with ca. 8 raised lines; terminal bud 1.3–2.2 cm. long; lamina with slightly recurved margin, marginal thickening not obvious.

DISTRIBUTION. Central and Northern provinces of Papua New Guinea (MAP 39).

SELECTED SPECIMENS SEEN. **Papuasias:** see Stevens, *loc. cit.*

ECOLOGY. Lower montane rain forest, 1050–1525 m. alt. Flowering in February (late bud).

123b. *Calophyllum carrii* P. F. Stevens var. *longigemmatum* P. F. Stevens, Austral. Jour. Bot. 22: 361. 1974. TYPE: Nederlands Nieuw-Guinea [Irian Jaya], Hollandia, mouth of Tami River, 15 m., 8 July 1956, *BW 2813* coll. Schram (holotype, LAE; isotypes, BO, CANB, K, KEP, L, SING).

Tree ca. 30 meters tall; trunk without obvious buttresses; outer bark dark gray, flaking off in irregular, rectangular scales; under bark reddish and cream mottled; inner bark creamy red; latex yellow.

Twigs 4.5–7 mm. across, usually with 8 raised lines; terminal bud 2–3 cm. long; lamina with strongly recurved margin, marginal thickening ca. 1 mm. wide.

DISTRIBUTION. Mainland New Guinea; known only from a small area along the northern coast (MAP 39).

SELECTED SPECIMENS SEEN. **Papuasias:** see Stevens, *loc. cit.*

ECOLOGY. Lowland rainforest, 15–300 m. alt.

Conoidal galls ca. 1 mm. tall sometimes occur on the lower surface of the lamina (*BW 2813*).

The epithet *longigemmatum* refers to the distinctive terminal buds of this variety.

Calophyllum carrii can be recognized by its long, plump terminal bud, obovate to suboblong leaf blades with the midrib on the upper surface depressed for at least half its length, and flower with (usually) eight tepals. Its indumentum is not well developed, and the older twigs at least are striate. The specific epithet commemorates C. E. Carr, who collected the type specimen during his fatal trip to New Guinea.

Although the two varieties are readily distinguished by the characters given above, neither is well known.

124. *Calophyllum collinum* P. F. Stevens, sp. nov.

Calophyllum sp. D, aff. *C. sil* Lauterb.; P. F. Stevens, Austral. Jour. Bot. 22: 397. 1974.

A speciebus aliis Calophylli in internodiis brevibus 0.3-2 cm. longis, lamina parva costa supra valde sulcata venulis 11 usque ad 20 per 5 mm., fructu subsphaerico strato exteriori 1.5-3 mm. crasso e putamine haud munde secedenti, differt.

Tree 22-36 meters tall, d.b.h. to 85 cm.; trunk without buttresses; outer bark brown (gray), fissures at first short and distinct, becoming confluent, inner surface brown (orange-brown); under bark red; inner bark red or reddish; latex yellow, clear, viscous (becoming green).

Twigs slightly flattened, 1.2-3.5 mm. across, strongly 4-angled, often with 4 additional raised lines, drying dark brown, transiently subfarinose to subsersistently tomentose; axillary innovations lacking basal scars; internodes 0.4-2 cm. long; uppermost pair of axillary buds rounded, ca. 1 mm. long, subspreading; terminal bud plump, 6-9 mm. long, with brown, subtomentose to subcrustaceous indumentum (hairs, FIGURE 35, x, y, cc-ee), underdeveloped internode to 1 mm. long. Petiole (0.45-)0.6-1.2 cm. long, broadly concave above and convex below, glabrescent to subsersistently tomentose; lamina obovate to elliptic (rarely suboblong), (1.8-)2.3-8 by (1-)1.3-4.5 cm., rounded to subretuse or subcuneate at apex, acute to cuneate at base, slightly undulate and not recurved or slightly so at margin, coriaceous, drying umber to olivaceous above and fulvous to olivaceous below, transiently farinose to subsersistently puberulo-tomentose on midrib below, the midrib above gradually narrowed from base, strongly sulcate but at least margins raised, 0.2-0.4 mm. wide at midpoint, becoming raised toward apex, below raised, striate, the venation obscure to subapparent on both surfaces, raised to \pm flat, 11 to 20 veins/5 mm., angle of divergence 65-80°. Inflorescences from foliate axils along twigs, with scars of 7 to 21 flowers, unbranched, farinose to subtomentose, lowest internode 1-10 mm. long; bracts not known; pedicels 4-9 mm. long, glabrous. Flower not known. Fruit subspherical (ovoid), 1.2-1.8 by 1.1-1.7 cm., rounded (rarely acute—*Stevens et al.* 921) at apex, drying brown, smooth; outer layer not detaching cleanly from stone, 1.5-3 mm. thick, compact apart from air spaces developing under skin; stone subspherical to ellipsoid, 0.9-1.4 by 0.8-1 cm., rounded (rarely obtuse) at apex, the walls 0.3-0.5 mm. thick, to 0.7 mm. thick at base, smooth, unmarked; spongy layer thin.

TYPE: Papua, Western District, Ningerum, 110 m., 29 August 1970, *NGF 42992* coll. *Henty & Barlow* (holotype, A; isotypes, K, L, LAE, SING).

DISTRIBUTION. Eastern New Guinea (MAP 41).

ADDITIONAL SPECIMENS SEEN. **Papuaia**, IRIAN JAYA, Snow Mountains: Bernhard Camp, Idenburg R., 550 m., *Brass & Versteegh 13576* (A, L). PAPUA NEW GUINEA, MOROBE: near Garaina, 520 m., *NGF 45057* (A, E, K, L, LAE, M, SING). Western: 8 km. from Kiunga, 25 m., *Stevens et al. 888* (A), 890 (A); 24 km. from Kiunga, 30 m., *Stevens et al. 921* (A).

ECOLOGY. Colline forest or lowland forest with colline aspect, 25–520 m. alt. Fruiting March, July, and August (fruit blue to blackish—field notes of *NGF 45057* mention dark green fruit, but it is likely that these would finally turn bluish).

Calophyllum collinum can be recognized by its short internodes, its strongly four-angled twigs that usually have an additional four raised lines, and its small, oblong-obovate leaf blades with a strongly sulcate midrib and rather dense venation (11 to 20 veins/5 mm.). Its fruits have a thick outer layer that is compact except for air spaces that sometimes develop under the skin. The species looks like a plant from forests at higher altitudes, as Y. Lelean remarked when we first found the plant; this suggested the specific epithet.

Calophyllum collinum is a fairly common tree around Kiunga, especially noteworthy because of its clean, brown-colored bole that becomes deeply fissured only in very large specimens. Its relationships are not clear (see also Stevens, *loc. cit.*), but it can be readily distinguished from *C. sil* by the characters given in the diagnosis. Although the high-altitude variant of *C. sil* may have a midrib similar to that of *C. collinum*, it has larger leaves with less dense venation and twigs with longer internodes.

125. *Calophyllum costatum* J. F. Bailey, Queensland Agr. Jour. 5: 392. *pl.* 136. 1899 (1 Oct.); F. M. Bailey, Queensland Fl. 1: 104. 1899 (Dec.), Comprehens. Catal. Queensland Pl. 54, *fig.* 40. 1913. TYPE: Australia, Queensland, Evelyn [North Kennedy], 6 July 1894, *J. F. Bailey s.n.* (holotype, BRI; isotype, LAE (frag.)).

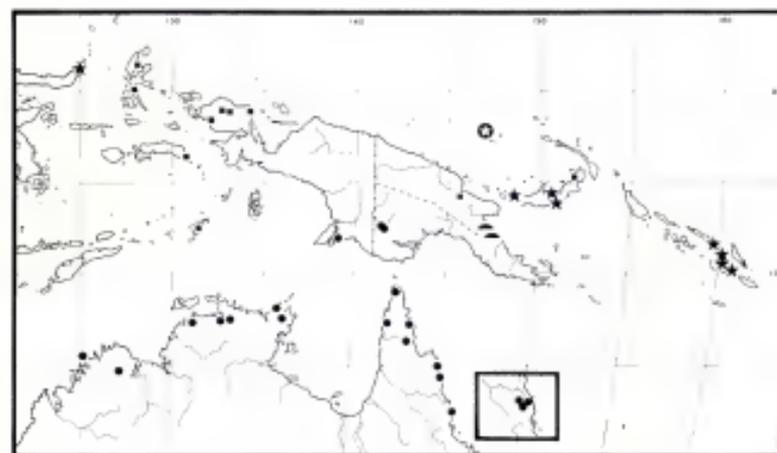
Tree to 25–33 meters tall, d.b.h. to 60 cm.; trunk without buttresses; outer bark dark brown or dark grayish, flaky or peeling off and cracked only in places, inner bark pink, layered, fibrous; latex pink-cream to whitish (turning brown on exposure (*Hyland 8912*)).

Twigs flattened, 2–4 mm. across, at most obscurely 4-angled, drying brown when young, whitish gray to yellowish white when older, subpersistently puberulent; axillary innovations lacking basal scars; internodes 0.5–2(–3) cm. long; uppermost pair of axillary buds pointed, to 3.5(–6.5) mm. long, erect, usually inconspicuous; terminal bud plump, 6.5–11 mm. long, with brownish, puberulo-tomentose indumentum (hairs, FIGURE 35, gg, hh), underdeveloped internode 1–3(–6) mm. long. Petiole 0.7–1.9 cm. long, broadly and shallowly concave above, convex below, glabrous; lamina elliptic to obovate, 4.7–8.8 by 2.2–3.9 cm., subacute to rounded at apex, acute to cuneate at base, distantly

and shallowly undulate but not recurved at margin, thinly coriaceous, drying amber above and slightly paler below, subsersistently farinose on midrib below, the midrib above narrowing gradually from base, strongly sulcate in bottom $\frac{1}{3}$ of lamina, becoming raised, 0.2–0.3 mm. wide at midpoint, below raised, obscurely angled to striate, the venation above and below \pm clear, raised (rarely subobscure), 6 to 11 (to 14) veins/5 mm., angle of divergence 55–65°. Inflorescences from foliate axils, with 5 to 7 flowers, unbranched, the axis to 1.7 cm. long, puberulent, lowest internode ca. 8 mm. long; bracts ovate, to 8 mm. long, deciduous; pedicels 5–7 mm. long, puberulent. Flower (?)hermaphroditic; tepals 8, the outer pair ovate, ca. 7.5 by 6.5 mm., puberulent on back, the inner ones suborbicular, ca. 7 by 7 mm., outer pair puberulent dorsally down middle; stamens 95 to 140, the filaments to 2.5 mm. long, the anthers oblong, ca. 2 mm. long, acute at apex; ovary ca. 1.3 mm. long, the style unknown, the stigma peltate, ca. 1 mm. across. Fruit ellipsoid to ovoid, 2.8–3.5 by 2.3–3.8 cm., \pm acute at apex, drying \pm vinaceous-brown, shallowly to rather sharply and deeply longitudinally wrinkled; outer layer detaching cleanly from stone, 1–2.5 mm. thick, compact; stone ellipsoid to ovoid, 2.3–3 by 1.9–2.2 cm., subacute to rounded at apex, the walls 1.2–1.5 mm. thick, to 3 mm. thick near base, smooth, unmarked, apparently with basal plug 3 mm. across; spongy layer (?)thin.

DISTRIBUTION. Northeastern Queensland, Australia (MAP 40).

SELECTED SPECIMENS SEEN. **Australia.** QUEENSLAND: Bellenden Kerr, 1075 m., L. S. Smith 14698 (BRI); Ravenshoe, *Manuell* 41 (BRI); Middle Creek, *Herb. Flecker* 6605 coll. *Flecker*; Atherton, *Rhys s.n.*, Feb. 1916 (BRI); Evelyn,



MAP 40. Distribution of *Calophyllum sil* (circles), *C. sil* variant (squares), *C. leleanii* (stars), *C. waliense* (star in solid circle), and *C. streimannii* (half-circles) in Malaysia. Inset: *C. costatum*.

J. F. Bailey s.n., 15 April 1908 (K); S.F.R. [State Forest Reserve] 265 (near Crater), 1000 m., *Stocker 670* (A, CANB, K, KEP, LAE); S.F.R. [State Forest Reserve] 1203, Dirran, 1140 m., *Irvine 1203* (A, K, LAE); Boonjie L.A. [Logging Area], 680 m., *Hyland 8912* (A); Cook Distr., Hugh Nelson Range, *L. S. Smith 10507* (A).

ECOLOGY. Canopy tree of colline forest, 680–1140 m. alt. Flowering in November; fruiting January and March.

Calophyllum costatum can be recognized by its plump, moderate-sized terminal bud; its fairly small lamina that is more or less cuneate at the apex and has relatively clear and distant venation; and its rather large fruits (ca. 3 cm. long) that are broadly wrinkled. The outer layer of the fruit is comparatively thick (1–2.5 mm. across); the stone is thick walled and may have a basal plug. The midrib of the dried leaf is very prominent, and this fact suggested the specific epithet.

Calophyllum costatum is perhaps related to *C. obscurum* (q.v.).

The original description of *Calophyllum costatum* must be attributed to Bailey *fillius*, whose publication antedates that of his father by two months.

126. *Calophyllum obscurum* P. F. Stevens, Austral. Jour. Bot. 22: 380, fig. 10. 1974. TYPE: Solomon Islands, Malaita, Are Are District, west coast, Kiu, 13 Feb. 1963, *BSIP 3875* (holotype, LAE; isotypes, K, L, SING).

Tree to 30 meters tall, d.b.h. to 90 cm.; outer bark yellow to gray-brown, scaly, fissured; latex yellow, opaque.

Twigs slightly flattened, 2–2.5 mm. across, 4-angled, drying grayish brown, subpersistently grayish farinose-puberulent; axillary innovations lacking basal scars; internodes 0.5–1.75(–3) cm. long; uppermost pair of axillary buds rounded, to 1.5 mm. long, \pm spreading, inconspicuous; terminal bud plump, 0.7–1(–1.7) cm. long, with subcrustaceous, grayish indumentum (hairs, FIGURE 37, a, b), underdeveloped internode 1–4 mm. long. Petiole 0.9–2.5 cm. long, flat to shallowly concave above, convex below, persistently farinose; lamina elliptic, ovate, or obovate, 7–11.5 by 3.3–6 cm., obtuse to subacuminate at apex, acute at base, undulate but slightly recurved at margin, coriaceous, drying near umber above and sepia below, subpersistently farinose on midrib below, the midrib above narrowing gradually from base, rather indistinct, margins slightly raised near base, 0.25–0.35 mm. wide at midpoint, becoming

FIGURE 37. Hairs (from terminal bud, unless otherwise noted). a, b, *Calophyllum obscurum* (*BSIP 7741*): b, from above. c–f, *C. sil*: c, d, *NGF 33731*; e, *NGF 36754*; f, *bb 24368*. g, h, *C. laticostatum*: g, *NGF 3284*, from stem; h, *LAE 58797*. i, *C. archipelagi* (*Backer 27827*). j, k, *Calophyllum* sp. 129 (*bb 19445*). l, m, *C. peekelii*: l, *NGF 18330*, from above; m, *BSIP 8804*, from above. n, o, *C. leleanii*: n, *Brass 3447*; o, *Musser et al. S-20a*. p, *C. waliense* (*LAE 59253*). q–t, *C. vexans*: q, *Brass 8337*; r, *LAE 51230*, from below; s, *bb 30923*, from below; t, *NGF 18307*. u, v, *C. papuanum* (*NGF 23956*). w–y, *C. euryphyllum*: w, *NGF 27335*; x, *Hoogland 4662*; y, *LAE 59189*. Scale = 120 μ m. (in w, scale = 240 μ m.).



raised, below raised, subangled, the venation obscure above, obscure to subapparent below, 9 to 16 veins/5 mm., angle of divergence 60-75°. Inflorescences from foliate axils, with 5 to 11 flowers; unbranched (rarely with 3-flowered branches to 0.7 cm. long), the axis 0.7-2.8 cm. long, puberulent, lowest internode (0.3-)1-1.7 cm. long; bracts unknown; pedicels 0.8-1.2 cm. long, puberulent. Flower known only in late bud, (?)hermaphroditic; tepals 8, the outer 4 suborbicular, ca. 5.5 by 5.5 mm., farinose-puberulent on back; stamens 200 to 250, the anthers oblong, 1.5-2.3 mm. long, acute at apex; ovary ca. 1 mm. long, the style ca. 1.5 mm. long, the stigma peltate, 1.6-2.4 mm. across, irregularly fringed. Fruit \pm spherical, 2.4-3.1 by 2.2-2.7 cm., sharply apiculate, drying grayish brown, wrinkled; outer layer detaching \pm cleanly from stone, 0.5-1.3 mm. thick, compact; stone subspherical, 2.2-2.9 by 2-2.6 cm., rounded at apex, the walls 1.5-2 mm. thick (3-4 mm. thick at base), smooth or slightly rugose, unmarked; spongy layer thin.

DISTRIBUTION. The Solomon Islands (MAP 43).

SPECIMENS SEEN. **Papuasia**. SOLOMON ISLANDS: see Stevens, *loc. cit.*

ECOLOGY. Ridges in primary rainforest, or raised, sometimes flooded, coral platforms; 60 m. alt. Flowering February and March (flower scented); fruiting August and December (fruit green to grayish).

Calophyllum obscurum can be recognized by its plump terminal bud and its medium-sized leaf blades that dry dull umber-sepia and have obscure, fairly close venation and a rather indistinct midrib on the upper surface. The inflorescence is covered in grayish, farinose-puberulent indumentum, and the wrinkled fruits have a thin outer layer and a thick-walled stone that appears to lack a basal plug. In two collections the flower is reported to be yellow; this color may be caused by the presumably brownish indumentum covering the white tepals. The specific epithet alludes both to the obscure venation and to the generally undistinguished appearance of the specimens.

The thick-walled stone that lacks a basal plug and the indumentum covering the entire inflorescence immediately distinguish *Calophyllum obscurum* from the other species of *Calophyllum* in the Solomon Islands. It is perhaps related to *C. carrii*, from mainland New Guinea, although that species has more robust twigs, leaf blades with a depressed midrib on the upper surface, clearer venation, and longer pedicels. Ripe fruits of *C. carrii* are unknown. *Calophyllum obscurum* is also similar in many points to *C. costatum*, from Australia; that species, however, has yellowish twigs, smaller leaf blades with less dense venation and a more prominent midrib, and a fruit that, although of similar size, has a thicker outer layer and a stone apparently with a basal plug. The hairs of all these species are rather similar (FIGURES 35, aa, bb, ff-hh; 37, a, b).

127. *Calophyllum* sil Lauterb. Bot. Jahrb. 58: 14. 1922; O. Schwarz, Repert. Sp. Nov. 24: 89. 1927; T. C. Whitmore, Gard. Bull. Singapore 22: 12. 1967; P. F. Stevens, Austral. Jour. Bot. 22: 395. 1974. TYPE: Deutsch

Neu-Guinea [Irian Jaya], Südküste bei Gelieb, 31 Oct. 1907, *Branderhorst 179* (holotype, s, destroyed; isotypes, BO, K, L, U).

- C. ramiflorum* O. Schwarz, Repert. Sp. Nov. 24: 88. 1927. SYNTYPES: Australia [Northern Territory], Port Darwin, cliffs near Hospital, *Bleeser 502* (NSW, MEL); Finniso River District, *Bleeser A27* (n.v.).
- C. procerum* A. C. Smith, Jour. Arnold Arb. 22: 344. 1941. TYPE: Papua, Middle Fly River, Lake Daviumbu, Aug. 1936, *Brass 7589* (holotype, A; isotypes, BRI, L).
- Calophyllum* sp. Lauterb. Nova Guinea Bot. 8: 309. 1910.
- C. warburgii* auct., non Engler; A. C. Smith, Jour. Arnold Arb. 22: 345. 1941, *quoad Brass 7724*.

Tree 4-30 meters tall, d.b.h. to 139 cm.; trunk without buttresses (with spurs); outer bark yellowish at first, becoming rusty brown to gray, \pm deeply fissured, with transverse cracks between fissures, scaling or not; under bark bright red; latex yellow or greenish yellow, clear, sticky, sometimes aromatic.

Twigs slightly flattened, 2.6-4 mm. across, strongly 4-angled (rounded or with 6 raised lines), drying brown, sparsely brown-farinose; axillary innovations lacking basal scars; internodes 0.3-3.5 cm. long; uppermost pair of axillary buds rounded, ca. 1 mm. long, spreading, inconspicuous; terminal bud plump, 5-10(-13) mm. long, with brown, puberulent indumentum (hairs, FIGURE 37, c-f), underdeveloped internode to 2.5(-3.5) mm. long. Petiole 0.6-1.5(-2) cm. long, broadly concave above, convex below, glabrous when mature; lamina obovate to elliptic (suboblong), (2.8-)5-12.5 by (1-)2.5-5.5 cm., acute to cuneate or rounded at apex, cuneate, acute, or broadly rounded and ultimately shortly acute at base, broadly undulate but slightly (rarely strongly and broadly) recurved at margin, coriaceous, drying \pm cinnamon-sepia on both surfaces or greenish olivaceous to fuscous-black above and olivaceous below, glabrous or sparsely farinose-puberulent on midrib below (also above when young), the midrib above gradually narrowed from base, depressed, 0.25-0.6 mm. wide at midpoint, becoming raised in upper $\frac{1}{6}$ - $\frac{1}{4}$ (- $\frac{2}{3}$) of lamina, below raised, striate to obscurely angled, the venation above and below apparent, raised, on lower surface often with latex canals ascending obliquely over veins, (5 to) 7 to 13 veins/5 mm., angle of divergence (60-)70-80°. Inflorescences from usually foliate axils along stem, with 3 to 13 flowers, usually unbranched (very rarely with 3-flowered branches to 5 mm. long), the axis 0.3-4.5 cm. long, farinose-puberulent, lowest internode (0.1-)0.2-0.7(-1.2) cm. long; bracts ovate, to 3.5 mm. long, densely puberulent below, deciduous; pedicels 3-7 mm. long, farinose-puberulent. Flower (?) hermaphroditic; tepals 4 (to 6), the outer two ovate, 3.5-4 by 2.5-3 mm., sparsely farinose on back, the inner ones elliptic to obovate, 4.5-6 by 2.5-4 mm.; stamens 45 to 80, the filaments to 2.5 mm. long, the anthers oblong, 0.5-1.3 mm. long, \pm retuse at apex; ovary 1.3-1.5 mm. long, the style 1.5-1.7 mm. long, the stigma peltate, 0.5-0.7 mm. across, slightly radiate. Fruit spherical to ovoid, 1.3-1.9 by 1-1.6 cm., \pm acute at apex, drying vinaceous-brown, sharply wrinkled; outer layer not detaching cleanly from stone, 0.4-1.2 mm. thick, to 2 mm. thick toward apex, compact; stone \pm spherical, 0.8-1.3

by 0.8–1.2 cm., rounded at apex, the walls 0.15–0.4 mm. across, smooth, (?)unmarked; spongy layer thin.

DISTRIBUTION. Southern mainland New Guinea and northern Australia; forms of uncertain status from the Moluccas, northern mainland New Guinea, and New Britain (Map 40).

SELECTED SPECIMENS SEEN. **Moluccas.** HALMAHERA: Tobelo, N. Totodokoe, 30 m., *bb* 33807 (?) (BO, L, SING); Weda, Tilope, 25 m., *bb* 24843 (?) (BO, L, SING). SERAM: Kiandarat, 60 m., *bb* 25830(?) (BO, L, SING). TANIMBAR: Otimmer, 100 m., *bb* 24368 (?) (BO, L, SING). **Papuaasia:** see Stevens, *loc. cit.* Also, IRIAN JAYA. Vogelkop: Beriat (\pm 12 km. S. of Tenimaboean), 10 m., *BW* 6259 (?) (L). PAPUA NEW GUINEA. Madang: Imbron R., 30 m., *NGF* 49237 (?) (A, L, LAE). Western: 2 km. W. of Iokwa, 10 m., *LAE* 60448 (L). **Australia.** WESTERN AUSTRALIA: Mitchell Plateau, N. Kimberley, *Beard* 7013 (DNA, NSW, PERTH); Prince Regent R. Reserve, Gariyeli Creek, Fern Gulley, *George* 12822 (PERTH); Bonaparte Archipelago, Osborn Is., *P. G. Wilson* 11061 (PERTH). NORTHERN TERRITORY: Cannon Hill, *Must* 791 (CANB, DNA, K, LAE); W. face of Mt. Brockman Range, 30 m., *Schodde* AE2 (CANB, DNA, K); Bay no. 3 [Arnhem Bay] is., *R. Brown* "6302" (BM, K); Sampit Creek Gorge, Arnhem Land, *McKean* B796 (CANB); 65 km. NE. Pine Creek, W. Arnhem Land, *Balgooy & Byrnes* 1348 (DNA, K, L, LAE); 3 km. S. of E. Alligator R. crossing, *Byrnes* 2187 (CANB, DNA, LAE); Jim Jim Falls area, *R. E. Fox* 521 (DNA); Caledon Bay, *Byrnes* 973 (DNA); Lee Point, *Byrnes* 1734 (DNA); Gulmarri, Elcho Is., *Dunlop* 3949 (DNA); Giddy R. crossing, *Byrnes* 2592 (DNA, CANB); Port Darwin, *Holtze* 38 (MEL). QUEENSLAND: Jardine R., *Gittins* 1844 (NSW); Iron Range, 20 m., *Brass* 19294 (A, CANB, K, SING); W. of Bamaga, ca. 2.7 km. SW. of Cape York, *L. S. Smith* 12485 (A, CANB, K, L, LAE); Scrubby Creek, 9 $\frac{1}{2}$ km. N. of Rocky R., 50 m., *Hyland* 5433 (L); Claudie R., 80 m., *Dockrill* 564 (K, L); ARBOF. Res. 1, between McIVOR R. and Cape Flattery, 20 m., *Hyland* 6552 (K, L); Cook Distr., Annam R. junction with Parrot Creek, 215 m., *L. S. Smith* 14321 (A, CANB, L, LAE, MEL); Weipa Concession, Marmoss Creek, 10 m., *Dockrill* 859 (LAE); Granite Creek, Lower Bloomfield R., *L. S. Smith* 11086 (L); Etty Bay, Innisfail, *L. S. Smith & Webb* 3265 (A); Trinity Harbour, *W. Hill* 54 (MEL).

ECOLOGY. Savanna woodland or riverine gallery forest (see also Beard, 1976, as *C. australianum*), rarely secondary forest; 7–215 m. alt. Flowering April, and June to August (flower scented); fruiting May, and September to November (fruit bluish to purple-black).

Pajmans 376 and *L. S. Smith* 11086 have galls on the leaf; these are slightly transversely elongated pustules at right angles to, and often near, the midrib.

The variant grows in rainforest, 10–630 m. alt.

LOCAL USE. The wood is used for larger dugout canoes on the Fly River (Western Province, Papua New Guinea).

Calophyllum *sil* can be recognized by its plump terminal bud; its moderate-sized and more or less elliptic lamina that has a depressed midrib on the upper surface and that dries more or less concolorous; its four-teped flowers; and its fruits, which dry sharply wrinkled and vinaceous-brown, with the

outer layer moderately developed, compact, and not detaching from the thin-walled stone. The specific epithet, *sil*, is a name given to this species in the southern part of Irian Jaya.

Variation within *Calophyllum sil* is discussed in Stevens (*loc. cit.*). The specimens from New Guinea cited above with a question mark belong to the variant that usually grows at a moderate elevation (but *BW 6259* was collected at 10 m. alt.) in rainforest; the status of this variant is unclear, since all except one of the specimens (*NGF 36754*) are sterile. The specimens cited above from the Moluccas region are also all sterile. Some (e.g., *bb 33807*) have rather thickly coriaceous leaf blades with broadly recurved margins, and the older leaves tend to dry fuscous-black on the upper surface.

Calophyllum sil is probably related to *C. laticostatum* and perhaps also to *C. collinum*. All have basically similar hairs (FIGURES 35, x, y, cc-ee; 37, c-h), blue fruits, and flowers often with four tepals (flowers of *C. collinum* are not known). In addition, both *C. sil* and *C. laticostatum* sometimes have latex canals on the lower surface of the leaf obliquely ascending over the normal latex canal/vein system. *Calophyllum sil* is not close to *C. australianum* (= *C. calaba* var. *australianum*), as was suggested earlier (Stevens, *loc. cit.*). Although young plants of *C. sil* have leaves similar in shape to those of *C. calaba* var. *australianum*, the twigs of the former are almost square in transverse section, while those of the latter are flattened; the hairs of the two are not notably similar (cf. FIGURES 37, c-f, and 12, q).

128. *Calophyllum laticostatum* P. F. Stevens, Austral. Jour. Bot. 22: 375, fig. 8. 1974. TYPE: Papua, Milne Bay, about 6 miles [8 km.] up the Dawa Dawa River, 250 feet [75 m.], March 1945, *NGF 1327* coll. L. S. Smith (holotype, LAE; isotypes, A, BRI, CANB, L, NSW).

Tree 15-43 meters tall, d.b.h. to 91 cm.; trunk without buttresses or spurs (?rarely with aerial roots); outer bark yellowish in young tree, becoming gray to brown, shallowly to rather deeply fissured, scaling or not, the inner surface dark red, or orange-brown and orange or red and brown mottled; under bark dark red; inner bark dark red; latex yellow (greenish yellow), clear, sticky.

Twigs slightly flattened, 2-5.5 mm. across, 4-angled, drying deep brown, subsersistently brown farinose-puberulent; axillary innovations lacking basal scars; internodes (0.4-)1-3 cm. long; uppermost pair of axillary buds rounded, to 2 mm. long, spreading, inconspicuous; terminal bud plump, (0.8-)1.3-2.7 cm. long, with \pm crustaceous, gray-brown indumentum (hairs, FIGURE 37, g, h), underdeveloped internode to 4 mm. long. Petiole (0.4-)0.7-1.4 cm. long, broadly concave above, glabrescent below; lamina elliptic to narrowly obovate, (3-)6.5-16 by (0.8-)1.4-4.5 cm., acute (rarely acuminate (*NGF 18373*)) at apex, narrowly cuneate at base, very base often shortly rounded, not undulate to rather distantly so and narrowly to broadly recurved at margin, coriaceous, drying \pm umber above and sabelline-sepia below, transiently farinose on midrib (rarely near margin) below, or glabrous, the midrib above narrowed gradually from base, broadly depressed, 0.2-1.6 mm. wide at

midpoint, below raised, striate, the venation above obscure to subapparent, below \pm apparent, raised, sometimes with latex canals ascending over veins on lower surface, (9 to) 11 to 20 veins/5 mm., angle of divergence (40-)60-70 (-80) $^{\circ}$. Inflorescences from foliate axils along twigs, with 5 to 21 flowers, unbranched (rarely with 3-flowered branches to 3 mm. long), the axis 1.2-5.5 cm. long, \pm puberulent, especially toward base, lowest internode 3-11 mm. long; bracts ovate, ca. 4 mm. long, deciduous; pedicels 2-11 mm. long, sparsely puberulent to glabrous. Flower known only from buds, (?)hermaphroditic; tepals 4 or 6, the outer pair ovate, ca. 5 by 4 mm.; stamens ca. 168, the anthers oblong, ca. 1 mm. long, \pm retuse at apex; ovary ca. 1 mm. long, the style ca. 1.2 mm. long, the stigma excentrically peltate, ca. 0.8 mm. across. Fruit ovoid to subspherical, 1.3-1.9 by 1.2-1.6 cm., rounded at apex, drying mid-brown, broadly and obscurely wrinkled; outer layer not detaching cleanly from stone, (0.5-)1-3 mm. thick, compact or with air spaces developing under skin; stone subspherical, 0.65-1.1 by 0.6-1 cm., rounded at apex, the walls 0.2-0.8 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Western New Guinea (MAP 39), possibly the Philippine Islands (Luzon).

SELECTED SPECIMENS SEEN. **Philippine Islands.** LUZON. Mt. Calvario, Dolores, 600 m., *FB 30019* (UC). **Papuaia:** see Stevens, *loc. cit.*

ECOLOGY. Well-drained lowland or colline rainforest, 20-1370 m. alt. Flowering in January; fruiting October, January, and March, submature fruit in May (fruit bluish).

YOUNG PLANT. The young plant is erect, and the terminal bud is functional.

Calophyllum laticostatum can be recognized by its fairly long (usually more than 1 cm.), plump terminal bud and its rather narrowly elliptic, coriaceous leaf blades that have a broadly sunken midrib narrowing gradually from the base. The fruits are small (less than 2 cm. long) and have a well-developed outer layer. The epithet *laticostatum* ("broad midrib") emphasizes one of the most prominent features of the species.

Calophyllum laticostatum is apparently related to *C. archipelagi* and *Calophyllum* sp. 129. The three taxa can be separated as shown in TABLE 15. Stevens (*loc. cit.*) compared *C. laticostatum* with the New Caledonian species *C. caledonicum* and *C. montanum* (= *C. caledonicum*). *Calophyllum caledonicum* is perhaps most closely related to the *C. vitiense*-*C. neo-ebudicum* complex and has larger fruits and flowers with eight or more tepals.

Relatively little material of *Calophyllum laticostatum* in flower and fruit is known, and there is a considerable amount of vegetative variation (see also Stevens, *loc. cit.*). The single specimen cited from the Philippine Islands (*FB 30019*) has a small terminal bud (figures in parentheses in the description above) and rather small leaves, and its pedicels are ca. 1 cm. long (usually less than 7 mm. in other specimens). However, when compared with the Papuan specimens, it agrees well in other vegetative characters, and its submature fruits seem to be of the same general type—albeit with a slightly thinner outer layer.

TABLE 15. Comparison of differences between *C. laticostatum*, *Calophyllum* sp. 129, and *C. archipelagi*.

	<i>C. laticostatum</i>	<i>Calophyllum</i> sp. 129	<i>C. archipelagi</i>
TERMINAL BUD LENGTH (mm.)	(8-)13-27	9-13	6-7.5
TWIG THICKNESS (mm.)	2-5.5	1.5-3	(1.3-)2-3(-3.5)
LEAF			
PETIOLE WIDTH (mm.)	(1.2-)2-3.5	1-2(-2.5)	1-2
LAMINA TEXTURE	Very coriaceous	Coriaceous	Coriaceous
VENATION DENSITY (veins/5 mm.)	(9 to) 11 to 20	6 to 11	(4 or) 5 to 9
LOWEST INTERNODE OF INFLORESCENCE, LENGTH (mm.)	3-11	12-18	8-15
TEPAL NUMBER	4 to 6	Unknown	8
PEDICEL LENGTH (mm.)	2-8(-11)	7-13	5-16
FRUIT			
LENGTH (cm.)	1.3-1.9	Ca. 1.4	Ca. 3
OUTER LAYER THICKNESS (mm.)	(0.5-)1-3	< 1	Ca. 0.5
AIR SPACES DEVELOPING IN OUTER LAYER	Under skin	Throughout	± Throughout

NGF 18373, from Kiunga, Western Province, Papua New Guinea, has leaf blades that are acuminate at the apex. Field notes of this specimen mention "much branched aerial roots." I have not seen such roots on plants of *Calophyllum laticostatum* either at Kiunga or on New Britain.

129. *Calophyllum* sp.

FIGURE 36, a.

C. celebicum Koord. (*quoad Koorders 17305*) et *C. wawaroenti* Koord. in Koord.-Schum. Syst. Verzeich. (Fl. N.O. Celebes) 3: 87. 1914. *Nomina*.

Tree to 31 meters tall, d.b.h. to 55 cm.; trunk and bark unknown; latex yellow, pale yellow, or greenish.

Twigs slightly flattened, 1.5-3 mm. across, 4-angled, drying mid- to darkish-brown, brown farinose-puberulent when young, axillary innovations lacking basal scars; internodes 0.7-3 cm. long; uppermost pair of axillary buds rounded, ca. 0.5 mm. long, spreading, very inconspicuous; terminal bud plump, 0.9-1.3 cm. long, with subcrustose, grayish brown indumentum (hairs, FIGURE 37, j, k), underdeveloped internode to 1(-5) mm. long. Petiole 1.3-1.8 cm. long, broadly concave above, convex below, glabrous; lamina elliptic to subobovate, 9-20 by 2-4.8 cm., acute to subacuminate at apex, narrowly cuneate to subacute at base, rather strongly and closely undulate but not recurved at margin, thinly coriaceous, drying amber to sabelline-olivaceous above and amber to sabelline below, glabrous when mature, the midrib above narrowed gradually from base, broadly depressed, 0.35-0.6(-1) mm. wide at midpoint, below raised, subangled to striate, the venation usually apparent on both surfaces, raised, 6 to 11 veins/5 mm., angle of divergence 65-75(-80)°. Inflorescences from foliate axils, with scars of 11 to 15 flowers, unbranched, the axis to 5.5 cm. long, sparsely puberulent toward base, lowest internode 1.2-1.8 cm. long; bracts unknown; pedicels 0.7-1.3 cm. long, glabrous. Flower unknown. Fruit subspherical, ca. 1.4 by 1.4 cm., rounded at apex, drying vinaceous-brown, smooth; outer layer not detaching cleanly from stone, (?)thin, completely disorganized by large air spaces; stone ellipsoid, ca. 1.2 by 1 cm., minutely apiculate, the walls ca. 0.5 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Celebes, Moluccas (Soela Island), Poeloe Laut off southeastern Borneo (MAP 39).

SPECIMENS SEEN. **Borneo**, KALIMANTAN. Selatad: Poeloe Laut, Sei Paring, 100 m., *bb 13248* (BO). **Celebes**, SULAWESI: Minahassa, Menado, bij Bivak Totok, Ratatotok, 200 m., *Koorders 17305* (BO, L), bij Kajoewatoe, 200 m., *Koorders 17293* (BO, L), Gorontalo, Poso, 100 m., *bb 19445* (A, BO, L, SING). **SALAJAR**: Ond. Saleier, Lembang2, eil. Djampia, 245 m., *bb 22947* (L). **Moluccas**, MANGOLE: Kimakol, Lampaoe, 30 m., *bb 29806* (A, BO, L, SING).

ECOLOGY. (?)Forest, 30-200 m. alt. Fruiting January (almost ripe); fruit blue.

Calophyllum sp. 129 can be recognized by its only slightly flattened twigs; its large, plump terminal buds; and its rather thinly coriaceous, usually elliptic

lamina. The midrib on the upper surface of the lamina is broadly depressed and narrows gradually from the base. The pedicels are relatively long and slender, and the fruits are subspherical, with the outer layer probably thin and completely disorganized by air spaces.

Calophyllum sp. 129 is closely related to *C. laticostatum* and *C. archipelagi*, but can be separated from them by the differences given in TABLE 15.

130. *Calophyllum archipelagi* P. F. Stevens, sp. nov.

FIGURE 33, d.

A speciebus aliis Calophylli in costa in pagina superiore laminae depressa, lamina tenuiter coriacea, axe inflorescentiae 2.5-6.5 cm. longo, tenui, et fructu submagno circa 3 mm. longa, differt.

Tree 10-30 meters tall, d.b.h. to 55 cm.; outer bark dark brown, rough; inner bark red-brown.

Twigs flattened, (1.3-)2-3(-3.5) mm. across, \pm strongly 4-angled, drying blackish to brown, brown-farinaceous when young; axillary innovations lacking basal scars; internodes (0.5-)1-5 cm. long; uppermost pair of axillary buds rounded, less than 1 mm. long, suberect, inconspicuous; terminal bud plump to conical, 6-7.5 mm. long, with grayish to ferruginous, subrustaceous indumentum (hairs, FIGURE 37, i), underdeveloped internode to 1(-6) mm. long. Petioles 0.7-1.6 cm. long, broadly concave above, convex below, farinose when young; lamina elliptic, 4.6-15 by 2.3-5.1 cm., \pm acute at apex, acute to narrowly cuneate at base, strongly but distantly undulate and slightly recurved at margin, coriaceous, drying sepia to olivaceous above and cinnamon to sepia below, very transiently sparsely farinose on midrib below, the midrib above gradually narrowed from base, depressed, 0.35-0.7 mm. wide at midpoint, below raised, angled toward apex and striate toward base, the venation apparent on both surfaces, raised, (4 or) 5 to 9 veins/5 mm., angle of divergence 65-75(-80)°. Inflorescences from foliate axils along twigs, with 9 to 17 flowers, usually not branched (rarely with 3-flowered branches to 1 cm. long), lowest flowers sometimes flabellately arranged, the axis 2.5-6.5 cm. long, sparsely farinose, lowest internode 0.8-1.5 cm. long; bracts not known; pedicels 0.5-1.6 cm. long, sparsely farinose. Flower known only in bud, (?)hermaphroditic; tepals 8, the outer pair broadly ovate, ca. 5 by 4.5 mm., the inner ones \pm glabrous; stamens 180 to 190, the anthers oblong, 1.3-2.2 cm. long, retuse at apex; ovary ca. 1.5 mm. long, the style ca. 2.7 mm. long, the stigma peltate, ca. 1 mm. across. Fruit ellipsoid to ovoid, ca. 3 by 2 cm., rounded at apex, drying brown to vinaceous, smooth to broadly and irregularly wrinkled; outer layer not detaching cleanly from stone, ca. 0.6 mm. thick, with large air spaces developing; stone ellipsoid, 2.1-2.4 by 1.2-1.8 mm., rounded at apex, the walls 0.6-0.9 mm. thick, smooth, unmarked; spongy layer (?)thin.

TYPE: Java, Kangean, G. Eteng bij Tambajangan, 30 March 1919, *Backer* 27827 (holotype, BO; isotypes, A, BO (several), L).

DISTRIBUTION. Kangean Island off northeastern Java, the Lesser Sunda Islands (MAP 39).

ADDITIONAL SPECIMENS SEEN. **Java and adjacent islands.** TIMUR: Kangean Is., G. Eteng, Tambajangan, *Backer 27596* (BO). **Lesser Sunda Islands.** SUMBAWA: Mangkar Moenteh, 70 m., *bb 14016* (BO), 350 m., *bb 11477* (BO). KOMODO: sine loco, *Saakov 39* (BO). FLORES: Maomere, Managadjoeng, 500 m., *bb 9654* (BO); W. part, near Reo, *Kostermans & Wirawan 921* (AAU, G, L); Nunang, See, 650 m., *Schmutz 775* (L).

ECOLOGY. Hilly ground (sometimes limestone) or ground flooded during rainy season, 70-650 m. alt. Flowering (almost open buds) April and May; submature fruit August and October.

Calophyllum archipelagi can be recognized by its elliptic leaves with a broadly depressed midrib on the upper surface, its relatively short (less than 8 mm.), plump terminal buds, and its rather large (ca. 3 cm.) fruits with thin outer and woody layers. The specific epithet alludes to the fact that all the specimens of this taxon have been collected from the Sunda Archipelago.

Calophyllum archipelagi is perhaps related to *C. laticostatum* (from Papuasia) and *Calophyllum* sp. 129 (mostly from the Celebes and Moluccas). Both of the latter taxa have less flattened young twigs and older twigs that dry striate (vs. more or less terete as in *C. archipelagi*). Other differences between these taxa are given in TABLE 15.

Two specimens of *Calophyllum archipelagi* have fruits. The fruits of *Saakov 39* dried vinaceous, and the lamina margin dried much paler than the rest of the leaf; *bb 9654* has fruits that dried brown, although they are identical in structure to those of *Saakov 39*, and the lamina margin did not dry paler than the rest of the leaf. In this latter character *bb 9654* is like the other specimens cited above.

Schmutz 775 is a sterile specimen, perhaps collected from a sapling. The midrib is narrowly depressed only at the base of the lamina.

131. *Calophyllum peekelii* Lauterb. Bot. Jahrb. **58**: 11. 1922; P. F. Stevens, Austral. Jour. Bot. **22**: 386. 1974. SYNTYPES: Neu-Mecklenburg [New Ireland], Namatanai, Jan. 1909, *Peekel 781*, Namarodu, Jan. 1909, *Peekel 132*; Key Inseln, Pulu Ubur, *Warburg 20041* (all n, destroyed).

FIGURE 6, h, i.

C. kajewskii A. C. Smith, Jour. Arnold Arb. **22**: 353. 1941; F. S. Walker, Forests Brit. Solomon Is. Prot. 123. 1948; T. C. Whitmore, Guide Forests Brit. Solomon Is. 77. 1966, Gard. Bull. Singapore **22**: 9. 1967; Foreman, Check List Vasc. Pl. Bougainville, 42, 84. fig. 1974. TYPE: Bougainville, Buin, Koniguru, 800 m., 6 Aug. 1930, *Kajewski 2024* (holotype, s; isotypes, BO, BRI, C, G, L, NSW, P, SING).

Tree 20-40(-63) meters tall, d.b.h. to 180 cm.; trunk sometimes with small, thick buttresses or spurs to 1.6 meters tall; outer bark dark brown, deeply fissured, scaling, thick, the inner surface blackish, or brownish black and yellow mottled; under bark pink-brown to deep red; inner bark pink-brown to deep red; latex clear (opaque) yellow, very sticky. Crown broad, branches spreading, leaves suberect.

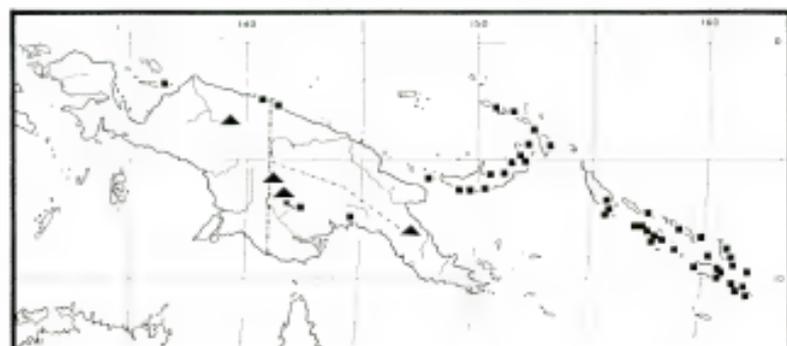
Twigs not to somewhat flattened, 3.8–6.5 mm. across, strongly 4-angled to alate (rarely obscurely angled), drying dark brown, glabrous or sparsely transiently farinose when young; axillary innovations lacking basal scars; internodes (0.5–)1–7 cm. long; uppermost pair of axillary buds rounded, less than 1 mm. long, spreading, inconspicuous; terminal bud plump, 0.9–1.5 cm. long, with crustaceous, grayish brown indumentum (hairs, FIGURE 37, l, m), underdeveloped internode 2–5 mm. long. Petiole 1.1–2 cm. long, broadly concave above, convex to subangled below, glabrous when mature; lamina obovate to oblong or subelliptic, 8.5–17.5(–21.5) by 3.5–10 cm., rounded to shallowly retuse at apex, acute at base, distantly undulate and not recurved to slightly so at margin, rather thickly coriaceous, drying sepia to vinaceous-buff above and sepia to sabelline below, sparsely farinose on midrib when young, soon glabrescent, the midrib above narrowing rather gradually from base, slightly raised, center \pm sulcate, below raised, angled to striate, the venation apparent above and below, raised, 6 to 9 (to 12) veins/5 mm., angle of divergence 65–75°. Inflorescences from foliate axils, with 7 to 21 (to 31) flowers (with 5-flowered branches to 1.7 cm. long), the axis 1.5–8 cm. long, glabrous (rarely farinose toward base), basal internode (0.1–)0.4–1.1(–2) cm. long; bracts ovate, to 4 mm. long, soon deciduous; pedicels 0.7–1.5(–2) cm. long, glabrous. Plants (?)dioecious; tepals 8, sometimes glabrous, the outer pair broadly ovate, 4–5 by 3.5–5.5 mm., the inner ones elliptic to obovate, 4.5–7.3 by 6–6.3 cm.; stamens 210 to 290, in staminate flower the filaments to 6 mm. long, the anthers oblong, 1.7–2.5 mm. long, apiculate, in pistillate flower filaments to 2 mm. long, anthers 1–1.5 mm. long; ovary ca. 2.5 mm. long, the style 2.7–3.5 mm. long, the stigma peltate, in pistillate flower ca. 4 mm., or in staminate flower ca. 2 mm. across, irregularly dentate at edge. Fruit spherical to ovoid, 4.5–7 by 4.2–6 cm., rounded to obtusely pointed at apex, drying brownish, with broad, shallow, longitudinal wrinkles; outer layer detaching cleanly from stone, 2–4 mm. across, compact; stone spherical to \pm ovoid-ellipsoid, 3.8–6 by 3.7–5.2 cm., rounded to obtusely pointed at apex, the walls 3–5 mm. thick, smooth, unmarked, basal plug to 7 mm. across; spongy layer thin.

DISTRIBUTION. Japen Island; scattered on mainland New Guinea; New Britain and New Ireland to the Solomon Islands (MAP 41).

SELECTED SPECIMENS SEEN. **Papuasias:** see Stevens, *loc. cit.* Also, PAPUA NEW GUINEA. Gulf: Aird [Kikori] R., [T. F.] Bevan *s.n.*, MEL 75535 (fruit only) (MEL).

ECOLOGY. Usually in well-drained primary lowland rainforest, also in seasonally inundated rainforest, swamps, forest growing over limestone; to 311 m. alt. Flowering (or late bud) February, April, August, September, and December (flower scented); fruiting January, February, June, September, and November (fruit dull green or blue-green (NGF 18330), perhaps eaten by flying foxes (LAE 66044)).

Details of regeneration of *Calophyllum peekelii* on Kolombangara (the Solomon Islands) are given by Whitmore (1974, as *C. kajewskii*): dispersal



MAP 41. Distribution of *Calophyllum peekelii* (squares) and *C. collinum* (triangles) in Papuaia.

of the seed is poor (the fruits are reported to be blue-black—see above), and development of trees from seedlings takes place in high forest or in gaps. The growth rate of the tree seems to increase with size (Whitmore, 1974, fig. 7.2).

There are small, crateriform galls on the upper surface of the leaf, mostly near the midrib, in *NGF 39344*.

GERMINATION AND YOUNG PLANT. The radicle pushes out the basal plug from the stone during germination. The seedling has three pairs of leaves separated by well-developed internodes; the lowest pair is only ca. 1 cm. long and soon drops off. Subsequently produced internodes are also well developed, growth is erect, and the terminal bud is functional. (*NGF 12352*; *Stevens, LAE sheet no. 125333*.)

LOCAL NAMES AND USES. "Baula," "bau'ula" (Kwara'ae, Solomon Islands). The wood is strong and is excellent for building canoes or houses. The bark can be removed from the log, dried, and used as a fuel; the flammable latex in the bark ensures a good blaze.

Calophyllum peekelii is a very distinctive species with its stout, strongly four-angled twigs, its obovate to oblong, coriaceous leaf blades that are rounded to retuse at the apex, and its large fruits the size of a small orange. The fruits have a thick-walled stone with a basal plug that is pushed out during germination. The specific epithet commemorates the missionary G. Peekel, who lived in New Guinea for over forty years.

There is little variation within *Calophyllum peekelii*, but as with the other possibly dioecious taxa, more material and field observations are needed to determine whether or not the species is dioecious or has some other breeding system.

Saplings of *Calophyllum peekelii* have leaves with blades up to 42 by 14 cm. that are rather abruptly acuminate at the apex.

The only record of *Calophyllum peekelii* from the Gulf Province of Papua New Guinea is based on detached fruits. However, as noted above, these are very distinctive.

A neotype of *Calophyllum peekelii* is not selected since it is not clear that all of the syntypes have been destroyed. The correct application of the name *C. peekelii* is discussed in Stevens (*loc. cit.*).

132. *Calophyllum leleanii* P. F. Stevens, sp. nov.

FIGURE 40, e-g.

- C. solomonense* A. C. Smith, Jour. Arnold Arb. 22: 346. 1941, *typo excepto*;
T. C. Whitmore, Guide Forests Brit. Solomon Is. 78. 1966, *pro parte*,
Gard. Bull. Singapore 22: 9. 1967, *pro parte*; P. F. Stevens, Austral.
Jour. Bot. 22: 398. 1974, *pro parte*.
C. grandifolium Koord. ex Koord.-Schum. Syst. Verzeich. (Fl. N. O.
Celebes) 3: 87. 1914. *Nomen*.

A speciebus aliis *Calophylli* in gemma terminali aliquanto longo, lamina plerumque 10-28 cm. longo et 4.5-10 cm. lato, nervis lateralibus manifestis, et fructu strato exteriore 0.6-2 mm. crasso, putamine parietibus 1.3-2 mm. crassis et obturamento circa 10 mm. in transverso proviso, differt.

Tree 8-25 meters tall, d.b.h. to 54 cm.; trunk without buttresses; outer bark orange to yellowish when young, becoming brown to gray, scaly, the inner surface yellow to orange; under bark red; inner bark red; latex yellow, clear or opaque.

Twigs flattened, (3)-4-6 mm. across, slightly 2-, 4-, or 6-angled, with obscure horizontal lines at nodes, drying brown, farinose-puberulent when young; axillary innovations lacking basal scars; internodes (0.7)-1.5-10 cm. long; uppermost pair of axillary buds subacute, 1-6 mm. long, spreading to suberect; terminal bud often narrowly conical, 0.8-2 cm. long, with brown, crustaceous to adpressed indumentum (hairs, FIGURE 37, n, o; cf. 37, d), underdeveloped internode to 4.5 mm. long. Petiole 1.1-2.5 cm. long, concave above and convex to angled below, puberulent when young; lamina elliptic or ovate to suboblong, (5.5)-10-28 by (2.5)-4.5-10 cm., obtuse to short-acuminate at apex, acute to cuneate at base, narrowly recurved and undulate at margin, coriaceous, drying amber to grayish sepia above and fulvous to olivaceous below, sparsely puberulent on midrib below when young, the midrib above abruptly narrowed at to gradually narrowed from base, \pm raised, center sulcate, 0.2-0.9 mm. wide at midpoint, below strongly raised, angled, the venation apparent on both surfaces, especially so above, raised, latex canals sometimes raised, 5 to 10 veins/5 mm., angle of divergence 50-80°. Inflorescences from foliate axils near ends of twigs, with 5 to 11 flowers (with 3-flowered branches to 3 mm. long), the axis 0.3-2.5 cm. long, subglabrous, lowest internode 1-10 mm. long; bracts not known; pedicels 0.8-1.7 cm. long, glabrous. Flower staminate or hermaphroditic; tepals 4, 7, or 8, glabrous or almost so, the outer pair suborbicular, 6-7.5 by 5.5-8 mm., fleshy, strongly concave, the next pair suborbicular, ca. 7 by 6 mm., the inner ones spatulate-ligulate, 8.5-11 by 3-4.2 mm.; stamens 330 to 420, the filaments to 7 mm.

long, the anthers elliptic-oblong, 0.8–1.5 mm. long, retuse at apex; ovary in hermaphroditic flower ca. 2 mm. long, in staminate flower absent, the style ca. 2.7 mm. long, the stigma peltate, ca. 0.9 mm. across. Fruit subspherical, 1.8–3.5 by 1.6–3.1 cm., \pm apiculate, drying grayish brown, wrinkled; outer layer not detaching cleanly from stone, 0.6–2 mm. thick, to 4 mm. thick when fresh, compact; stone spherical to ellipsoid, 1.6–2.5 by 1.4–1.9 cm., rounded to obscurely apiculate at apex, the walls 1.3–2 mm. thick, to 3 mm. thick at base, smooth, unmarked, basal plug ca. 10 mm. across; spongy layer thin.

TYPE: Papua New Guinea, West New Britain District, Hoskins Sub-District, Mt. Lollo, 1260 feet (386 m.), 13 Feb. 1971, LAE 51145 coll. Lelean & Stevens (holotype, A; isotypes, K, L, LAE).

DISTRIBUTION. Scattered; Sulawesi (probable), New Britain, and the Solomon Islands (MAP 40).

ADDITIONAL SPECIMENS SEEN. **Celebes.** SULAWESI: Minahassa, *Koorders* 17291 (BO, LL, P), 17298 (BO, K, L, P); Sungei Sadaunta, *Musser et al. S-20a* (A). **Papuaia.** PAPUA NEW GUINEA. New Britain: Kandrian Subdistr., Fullerborn village, 60 m., NGF 21788 (A, CANB, L, LAE); toad W. of Fullerborn Harbour, about 1 mile, 100 m., NGF 12957 (L); near Kandrian, *Stevens s.n.*, LAE sheet no. 140450 (LAE); Mt. Lollo, NGF 6607 (A, BO, CANB, K, L, LAE), 30510 (LAE). SOLOMON ISLANDS. Guadalcanal: Makina area, Marau, 270 m., BSIP 9458 (K, L); Rere R., BSIP 2794 (K, L), 3317 (L); Sandfly Is., Florida, 45 m., BSIP 18090 (SING). Santa Isabel: Tataba, 50 m., Brass 3447 (A, BR, L); 1/2 mile due W. of Tataba, BSIP 2580 (K, L); Nahao Bay, 51 m., BSIP 7308 (K, L).

ECOLOGY. Locally common in primary slope and ridge forest; on Santa Isabel on soil derived from ultramafic rock; 45–914 m. alt. Flowering in December; fruiting December and April (fruit greenish).

LOCAL USES. The wood is used for making spears, and a dye is made from the plant (West Nakanai, Hoskins); it is a good timber tree.

Calophyllum leleanii can be recognized by its fairly long terminal bud and suberect to spreading uppermost axillary buds; its rather large lamina with the midrib on the upper surface often relatively inconspicuous; its large flowers, which have numerous stamens (more material is needed to confirm this); and its sharply and shallowly wrinkled fruits. The fruits have a fairly thick outer layer and stone wall; the stone has a basal plug. It is a pleasure to name this taxon after Mr. Y. Lelean, who has accompanied me on many field trips in Papua New Guinea.

Calophyllum leleanii seems most closely related to *C. waliense*; this is discussed further under *C. waliense*.

The specimens of *Calophyllum leleanii* from Sulawesi are included with some hesitation. They are all sterile, but in all details including hair structure (FIGURE 37, n, o) they agree with specimens from New Britain and the Solomons. However, more collections of *C. leleanii* are needed, both to confirm its range and to establish the distribution of staminate and hermaphroditic flowers

in the population (see also Stevens, *loc. cit.*, as *C. solomonense*).

The type specimen of *Calophyllum solomonense* has long seemed to me rather different from the other specimens that were included in the species; the terminal bud has tomentose indumentum, with the hairs long and often branched at the base (cf. FIGURES 37, n, o, and 14, a-m), and the pedicels of the submature fruits are rather long and slender. In both these and other characters the type agrees with *C. soulattri*; therefore, *C. solomonense* is reduced to synonymy under *C. soulattri*.

133. *Calophyllum waliense* P. F. Stevens, sp. nov. FIGURE 38, e-g.

A speciebus aliis Calophylli quibus laminis cordatis habent a costa in pagina superiore laminae depressa et putamine signato parietibus circa 2 mm. crassis obturamento basali proviso, differt.

Tree 20-25 meters tall; trunk without buttresses; outer bark cream-brown to dark brown, slightly fissured; latex yellow, clear, sticky.

Twigs flattened, 2.5-5.5 mm. across, 6-angled, soon becoming rounded, with obscure horizontal lines at nodes, drying brown, sparsely brown-farinose when young; axillary innovations lacking basal scars; internodes 1.5-3.5(-7) cm. long; uppermost pair of axillary buds subacute, to 2.5 mm. long, erect to spreading; terminal bud plump to narrowly conical, 0.8-1.3 cm. long, with gray-brown, crustaceous indumentum (hairs, FIGURE 37, p), underdeveloped internode absent (-2 mm. long). Petiole 3-5 mm. long, concave above and convex below, glabrous; lamina elliptic to suboblong, (9-)14.5-27 by (3.8-)6-10.3 cm., rounded to acute at apex, cordate at base, undulate and narrowly recurved at margin, coriaceous, drying dark brick to olivaceous above and sabelline below, farinose on midrib below when young, the midrib above gradually narrowed from base, depressed, 0.5-1.3 mm. wide at midpoint, below raised, becoming raised toward apex, angled (becoming striate toward base), the venation manifest on both surfaces, raised, latex canals sometimes raised, 4 to 7 veins/5 mm., at base to 14 veins/5 mm., angle of divergence 75-80°. Inflorescences from foliate axils near ends of twigs, with 5 to 7 flowers, unbranched, the axis 1.9-3.2 cm. long, flattened and strongly 4-angled, glabrous, lowest internode 3-9 mm. long; bracts not known; pedicels 1.3-1.5 cm. long, glabrous. Old flower only known, (?)hermaphroditic; outer tepals broadly ovate, ca. 6 by 5 mm., strongly concave, inner ones obovate, to 12.5 by 4.5 mm.; stamens (?)numerous, the anthers oblong, ca. 1.3 mm. long, subrounded at apex; ovary ca. 2.5 mm. long, the style ca. 2.5 mm. long, the stigma peltate, ca. 2 mm. across. Fruit broadly ovoid, ca. 3.8 by 3.3 cm. when preserved in spirit, obtuse at apex, drying dark brown, broadly corrugate-wrinkled; outer layer not detaching cleanly from stone, ca. 1.5 mm. thick, compact; stone spherical, ca. 3 by 2.8 cm., subobtuse at apex, the walls ca. 2 mm. thick, smooth, with 4 or 5 longitudinal markings, outer layer persisting over them, basal plug ca. 10 mm. across; spongy layer absent.

TYPE: Papua New Guinea, Bismarck Archipelago, Manus Island, Wali River near Deribat, 100 m., 3 July 1973, LAE 52411 coll. Foreman (holotype, A; isotypes, CANB, I, LAE).

DISTRIBUTION. Papua New Guinea, known only from Manus Island (MAP 40).

ADDITIONAL SPECIMENS SEEN. **Papuaia**, PAPUA NEW GUINEA. **Manus**: ridge between Liap and Derimbat, 100 m., LAE 59253 (A, L, LAE), LAE 59255 (A, L, LAE).

ECOLOGY. Lowland forest on ridges ca. 100(-7550) m. alt. Young fruit July and October; fruit greenish.

GERMINATION AND YOUNG PLANT. The radicle pushes out the basal plug. The seedling has two pairs of leaves separated by an internode ca. 1.3 cm. long. Subsequent internodes are well developed, the plant is erect, and the terminal bud is functional. (Seedlings from LAE 52411.)

Calophyllum waliense is a distinctive species. Its robust twigs are six-angled, and its terminal buds have furfuraceous indumentum. The lamina is large, cordate at the base, and with a depressed midrib on the upper surface. The fruits are large, and the thick-walled stone has four or five longitudinal stripes and a basal plug. The specific epithet is derived from the Wali River, where the type specimen was found.

Calophyllum waliense is superficially similar to *C. grandiflorum*, from Java, but in the latter species the twigs dry yellowish, rather than brown, the thinner leaf blade lacks a depressed midrib and has less dense venation, and the inflorescence and flowers are much larger. The structure of the fruit is different, and the seed of *C. grandiflorum* germinates by breaking the stone to one side of the base, the seedling having only a single pair of leaves. *Calophyllum waliense* is related neither to *C. grandiflorum* nor to members of the *C. venulosum* group.

The closest relative of *Calophyllum waliense* is probably *C. solomonense*: their twigs and terminal buds are similar, and their leaf blades dry a similar color with the very margin often brighter than the rest of the lamina. The stones of both species have thick walls and a basal plug. *Calophyllum waliense* differs from *C. solomonense* most obviously in its cordate lamina with a depressed midrib on the upper surface and in its longitudinally marked stone.

Calophyllum waliense may grow at 550 meters on Mt. Dremsel, Manus. The sheet of LAE 53644 at Leiden has a shoot of *C. waliense* (with a number tag) as well as one of *C. euryphyllum*; all other duplicates of this number that I have seen are of the latter species.

134. *Calophyllum euryphyllum* Lauterb. Bot. Jahrb. 58: 14, 1922; T. C. Whitmore, Gard. Bull. Singapore 22: 12, 1967, *pro parte*; P. F. Stevens, Austral. Jour. Bot. 22: 365, fig. 4, 1974. TYPE: Nordost-Neu-Guinea [Papua New Guinea], Lagerberg, Augusta Fluss Station, Sept. 1887, *Hollrung* 761 (holotype, ♂ (destroyed); isotype, WRSI).

C. peekelii auct., non Lauterb.; T. C. Whitmore, Gard. Bull. Singapore 22: 11, 1967, *pro parte*.



FIGURE 38. a, b, *Calophyllum goniocarpum*: a, bb 17942, habit, $\times 0.5$; b, bb 33771, terminal bud, $\times 3$. c, d, *Calophyllum* sp. 143 (NGF 24444): c, terminal bud, $\times 6$; d, habit, $\times 0.5$. e-g, *C. waliense* (LAE 52411). e, g, stone, $\times 0.75$: e, from outside; g, longitudinal section, plug displaced. f, terminal bud, $\times 3$.

Tree 12-26 meters tall, d.b.h. to 100 cm.; trunk without or with only very short buttresses; outer bark brown, becoming fissured, \pm scaling, the inner surface dark red; under bark buff, reddish buff, or red-brown; inner bark red; latex clear yellow (rarely yellowish white), sticky.

Twigs strongly flattened, 2.5-6.5 mm. across, 4-angled and with two additional raised lines, drying dark brown, rather persistently farinose to short-tomentose; axillary innovations lacking basal scars; internodes (1-3-10(-16) cm. long; uppermost pair of axillary buds pointed, (1-3-10(-14) mm. long, spreading, supernumerary axillary buds often present; terminal bud subconical, 0.7-1.6 cm. long, with brown, puberulo-tomentose indumentum (hairs, FIGURE 37, w-y), underdeveloped internode (2-4-11 mm. long. Petiole 1.6-3.5(-4.2) cm. long, broadly and usually deeply concave above, angled below, usually persistently puberulent; lamina ovate to subelliptic, (6.5-8.5-19 by (1.5-5.4-12 cm., subtuse to subacuminate at apex, broadly rounded to cuneate or acute at base, at most slightly and distantly undulate and slightly recurved at margin, coriaceous, drying sabelline to near olivaceous (with grayish covering) above and fulvous to sabelline-sepia below, glabrescent or subsersistently farinose-puberulent on midrib on both surfaces, the midrib above quickly narrowed near base, becoming \pm raised, the center strongly sulcate at first, 0.3-0.6 mm. wide at midpoint, below strongly raised, angled, the venation \pm obscure on both surfaces, or subapparent below, slightly raised, latex canals sometimes also slightly raised below, 9 to 13 veins/5 mm., angle of divergence 60-80°. Inflorescences from upper foliate axils, sometimes 2 per axil, with 5 to 15 flowers, usually unbranched (flabellate and/or with 3-flowered branches to 1.2 cm. long), the axis 1.2-5 cm. long, densely puberulent, lowest internode 0.5-1.3 cm. long; bracts ovate, 3-5.5 mm. long, deciduous; pedicels 0.7-1.2 cm. long, densely puberulent. Flower (?) hermaphroditic; tepals 4, the outer pair ovate, 8-9.5 by 6-7.5 mm., densely puberulent on back, the inner pair elliptic-ovate, 8-10 by 7-8 mm., sometimes puberulent in band down back; stamens 70 to 180, the filaments to 6 mm. long, the anthers oblong, 2-3 mm. long, apiculate; ovary to 3 mm. long, densely puberulent, the style ca. 3.5 mm. long, glabrous, the stigma peltate, ca. 3 mm. across, irregularly lobed. Fruit subspherical, 2.8-6 by 2.8-6 cm., rounded at apex, drying snuff-brown, rather closely and shallowly wrinkled; outer layer not detaching cleanly from stone, 2-5 mm. thick, compact; stone spherical, 2.5-5.5 by 2.5-5.5 cm., rounded at apex, the walls 0.5-1.4 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Northern New Guinea, the Bismarck Archipelago, and the Aru Islands (MAP 43).

SELECTED SPECIMENS SEEN. **Papuaia.** IRIAN JAYA. Aru: Wakatoebi, P. Oedjir, 20 m., *bb* 25490 (L, MO). Vogelkop: Doré, *van Hasselt* 6 (BO). Geelvink Bay: Meos Num, 10 m., *BW* 15513 (L). PAPUA NEW GUINEA. Morobe: Umboi Is., Liplip-Mambi R. area, 200 m., *LAE* 66098 (L, LAE). For additional specimens, see Stevens, *loc. cit.*

ECOLOGY. Usually primary rainforest, sometimes over coral; to 610 m. alt. Flowering August and September; fruiting May, June, and November (fruit greenish).

GERMINATION AND YOUNG PLANT. The radicle breaks the stone wall to one side of the base. The seedling has two pairs of leaves separated by an internode 0.5–2 cm. long. Subsequently produced internodes are much longer, the terminal bud is functional, and the plant is erect. (*LAE 53644, 58539, 59189, Noona Dan Exp. 2014*; see also Stevens, *loc. cit.*)

Calophyllum euryphyllum is a very distinctive species with its strongly flattened, usually puberulent twigs; well-developed and spreading uppermost pair of axillary buds; rather large, ovate leaf blades with inconspicuous venation; flowers with four tepals and a puberulent ovary; and spherical fruits that have a compact outer layer and a thick-walled stone lacking a basal plug. The leaf blades are quite broad; hence Lauterbach coined the epithet *euryphyllum* (Greek—*eury*s, "broad," and *phyll*on, "leaf").

UPNG 2019, from the Kiriwina Islands, has the facies of *Calophyllum euryphyllum*, but the midrib on the upper surface of the lamina narrows gradually from the base, and the flowers have nine tepals. The specimen is rather poor, and further collections are needed to establish the identity of this plant.

The relationships of *Calophyllum euryphyllum* are unclear. It is possibly close to *C. papuanum* and its relatives, which have very different terminal buds, fruits, and germination; to *C. obscurum*, which has much smaller leaves and fruits; and to *C. costatum*, which also has small leaves and fruits that probably have a basal plug. *Calophyllum carrii* may also be a member of this group; its fruits are unknown, but its leaf has a depressed midrib. Hairs of all of these taxa are much branched and are generally similar.

135. *Calophyllum papuanum* Lauterb. Bot. Jahrb. 58: 9. fig. 2. 1922; Engler in Engler & Prantl, Nat. Pflanzenfam. ed. 2. 21: fig. 82. 1925; A. C. Smith, Jour. Arnold Arb. 22: 348. 1941; Hartley *et al.* Lloydia 36: 276. 1973; P. F. Stevens, Austral. Jour. Bot. 22: 382. 1974. **TYPE:** Süd-Neu-Guinea [Irian Jaya], südliches Hellwig-Gebirge, 1450 m., 23 Dec. 1912, *Pulle 799* (holotype, v; isotypes, w, x, l).

FIGURES 4, a; 6, a, b.

Tree (5–)16–40 meters tall, d.b.h. to 92 cm.; trunk sometimes with spurs or buttresses to 3 meters; outer bark dark gray to brown, becoming strongly fissured and flaking when mature, the inner surface purplish to red-black; under bark dark red to pink; inner bark dark to pale red; latex clear yellow, very sticky (light yellow, milky). Crown conical at first, becoming irregular, spreading.

Twigs strongly flattened, 2–5(–8) mm. across, (rarely 2-) 4- or 6-angled, often with inconspicuous transverse raised line at nodes, drying brown, subsersistently tomentose (rarely farinose-puberulent); axillary innovations

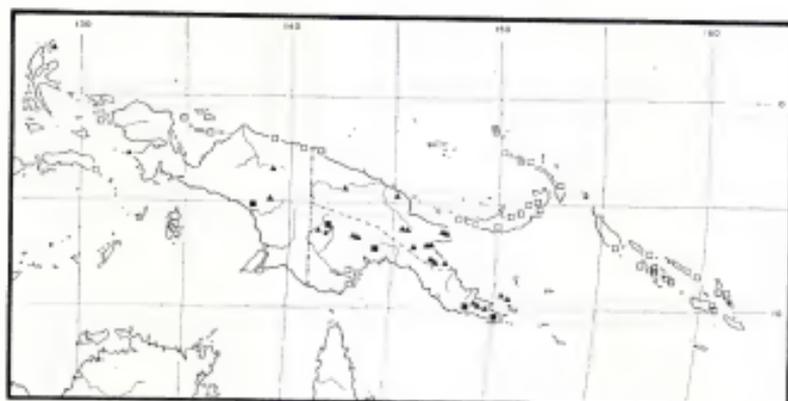
lacking basal scars; internodes 1-6 cm. long; uppermost pair of axillary buds \pm pointed, 2.5-4.5 mm. long, erect; terminal bud strongly flattened, 7-15 mm. long, with brown, tomentose indumentum (hairs, FIGURE 37, u, v), underdeveloped internode to 3 mm. long. Petiole 0.6-2.5 cm. long, narrowly concave above, angled below, usually subsersistently tomentose; lamina ovate to subobovate, subcuneiform or suboblong, (2.4-)6.5-17(-22) by (1.4-)3.5-8 (-11) cm., subacute to rounded at apex, cuneate to rounded at base, slightly undulate and not recurved to slightly so at margin, coriaceous, drying umber to olivaceous (shiny) above and umber to olivaceous below, when young with indumentum on both surfaces, often persistently subtomentose on lower surface, the midrib above usually narrowing gradually from base, \pm depressed at first, soon becoming \pm raised, (0.2-)0.4-0.8 mm. wide at midpoint, below raised, angled, the venation above subobscure, below \pm apparent, raised, 5 to 12 veins/5 mm., angle of divergence 60-80°. Inflorescences from foliate axils near ends of twigs, with (1 to) 3 to 7 (to 11) flowers, usually unbranched, the axis (0.3-)0.7-1.5 cm. long, short-tomentose to sparsely puberulent, lowest internode 0.3-1.2 cm. long; bracts ovate, to 5.5 mm. long, soon deciduous; pedicels 0.5-1.3 cm. long, puberulent to subtomentose. Plant (?)dioecious; tepals usually 8, the outer pair broadly ovate, 4.5-9.2 by 4.5-9 mm., short-tomentose on back, the inner ones oblong to obovate, 6-14 by 4-12 mm., at least outer pair puberulo-tomentose on back; stamens (70 to) 150 to 300, in staminate flower the filaments 3.5-10 mm. long, the anthers oblong, 2.3-5 mm. long, apiculate, sometimes papillate on apiculus, in pistillate flower filaments ca. 3 mm. long, anthers 0.5-1 mm. long; ovary 2.3-5.5 mm. long in pistillate flower, smaller in staminate flower, tomentose, the style 1.5-2.5 mm. long, the stigma peltate, 3-5.5 mm. across (absent in staminate flower). Fruit \pm spherical, 2-4 by 2-4 cm., rounded at apex, drying brown, smooth; outer layer not detaching cleanly from stone, 1.5-5 mm. thick, \pm compact, but air spaces developing near stone; stone subspherical, 1.4-3 by 1.4-3 cm., rounded (obscurely 2- to 4-angled) at apex, the walls 1-2.5 mm. thick, barely developed just to one side of base, irregularly pock marked; spongy layer thin.

DISTRIBUTION. Moluccas, mainland New Guinea, and Fergusson and Goodenough islands (MAP 42).

SELECTED SPECIMENS SEEN. **Moluccas**, MOROTAI: G. Sangowo, 800 m., *Koster-mans 1073* (A, BO, L). **Papuaasia**: see Stevens, *loc. cit.* Also, PAPUA NEW GUINEA, Papuan islands: E. Slopes Mt. Kilkerran (Woiatabu), NE. Fergusson Is., 1600 m., *LAE 68957* (A).

ECOLOGY. Usually canopy tree of colline or montane forest often dominated by Fagaceae, rarely in more or less swampy forest or depleted *Agathis* forest over limestone with thick clay cover; (2-)120-1830 m. alt. Flowering January to March, May, July, September, November, and December (flower scented); fruiting January, April, and September (fruit greenish).

GERMINATION AND YOUNG PLANT. The radicle pushes through the area of very thin stone just to one side of the base (cf. Stevens, *loc. cit.*). The seedling



MAP 42. Distribution of *Calophyllum papuanum* (triangles), *C. vexans* (open squares), and *C. vexans* variant (solid squares) in Papuaia.

has three (rarely two) pairs of leaves separated by well-developed internodes; the lowest pair of leaves may drop off well before the others. Subsequent internodes are also well developed, the terminal bud is functional, and growth is erect. Germination is similar in fruits with angled and with rounded stones (*NGF 10331*, *LAE 54757*, *Pullen 1125*—rounded; *LAE 58071*—angled).

LOCAL USE. The wood is used in building.

Calophyllum papuanum is a very distinctive species with a flattened terminal bud and medium-sized leaf blades that usually have subpersistent, puberulotomentose indumentum over the lower surface. The flower has a tomentose ovary, and the rather large, spherical fruits are 2–4 cm. long and have a pock-marked stone. The specific epithet is taken from "Papua," which once referred to the entire island of New Guinea.

Calophyllum papuanum is related to *C. pauciflorum* and *C. vexans*; for the differences separating these species, see TABLE 16.

Plants of *Calophyllum papuanum* growing at higher altitudes have angled stones; those growing at lower altitudes have rounded ones (Stevens, *loc. cit.*). Other interesting variation is shown by specimens from the hills south of the Sepik River. These specimens have rather small, narrow, subovate leaf blades that are minutely rounded at the base; fruits are not known from plants with leaves of this type.

136. *Calophyllum pauciflorum* A. C. Smith, *Jour. Arnold Arb.* **22**: 348. 1941; Hartley *et al.* *Lloydia* **36**: 276. 1973; P. F. Stevens, *Austral. Jour. Bot.* **22**: 384. 1974. TYPE: New Guinea, Mt. Alok, Yunzaing, 4500 feet [1372 m.], 21 April 1936, *J. & M. S. Clemens 2378* (holotype, A).

- C. congestiflorum* A. C. Smith, Jour. Arnold Arb. 22: 349. 1941. TYPE: Netherlands New Guinea [Irian Jaya], 15 km. south-west of Bernhard Camp, Idenburg River, 1800 m., Jan. 1939, Brass & Versteegh 11902 (holotype, A; isotypes, BO, BRI, L, LAE).
- Calophyllum* sp. Lane-Poole, Forest Res. Terr. Papua New Guinea, 117. 1925.

Tree 8-36 meters tall, d.b.h. to 48 cm.; trunk not buttressed (fluted at base); outer bark brown to dark brown (light gray), fissured and scaling, the inner surface brown to dark brown; under bark dark red; inner bark reddish brown; latex clear yellow, sticky (gray, cloudy).

Twigs strongly flattened, 1.25-3 mm. across, 4- or 6-angled (2-angled when older), with inconspicuous transverse raised line at nodes, drying brown, glabrous or sparsely brown-farinoso; axillary innovations lacking basal scars; internodes 0.3-5 cm. long, to 10 cm. long on leader shoots; uppermost pair of axillary buds \pm pointed, 1-4.5 mm. long, at first inconspicuous; terminal bud strongly flattened, 5-11 mm. long, with brown, farinose-puberulent indumentum (hairs, FIGURE 39, a), underdeveloped internode absent (-2 mm. long). Petiole 2-8 mm. long, deeply channeled above, angled below, \pm glabrous when mature; lamina rhombiform, cuneiform, elliptic, or obovate, 2.5-5.5 (-9.5) by 0.9-2.5(-4) cm., obtusely pointed to rounded at apex, cuneate at base, slightly undulate or recurved at margin, coriaceous, drying umber to cinnamon-sepia above and fulvous-umber to sabelline below, when young sparsely puberulent on both surfaces, glabrescent or persistently sparsely farinose near midrib below, the midrib above narrowed gradually from base, \pm depressed at first with margins raised, becoming \pm raised with center sulcate, (0.3-)0.4-0.55 mm. wide at midpoint, below raised, angled, the venation subobscure on both surfaces, slightly raised (rarely impressed), 7 to 12 veins/5 mm., angle of divergence 50-70°. Inflorescences from upper foliate axils (very rarely terminal), with 3 to 5 flowers, unbranched, the axis 0.3-1.2(-1.5) cm. long, farinose-puberulent at least toward base, lowest internode 2-4 mm. long; bracts ovate to elliptic, 2.5-4.5 mm. long, deciduous; pedicels 2-6 mm. long, glabrous or sparsely farinose-puberulent. Plant (?)dioecious; tepals 8 (rarely 7), the outer pair ovate, ca. 3.75 by 3.5 mm., sometimes farinose on back toward base, the inner ones oblong to obovate, to 5.5 by 6.5 mm.; stamens 70 to 125, the filaments to 4.5 mm. long, the anthers suboblong, 0.7-1.7 mm. long, apiculate; ovary 1-2 mm. long, the style ca. 1 mm. long, the stigma peltate, 1.5-2.5 mm. across, radiate. Fruit spherical, 1.5-1.9 by ca. 1.7 cm., rounded at apex or apiculate, drying brown-vinaceous, smooth or finely striate; outer layer not detaching cleanly from stone, 3-4.8 mm. thick, \pm compact; stone spherical, 1-1.3 by 1-1.3 cm., usually rather obscurely 2- or 3-angled, rounded at apex, the walls 0.7-1.5 mm. thick, thinner just to one side of base, pitted; spongy layer thin.

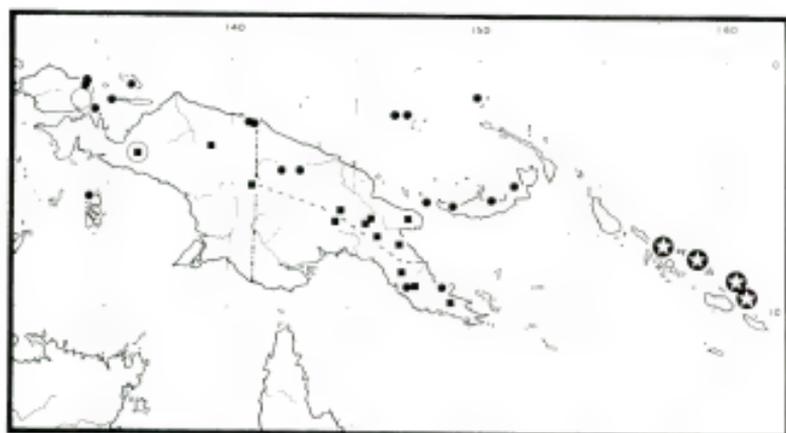
DISTRIBUTION. New Guinea, excluding the Vogelkop Peninsula (MAP 43).

SELECTED SPECIMENS SEEN. **Papuaia:** see Stevens, *loc. cit.*

ECOLOGY. Lower or sometimes upper montane forest, often dominated by

TABLE 16. Some differences between *Calophyllum papuanum*, *C. pauciflorum*, and *C. vexans*.

	<i>C. papuanum</i>	<i>C. pauciflorum</i>	<i>C. vexans</i>
TERMINAL BUD STRONGLY FLATTENED	+	+	+ -
TWIG THICKNESS (mm.)	2-5(-8)	1.25-3	1.5-2.5
LAMINA			
LENGTH (cm.)	(2.4-)-6.5-17(-22)	2.5-5.5(-9.5)	3.4-12.5
INDUMENTUM ON LOWER SURFACE			
± PERSISTENT, SUBTOMENTOSE	+(-)	-	-
VENATION ON UPPER SURFACE OBSCURE	+	+	-(+)
FLOWER			
ANTHER LENGTH, STAMINATE FLOWER (mm.)	2.3-5.5	0.7-1.7	1.8-2.6
HAIRS ON PISTIL	Dense on ovary, some on style	None	Sometimes few on style
FRUIT LENGTH (cm.)	2-4	1.5-1.9	1.8-2.7



MAP 43. Distribution of *Calophyllum euryphyllum* (solid circles), *C. hirastimum* (open circles), *C. pauciflorum* (squares), and *C. obscurum* (stars in solid circles) in Papuaia.

Castanopsis or *Nothofagus*: 1550–2900 m. alt. Flowering January and April; fruiting January, February, and September (fruit greenish).

GERMINATION AND YOUNG PLANT. The radicle probably breaks through the stone wall just to one side of the base. The seedling has three pairs of leaves separated by well-developed internodes. Subsequently produced internodes are longer, the young plant is erect, and the terminal bud is functional. (Pers. obs.)

LOCAL USE. The wood is good as a green fuel.

Calophyllum pauciflorum is a distinctive species recognizable by its flattened terminal buds and its small, often cuneiform-rhombiform leaf blades that appear glabrous when mature. The midrib on the upper surface of the blade

FIGURE 39. Hairs (from terminal bud, unless otherwise noted). a, *Calophyllum pauciflorum* (Hartley 13122), from above. b, c, *C. hirastimum*, hairs to ca. 420 μm . long: b, BW 14295; c, Kanehira & Hatusima 13980. d–f, *C. heterophyllum*, bases birefringent: d, Brass 7385; e, Kalkman 4554; f, Brass 7099. g–j, *C. goniocarpum*, base or entire hair birefringent: g, LAE 56132; h, NGF 1387; i, Brass 27669; j, LAE 68580. k, s, *C. morobense*: k, NGF 46766; s, NGF 24490. l, m, *C. trachycaule* (Brass 5654), slightly birefringent, walls sometimes rough. n, *Calophyllum* sp. 143 (NGF 24444), basal projection sometimes lacking. o, *C. suberosum* (NGF 37159). p, *C. persimile* (NGF 18303), from stem. q, r, t, *C. streimannii*: q, LAE 52775; r, t, NGF 24285. u, v, *C. rufinerve* (Kanehira & Hatusima 12218), slightly birefringent, apex and base of hair ca. 900 μm . long. Scale = 120 μm . (in l, scale = 240 μm .)



narrows gradually from the base, and the venation is more or less obscure. The inflorescences have only three to five flowers, and the fruits are less than 2 cm. long. The few-flowered inflorescences suggested the specific epithet.

Calophyllum pauciflorum is related to *C. vexans* and especially to *C. papuanum*; for the differences separating these taxa, see TABLE 16. The differences are mostly in the size of parts and the prominence of the indumentum, but there is never any trouble in identifying specimens. Although specimens of *C. papuanum* from higher altitudes have smaller leaves and fruits with angled stones (and in these characters approach *C. pauciflorum*), in indumentum development, venation prominence, and midrib type, they are like specimens of *C. papuanum* from lower altitudes. The anthers of Carr 14143 (*C. papuanum*, collected at 1585 m. alt.) are 2.3-2.5 mm. long—considerably longer than those of *C. pauciflorum*. In most characters of wood anatomy studied by van der Graaff and Baas (1974), the two were indistinguishable, except that *C. papuanum* had wider vessels.

The similarities between the three taxa (flattened terminal bud, twig type, branched to almost stellate hairs, more or less well-developed dioecy, mushroomlike stigma, and pocked, often angled, stone) are considerable, and it is of interest to see that the three taxa replace one another geographically and/or ecologically. Although *C. papuanum* and an imperfectly known form of *C. vexans* grow within a few hundred yards of each other in apparently similar habitats near Kiunga in the Western Province of Papua, the identity of the form of *C. vexans* is in doubt (see the discussion after that species).

Specimens of *Calophyllum hirasimum* have been confused with *C. pauciflorum*; this is discussed further under *C. hirasimum*.

More collections of *Calophyllum pauciflorum* are needed to evaluate the variation in stamen and pistil size and to ascertain whether or not the species is dioecious (see also Stevens, *loc. cit.*). There are a few stamens persisting at the base of an immature fruit on Kalkman 4318; these have anthers ca. 1.7 mm. long—the size of anthers in staminate flowers. However, the anthers have apparently not dehisced, and so the fruits may have been produced by functionally pistillate flowers.

137. *Calophyllum vexans* P. F. Stevens, Austral. Jour. Bot. 22: 407, fig. 16. 1974. TYPE: Solomon Islands, New Georgia group, North-west Shortland Island, Kupala Point, 10 feet [3 m.], 7 March 1965, BSIP 13206 coll. Runkera et al. (holotype, LAE; isotype, L).

C. gaimanum P. F. Stevens, Austral. Jour. Bot. 22: 367, fig. 5. 1974. TYPE: Papua, east bank of Lower Fly River, Nov. 1936, Brass 8337 (holotype, LAE; isotypes, A, BO, BRI, G, K, L).

Calophyllum sp. Lane-Poole, Forest Res. Terr. Papua New Guinea, 117. 1925; F. S. Walker, Forests Brit. Solomon Is. Prot. 123. 1945.

C. cerasiferum auct., non Vesque; T. C. Whitmore, Guide Forests Brit. Solomon Is. 77. 1966, Gard. Bull. Singapore 22: 13. 1967.

Tree 12-35 meters tall, d.b.h. to 60 cm.; trunk sometimes with buttresses or stilt roots to 1.7 meters tall; outer bark brown, smooth at first, becoming

fissured and \pm scaly, the inner surface blackish; under bark red to red-brown; inner bark reddish, fibrous; latex yellow (white or greenish), clear (turning cloudy), sticky.

Twigs flattened, 1.5–2.5 mm. across, 4-angled to subulate, with inconspicuous transverse raised line at nodes, drying brown, farinose-puberulent at least when young, or subglabrous; internodes 0.5–8 cm. long; axillary innovations lacking basal scars; uppermost pair of axillary buds \pm pointed, 1–4 mm. long, erect; terminal bud strongly flattened to conical, (3.5–)6–12 mm. long, with subcrustaceous to puberulent, brown indumentum (hairs, FIGURE 37, q–t), underdeveloped internode 0.5–3.5 mm. long. Petiole 0.4–1.4 cm. long, \pm deeply concave above, convex to angled below, glabrous when mature; lamina elliptic to trapeziform, subovate, subobovate, or oblong, 3.4–12.5 by 1.2–4.7 cm., acute to subacuminate at apex, acute to cuneate at base, or rounded toward and attenuate at very base, not undulate to moderately so and recurved at margin, coriaceous, drying sepia to near sabelline-olivaceous above and sepia to honey below, glabrescent or subsersistently farinose on and near midrib, the midrib above narrowed gradually from base (depressed at first), at least margins soon becoming raised, center usually clearly sulcate, (0.1–)0.3–0.6(–0.7) mm. wide at midpoint (disappearing up to 5 mm. below apex), below raised, striate to angled, the venation apparent (rarely subobscure), raised, (6 to) 8 to 11 (to 16) veins/5 mm., angle of divergence (40–)55–75°. Inflorescences from foliate axils (rarely terminal on short, leafy axillary shoots), sometimes 2 per axil, with 3 to 5 (rarely to (?)7) flowers, unbranched, the axis 0.1–1.3 cm. long, subglabrous or farinose-puberulent, lowest internode 1–6 mm. long; bracts ovate, ca. 3.5 mm. long, deciduous; pedicels 2–8.5 mm. long, glabrous or sparsely farinose. Plant (?)dioecious; tepals 4 to 8, the outer pair ovate, 2.7–5 by 2.8–4 mm., sparsely subpuberulent on back toward base, the inner ones elliptic to obovate, 5–6 by 2.5–4.5 mm.; stamens 30 to 105, the filaments 3–4 mm. long, connate at very base, the anthers oblong, 1.8–2.6 mm. long, apiculate, sometimes papillose on apiculus in pistillate flowers; ovary 1–2 mm. long, the style 1.2–1.7 mm. long, sometimes with sparse hairs, at least in staminate flowers, the stigma peltate, 1.8–2.5 mm. across, radiate, sometimes absent in staminate flowers. Fruit spherical to ovoid-ellipsoid, 1.8–2.7 by 1.4–2.2 cm., rounded at apex, drying brown-vinaceous, smooth to sharply and shallowly wrinkled; outer layer not detaching cleanly from stone, 1.5–2.75 mm. across, compact; stone ellipsoid to subovoid, (1–)1.4–1.7 by (0.75–)0.9–1.4 cm., rounded at apex, sometimes subangled, the walls 0.7–2.2 mm. across, pocked; spongy layer thin.

DISTRIBUTION. Throughout Papuaia at suitable elevations (MAP 42).

SELECTED SPECIMENS SEEN. **Moluccas.** SERAM: Kiandarat, 60 m., *bb* 25839 (L). **Papuaia:** see Stevens, *loc. cit.*, *C. gaimanum* and *C. vexans*. Also, IRIAN JAYA. Geelvink Bay: Eil. Biak, Seroei, 50 m., *bb* 30923 (L, SING). PAPUA NEW GUINEA. Morobe: Umboi Is., Lip Lip–Mambi R. area, 200 m., *LAE* 66100 (K, L, LAE).

ECOLOGY. Usually well-drained lowland or colline rain forest, but swampy forest in Western Province; to 900(-1450) m. alt. Flowering November to July (flower scented); fruiting January, April, June, and October (fruit greenish).

GERMINATION AND YOUNG PLANT. The radicle emerges through the area of thin wall just to one side of the base of the stone (*NGF 12351*). The young plant is erect, and the terminal bud is functional.

LOCAL NAME. "Kaumanu" (Kwara'ae, Solomon Islands).

Calophyllum vexans can be recognized by its often flattened terminal bud, its angled twigs, and its leaf blades, which are widest near the middle and which have rather distinct venation and a midrib that is prominent on the upper surface and that narrows gradually from the base. The inflorescence is small, and the plants appear to be dioecious; the fruits have a pock-marked stone. Circumscribing the limits of this taxon has been difficult; hence the epithet *vexans* ("vexing," "annoying").

The differences separating *Calophyllum vexans* from its relatives, *C. papuanum* and *C. pauciflorum*, are listed in TABLE 16.

Although *Calophyllum gaimanum* is reduced to synonymy under *C. vexans*, it could represent a taxon that may have to be recognized formally when the variation within this rather variable species is better understood (see also Stevens, *loc. cit.*). The type of *C. gaimanum* and *NGF 17736* (from the Western Province), and specimens from Umboi Island, New Britain, and New Ireland (but not from Mussau Island) all have a strongly flattened terminal bud and rather narrowly elliptic leaves. In what are presumably staminate flowers, the pistil is relatively well developed; there may be hairs on the style (e.g., *Brass 8337*, *LAE 51230*) or not (e.g., *NGF 46049*). I have not seen hairs on the styles of pistillate plants (e.g., *LAE 52191*). *NGF 27406*, from New Britain, lacks a strongly flattened terminal bud but in other respects agrees with the rest of this group. On *Brass 8337* and *NGF 17736* the midrib usually disappears up to 5 mm. below the apex of the lamina, but this seems to be the only difference between the Papuan specimens and those from the Bismarck Archipelago. Some axillary inflorescences of *Brass 8337* terminate short, leafy lateral shoots; similar inflorescences were noticed on *Noona Dan Expedition 1127*, collected on Mussau Island.

Specimens from the Solomon Islands have a broader lamina and lack an obviously flattened terminal bud; specimens from Irian Jaya have a similar terminal bud, but can be distinguished by other characters such as color of the dried plant and venation density of the lamina.

All specimens of *Calophyllum vexans* collected in Papua (except *Brass 8337* and *NGF 17736*) form another distinct group that has subulate twigs and leaves with rather short petioles; the midrib on the upper surface of the living leaf is dark green, and the lamina is rather soft and fleshy and has an undulate margin. The midrib on the upper surface of the living leaf of the form on New Britain is only slightly raised and is yellowish white; the blade is more coriaceous, and the margin is not undulate. *bb 25839* (Seram)

probably belongs to the same group as the Papuan specimens; flowers of the Papuan specimens are not known.

There is discussion of further minor variation within *Calophyllum vexans* in Stevens (*loc. cit.*), as well as details of size variation of stamens and pistils in staminate and pistillate flowers.

138. *Calophyllum hirasimum* P. F. Stevens, sp. nov. FIGURE 36, j-l.

C. congestiflorum auct., non A. C. Smith; Kanehira & Hatusima, Bot. Mag. Tokyo 56: 560, fig. 1. 1940.

A speciebus aliis Calophylli in lamina suboblunga, inflorescentiis paucifloribus bracteis subpersistentibus foliaceis, floribus cum 4, raro 6, tepalis, et fructu ellipsoideo circa 1.4 cm. longo putamine parietibus circa 2 mm. crassis, differt.

Tree 4-18 meters tall, d.b.h. to 30 cm.; bark not known.

Twigs flattened, 1-2 mm. across, 4-angled when young, becoming subterete, drying dark brown, subpersistently farinose; axillary innovations lacking basal scars; internodes 1-6 cm. long; uppermost pair of axillary buds \pm rounded, (1-)1.5-2 mm. long, erect; terminal bud conical, 2-6(-9) mm. long, with brown, tomentose to subcrustaceous indumentum (hairs, FIGURE 39, b, c), underdeveloped internode to 1 mm. long. Petiole 5-10 mm. long, usually broadly concave above, convex below, farinose when young; lamina elliptic to oblong-elliptic or obovate, 2.8-6.7 by 1.4-3.2 cm., rounded at apex, acute at base, slightly undulate and recurved at margin, coriaceous, drying dark brick to amber (shiny) above and sepia to sabelline below, the midrib subpuberulent on both surfaces, \pm persistently so below, the midrib above narrowed near base, raised, 0.07-0.15 mm. wide at midpoint, below raised, angled to striate, the venation subapparent above and apparent below, raised, 9 to 12 (to 15) veins/5 mm., angle of divergence 65-70°. Inflorescences from foliate axils near ends of twigs, with 3 to 7 flowers, not branched, the axis 0.8-2.8 cm. long; \pm puberulent toward base, lowest internode 0.4-1.4 cm. long; bracts often foliaceous, to 2.8 by 1.5 cm., subpersistent; pedicels 0.5-1 cm. long, glabrous. Flower (?)hermaphroditic; tepals 4 (or 6), sometimes glabrous, the outer pair suborbicular, 3.5-4 by 3.5-4 mm. (rarely 2.5 by 1.5 mm.), the inner ones elliptic to obovate, to 6.5 by 4 mm.; stamens 50 to 85, the filaments to 2.5 mm. long, almost free, the anthers elliptic, ca. 1 mm. long, retuse at apex; ovary ca. 1.7 mm. long, the style ca. 1.5 mm. long, the stigma peltate, ca. 1 mm. across, 3-radiate. Fruit ellipsoid, ca. 1.4 by 1 cm., mucronulate, drying brown, slightly pruinose, smooth; outer layer not detaching cleanly from stone, thin, disorganized by large air spaces; stone ellipsoid, ca. 1.15 by 0.95 cm., rounded at apex, the walls to 2 mm. thick, somewhat thinner at base, smooth, unmarked; spongy layer thin.

TYPE: Netherlands New Guinea [Irian Jaya], Vogelkop Peninsula, S. slope Mt. Nettoti, path Anjai-Wekari River, 1750 m., 30 Nov. 1961, *van Royen & Sleumer* 7896 (holotype, σ ; isotype, ι).

DISTRIBUTION. Western New Guinea (MAP 43).

ADDITIONAL SPECIMENS SEEN. **Papuaia**. IRIAN JAYA. Vogelkop: Arfak Mts., Angi, by Iray, Lake Giji, 2100 m., *Kanehira & Hatusima 13980* (A, BO); Res. Manokwari, Iraay (Anggi Gigi Meer), 2150 m., *BW 265* (CANB, L, LAE); Anggi Gita Lake, Mt. Kongremottie, 2040 m., *BW 14100* (A, L), summit of Mt. Misjnuak (= Mesenuk), 2150 m., *BW 14068* (A, L), Mt. Tidjei, 2100 m., *BW 14295* (A, L), mountain summit, 2100 m., *Kostermans 2490* (BO); Ransiki, Moendi-Berg, 1900 m., *BW 2249* (CANB, KEP, L, LAE). SNOW MOUNTAINS: Wissel Lake region, Is. Maiarie en Tage riviertje, 1750 m., *Eyma 4953* (A, BO, K, L, SING).

ECOLOGY. Locally abundant small tree of primary *Nothofagus*-conifer forest, remnant Ericaceae-Myrtaceae-*Nothofagus* scrub, or secondary forest; 1750–2150 m. alt. Flowering January, July, and November (floral axis reportedly red); fruiting January and April (fruit purple).

Calophyllum hirasimum can be recognized by its small, oblong-elliptic-ovovate leaf blades with rather evident venation; its inflorescences, which have subsistent, foliaceous branches; and its ellipsoid fruits, which have a thin outer layer that is disorganized by air spaces, and a smooth, thick-walled stone. The specific epithet combines the names of R. Kanehira and S. Hatusima, who made very important collections, including the only fruiting collection of this species, in western Irian Jaya.

Although confused with *Calophyllum pauciflorum* (*BW 265* and *2249* were cited under that species with hesitation by Stevens, 1974a), *C. hirasimum* is not closely related to it. In *C. hirasimum* the terminal bud is not flattened (vs. flattened in *C. pauciflorum*) in the plane of the expanded lamina; the young twigs are basically four-angled (vs. two-angled); the lamina is oblong to obovate (vs. rhombiform); the midrib above narrows quickly (vs. gradually) near the base; the inflorescence axis is extended (vs. compact); the bracts are foliaceous and subsistent (vs. small and deciduous); the fruit is purple (vs. greenish); and the stone is smooth (vs. pock marked). The hairs of the two are also quite different (cf. FIGURES 39, b, c; and 39, a); *C. pauciflorum* has a hypodermis in the leaf, while *C. hirasimum* does not (Stevens, 1974a).

Two specimens, *BW 14068* and *Eyma 4953*, have somewhat more coriaceous leaf blades than do the others, and *Eyma 4953* has a very short pair of uppermost axillary buds; in other respects these specimens are not unusual. *BW 2249* and *Kanehira & Hatusima 13980* have rather dense venation (11 to 15 veins/5 mm.), and these specimens have somewhat shorter leaf blades than the others; both specimens have the inflorescence typical of the species. The description of the fruit above is taken from *Kanehira & Hatusima 13980*.

139. *Calophyllum trachycaule* Lauterb. Bot. Jahrb. 58: 13. fig. 3. 1922; A. C. Smith, Jour. Arnold Arb. 22: 346. 1941; P. F. Stevens, Austral. Jour. Bot. 22: 405. 1974. TYPE: Nordost-Neu-Guinea [Papua New Guinea], Sepikgebiet, Augusta-Flussgebiet, Etappenberg, 850 m., 30 Oct. 1912, *Ledermann 9572* (isotypes, K, I).

Tree 10–20 meters tall, d.b.h. to 52 cm.; spurs and buttresses absent; outer bark light or straw brown, with many shallow fissures, not peeling, the inner surface orange and greenish straw mottled; under bark deep red; inner bark red, with darker spots and lines in outer part; latex white, not sticky (*Stevens et al. 910*), or copious, yellowish, milky (*BW 12877*).

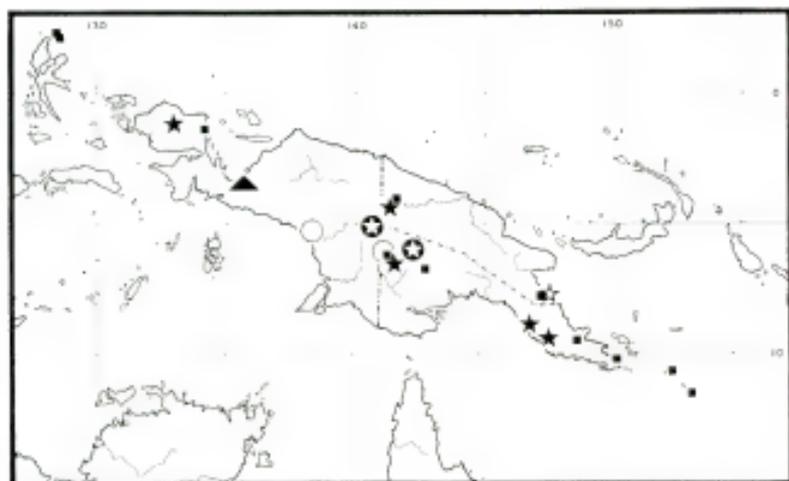
Twigs somewhat flattened, 1.8–3.5 mm. across, 4-angled or rounded, drying brown when young, often yellowish when older, (sub)persistently brown-tomentose; axillary innovations lacking basal scars; internodes (0.5–)1–6 cm. long; uppermost pair of axillary buds subrounded, 1.5–3(–5) mm. long, erect; terminal bud plump, 6–11 mm. long, with brown, tomentose indumentum (hairs, *FIGURE 39*, l, m), underdeveloped internode to 1.5 mm. long. Petiole 0.6–1.5 cm. long, narrowly to broadly concave above, convex below, persistently tomentose; lamina elliptic or oblong to subovate, (5–)7–14 by 1.5–4.5 cm., subacuminate to rounded at apex, rounded to cuneate or acute at base, obscurely undulate and slightly recurved at margin, coriaceous, drying amber to near sabelline above and near sabelline to sepia below, ± persistently tomentose on midrib below (also above), the midrib above gradually narrowed from base, raised, 0.2–0.35 mm. wide at midpoint, below raised, slightly striate, angled toward base, the venation obscure on both surfaces (subapparent below), slightly raised, latex canals often depressed, 12 to 20 veins/5 mm., angle of divergence 70–80°. Inflorescences from foliate or defoliate axils, with 7 to 19 flowers (with 3-flowered branches to 6 mm. long), the axis 0.8–3.7 cm. long, tomentose, lowest internode 3–6 mm. long; bracts unknown; pedicels 2.5–6 mm. long, tomentose. Flower (?)hermaphroditic; tepals 4, the outer pair ovate, 5–6 by 4–5 mm., the inner pair ± elliptic, 6–8 by 4.5–6 mm.; stamens ca. 180, the filaments to 3.75 mm. long, the anthers elliptic, 0.5–0.7 mm. long, retuse at apex; ovary 1.5–2 mm. long, the style ca. 2.5 mm. long, the stigma peltate, ca. 1 mm. across, 4-radiate. Fruit ellipsoid, ca. 2.4 by 2 cm., rounded at apex, drying vinaceous, smooth; outer layer not detaching cleanly from stone, 2.2–3 mm. thick, compact apart from air spaces developing under skin; stone ellipsoid, ca. 1.8 by 1.2 cm., acute at apex, 3- or 4-angled, the walls 1.3–1.7 mm. thick, 2.3–2.8 mm. thick at angles and ca. 0.15 mm. thick just to one side of base, rather rough; spongy layer thin.

DISTRIBUTION. Occasional in New Guinea (*MAP 44*).

ADDITIONAL SPECIMENS SEEN. **Papuaia**, IRIAN JAYA. Vogelkop: N. slopes of Upper Aifat Valley, between Senopi and Aifatfekaan, W. of Kebar Valley, 1050 m., *BW 12877* (?) (A (frag.), L, LAE). PAPUA NEW GUINEA. Western: Kiunga, 18 m., *Stevens et al. 910* (A). Central: Kubuna, 100 m., *Brass 5654* (A, BO, K, LAE, NY, US); Koitaki, 457 m., *Carr 12887* (K, L, LAE, NY, SING).

ECOLOGY. Lowland or colline forest, 18–850 m. alt. Flowering in October; fruiting in November (fruit blue).

Calophyllum trachycaule can be recognized by the well-developed, tomentose indumentum that covers the inflorescence axis and pedicels (but not the tepals), stem, leaf midrib, and terminal bud; by its leaves, which have



MAP 44. Distribution of *Calophyllum goniocarpum* (squares), *C. trachycaule* (solid stars), *C. rufinerve* (triangle), *C. piluliferum* (circles), *C. heterophyllum* (stars in solid circles), and *Calophyllum* sp. 143 (open star) in Papuaia.

dense, obscure venation and impressed latex canals; by its short pedicels; and by its medium-sized fruits with angled stones. The epithet *trachycaule* means "rough stemmed," an allusion to the indumentum on the twigs.

Calophyllum trachycaule is closely related to *C. goniocarpum*; some differences between these and other related taxa are summarized in TABLE 17. All these taxa have leaf blades of a similar texture and color when dry, the margins are barely undulate and slightly revolute, and the venation is dense and somewhat obscure. Flowers are known from three taxa (*C. trachycaule*, *C. goniocarpum*, and *C. rufinerve*); all have four tepals. The outer layer of the fruit has a distinctive texture when dry: in young fruit it is compact, with a few prominent, but not dense, fibers; in fruit near maturity it is more or less disorganized by air spaces. In all taxa (except for *C. rufinerve*, fruit of which I have not seen) the stones are moderately to very strongly angled, the walls are often rough or pock marked, and there is a thin area just to one side of the base (FIGURE 6, c-e). Hairs in all taxa are similar, with thick-walled, often verruculose, basal cells and more or less thin-walled apical cells; there is usually a single basal branch, and the hairs are frequently completely birefringent. Plants of both *C. heterophyllum* and *C. goniocarpum* vary considerably in size.

The limits and number of the taxa in the *Calophyllum trachycaule* complex are difficult to judge. There is great variation in leaf shape and size and in general robustness of the plant (cf. FIGURE 38, a, and 38, c; see especially *C. goniocarpum*) and considerable variation in fruit size, superimposed on a general similarity in leaf type (which extends to anatomical details of the

TABLE 17. Variation of some characters in *Calophyllum trachycaule* and its relatives.

	<i>C. trachycaule</i>	<i>C. heterophyllum</i>	<i>C. rufinerve</i>	<i>C. goniocarpum</i>	<i>Calophyllum</i> sp. 143	<i>C. piluliferum</i>
TERMINAL BUD						
LENGTH (mm.)	6-11	6-10(-12)	5-11	5-14	2-4	4-6
INDUMENTUM	Tomentose	Crustaceous- subtomentose	Tomentose	Furfuraceous- short-tomentose	Subcrustaceous	± Subcrustaceous
LAMINA						
LENGTH (cm.)	(5-)7-14	4.5-9.5	6.8-12.5	(4.2-)6-23	2.2-5.2	4.3-8.8
APEX SHAPE	Subacuminate- rounded	Truncate- subacute	Acute	Subacuminate- retuse	Acute- subcuneate	Acute- bluntly acuminate
VEINS/5 mm.	12 to 20	6 to 11 (to 14)	12 to 16	9 to 17	10 to 14	12 to 22
INFLORESCENCE						
TERMINAL INTERNODE SHORTER THAN OTHERS	No	Yes	—	No	No	No
PEDICEL						
LENGTH (mm.)	2.5-6	4-16	Ca. 10	(0.35-)5-9 (-18 in fruit)	5-10	6-12
INDUMENTUM	Tomentose	None to sparse- puberulent	"Pilose"	None	None	None
FRUIT LENGTH (cm.)	Ca. 2.4	Ca. 1.2	Ca. 0.5	1.7-2.8	Ca. 0.8	Ca. 1.1

blade) and fruit structure. More intensive field work, together with knowledge of germination and seedling, may help to clarify the limits of the taxa involved; few collections with flowers are known. Around Kiunga (Western Province), *C. trachycaule* sensu stricto, the local form of *C. goniocarpum*, and what may be a form of *C. piluliferum* grow in close proximity in well-drained forest on ridges, while near Buso (Morobe Province), the local form of *C. goniocarpum* and *Calophyllum* sp. 143 apparently grow in the same general area.

Lamina shape variation in *Calophyllum trachycaule* has been discussed earlier (Stevens, *loc. cit.*). *BW 12877* and Stevens *et al.* 910 have blades that are more or less acute at the apex and base and so approach the type specimen; the specimens from the Central Province have suboblong blades that are more rounded at the apex and the base. *BW 12877* is also somewhat similar to the type (and only) specimen of *C. rufinerve* and is only provisionally included in *C. trachycaule*.

140. *Calophyllum heterophyllum* P. F. Stevens, Austral. Jour. Bot. 22: 371. fig. 7. 1974. TYPE: Nederlands Nieuw-Guinea [Irian Jaya], Star Mts., Sibil-valley, 1200-1300 m., 26 May 1959, *Kalkman 4151* (holotype, LAE; ISOTYPES, A, BM, BO, CANB, L).

More or less prostrate shrub 1 meter tall to canopy tree 29 meters tall, d.b.h. to 35 cm.; trunk not buttressed; outer bark brown, smooth; latex yellowish, copious.

Twigs flattened, 2-3.5 mm. across, usually obscurely 4-angled, drying yellowish brown, brown-puberulent when young; axillary innovations lacking basal scars; internodes 1-3(-5) cm. long; uppermost pair of axillary buds rounded, to 1.5 mm. long, suberect; terminal bud plump, 0.6-1(-1.2) cm. long, with brown, crustaceous to puberulo-tomentose indumentum (hairs, FIGURE 39, d-f), underdeveloped internode to 1(-3.5) mm. long. Petiole 0.35-1.1 cm. long, concave above and convex below, subsersistently puberulent; lamina oblong, elliptic, ovate, or obovate, 4.5-9.5 by 2-4 cm., broadly truncate to subacute at apex, rounded to cuneate at base, obscurely undulate and flat to recurved at margin, coriaceous, drying dull brick to sepia above and umber to honey-sabelline below, subsersistently puberulent on midrib above, margin, and especially midrib below, the midrib above narrowing gradually to rather quickly near base, flat or subdepressed at first with margins raised, becoming raised, 0.25-0.3 mm. wide at midpoint, below raised, striate, the venation subobscure above and subobscure to apparent below, raised to depressed, 6 to 11 (to 14) veins/5 mm., angle of divergence 75-85°. Inflorescences from foliate axils along twigs, with (3 to) 5 to 11 flowers (sometimes flabellately arranged), unbranched (rarely with 3-flowered branches to 0.6 cm. long), the axis 1-3.2 cm. long, puberulent (?glabrous toward apex), lowest internode 0.2-1.3(-1.7) cm. long, uppermost internode often very much shorter than others, terminal five flowers appearing umbellate; bracts not known; pedicels 0.4-1.6 cm. long, glabrous or sparsely puberulent. Flower (?)her-

maphroditic; tepals 4 (rarely 5), the other pair broadly ovate, ca. 5.5 mm. by 3.5–4 mm., the inner pair elliptic-obovate, 6–7.5 by ca. 3.5 mm.; stamens 100 to 110, the filaments to 3 mm. long, the anthers oblong, ca. 1 mm. long, truncate to slightly retuse at apex; ovary ca. 1.1 mm. long, the style ca. 2.5 mm. long, the stigma excentrically peltate, 0.7–1 mm. across, 4-radiate. Immature fruit subspherical, ca. 1.2 by 1.2 cm., drying maroon, smooth; outer layer soon disorganized by air spaces; stone (?)angled.

DISTRIBUTION. Western New Guinea (MAP 44); little collected.

ADDITIONAL SPECIMENS SEEN. **Papuaia**, IRIAN JAYA. Vogelkop: N. slopes of upper Aifat Valley, between Senopi and Aifatfekaan, W. of Kebar Valley, 810 m., *BW 12831* (?) (L). Snow Mountains: Star Mts., Sibil Valley, 1200–1300 m., *Kalkman 4554* (A, L, LAE, SING). PAPUA NEW GUINEA. Western: Palmer R., 3 km. below junction Black R., 100 m., *Brass 7385* (A, BO, L).

ECOLOGY. Variable: shrubs or treelets, in heathy vegetation developed over poor, white, badly drained loam, 1200–1300 m. alt. (Star Mts.); large tree in primary forest, 810 m. (Kebar Valley); canopy tree common on lower ridges, 100 m. alt. (Palmer R.).

Calophyllum heterophyllum can be recognized by its plump terminal bud and its medium-sized lamina with obscure venation, at least on the upper surface, and usually only 7 to 11 veins/5 mm. The terminal internode of the inflorescence is often notably shorter than the others, or even undeveloped, so there often appears to be a terminal umbel of five flowers. The flowers have four tepals, with the outer pair rather thick. The stone is possibly angled. The epithet *heterophyllum* was chosen because of the considerable variation in leaf size and shape occurring on a single specimen.

The delimitation and relationships of *Calophyllum heterophyllum* are unclear. *Brass 7385* was collected at much lower altitudes and from a much larger tree than the other specimens; it has immature fruits. The margin of the lamina is considerably more recurved than that of the other specimens, but the venation density and inflorescence are similar, and the specimen has a similar facies. The fruits are still very immature, but the center part (stone plus embryo) appears to be angled. This suggests a relationship of *C. heterophyllum* to the *C. trachycaule* complex, from which the venation density and inflorescence type most readily distinguish it (TABLE 17).

BW 12831 has crustaceous indumentum on the terminal bud, and there are up to 13 veins/5 mm. *Brass 7099* (A, BO, K, L) was earlier cited as *Calophyllum* sp. B, aff. *C. heterophyllum* (Stevens, *loc. cit.*); it was collected in the same area as *Brass 7385*. It has elliptic-oblong leaf blades only 2.2–4.5 cm. long, and its immature fruits, which have dried spherical, smooth, and the same color as those of *Brass 7385*, are less than 8 mm. across. However, it is possibly to be included in *C. heterophyllum*. The field notes of *Brass 7099* mention a spurred trunk and thick, flaky, suberose bark. As with other members of the *C. trachycaule* complex, *C. heterophyllum* needs careful study in the field.

141. *Calophyllum rufinerve* Kanehira & Hatusima, Bot. Mag. Tokyo **56**: 563, fig. 4, 1942; P. F. Stevens, Austral. Jour. Bot. **22**: 409, 1974. TYPE: Dutch New Guinea [Irian Jaya], Dalman, 45 km. inward of Nabire, 400 m., 2 May 1940, Kanehira & Hatusima 12218 (isotype, λ).

Tree 20 meters tall; bark unknown.

Twigs somewhat flattened, 1.5–2 mm. across, strongly 4-angled, drying brown when young, yellowish when older, subsersistently brown-tomentose; axillary innovations lacking basal scars; internodes 0.5–3 cm. long; uppermost pair of axillary buds rounded, to 2 mm. long, erect; terminal bud plump, 5–11 mm. long, with brown, tomentose indumentum (hairs, FIGURE 39, u, v), underdeveloped internode absent. Petiole 0.8–1.3 cm. long, deeply concave above, convex below, tomentose; lamina subovate to elliptic, 6.8–12.5 by 1.9–3.4 cm., acute at apex, cuneate to subrounded at base, obscurely undulate and slightly recurved at margin, coriaceous, drying fulvous-umber on both surfaces, subsersistently tomentose on midrib below, the midrib above gradually narrowed from base, raised, 0.2–0.35 mm. wide at midpoint, below raised, striate, the venation obscure above, subapparent below, slightly raised, latex canals \pm impressed, 12 to 16 veins/5 mm.; angle of divergence 75–80°. Inflorescences from (?)defoliate axils, \pm fasciculate, with 1 to 3 flowers, axis absent; bracts unknown; pedicels ca. 1 cm. long, pilose. Tepals 4, glabrous, rounded-elliptic, ca. 2.5 mm. long; stamens ca. 25, ca. 1.2 mm. long; ovary ca. 1 mm. long, stigma dilated. Fruit spherical, ca. 5 mm. across.

DISTRIBUTION. Irian Jaya (MAP 44); known only from the type location.

ECOLOGY. *Agathis* forest, 400 m. alt. Flowering and fruiting in May; fruit black.

Calophyllum rufinerve is a very poorly known taxon that can be characterized by the tomentose indumentum on the terminal bud, twig, and midrib, the pilose pedicels, the fasciculate inflorescence, and the small, spherical fruits only about 5 mm. across. The epithet *rufinerve* means "reddish nerved," an appropriate name because of the reddish indumentum that persists on the midrib.

The fruits of *Calophyllum rufinerve* may have angled stones, but only *Calophyllum* sp. 143 of the *C. trachycaule* complex has fruits comparable in size to those of *C. rufinerve*, and that taxon has very much smaller leaves and a different inflorescence (see TABLE 17). Stevens (*loc. cit.*) suggested that *C. rufinerve* and *C. soulattri* were related, but the latter species often has glabrous pedicels, and its fruits are about twice as big.

The description of the flower and fruit above are taken from Kanehira and Hatusima's original description. They cite the date and altitude of collection of the type specimen as March 2 and 500 meters; on the isotype at the Arnold Arboretum, the date is given as May 2, and the altitude as 400 meters.

142. *Calophyllum goniocarpum* P. F. Stevens, Austral. Jour. Bot. **22**: 369, fig. 6, 1974. TYPE: Papua, Misima Island, Quartz Mountain, 150 m.,

8 Aug. 1956, *Brass* 27669 (holotype, LAE; isotypes, A, BO, K, L).

FIGURES 6, c-e; 38, a, b.

(Shrub or) tree, to 36 meters tall, d.b.h. to 60 cm.; buttresses and spurs absent; outer bark brown, gray-brown, pale yellowish brown, olive, or yellow-green, with long, shallow fissures or small lenticels, the inner surface yellowish straw; under bark brownish, yellow, or red with yellow on back; inner bark reddish; latex opaque yellow, not very sticky, to pale honey, sticky, or watery, resinous.

Twigs slightly flattened, 2-4.5 mm. across, usually rather strongly 4-angled, drying (dark) brown (yellowish when older), with brown, \pm transient to subsistent, puberulent to short-tomentose indumentum; axillary innovations lacking basal scars; internodes 0.5-5(-7.5) cm. long; uppermost pair of axillary buds rounded, 1-4 mm. long, suberect to erect; terminal bud plump, 0.5-1.4 cm. long, with gray to brown, furfuraceous to short-tomentose indumentum (hairs, FIGURE 39, g-j; cf. 39, d), underdeveloped internode absent (-2.5 mm. long). Petiole 0.4-3 cm. long, \pm concave above, convex below, glabrescent; lamina obovate to oblong or elliptic, (4.2-)6-23 by (2-)2.5-9.5 cm., obscurely acuminate to retuse at apex, acute to cordate at base, distantly undulate and slightly recurved at margin, coriaceous, drying near bay or umber to near sabelline above to umber, honey, or sabelline below, soon glabrescent or subsistent puberulent to subtomentose on midrib below, the midrib above \pm abruptly narrowing at base, becoming \pm raised, 0.2-0.5 mm. wide at midpoint (disappearing up to 5 mm. below apex), below raised, striate (weakly angled), the venation usually obscure on both surfaces, slightly raised, latex canals sometimes also raised, 9 to 17 veins/5 mm., angle of divergence 60-80°. Inflorescences from foliate axils, with 5 to 17 flowers (with 3-flowered branches to 1 cm. long), the axis 1-6 cm. long, puberulent to subtomentose at base (also elsewhere), lowest internode 0.3-3.6 cm. long; bracts ovate, to 5 mm. long, soon deciduous; pedicels (0.35-)0.5-0.9 cm. long, to 1.8 cm. long in fruit, glabrous. Flower (?)hermaphroditic; tepals 4 (rarely 5), the outer pair ovate, 4.5-5 by 3.5-4 mm., the inner pair elliptic-obovate, to 6 by 4 mm.; stamens 50 to 180, the filaments to 3 mm. long, the anthers oblong to elliptic, 0.5-2 mm. long, truncate to retuse at apex; ovary 1.2-1.5 mm. long, the style ca. 2.5 mm. long, the stigma pelate, ca. 0.7 mm. across, 3-radiate. Fruit ellipsoid to spherical, 1.7-2.8 by 1.2-2.6 cm., rounded at apex, drying pruinose- to vinaceous-brown, smooth; outer layer not detaching cleanly from stone, 1.5-5 mm. thick, air spaces often developing especially under skin; stone ellipsoid to subspherical, 1.4-2 by 0.8-2.6 cm., acute to obtuse at apex, (2- or) 3- or 4- (or 5-)angled, the walls 0.5-1.4 mm. thick, to 2 mm. thick in angles, ca. 0.3 mm. thick just to one side of base, rough or pock marked; spongy layer thin.

DISTRIBUTION. New Guinea and the Moluccas (MAP 44).

SELECTED SPECIMENS SEEN. **Moluccas.** MOROTAI: subdistr. Tobelo, N. Totodokoe, 40 m., *bb* 33914 (A, BO, BRI, K, L, LAE, NY, P, SING), 30 m., *bb* 33771 (A, BRI, K, LAE, SING). **Papuaia.** IRIAN JAYA. Vogelkop: Warnapi, N. of Ransiki

(80 km. S. of Manokwari), 10 m., *Kostermans 4757* (BO, L). PAPUA NEW GUINEA. West Sepik: August R., *NGF 3837* (?) (BO, CANB, K, L, LAE, SING). Morobe: Buso R., 5 m., *NGF 24474* (A, CANB, LAE, M, SING), *Conn 318* (A); Natter Bay logging area, 93 km. SE. of Lae, 100 m., *LAE 68580* (A). Southern Highlands: Mt. Bosavi, No. side, near mission station, 700-800 m., *Jacobs 8961* (L, LAE, US). Western: SW. corner of airstrip, Kiunga, *NGF 18312* (A, CANB, L, LAE, M, MO). Milne Bay: Mayu Is., junction of Mayu and Ugat rivers, 330 m., *LAE 56132* (A, CANB, E, K, L, LAE, M, MO, US); about half way along the N. shore of Milne Bay, *NGF 1387* (?) (E, L, LAE, SING). Papuan Islands: Tagula Is., Mt. Riu, 700 m., *Brass 27842* (A, K, L, LAE, US), Rambuso, 150 m., *Brass 28042* (A, K, L, LAE, US).

ECOLOGY. Well-drained, often colline forest, rarely swamp forest (*Kostermans 4757*); 10-800 m. alt. Flowering in August; fruiting March, April, July, August, and October (fruit bluish to blackish, sometimes apparently dull green (*LAE 68580*)).

Calophyllum goniocarpum can be recognized by its plump terminal buds, its usually only moderately well-developed indumentum, its medium-sized to large leaf blades with fine, often rather dense venation, its inflorescence axis at least 1 cm. long, and its fruits with angled stones. The epithet *goniocarpum* was chosen because of this last characteristic.

Some of the characters by which *Calophyllum goniocarpum* can be distinguished from other members of the *C. trachycaule* complex are given in TABLE 17. *Calophyllum goniocarpum* is a large-fruited member of the complex and lacks very well developed indumentum.

There is considerable variation in the specimens assigned to *Calophyllum goniocarpum*. Variation in floral characters is poorly known; however, it may be noted that specimens from the Moluccas and the Vogelkop Peninsula (clearly more similar to one another than to any other specimens with angled stones) have flowers with 140 to 180 stamens, while those from the Papuan Islands have 50 to 80. Specimens from around Kiunga have stones that are subspherical in transverse section, the angles being poorly marked; elsewhere in the range of the species, the stones are almost triangular or square in cross section. *NGF 1387*, from the Milne Bay area, has rounded twigs ca. 1.3 mm. across that dry yellowish, the terminal bud is as short as 3.5 mm., and the lamina is as little as 4.3 cm. long. Although probably belonging to a taxon with angled stones, *NGF 1387* is included here mainly for convenience; it has not been included in the description.

Possible confusion between *Calophyllum brassii* and *C. goniocarpum* is discussed under *C. brassii*.

143. *Calophyllum* sp.

FIGURE 38, c, d.

Tree 6-10 meters tall, d.b.h. to 10 cm.; trunk without buttresses; outer bark grayish brown, fissured, the inner surface orange-yellow; under bark orange-reddish; inner bark reddish; latex yellow.

Twigs flattened, 0.7-1.3(-2) mm. across, \pm 4-angled, drying dark brown when young, yellowish brown when old, transiently subfarinose; axillary

innovations lacking basal scars; internodes 0.5–1.5(–3) mm. long; uppermost pair of axillary buds rounded, to 1 mm. long, erect; terminal bud plump, 2–4 mm. long, with brown, adpressed, subcrustaceous indumentum (hairs, FIGURE 39, n), underdeveloped internode absent. Petiole 4–9 mm. long, strongly concave above, convex below, glabrous; lamina elliptic, 2.2–5.2 by 0.5–1.5 cm., acute to subcuneate at apex, cuneate at base, not undulate but slightly recurved at margin, coriaceous, drying umber above and sabelline below, with transient, adpressed indumentum on midrib below (also above), the midrib above gradually narrowed from base, raised, 0.1–0.15 mm. wide at midpoint, below raised, striate or subangled, the venation subobscure above, subapparent below, raised, 10 to 14 veins/5 mm., angle of divergence ca. 65°. Old inflorescences from foliate (rarely defoliate) axils, with 3 to 7 flowers, unbranched, the axis 0.5–1.8 cm. long, puberulent toward base, lowest internode 2–4 mm. long; bracts not known; pedicels 5–10 mm. long, glabrous. Flower not known. Fruit spherical, about 8 by 8 mm., drying purplish brown, smooth; outer layer not separating cleanly from stone, thin, air spaces developing; stone subspherical, ca. 6 by 6 mm., \pm rounded at apex, 3- (rarely 2-)angled, the walls 0.2–0.25 mm. thick, to 0.5 mm. thick in angles, \pm smooth; spongy layer thin.

DISTRIBUTION. Known only from Papua New Guinea (MAP 44).

SPECIMENS SEEN. **Papuaia.** PAPUA NEW GUINEA. Morobe: Mt. Kawea, Buso, 800 m., NGF 24444 (A, CANB, E, K, L, LAE, M, SING), 600 m., LAE 52306 (L, LAE).

ECOLOGY. Rather stunted forest on soil derived from ultramafic rock, 600–800 m. alt. Fruiting in April; fruit blackish.

Calophyllum sp. 143 can be distinguished from the other taxa known to have angled stones by its short terminal buds, small, elliptic leaf blades, and very small fruits (see TABLE 17). The fruits seen (from LAE 52306) were probably ripe, to judge by both their color and the fact that the embryo filled the stone. Unfortunately, they did not germinate.

144. *Calophyllum piluliferum* P. F. Stevens, Austral. Jour. Bot. 22: 387. fig. 11. 1974. TYPE: Papua New Guinea, Western District, Kiunga, 45 m., 8 Aug. 1971, LAE 51772 coll. Streimann & Katik (holotype, LAE; isotypes, A, CANB, L, SING).

Tree ca. 18 meters tall, d.b.h. ca. 23 cm.; trunk without buttresses, but pneumatophores perhaps present (*Pullen* 7531); outer bark light gray, slightly vertically cracked, with few pustules; under bark reddish; inner bark paler red; latex yellow.

Twigs flattened, 1–1.5 mm. across, obscurely 4-angled, drying brown when young, yellowish or whitish brown when older, transiently farinose-puberulent; axillary innovations lacking basal scars; internodes 0.5–3 cm. long; uppermost pair of axillary buds rounded, to 1.5 mm. long, \pm erect; terminal bud plump, 4–6 mm. long, with brown, \pm subcrustaceous indumentum (hairs, FIGURE

43, a, b), underdeveloped internode to 1 mm. long. Petiole 0.6–1.2 cm. long, shallowly concave above, convex below, glabrescent, drying blackish; lamina elliptic to suboblong, 4.3–8.8 by 1.4–3.2 cm., acute to bluntly acuminate at apex, attenuate at base, barely undulate but slightly recurved at margin, coriaceous, drying sabelline on both surfaces, \pm transiently farinose-puberulent on midrib below, the midrib above gradually narrowed from base, raised, 0.1–0.2 mm. wide at midpoint (disappearing just below apex), below raised, striate, venation obscure to apparent, the latter especially below, raised, 12 to 22 veins/5 mm., angle of divergence 65–75°. Infructescences from foliate axils, with scars of 3 to 11 flowers, rarely branched, the axis 0.15–1.6 cm. long, glabrous, lowest internode 2–4 mm. long; bracts unknown; pedicels 0.6–1.2 cm. long, glabrous. Flower unknown; few stamens persisting at base of fruit, the filaments to 2 mm. long, the anthers oblong, ca. 0.5 mm., retuse at apex. Fruit spherical, ca. 1.1 by 1.1 cm., rounded at apex, drying pruinose-brown, smooth; outer layer not detaching cleanly from stone, ca. 0.5 mm. thick, with large air spaces developing; stone ellipsoid, ca. 9.5 by 7.5 mm., obtuse at apex, 3- or 4-angled, the walls ca. 0.4 mm. thick, to 1 mm. thick in angles, \pm smooth; spongy layer thin.

DISTRIBUTION. Southern New Guinea (MAP 44).

ADDITIONAL SPECIMENS SEEN. **Papuasias**. IRIAN JAYA. Digul: Asmat region, Erma, 0 m., *BW 6577* (L). PAPUA NEW GUINEA. Western: Upper Fly R. along the Binge R., 10 m. *Pullen 7531* (CANB).

ECOLOGY. Forest in or near swamps, to 40 m. alt. Fruiting in August; fruit blackish red.

Calophyllum piluliferum can be recognized by its rather small leaves that are acute to bluntly acuminate at the apex and attenuate at the base, and by its fairly small, spherical fruits with angled stones. Older twigs dry pale brown. The epithet *piluliferum* was chosen because the round fruits are like small balls (*pilus*, Latin "ball").

Calophyllum piluliferum is related to *C. trachycaule*; some characters by which it can be differentiated from this and related taxa are given in TABLE 17.

The leaf blades of *BW 6577* are somewhat thin, and their venation is notably prominent; however, it seems that the specimen was collected soon after a flush of growth.

There are three collections from Papuasias in which the leaf base is so narrowly attenuate that the petiole appears to be much longer than it actually is (cf. also *Calophyllum venulosum* var. *tenuivenium*); they are perhaps close to *C. piluliferum*. *Stevens et al. 913* was also collected at Kiunga, but its pale yellow-drying twigs are about 2 mm. across, and the lamina is apparently 11.5 by 3.4 cm., with the "petiole" ca. 2 cm. long. Two collections from Japen Island, Irian Jaya (*bb 30480* (A, L, SING) and *bb 30481* (A, L)), have a similarly long "petiole" but differ in facies; the lamina of *bb 30481* is up to 22 by 4.3 cm. More collections are needed to assess the status of these collections.

145. *Calophyllum streimannii* P. F. Stevens, Austral. Jour. Bot. 22: 401. fig. 14. 1974. TYPE: Papua New Guinea, Morobe District, 24 km. SW. of Morobe on the Mo River, 300 m., 28 Jan. 1972, NGF 24285 coll. *Streimann* (holotype, LAE; isotypes, A, CANB, K, L, SING).

Tree 15-35 meters tall, d.b.h. ca. 30 cm.; trunk without buttresses; outer bark yellowish to dark gray, with longitudinal fissures; under bark reddish; inner bark cream; latex yellow.

Twigs slightly flattened, 2-4 mm. across, \pm strongly 4-angled, drying dark brown, transiently farinose to subpersistently puberulo-tomentose; axillary innovations lacking basal scars; internodes 0.5-5 cm. long; uppermost pair of axillary buds rounded, to 2 mm. long, suberect, not very conspicuous; terminal bud plump, 5.5-10 mm. long, with crustaceous to puberulo-tomentose indumentum (hairs, FIGURE 39, q, r, t), underdeveloped internode to 1 mm. long. Petiole (0.4-)1.5-2.5 cm. long, concave above, convex below, glabrous or subpersistently pubescent; lamina suboblong to elliptic or subobovate, 5.2-14 by 2.2-6 cm., acuminate to subacute at apex, acute to attenuate at base, rather distantly undulate and sharply recurved at margin, coriaceous, drying sabelline- to hazel-olivaceous above and fulvous-umber to sepia below, glabrescent or with subpersistent indumentum on midrib below, the midrib above narrowing gradually from base, becoming \pm raised, surrounding blade raised or not, 0.3-0.5 mm. wide at midpoint, below raised, \pm angled, the venation above subobscure to apparent, below apparent, raised, 6 to 10 veins/5 mm., angle of divergence 65-80°. Infructescences from foliate axils, with the scars of 7 flowers, unbranched, the axis ca. 2 cm. long, persistently puberulent to subtomentose, at least toward base, lowest internode 0.7-1 cm. long; bracts unknown; pedicels ca. 6 mm. long, (?)glabrous. Flower known only in bud, (?)hermaphroditic; tepals 8; stamens ca. 80, the anthers oblong, ca. 1.3 mm. long, acuminate at apex. Fruit ovoid to ellipsoid, 3.6-5 by 2.8-3.8 cm., pointed at apex, drying dark brown, smooth; outer layer detaching cleanly from stone or not, 4-5 mm. thick, compact; stone ovoid, ca. 2.5 by 1.9 cm., obtuse at apex, the walls 1-1.75 mm. thick, 3 mm. thick at base, smooth, unmarked, with basal plug ca. 8 mm. across; spongy layer thin.

DISTRIBUTION. Morobe Province, Papua New Guinea (MAP 40).

SELECTED SPECIMEN SEEN. **Papuasiasia**. PAPUA NEW GUINEA. Morobe: BUSO, 30 m., LAE 52755 (A, CANB, K, L, LAE).

ECOLOGY. Ridges or hillsides, often with dipterocarps, 30-300 m. alt. Fruiting in January; fruit blue.

GERMINATION AND YOUNG PLANT. The radicle pushes out a plug from the base of the stone. The seedling has two pairs of leaves separated by an internode of ca. 1 cm. Subsequently produced internodes are longer, the terminal bud is functional, and the plant is erect. (NGF 24285, 24491.)

Calophyllum streimannii can be recognized by its suboblong to elliptic, medium-sized to rather large leaf blades that are acuminate at the apex,

somewhat sharply recurved at the margin, and with only 6 to 10 veins/5 mm. The fruit is large (3.6–5 cm. long) and is pointed at the apex; the outer layer is thick (4–5 mm.), and the stone has a basal plug. The epithet commemorates the collector, H. Streimann.

Calophyllum streimannii is a rather heterogeneous taxon. *NGF 28084* is included with hesitation; it differs in a number of details from the other specimens (see Stevens, *loc. cit.*); the details of the flower bud in the description above are taken from this specimen.

Calophyllum streimannii may also occur in the Western Province (*Foreman s.n.*, *LAE sheet 129036*, 8 km. N. of Kiunga on road to Rumingae, 30 m. (*LAE*)).

Calophyllum streimannii is perhaps close to *C. morobense*, but it has larger leaves with more distant venation and fruits about twice as large that dry smooth rather than sharply wrinkled. The hairs of the two species are fairly similar (cf. *FIGURE 39, q, r, t, and 39, k, s*).

146. *Calophyllum morobense* P. F. Stevens, *Austral. Jour. Bot.* **22**: 378, *fig. 9, 1974* ("C. morobensis"). TYPE: Papua New Guinea, Morobe District, Sunkwep road, 220 feet [65 m.], 19 April 1971, *NGF 46766* coll. *Katik* (holotype, *LAE*; isotypes, A, CANB, E, G, K, M, SING).

Tree to 21 meters tall, d.b.h. to 30 cm.; trunk without buttresses or spurs; outer bark dull greenish with slightly raised, elongated orange patches, or light gray, with shallow, boat-shaped fissures, the inner surface dull orange; under bark dull dark red; inner bark cream to reddish; latex whitish near outer bark, brownish near wood, or yellow (*NGF 24490*). Branching horizontal, crown open.

Twigs flattened, ca. 1.5 mm. across, 4-angled, drying dark brown, sparsely puberulent when young; axillary innovations lacking basal scars; internodes 1–3.5(–7.5) cm. long; uppermost pair of axillary buds rounded, ca. 0.5 mm. long, spreading, inconspicuous; terminal bud plump to narrowly conical, 2.5–5 mm. long, with brown indumentum (hairs, *FIGURE 39, k, s*), underdeveloped internode absent. Petiole 0.6–1 cm. long, concave above, convex below, glabrous at maturity; lamina elliptic to ovate or suboblong, 4.5–9 by 2–4.5 cm., acuminate at apex, acute to cuneate at base, slightly undulate and not recurved or slightly so at margin, coriaceous, drying bay to cinnamon above and bay to umber below, glabrous at maturity, the midrib above gradually narrowed from base, ± depressed at first, eventually becoming slightly raised, 0.1–0.2(–0.3) mm. wide at midpoint, below slightly raised, striate, the venation subobscure to apparent on both surfaces, slightly raised or not, latex canals sometimes impressed, 13 to 16 veins/5 mm., angle of divergence 75–80(–85)°. Infructescences from foliate axils, with scars of 7 flowers, unbranched, the axis 1–1.5 cm. long, glabrous, lowest internode ca. 3 mm. long; bracts unknown; pedicels 5–7 mm. long, glabrous. Flower unknown. Fruit ovoid to subspherical, ca. 2.8 by 2.2–2.8 cm., acute at apex, drying brown, sharply and closely wrinkled; outer layer detaching cleanly from stone or not, 2–3.5 mm. thick, compact; stone ovoid to ellipsoid, 2.2–2.7 by 1.8–1.9 cm., ± obtuse at apex,

the walls 1.3–1.5 mm. thick, smooth apart from shallow, elongated pock marks, probably with basal plug ca. 6 mm. across; spongy layer thin.

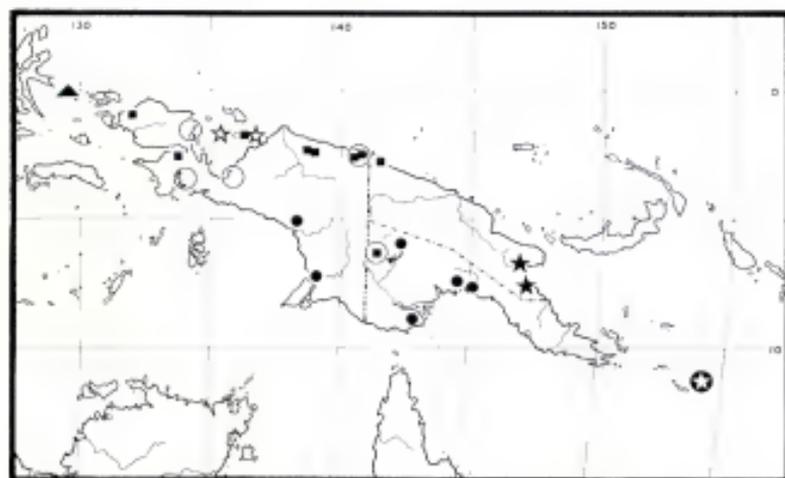
DISTRIBUTION. Morobe Province, Papua New Guinea (MAP 45).

SELECTED SPECIMEN SEEN. **Papuasias**. PAPUA NEW GUINEA. Morobe: near Buso Village, 5 m., NGF 24490 (A, CANB, E, K, LAE, M, SING).

ECOLOGY. Alluvium in lowland rainforest, 5–35 m. alt. Fruiting in April; fruit bluish to almost black.

Calophyllum morobense can be recognized by its medium-sized, strongly acuminate leaf blades with a relatively inconspicuous midrib on both surfaces and fairly dense venation (13 to 16 veins/5 mm.). The fruits are relatively large, more or less acute at the apex, and dry strongly wrinkled; the stone walls are 1.2–1.5 mm. thick. Plants referable to this taxon have been collected only from Morobe Province, Papua New Guinea—hence the epithet.

It was earlier thought (Stevens, *loc. cit.*) that *Calophyllum morobense* was similar in leaf to *C. pulcherrimum* and *C. floribundum* (= *C. tetrapterum*); however, the midrib on the upper surface of the lamina is not surrounded by raised blade as in *C. pulcherrimum*, nor is it sharply raised as is usual in *C. tetrapterum*. *Calophyllum morobense* does not seem to be particularly closely related to these or any other West Malesian species but is most similar to *C. streimannii*. For the differences separating these species, see *C. streimannii*.



MAP 45. Distribution of *Calophyllum macrophyllum* (triangle), *C. persimile* (squares), *C. novoguineense* (open circles), *C. suberosum* (solid circles), *C. morobense* (solid stars), *C. insularum* (open stars), and *C. acutiputamen* (star in solid circle) in Papuasias.

147. *Calophyllum acutiputamen* P. F. Stevens, Austral. Jour. Bot. **22**: 359, fig. 1, 1974. TYPE: Papua, Rossel Island, Abaleti, 300 m., 5 Oct. 1956, Brass 28325 (holotype, LAE; isotypes, A, BO, K, L, US).

(?) Large tree; bark unknown; latex reported to be "not milky."

Twigs slightly flattened, 2-2.5 mm. across, 4-angled and with two additional raised lines, drying dark brown, with subadpressed indumentum when young; axillary innovations lacking basal scars; internodes 0.5-3(-5.5) cm. long; uppermost pair of axillary buds \pm pointed, ca. 1 mm. long, erect and adpressed to terminal bud; terminal bud conical, 7-9 mm. long, with subadpressed, brown indumentum (hairs, FIGURE 43, c, d), underdeveloped internode to 1 mm. long. Petiole 0.7-1.2 cm. long, narrowly channeled above, angled below, \pm glabrous when mature; lamina elliptic to subobovate, 5.5-8 by 1.5-2.4 cm., acute at apex, cuneate at base, not undulate and not recurved to slightly so at margin, very coriaceous, drying cinnamon-sepia above and cinnamon below, subsperisulently puberulent on midrib below, the midrib above narrowed gradually from base, raised, 0.3-0.35 mm. wide at midpoint, below raised, angled, the venation on both surfaces obscure, slightly raised, 9 to 11 (to 13) veins/5 mm., angle of divergence 55-60°. Infructescences from foliate axils, with scars of 3 to 5 flowers, unbranched, the axis 0.5-1 cm. long, with sparse, subadpressed hairs, lowest internode ca. 4 mm. long; bracts unknown; pedicels 5-6 by 3 mm., sparsely puberulent. Flower unknown. Fruit ellipsoid, 4-4.3 cm. by 2.6-2.8 cm., \pm apiculate, drying brown, with shallow, longitudinal corrugations; outer layer not detaching cleanly from stone, ca. 3.5 mm. thick, with large air spaces developing; stone ellipsoid to subobovoid, ca. 3.5 by 1.5 cm., acute at apex, the walls 0.8-1.2 mm. thick, thinner to one side of base, \pm smooth, unmarked; spongy layer thin.

DISTRIBUTION. Papuaasia; known only from the type collection from Rossel Island (MAP 45).

ECOLOGY. Canopy tree on ridges in colline forest, ca. 300 m. alt. Submature fruit in October.

Calophyllum acutiputamen can be recognized by its more or less conical terminal bud; its unbranched, simple hairs; its elliptic, flat-drying leaves with obscure venation; and its relatively large (ca. 4 cm. long), ellipsoid fruits. The outer layer of the fruit is almost disorganized by air spaces although the skin is practically smooth; the stone is very sharply pointed at the apex. This latter feature suggested the specific epithet (*acutiputamen* means "pointed stone").

148. *Calophyllum suberosum* P. F. Stevens, Austral. Jour. Bot. **22**: 403, fig. 15, 1974, *pro parte*. TYPE: Papua New Guinea, Western District, Oriomo River, 70 feet [21 m.], 19 Jan. 1959, NGF 10410 coll. White & Gray (holotype, LAE; isotypes, A, BO, BRI, CANB, K, L, SING).

C. peekelii auct., non Lauterb.; T. C. Whitmore, Gard. Bull. Singapore **22**: 11, 1967, *pro parte*.

Tree 15-35 meters tall, d.b.h. to 60 cm.; trunk with stilt roots to 2 meters tall; outer bark (yellowish) gray-brown, deeply fissured, with flakes or scales, the inner surface straw brown; under bark pale reddish brown; inner bark pale reddish brown; latex clear yellow, very sticky.

Twigs flattened, 5-7(-9) mm. across, 4- or obscurely 6-angled, with obscure transverse lines at nodes, drying yellowish, sparsely brown-farinoso when young; axillary innovations lacking basal scars; internodes 1-7.5 cm. long; uppermost pair of axillary buds acute (rounded), 2-5 mm. long, \pm erect; terminal bud narrowly conical, 0.8-1.3 cm. long, with brown, crustaceous to subfurfuraceous indumentum (hairs, FIGURE 39, o; also moruloid), underdeveloped internode to 2 mm. long. Petiole 2-3.3 cm. long, broadly concave above, convex below, glabrous when mature; lamina ovate to elliptic, 16-35 by 7.5-14.2 cm., acute to rounded at apex, broadly rounded and finally acute at base, undulate and slightly recurved at margin, coriaceous, drying umber to sabelline-olivaceous above and near sabelline below, transiently brown-farinoso on midrib below, the midrib above gradually narrowed from base, raised, surrounding blade raised, 0.4-0.7 mm. wide at midpoint, below strongly raised, \pm angled, the venation apparent above and especially below, raised, latex canals sometimes also raised, 5 to 8 (or 9) veins/5 mm., angle of divergence 70-80°. Inflorescences from foliate axils, with scars of 3 to 5 flowers, unbranched, the axis 1.5-2.8 cm. long, farinoso at least toward base, lowest internode 1-1.5 cm. long; bracts unknown; pedicels in fruit 1.5-3 cm. by 6 mm., glabrous. Flower unknown. Fruit in spirit spherical to ovoid, 8-9.5 by 7-8 cm., rounded to very obtusely pointed at apex, with broad, longitudinal ridges; outer layer not detaching cleanly from stone, 4-7 mm. thick, compact; stone spherical, 6-7 by 6-7 cm., rounded at apex, the walls ca. 0.7 mm. thick, smooth, (?)unmarked; spongy layer ca. 2 cm. thick.

DISTRIBUTION. Southern New Guinea (MAP 45).

ADDITIONAL SPECIMENS SEEN. **Papuaia**. IRIAN JAYA. Mimika: Asmat subdistr., Erma, *BW* 3231 (CANB, L), 6501 (L), 6504 (L), 6547 (L). Digul: along R. Digoel, near Koeweh, 5 m., *BW* 4839 (L). PAPUA NEW GUINEA. Western: Kiunga, Tuidemasuk Road, *NGF* 18335 (A, CANB, L, LAE), near airstrip, *Stevens et al.* 780 (A); Fly R., *d'Albertis s.n.*, anno 1877 (*herb. Becc.* 1144) (FI); 32 km. from mouth of Oriomo R., 45 m., *NGF* 37159 (A, L, LAE, SING); near Oriomo Station, 20 m., *LAE* 60418 (A, L, LAE). Gulf: Kikori R., *NGF* 4551 (A, BO, E, K, L, LAE, SING); Purari R. near Ravi Kawai, *Pullen* 6466 (CANB), *Craven & Schodde* 832 (A, CANB, L, LAE).

ECOLOGY. Swamp forest; river banks sometimes subject to tidal influence; below 45 m. alt. Fruiting January, March, and November (fruit green, embryo bright purple (*NGF* 10410; pers. obs.); fruit floats in water (*NGF* 37159) and may be dispersed by rivers).

GERMINATION AND YOUNG PLANT. The radicle breaks the stone just to one side of the base. The seedling has three, or sometimes two, pairs of leaves separated by internodes 4-17 cm. long; the lowest pair may fall off before the others. Subsequently produced internodes are also long, the terminal bud is functional, and the plant is erect. (*NGF* 18335, *Stevens et al.* 780.)

Calophyllum suberosum is a distinctive species that can be recognized by its large, ovate, coriaceous leaf blades in which the midrib on the upper surface is surrounded by raised blade. The very large fruits and the yellow-drying twigs are also characteristic. The epithet *suberosum* ("corky") was chosen because the fruit has a well-developed spongy layer and is apparently able to float.

Calophyllum suberosum is superficially similar to *C. persimile*; specimens of the two species were included in the original description of *C. suberosum*. The differences between the two species are discussed under *C. persimile* and listed in TABLE 18.

149. ***Calophyllum persimile*** P. F. Stevens, sp. nov. FIGURE 40, k.

C. suberosum P. F. Stevens, Austral. Jour. Bot. 22: 403. 1974, *pro parte*.
Calophyllum sp. C, P. F. Stevens, Austral. Jour. Bot. 22: 395. 1974.

A *Calophyllum suberoso*, quo ut videtur simili est, in lamina angustiore elliptica-oblonga percrassa apice retusa vel obtusa basi plerumque acuta, trunco radicibus grilliformibus haud proviso, et latice opaco, differt.

Tree 20–25 meters tall, d.b.h. to 40 cm.; trunk sometimes with small buttresses; outer bark yellow, or gray, red-brown, and yellowish mottled, or pale brown (rarely brownish black), fissured (scaly), the inner surface bright yellow (brownish under fissures); under bark red-brown or red and pale red mottled; inner bark red to cream; latex yellow, opaque, slightly viscous or not.

Twigs slightly flattened, [1.5–]3–6.5 mm. across, strongly 4-angled to subulate, or 6-angled, with obscure transverse lines at nodes, drying brown and shiny when young, later yellowish, transiently and sparsely brown-farinose; axillary innovations lacking basal scars; internodes 1–7.5(–9) cm. long; uppermost pair of axillary buds subacute, [1–]2.5–3.5 mm. long, erect; terminal bud plump to conical, [4–]7–9 mm. long, with brown, crustaceous to furfuraceous indumentum (hairs, FIGURE 39, p; cf. 39, o; also moruloid), underdeveloped internode to 2 mm. long. Petiole [1–]1.6–3.7 cm. long, shallowly concave to flat above and concave below, glabrous; lamina elliptic to oblong (rarely subovate), [5–]10–30 by [2.5–]3.5–9(–11.3) cm., retuse to rounded (rarely obtuse) at apex, acute to decurrent (rarely broadly rounded and ultimately acute) at base, slightly and distantly undulate and not recurved to slightly so at margin, very coriaceous, drying sepia to umber above and sepia-umber to sabelline below, sparsely subfarinose on midrib below, the midrib above gradually narrowed from base, raised, surrounding blade raised, 0.3–0.8 mm. across at midpoint, below raised, rounded to angled, the venation subapparent on both surfaces, raised, 4 to 10 veins/5 mm., angle of divergence [50–]65–80°. Inflorescences from foliate axils, with ca. 5 flowers, unbranched, the axis 1–2.1 cm. long, farinose toward base, lowest internode 0.4–1.3 cm. long; bracts ovate, 5–6.5 mm. long, farinose-puberulent beneath, subpersistent; pedicels 3–8 mm. long, glabrous. Flower (?) hermaphroditic; tepals 4, glabrous, the outer pair suborbicular, ca. 5 by 6 mm., the inner pair suboblong to

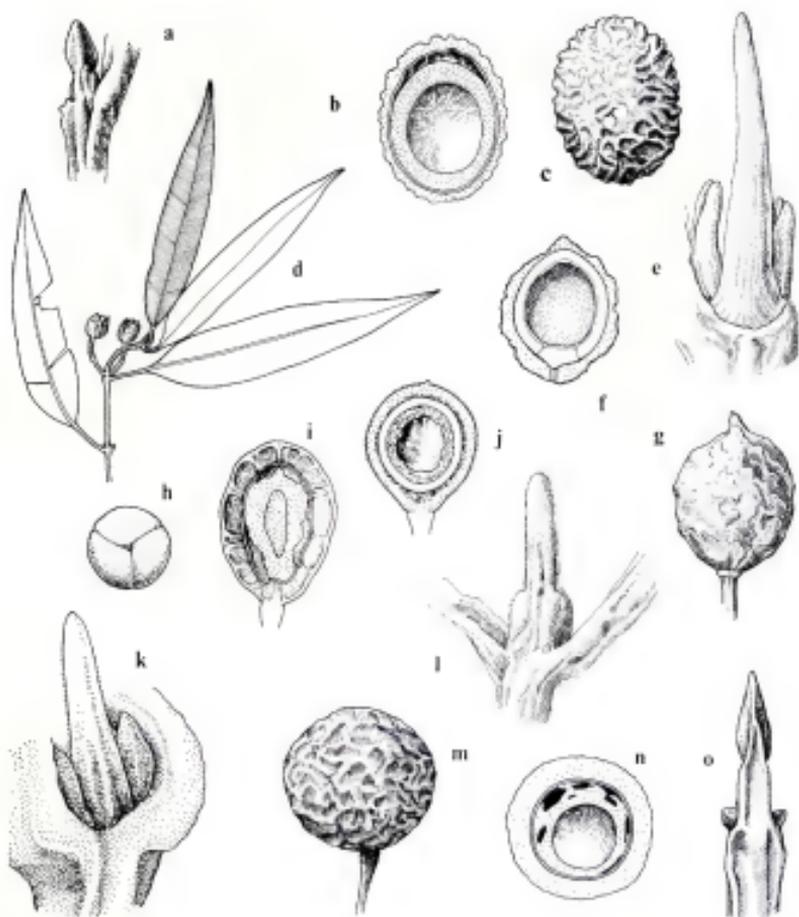


FIGURE 40. a-c, *Calophyllum rugosum*. a, *Pollane* 3494, terminal bud, $\times 3$. b, c, *Pollane* 30978, fruit, $\times 1$: b, longitudinal section; c, from outside. d, *C. insularum* (*bb* 30941), habit, $\times 0.5$. e-g, *C. leleanii*. e, *NGF* 6607, terminal bud, $\times 3$. f, g, *Brass* 3477, fruit, $\times 1$: f, longitudinal section; g, from outside. h, j, *C. molle* (*KEP* 77929), fruit, $\times 0.75$: h, stone, from apex; j, entire fruit, longitudinal section. i, *C. rubiginosum* (*FRI* 8709), fruit, longitudinal section, $\times 1$. k, *C. persimile* (*NGF* 18303), terminal bud, $\times 3$. l, *Calophyllum* sp. 151 (*Stevens et al.* 46), terminal bud, $\times 6$. m-o, *Calophyllum* sp. 163 (*S* 19958). m, n, fruit, $\times 1.5$: m, from outside; n, transverse section. o, terminal bud, $\times 3$.

suborbicular, ca. 9 by 8 mm.; stamens ca. 90, the filaments to 3 mm. long, the anthers oblong, 2-2.5 mm. long, acute at apex; ovary ca. 2.5 mm. long, the style ca. 2.5 mm. long, the stigma peltate, 3.5-5 mm. across, 3-radiate. Immature fruit ovoid, ca. 3 by 2.2 cm., smooth; outer layer ca. 3 mm. thick; stone not known.

TYPE: Papua New Guinea, Western District, SW. corner of Airstrip, Kiunga, 25 m., 15 Sept. 1972, *NGF 18303* coll. *Streimann & Lelean* (holotype, A; isotypes, E, CANB, K, L, LAE, M, MO, SING).

DISTRIBUTION. Western Papuasias (MAP 45).

ADDITIONAL SPECIMENS SEEN (* denotes specimen with leaf anatomy examined).

PAPUASIA. IRIAN JAYA. Vogelkop: Warsamson Valley, E. of Sorong, 50 m., *BW 12327* (L, LAE*), Geelvink Bay: Japen Is., Aisaoc, bivouac Sebosiani, 210 m., *BW 9229* (CANB, L, LAE*), 180 m., *BW 10007* (L, LAE*), 200 m., *BW 10539* (L, SING), 200 m., *BW 10547* (L, LAE*). Djajapura: Bodem R., 60 km. SE. of Sarmi, 70 m., *BW 8092* (L*, LAE, CANB); Kwansem R., 200 km. W. of Hollandia, 138 m., *BW 2378* (L, LAE*, SING); Cycloop Mts., So. slope of Makanoi Range, W. of Kujabu R., 560 m., *van Royen & Sleumer 6561* (A*, CANB, L, LAE); Hollandia, 50 m., *bb 25081* (A*, BO, L), *Kostermans & Soegeng 287* (K*, L). Fak-Fak: Anakasi (Babu), 50 m., *bb 32697* (L). PAPUA NEW GUINEA. West Sepik: Vanimo, 30 m., *LAE 52952* (LAE*), 30 m., *LAE 53835* (L, LAE), *VTA 2184* (LAE). Western: Rumginae Road, 8 km. from Kiunga, 45 m., *Stevens et al. 808* (A*), 45 m., *Stevens et al. 809* (A*), 12 km. from Kiunga, 30 m., *Stevens et al. 843* (A*).

ECOLOGY. Well-drained rain forest (Papua New Guinea); moist valleys, or rain forest inundated in wet season (Irian Jaya); 20-560 m. alt. Flowering in September.

Van Royen & Sleumer 6561 has rather irregular spherical galls ca. 2.5 mm. across (the center is raised) near the midrib on the lower surface of the lamina; in *Kostermans & Soegeng 287* similar galls occur near the midrib and the margin.

GERMINATION AND YOUNG PLANT. The seedling has (two or) three pairs of leaves separated by internodes 1-2.5 cm. long. Subsequently produced internodes are less than 4 cm. long, the young plant is arched, the leaves are held in one plane, and the terminal bud is functional; the stem straightens later. In older plants the internodes are considerably more than 4 cm. long. (*Stevens et al. 809.*)

Calophyllum persimile can be recognized by its usually strongly four-angled twigs; its large, very coriaceous, usually elliptic to oblong leaf blades with the midrib on the upper surface surrounded by raised lamina; and its four-lobed flowers. The young plant does not grow very fast, and the stem is initially arched. The epithet *persimile* ("very similar") was chosen because of the considerable similarity of dried specimens of this species to those of *C. suberosum*.

When I described *Calophyllum suberosum*, I included in it specimens of the species here described as *C. persimile*. However, I found plants of two

TABLE 18. Differences between *Calophyllum suberosum* and *C. persimile*.

	<i>Calophyllum suberosum</i> *	<i>Calophyllum persimile</i> †
STILT ROOTS‡	Large	Lacking or very small
COLOR OF OUTER BARK AND ITS INNER SURFACE‡	Grayish or brownish	Often yellowish or bright yellow
LATEX‡	Clear yellow, sticky	Opaque yellow, ± fluid
LAMINA		
SHAPE	Ovate to elliptic	Elliptic to oblong (rarely subovate)
TEXTURE	Coriaceous	Very coriaceous
LENGTH : BREADTH RATIO	2-2.5	(2-)2.5-3
UPPER EPIDERMIS		
THICKNESS OF CUTICLE PLUS OUTER PERICLINAL CELL WALL (µm.)	7-16	18-26.4
TOTAL HEIGHT OF CELL (µm.)	19.5-22	28.6-39.5
LOWER EPIDERMIS		
THICKNESS OF CUTICLE PLUS OUTER PERICLINAL CELL WALL (µm.)	10-11	16.5-22
TOTAL HEIGHT OF CELL (µm.)	18.5-23	22-33
INTERNODE LENGTH IN SEEDLING (cm.)‡	4-14	1-2.5
YOUNG PLANT		
GROWTH‡	Erect	Arching
INTERNODE LENGTH (cm.)‡	≥10	To 4
HABITAT‡	Swamp or riverside	Ridge forest or periodically inundated forest

*Leaf anatomy of specimens cited in Stevens (1974a) has been examined.

†Leaf anatomy of specimens denoted by an asterisk in specimen citation has been examined.

‡Based mainly on personal observations at Kiunga.

species with large, coriaceous leaves at Kiunga that differed most obviously in bark, seedling, and ecological preferences. Although it is not as easy to separate sterile material in the herbarium, this can be done using the characters listed in TABLE 18. *Calophyllum suberosum* and *C. persimile* have very similar hairs (FIGURE 39, o, p), twigs that dry yellowish, and large, coriaceous leaf blades with the midrib on the upper surface surrounded by raised blade. These characters alone distinguish the two species from all others in the genus. However, flowers of *C. suberosum*, ripe fruits of *C. persimile*, and observations on the ecology of both species from throughout their ranges are needed to clarify the relationship between them.

The differences in the seedling and young plant listed in TABLE 18 are independent of the environment. The first young plant of *Calophyllum persimile* that I saw was growing in a swamp with numerous seedlings and young plants of *C. suberosum*. The young plant of *C. persimile* had the characteristic arching and slow growth of the numerous young plants later seen in better-drained ridge forest.

There is some variation within *Calophyllum persimile*. The specimens cited from Japan Island (previously *Calophyllum* sp. C, aff. *C. savannarum*—see Stevens, *loc. cit.*) are similar in anatomy to the other specimens from Irian Jaya but are smaller in most of their parts (measurements in brackets in the description above); they are tentatively included in *C. persimile*. Leaves of *C. persimile* from the Western Province of Papua New Guinea lack a hypodermis, which is present in leaves of specimens from elsewhere in the range of the species (with the exception of LAE 53835). LAE 53835, from a sapling, has exceptionally long leaf blades (ca. 56 by 11 cm.) (Stevens, *loc. cit.*); it also has a rather thin cuticle plus outer periclinal epidermal wall complex on both the upper (ca. 15 μ m. thick) and the lower surface (ca. 10.5 μ m. thick) of the lamina. *Van Royen & Sleumer 6561* has leaf blades that are bluntly pointed at the apex, and its bark is reported as being blackish brown, but it probably belongs to *C. persimile*.

150. *Calophyllum gracillimum* M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 348. pl. 28. 1956; T. C. Whitmore, Tree Fl. Malaya 2: 172. 1973; Corner, Gard. Bull. Singapore Suppl. 1: 104. 1978. TYPE: Malaya, Pahang, Bukit Balai, Rompin, 9 May 1919, KEP 2715 coll. Lambak (holotype, KEP; isotypes, K, SING).

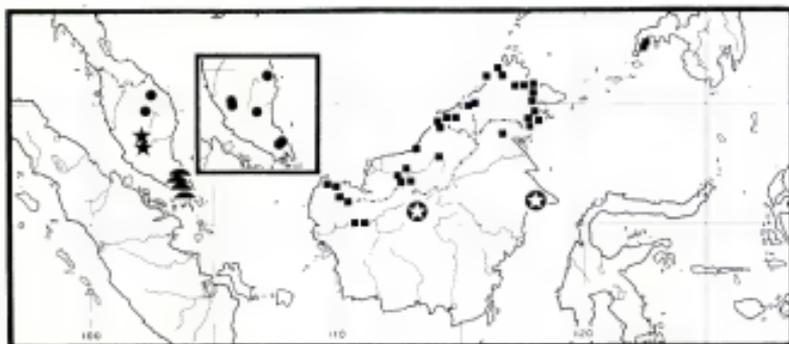
Tree to 15 meters tall, d.b.h. to 12 cm.; trunk without buttresses; outer bark pale greenish yellow-gray to biscuit colored, or pale brown and orange-brown mottled, with small lenticels in vertical rows, the inner surface dirty brown; under bark reddish; inner bark pale red; latex white or not apparent.

Twigs slightly flattened, 0.5–1 mm. across, \pm 4-angled when young, soon becoming rounded, drying yellowish (rarely brown), transiently farinose to subtomentose; axillary innovations lacking basal scars; internodes 0.5–3.5 cm. long; uppermost pair of axillary buds pointed, to 1.5 mm. long, erect; terminal bud (narrowly) conical, 1.5–4 mm. long, with brown, subtomentose indumentum (hairs, FIGURE 43, k), underdeveloped internode absent. Petiole

2.5-4.5(-7) mm. long, deeply concave above, convex below, glabrescent, often drying blackish; lamina ovate to elliptic, (1.7-)3-7(-10.3) by (0.9-)1.4-3(-3.8) cm., bluntly acuminate to acute at apex, cuneate at base, slightly undulate but not recurved at margin, thinly coriaceous, drying amber to sepia above and fulvous to sabelline below, glabrescent except for few hairs on midrib below, the midrib above gradually narrowed from base, raised, or level except for raised basal 2 mm., ca. 0.15 mm. wide at midpoint, below raised, subangled to \pm flat, sometimes with at least margins impressed, the venation obscure on both surfaces, sometimes latex canals impressed above and especially below, 6 to 9 veins/5 mm., angle of divergence 60-70°. Inflorescences from foliate axils near ends of twigs, with 1 to 3 (to 5) flowers, unbranched, the axis to 2(-14) mm. long, short-tomentose, lowest internode to 2(-10) mm. long; bracts ovate, ca. 3.5 mm. long, soon deciduous (rarely foliaceous, ca. 1.4 cm. long); pedicels 3.5-5(-9) mm. long, short-tomentose. Flower (?)hermaphroditic; tepals 6 (rarely 7), the outer pair broadly ovate to suborbicular, 4-5.5 by 4-5 mm., puberulo-tomentose on back, the next pair elliptic, ca. 6 by 4.5 mm., with \pm broad strip of indumentum down back, the inner pair suboblong to elliptic, ca. 5. by (?2-) ca. 3.5 mm.; stamens (?)numerous, the filaments to 3 mm. long, the anthers subelliptic to oblong, 0.4-0.7 mm. long, retuse at apex, with persistent hairs to 0.1 mm. long; ovary 1.3-2 mm. long, stigma and style unknown. Fruit spherical, ca. 1.1 by 1.1 cm., apiculate, drying vinaceous-brown, closely and sharply wrinkled; outer layer not detaching cleanly from stone, 0.5-0.9 mm. thick, compact; stone spherical, ca. 9 by 9 mm., rounded at apex, the walls ca. 0.2 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Malay Peninsula (MAP 46).

ADDITIONAL SPECIMENS SEEN. Malaya. SELANGOR: near the Gap, 800-900 m., *Ando et al.* 96 (probable) (KEP). TRENGGANU: Bukit Bauk F.R., *FRI* 2609 (?) (KEP, L, SING). PAHANG: Ulu Perah, *KEP* 11209 (KEP); Fraser's Hill, near



MAP 46. Distribution of *Calophyllum rotundifolium* (stars), *C. aureo-brunescens* (circles), *Calophyllum* sp. 151 (half-circles), *C. gracilipes* (squares), and *C. gracilipes* variant (stars in solid circles) in Malaya. Inset: *C. gracillimum*.

Jeriau waterfall, 975 m., *Stevens et al.* 20 (A). JOHORE: 13½ mile Mawai-Jemaluang road, SFN 28998 (A, BO, K, KEP, LAE, NY, P, SING).

ECOLOGY. Usually well-drained lowland or lower montane forest, also drier parts of swamp forest; to 975 m. alt. Flowering and fruiting February and May.

YOUNG PLANT. The plant is erect, and the terminal bud is functional.

Calophyllum gracillimum can be readily distinguished from other species of *Calophyllum* by its pale-drying twigs that often contrast with the blackish-drying petioles, and its small leaf blades that are bluntly acuminate at the apex, cuneate at the base, and with indistinct venation and often impressed latex canals. The inflorescences have one or a few flowers, and the anthers have hairs. The almost smooth, pale bark of the mature tree is also notable. The epithet *gracillimum* ("very slender") is appropriate for this species.

Calophyllum gracillimum is without obvious relatives. The small size of all its parts distinguishes it readily from the other taxa known to have hairs on their anthers (*C. canum* (sometimes); *C. molle*, and *C. rubiginosum*). It is superficially similar to the Fijian species *C. leucocarpum*, but the two can be easily separated as discussed under the latter species. *Calophyllum gracillimum* may be close to *Calophyllum* sp. 151, although the latter lacks hairs on its anthers and differs in a number of vegetative details (most obviously in its rounded twigs, longer petioles, midrib on the upper surface of the lamina surrounded by raised blade, and denser venation). More collections of both taxa are needed, especially from low altitudes in Johore where both occur; fruits of *Calophyllum* sp. 151 are not known.

Both FRI 2609 and *Ando et al.* 96 have twigs that dry dark brown, and although the latter specimen is probably *Calophyllum gracillimum*, the former may not be. It has rather prominent venation, an inflorescence with an axis to 1.4 cm. long bearing five flowers, and pedicels up to 9 mm. long. There is considerable variation in the development of the indumentum in *C. gracillimum*: specimens from Johore are short-tomentose on the twigs, while others are only farinose.

The uppermost measurements of the petiole and lamina in the description above are taken from sterile specimens, possibly saplings. The inflorescences are nearly always axillary (cf. Henderson & Wyatt-Smith, *loc. cit.*), although when borne in the uppermost leaf axils they may obscure the terminal bud, thus appearing to be terminal.

151. *Calophyllum* sp.

FIGURE 40, 1.

Tree 15–21 meters tall, d.b.h. to 25 cm.; trunk without spurs or buttresses; outer bark mottled brown-yellow, to pale brown, almost smooth (hoop marked), lenticels in vertical rows, the inner surface ± orange to pale brownish; under bark orange-reddish to orange-green; inner bark pale reddish; latex usually not obvious, slight moistening of cut surface, or colorless, not sticky (rarely opaque yellow, sticky).

Twigs somewhat flattened, (1.2–)1.6–2 mm. across, rounded, drying whitish

to grayish brown, sparsely puberulent when young; axillary innovations lacking basal scars; internodes 1.5–4 cm. long; uppermost pair of axillary buds rounded, 0.5–2 mm. long, erect; terminal bud plump to narrowly conical, 2.5–5 mm. long, with brown, \pm adpressed indumentum (hairs, FIGURE 43, i, j), underdeveloped internode absent. Petiole (0.4–)0.5–1.3 cm. long, broadly concave above, convex below, glabrescent; lamina ovate to subelliptic, (2.5–)4–6(–8.3) by (0.9–)1.7–3.2(–3.5) cm., rounded to subacute and \pm decurved at apex, acute to decurrent at base, slightly and distantly undulate but not recurved at margin, coriaceous, drying amber to near rosy buff above and sabelline to honey below, puberulent on midrib beneath when young, the midrib above narrowing gradually from base, initially strongly depressed, becoming raised, surrounding blade also raised, 0.2–0.3 mm. wide at midpoint, below raised, \pm angled, the venation above subobscure, apparent to subobscure below, flat or slightly raised, especially below, latex canals often impressed below, 8 to 13 veins/5 mm., angle of divergence 65–80°. Inflorescences from foliate axils near ends of twigs, with 5 (to 7) flowers, unbranched, the axis 0.6–1.4 cm. long, puberulent, lowest internode 3–7 mm. long; bracts elliptic-ovate, 1.8–2.8 mm. long, deciduous; pedicels 1–6.5 mm. long, puberulent. Flower (?) hermaphroditic; tepals 4, the outer pair suborbicular to elliptic, ca. 4.5 by 3.5–4 mm., puberulent on back, the inner pair elliptic-obovate, 5–6.5 by 4–5 mm., with puberulent strip down back; stamens 105 to 160, the filaments to 6.5 mm. long, perhaps with few minute hairs when young, the anthers elliptic, 0.35–0.6 mm. long, retuse at apex; ovary ca. 1.3 mm. long, the style unknown, the stigma peltate, 0.6–0.8 mm. across, 3-radiate. Fruit unknown.

DISTRIBUTION. Southern Malay Peninsula, Singapore (MAP 46).

ADDITIONAL SPECIMENS SEEN. **Malaya.** JOHORE: G. Pulai, 150 m., *Stevens et al.* 98 (A); Lenggong F.R., 30 m., *Stevens et al.* 60 (A); Renggam F.R., FRI 21635 (KEP), 240 m., *Stevens et al.* 46 (A), *Stevens et al.* 53 (= FRI 23440) (A), KEP 71267 (KEP); 42 miles, Mersing Road, Kluang, FRI 21621 (KEP); Panti F.R., KEP 70320 (?) (KEP), 5 m., *Stevens et al.* 112 (A). **Singapore:** Mandai forest (by zoo), 30 m., *Stevens et al.* 719 (A).

ECOLOGY. Well-drained lowland, mixed dipterocarp forest; sometimes in seasonally inundated forest; 5–240 m. alt. Flowering in November (all Malayan specimens); flower scented.

GERMINATION AND YOUNG PLANT. The seedling has one of two pairs of leaves separated by an internode 5–10 mm. long. Subsequently produced internodes are longer, the terminal bud is functional, and the plant is erect. The leaves of the seedling are 1.5–2.3 cm. wide; those produced in the first and immediately succeeding flushes are about half as wide. (*Stevens et al.* 46.)

Calophyllum sp. 151 can be characterized by its pale-drying, rounded twigs and its small leaves with relatively long petioles and blades that are rounded to subacute at the apices. The apex is rather strongly decurved, at least in the living leaf. The midrib on the upper surface of the lamina is initially depressed, but it soon becomes raised and is surrounded by raised blade. The inflorescence axis, pedicels, and backs of the outer and (partly) inner

tepals are all covered with indumentum; the flowers have four tepals and glabrous anthers.

Calophyllum sp. 151 may be related to *C. gracillimum*, but until both taxa are better known, it is premature to describe the former. The differences between the two are discussed under *C. gracillimum*.

152. *Calophyllum leptocladum* A. C. Smith & Darwin, Jour. Arnold Arb. 55: 221, figs. 4, 5, 1974, *pro majore parte*. TYPE: Fiji, Ngau, slopes of Mt. Ndelaitha, on north spur, toward Navukailangi, 350-500 m., 22 June 1953, A. C. Smith 7874 (holotype, US; isotypes, A, K, NY).

Tree 9-22.5 meters tall; outer bark yellow, with narrow, longitudinal cracks.

Twigs flattened, 1.2-1.6 mm. across, \pm 2-angled or rounded, drying brown to yellowish, brown-farinoso when young, or glabrous; axillary innovations lacking basal scars; internodes 0.5-2.5 cm. long; uppermost pair of axillary buds rounded (pointed), ca. 0.2(-0.5) mm. long, suberect to spreading; terminal bud narrowly conical, 2-3.7 mm. long, with brown to grayish, puberulent to subcrustose indumentum (hairs, FIGURE 43, e-h; cf. 37, o), underdeveloped internode absent (-1.5 mm. long). Petiole 4-10 mm. long, deeply concave above, convex below, glabrous when mature; lamina elliptic to suboblong, (2.8-)3.6-7(-8) by 1.4-2.4(-3.1) cm., acuminate at apex, acute to attenuate at base, slightly undulate or recurved at margin, thinly coriaceous, drying sepia to olivaceous above with midrib, margin, and venation often paler, umber to olivaceous below, glabrous or sparsely farinose on midrib below, the midrib above narrowed gradually from base, \pm raised, center strongly sulcate, surrounding lamina usually obscurely raised, 0.15-0.3 mm. wide at midpoint, below raised, subangled, the venation \pm apparent above and below, raised to subdepressed above, raised below, (10 to) 12 to 18 veins/5 mm., angle of divergence 60-75°. Inflorescences from foliate axils (very rarely terminal), with ca. 5 flowers, unbranched, the axis 0.6-1.5 cm. long, puberulent toward base, lowest internode 0.25-0.8(-1.2) cm. long; bracts narrowly ovate, to 2.5 mm. long, soon deciduous (rarely foliaceous, persistent); pedicels 0.2-1(-1.3) cm. long, glabrous. Flower (?)hermaphroditic; tepals 4, glabrous, the outer pair subelliptic, ca. 3 by 2.5 mm., the inner pair subobovate, to 4 mm. by 3 mm.; stamens ca. 60, the filaments to 2 mm. long, the anthers oblong, 0.6-1 mm. long, slightly retuse at apex; ovary ca. 1.3 mm. long, style ca. 1.5 mm. long, stigma peltate. Fruit ellipsoid, ca. 1.6 by 1.35 cm., rounded at apex, drying \pm vinaceous-tawny, irregularly wrinkled; outer layer detaching \pm cleanly from stone, 0.5-0.8 mm. thick, compact; stone ellipsoid, 1-1.35 by 0.85-1.15 cm., minutely apiculate, the walls 0.4-0.5(?-0.8) mm. thick, smooth, unmarked; spongy layer (?)thin.

DISTRIBUTION. Fiji Islands, Viti Levu, rare on Vanua Levu.

SELECTED SPECIMENS SEEN. See Smith & Darwin, *loc. cit.*, excl. Howard 104 and FDA 15722. Also, Viti Levu. NAMOSI: Mt. Vakarogasiu, 671 m., FDA 16127 (CHR). TAILEVU: Colo-i-Suva, 210 m., Bola II (K). NAVUA: Kadawa, side of Kadawa Trig. Hill, 150 m., C.S.I.R.O. S 1404/7 (K); Sociri

Cr[ee] (Kadava), Nabukelova distr., [FDA] H 419 (K). KANDAVU: Kandavu Is., 150 m., C.S.I.R.O. S 1404/3 (K).

ECOLOGY. Usually colline forest, (718-)50-670 m. alt. Flowering December and March; fruiting in June (fruit nearly white).

Galls—small, narrow projections ca. 1.5 mm. high on the upper surface of the lamina—are common and occur on over half the collections.

LOCAL USE. The wood makes good timber (Smith & Darwin, *loc. cit.*).

Calophyllum leptocladum can be characterized by its small, narrow terminal bud and its rather small leaf blades with dense venation. It has small, four-lobed flowers borne on few-flowered, axillary inflorescences. Its fruits are comparatively quite large (ca. 1.5 cm. long) and have a compact (0.5-0.8 mm.) outer layer that separates cleanly from the relatively thick (walls 0.4-0.5 mm. thick) stone. The epithet *leptocladum* means "slender (delicate) twigs."

Calophyllum leptocladum is at least superficially similar to *C. whitfordii* (from the Philippine Islands), and the two species have similar galls on the leaves. *Calophyllum whitfordii* can be most easily distinguished by its predominantly terminal inflorescences that nearly always have more than five flowers; the flowers have eight tepals. *Calophyllum whitfordii* also has leaves with less dense venation and a somewhat larger fruit with a thinner stone wall; the indumentum on the inflorescence axis extends to the pedicels and to at least the bases of the outer pair of tepals.

Smith and Darwin (*loc. cit.*) cited four specimens of *Calophyllum leptocladum* from Vanua Levu. *Howard 104* is a specimen of *C. neo-ebudicum* and so, probably, is *FDA 15722*. *Berry 4* and *FDA 15733* seem to be *C. leptocladum*.

153. *Calophyllum whitfordii* Merr. Philip. Jour. Sci. 1(Suppl.): 96. 1906, Enum. Philip. Fl. Pl. 3: 81. 1923, *pro majore parte*. TYPE: Philippine Islands, Luzon, Bataan Province, Lamao River, Mt. Mariveles, 2300 feet [701 m.], Feb. 1905, *FB 2613* coll. Meyer (isotypes, K, NY, SING, US).

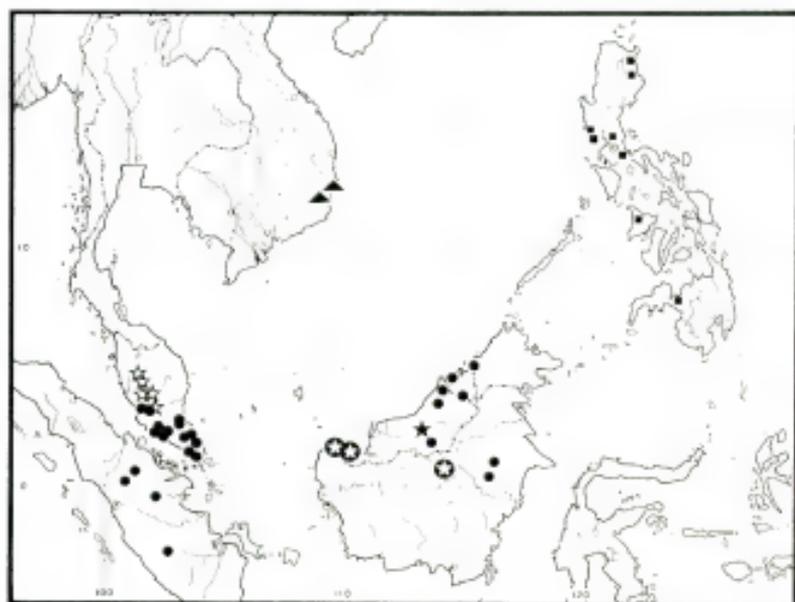
Tree to 28 meters tall, d.b.h. to 57 cm.; outer bark yellowish brown, fissured.

Twigs flattened, 1-2 mm. across, rather bluntly 4-angled, drying brown when young, later yellowish, at first farinose (puberulent); axillary innovations lacking basal scars; internodes 0.4-3.5 cm. long; uppermost pair of axillary buds pointed, to 1.5 mm. long, erect; terminal bud \pm conical to plump, 2.5-4.5(-6) mm. long, with grayish brown to brown, puberulo-tomentose indumentum (hairs, FIGURE 43, q-s, y), underdeveloped internode to 2 mm. long. Petiole (2.5-)5-11 mm. long, broadly concave above, convex below, subsersistently puberulent; lamina elliptic, 3.6-8.5 by 1.9-4.3 cm., bluntly acuminate to obtuse at apex, cuneate to acute at base (minutely rounded at very base), not recurved but slightly undulate at margin, coriaceous, drying umber to sepia above and cinnamon-sepia to sabelline-olivaceous below, subsersistently puberulent on midrib above and especially below, the midrib above narrowing gradually from base, slightly to strongly raised, sulcate or not, 0.07-0.25 mm. wide at midpoint, below raised, \pm angled, the venation above and below \pm apparent, raised, (6 to) 9 to 13 (to 15) veins/5 mm.,

angle of divergence 60–70(–75)°. Inflorescences terminal and/or axillary, with 7 to 15 flowers, often flabellate, usually with branches up to 2 cm. long and with 5 flowers, the axis 2–6 cm. long, puberulent, lowest internode at least 1.2 cm. long; bracts unknown; pedicels 5–11 mm. long, puberulent. Flower (?)hermaphroditic; tepals 8, the outer pair broadly ovate, 4.5–5 by ca. 4 mm., puberulent on back, the inner ones oblong to obovate or elliptic, 8–9 by 2.5–5 mm., outer two sometimes puberulent in strip down back; stamens 125 to 230, the filaments to 4.5 mm. long, the anthers oblong, 0.7–1.5 mm. long, retuse at apex; ovary 1.7–2 mm. long, the style to 3 mm. long, the stigma peltate, ca. 0.8 mm. across, 3- or 4-radiate. Submature fruit spherical to ellipsoid, 1–1.5 by 0.8–1.4 cm., apiculate, drying fuscous-black, finely striate to wrinkled; outer layer not detaching cleanly from stone, 0.5–0.8 mm. thick, compact; stone subspherical, 0.9–1.4 by 0.7–1.3 cm., rounded at apex, the walls 0.15–0.3 mm. thick, at base 0.5–1 mm. thick, smooth. (?)unmarked; spongy layer initially well developed.

DISTRIBUTION. The Philippine Islands (MAP 47).

SELECTED SPECIMENS SEEN. **Philippine Islands.** LUZON, Cagayan: sine loco, *FB 6667* (US). Isabela: Mt. Moises, *Clemens 16766* (?) (UC). Zambales: Subig, *Merrill 1759* (K, NSW, NY, US). Bataan: Mt. Mariveles, Lamao R., *FB 785*



MAP 47. Distribution of *Calophyllum rugosum* (triangles), *C. aureum* (open stars), *C. rubiginosum* (circles), *C. recurvatum* (stars in solid circles), *Calophyllum* sp. 164 (solid star), and *C. whitfordii* (squares) in Southeast Asia-Malesia.

(BM, BO, F, K, LY, NSW, NY, P, SING, US). Laguna: Famy, Minayotan, 442 m., *PNH 39394* (A, PNH, SING). Quezon: Malikboy, *FB 31478* (NY). MINDORO: sine loco, *FB 6855* (BO, LY, NY, US). MINDANAO. Davao: Mt. Galintan, 150 m., *BS 48913* (NY, UC).

ECOLOGY. Colline forest, 150-700 m. alt. Flowering January to March; submature fruit May to July.

Conoid galls 1-1.5 mm. tall are frequent on the lower and sometimes on the upper surface of the lamina.

Calophyllum whitfordii can be recognized by its small, conical, terminal buds usually less than 4.5 mm. long; its elliptic, rather small lamina that dries umber to sepia and often more or less nitid on the upper surface; its puberulent, terminal inflorescences; and its spherical, shallowly wrinkled fruit with a compact outer layer. Small, conoidal galls on the lamina are common. The epithet commemorates H. N. Whitford.

Although there is considerable variation in the prominence of the midrib on the upper surface of the lamina (in specimens such as *BS 48913* it is almost flat), this variation is not correlated with that of other characters. *Clemens 16766* has very short petioles (figures in parentheses in the description above).

The circumscription of *Calophyllum whitfordii* has given me much trouble. I originally thought that it was part of the variable *C. blancoi* complex, and it may be related to that species. However, its leaves do not dry grayish or so strongly bicolored as in *C. blancoi*; they are often more or less nitid on the upper surface and are smaller than is usual for *C. blancoi*. The conoidal galls so common in *C. whitfordii* are uncommon in *C. blancoi*, and the hairs of *C. whitfordii* are less branched than is usual in *C. blancoi*. The terminal bud of *C. blancoi* is plump and nearly always considerably larger than that of *C. whitfordii*, and there are minor differences in the fruit. *Calophyllum whitfordii* is also superficially similar to *C. leptocladum*, from the Fiji Islands, but these two species can be more easily separated (see *C. leptocladum*).

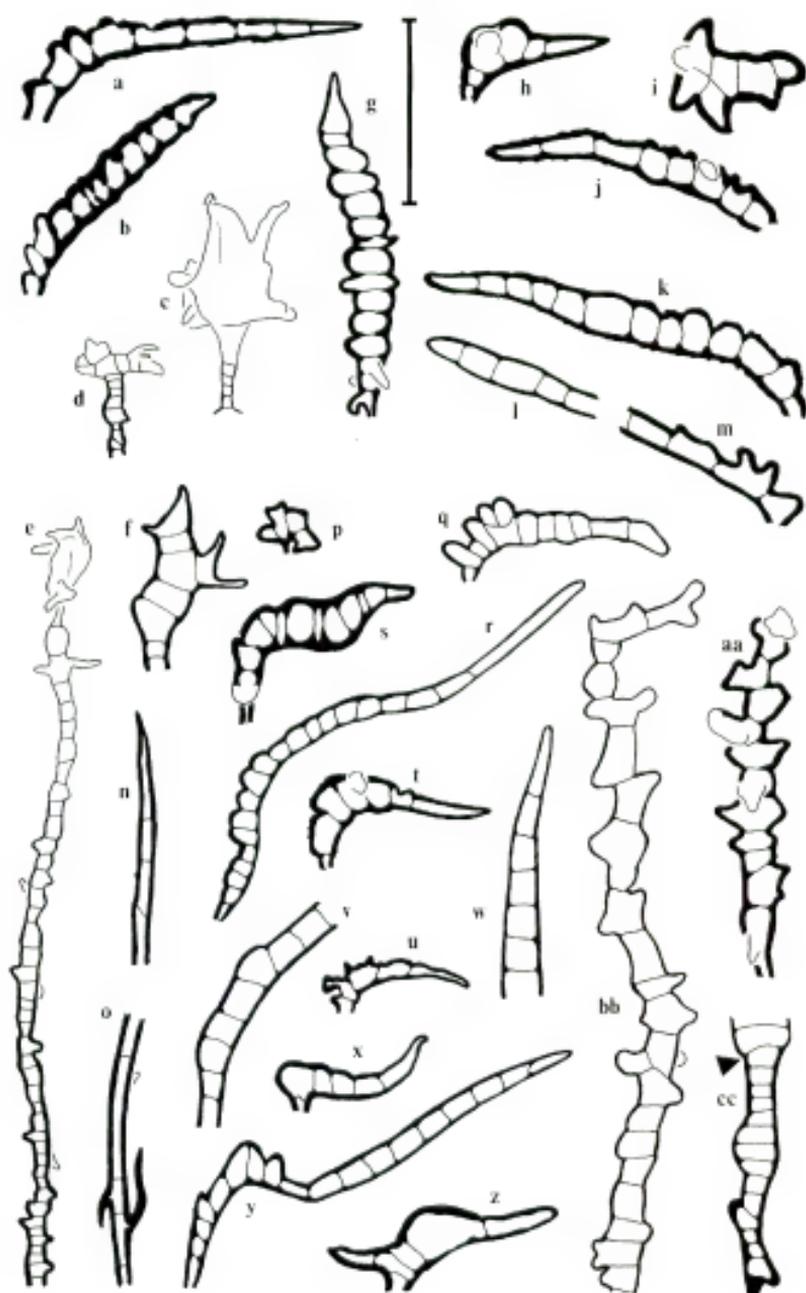
154. *Calophyllum rugosum* P. F. Stevens, sp. nov.

FIGURE 40, a-c.

A specibus aliis Calophylli in gemma terminali 2.5-4.5 mm. longa, lamina mediocri venulis lateralibus 3 usque ad 7 per 5 mm. saepe prominentioribus in pagina supra quam in pagina infra, inflorescentia terminali, et fructu in siccitate valde rugoso parietibus putaminis tenuis, differt.

Tree 5-12 meters tall, d.b.h. ca. 20 cm.; bark unknown.

Twigs flattened, 1.2-2 mm. across, 2- or \pm [strongly] 4-angled, drying dark brown to blackish, puberulent when young; axillary innovations lacking basal scars; internodes 0.6-6 cm. long; uppermost pair of axillary buds rounded, ca. 1 mm. long, erect; terminal bud conical to plump, 2.5-4.5 mm. long, with subadpressed, brown indumentum (hairs, FIGURE 41, a, b), underdeveloped internode absent (to 1 mm. long). Petiole [1.5-]4-10 mm. long, strongly concave above, convex below, glabrous at maturity; lamina elliptic to obovate (rarely suborbicular) [lingulate], 1.6-10.5 by 1.4-5.4 cm., rounded to shallowly retuse



at apex, cuneate to broadly rounded [cordate] at base, not undulate to distantly so and slightly recurved at margin, coriaceous to very coriaceous, drying cinnamon-sepia above and sabelline to cinnamon below, puberulent on midrib below when young, the midrib above abruptly narrowed at base, at first slightly depressed, becoming flat or slightly raised, 0.15–0.25 mm. wide at midpoint, below slightly raised, margins depressed, becoming subdepressed toward apex, the venation apparent (obscure) above, often obscure below, raised (subdepressed), 2 to 7 veins/5 mm., angle of divergence 50–75°. Infructescences terminal and from adjacent axils, with scars of up to 19 flowers (with 5-flowered branches up to 5 mm. long), the axis up to 5 cm. long, subtomentose to puberulent especially near base, lowest internode 1–2 cm. long; bracts unknown; pedicels 1.3–2.1 cm. long, glabrous. Damaged flower only known; tepals 6, the outer pair ovate-elliptic, ca. 6 by 5 mm. Fruit spherical to ellipsoid, 2–2.2 by 1.7–2 cm. (but see discussion), rounded to apiculate, drying brown-vinaceous, deeply wrinkled; outer layer detaching more or less cleanly from stone, 0.5–1.5 mm. thick, compact; stone ellipsoid to spherical, ca. 1.9 by 1.6–1.75 cm., rounded at apex, the walls ca. 0.25 mm. thick, smooth, not marked; spongy layer at first well developed.

TYPE: Indochine [Vietnam], Annam, Massif du Bi-Doupprès du Haut Donai, 2000 m., 14 Oct. 1940, *Poillane 30918* (holotype, α ; isotypes, ρ (several)).

DISTRIBUTION. Vietnam (MAP 47).

ADDITIONAL SPECIMENS SEEN. Vietnam: Nhatrang, 1800 m., *Poillane 3494* (α , ρ), massif du Hòn Bà, 1000–1500 m., *Chevalier 38865* (ρ).

ECOLOGY. Open, shrubby montane vegetation, rocky soil or "bordure grande forêt et celle de pin"; 1000–2000 m. alt. Submature fruit in October; fruit and peduncle pale, watery green.

Calophyllum rugosum can be recognized by its rather small terminal bud, its medium-sized lamina that is variously shaped at the base but always more or less rounded at the apex, its terminal inflorescence, and its deeply wrinkled fruits. The venation is often more prominent on the upper side

FIGURE 41. Hairs (from terminal bud, unless otherwise noted). a, b, *Calophyllum rugosum*: a, *Poillane 3494*; b, *Poillane 30918*. c–f, *C. rubiginosum*: c, f, *Soepadmo 86*, from stem; d, *Maingay, Kew dist. 168*; e, *Samat bin Abdullah 2174*, g, *C. rotundifolium* (*Robinson s.n.*). h–j, *C. sakarium* (*SAN 21612*), axillary bud: i, from above. k–m, *C. obliquinervium*: k, *SAN 33609*; l, m, *PNH 14132*, apex and base of hair ca. 330 μ m. long. n, o, *C. molle* (*FRI 8285*), apex and base of hair ca. 510 μ m. long. p–r, bb, cc, *C. gracilipes*. p, *S 22401*. q, *Hallier 2992*. r, *Williams 2193*. bb, cc, *Kostermans 6013*: bb, apex of hair (base similar to portion below arrow in cc); cc, basal part of hair ca. 1230 μ m. long (apex similar to w). s, y, *C. aurantiacum* (*Stevens et al. 195*). t, u, *C. echinatum*: t, *Cel./II-407*; u, *Cel./II-215*. v, w, *C. recurvatum* (*S 7737*), hairs to 720 μ m. long, base and apex of hair ca. 500 μ m. long. x, z, *C. brachyphyllum* (*BS 34482*). aa, *C. ardens* (*BRUN 297*), axillary bud. Scale = 120 μ m. (in c–e, scale = 240 μ m.).

of the lamina than on the lower, and the veins are relatively distant (3 to 7/5 mm.). The epithet *rugosum* ("wrinkled") was considered appropriate because the dried fruits are so strongly wrinkled.

The closest relative of *Calophyllum rugosum* is probably *C. rotundifolium*. The leaves of *Chevalier 38865* are almost identical to those of *Stone 7174* (*C. rotundifolium*), and the general color on drying and venation prominence of the leaves of *Poilane 3494* are also similar. The two species have similar hairs, with rather thick-walled cells about as broad as long. Lamina anatomy is also similar, although the anticlinal walls of the upper epidermis of *C. rotundifolium* (*Stone 7174*) are at most inconspicuously sinuous near the top, while those of all collections of *C. rugosum* are characteristically sinuous for much of the height of the cell (this may be only a trivial difference). Both species have a short palisade mesophyll, lignified spongy mesophyll, and vascular bundles that are not transcurrent abaxially (although they are transcurrent in *Poilane 30918*). The inflorescences of the two are quite different: in *C. rotundifolium* the axis is absent, while in *C. rugosum* it is well developed; the characteristic thick outer tepals of the flowers of *C. rotundifolium* do not occur in *C. rugosum*. The fruits of *C. rotundifolium* are unknown.

The three specimens assigned to *Calophyllum rugosum* are at first sight very different. *Poilane 30918* has long internodes and relatively large leaf blades that are cuneate or rounded at the base. *Poilane 3494* has short internodes and smaller leaf blades that are broadly rounded at the base. *Chevalier 38865* has long internodes and rather large, subsessile leaf blades that are cordate at the base; it is superficially very different from the other specimens (the characters in which it differs are enclosed in brackets in the description above). However, in anatomy, terminal bud, indumentum, general leaf type, and inflorescence position, all three are similar (although *Poilane 30918* has veins more or less prominent on the lower surface of the lamina, and—as might be expected—vascular bundles transcurrent abaxially in transverse section). The description of the flower is taken from a very damaged bud found between the leaves (not attached to the shoot) of *Poilane 3494*. *Chevalier 38865* has immature fruits that would possibly be about 1.5 cm. long when mature; in drying characteristics and general type they are similar to those of the type specimen.

Poilane 5083 (Nhatrang, Mère et l'Enfant, 2000 m. (r)) has a facies similar to that of *Calophyllum rugosum*, but it has a terminal bud ca. 6 mm. long, axillary inflorescences, flowers with eight tepals, a better-developed palisade mesophyll, and a thinner-walled upper epidermis with the anticlinal walls only very slightly sinuous near the top.

155. *Calophyllum rotundifolium* Ridley, Jour. Fed. Malay States Mus. 5: 29. 1915, Fl. Malay Penin. 1: 188. 1922; M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 337. 1956; T. C. Whitmore, Tree Fl. Malaya 2: 168. 1973. TYPE: Malaya, Selangor, Gunong Mengkuang [Lebah], 5000 feet [1524 m.], 17 Jan. 1913, *Robinson s.n.* (holotype, SING; isotypes, BM, K).

Tree ca. 9 meters tall, d.b.h. ca. 23 cm.; outer bark ochre, smooth, or surface cracked, with large lenticels; latex translucent.

Twigs flattened, 1.5–2 mm. across, slightly angled, drying dark brown, puberulent when young; axillary innovations lacking basal scars; internodes 1–4 cm. long; uppermost pair of axillary buds \pm rounded, 1–2 mm. long, erect, conspicuous; terminal bud plump, 2–3 mm. long, with short, brown, tomentose indumentum (hairs, FIGURE 41, g), underdeveloped internode not apparent. Petiole ca. 0.5 mm. long, concave above, convex below, \pm glabrous; lamina \pm orbicular, (1–)2.5–6.5 by (0.7–)2.4–5.5 cm., \pm retuse at apex, cordate at base, neither undulate nor recurved at margin, coriaceous, drying amber above and cinnamon-sabelline to amber below, subpersistently puberulent on midrib below, the midrib above narrowing quickly at base, \pm depressed at first, becoming raised, 0.1–0.3 mm. wide at midpoint, below impressed or slightly raised, \pm angled, the venation above subapparent, raised, below obscure to invisible, 7 to 10 veins/5 mm., angle of divergence (50–)60–70°. Inflorescences terminal, with 1 (rarely 2) flower(s), axis absent; bracts unknown; pedicels 1.1–1.6 cm. long, \pm glabrous. Flower (?)hermaphroditic; tepals 8, the outer pair elliptic to ovate, 0.6–1.2 by 0.4–0.9 cm., flat to subconcave, coriaceous, glabrous, the next pair \pm orbicular, 1.3–1.4 by ca. 1 cm., concave, the inner ones obovate, 1.2–1.4 by 0.8–1 cm.; stamens ca. 200, the filaments 4–8 mm. long, at base connate for 1.5–2 mm., the anthers oblong, 1–1.8 mm. long, rounded to retuse at apex; ovary ca. 3 mm. long, the style ca. 3 mm. long, the stigma peltate, ca. 1.5 mm. across, \pm 3-radiate. Fruit unknown.

DISTRIBUTION. Malaya, the southern part of the Main Range (MAP 46).

SELECTED SPECIMENS SEEN. **Malaya.** PAHANG/SELANGOR: G. Ulu Kali, 1738 m., *FRI 12585* (KEP), 1800 m., *Stone 8416* (KLU). SELANGOR: G. Mengkuang Lebah, 1646 m., *Derry s.n.*, 4 Mar. 1907 (SING).

ECOLOGY. Stunted montane forest, 1525–1800 m. alt. Flowering in January.

Calophyllum rotundifolium is a distinctive species characterized by its suborbicular leaf blades with the venation less prominent on the lower surface than on the upper, and by its usually single, terminal flowers with eight tepals, the outer pair of which are coriaceous and almost leaflike. The epithet *rotundifolium* ("round leaves") is very appropriate for this species.

Calophyllum clemensorum, from Borneo, has been confused with *C. rotundifolium*, but the two are probably not close since the former has leaf blades with clearer venation about equally prominent on both surfaces and a terminal inflorescence with an axis 2–4 cm. long. The closest relative of *C. rotundifolium* is probably *C. rugosum*, from Vietnam (for the differences separating them, see *C. rugosum*).

The thick, rather leaflike outer tepals of *Calophyllum rotundifolium* are distinctive. Although exceeding some of the leaves in size, they have steeply ascending (rather than widely divergent) venation and lack a midrib. It is possible that these outer tepals are bracts, but no buds were seen in their axils. Ridley (1915, *loc. cit.*) described the "inner sepals" as being only

2 mm. long, and although later authors have followed him in this, they appear to have been mistaken. Henderson and Wyatt-Smith (*loc. cit.*) described the venation on the upper side of the leaf as less prominent than that on the lower. This is normally the case in *Calophyllum*, but it is clearly otherwise in this species.

Leaf blades of saplings are suboblong and are up to 13 by 6.6 cm. (*Derry s.n.*, Stone 8416). In such specimens the terminal bud is up to 7 mm. long.

156. *Calophyllum aureo-brunnescens* M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 341. pl. 21. 1956; T. C. Whitmore, Tree Fl. Malaya 2: 172. 1973. TYPE: Malaya, Pahang, Gunong Tahan, 5000 feet [1524 m.], 11 June 1922, SFN 7855 coll. Haniff & Nur (holotype, SING; isotypes, K, KEP).

C. venustum auct., non Ridley; Ridley, Jour. Fed. Malay States Mus. 2: 110. 1909.

Tree 3-4.5 meters tall; trunk and bark unknown.

Twigs flattened, 1.5-3 mm. across, rounded, drying dark brown, sparsely puberulent when young; axillary innovations lacking basal scars; internodes (2-)3-5.5 cm. long; uppermost pair of axillary buds subacute, to 2.5 mm. long, suberect to spreading; terminal bud narrowly conical, 3.5-8 mm. long, with pale brown, crustaceous indumentum (hairs, FIGURE 43, 1; also moruloid), underdeveloped internode 1-6(-10) mm. long. Petiole 0.8-1.3 cm. long, broadly and rather shallowly concave above, convex below, glabrous when mature; lamina elliptic (rarely subovate or subobovate), (2.7-)3.5-6.7 by (1.1-)1.8-3.3 cm., acute to obtuse (retuse) at apex, acute at base, neither undulate nor recurved at margin, coriaceous, drying mid to dark brown above, paler and \pm pruinose below, sparsely puberulent on midrib below when young, the midrib above narrowing gradually from base, margins not clear, \pm depressed at first, becoming level, 0.2-0.35 mm. wide at midpoint, below raised, \pm striate (angled toward apex), the venation subapparent to obscure above, subapparent below, raised, (9 to) 11 to 16 veins/5 mm., angle of divergence (45-)50-70°. Inflorescences terminal and from adjacent foliate axils, with 7 to 11 flowers, branched or not, often flabellate, the axis 2.5-5 cm. long, inconspicuously farinose, lowest internode 1.3-3.5 cm. long; bracts \pm obovate, ca. 4 mm. long, soon deciduous; pedicels 0.7-1.1 cm. long, puberulent. Flower (?) hermaphroditic; tepals 8 (rarely 9), the outer pair broadly ovate, 6.5-7 by ca. 5 mm., the inner ones elliptic to obovate, 7-9 by 2.2-4 mm.; stamens ca. 200, the filaments to 3.5 mm. long, the anthers elliptic-oblong, 0.6-1.1 mm. long, retuse to apiculate; ovary 1.8-2 mm. long, style and stigma unknown. Fruit unknown.

DISTRIBUTION. Northeastern Malaya (MAP 46).

SELECTED SPECIMENS SEEN. **Malaya.** PAHANG: G. Tahan, Ridley 16015 (BM, K, SING); Padang Luas, 1676 m., F.M.S. Museum 12240 (SING); G. Ulu Kechau, 1829 m., KEP 42911 (K, KEP).

ECOLOGY. Montane forest, 1525-1830 m. alt. Flowering May to July.

Calophyllum aureo-brunnescens is an imperfectly known species that can be characterized by its rounded twigs, its narrowly conical terminal buds, its suberect to spreading uppermost pair of axillary buds, its rather small, basically elliptic lamina that is usually other than retuse at the apex, and its terminal inflorescence with eight-tepaled flowers. The epithet *aureo-brunnescens* means "gold-brownish"; I am not sure why it was coined.

It has been suggested that *Calophyllum aureo-brunnescens* may be close to *C. aureum*; for discussion see *C. aureum*.

157. *Calophyllum aureum* Symington ex M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 340. pl. 20. 1956; T. C. Whitmore, Tree Fl. Malaya 2: 171. 1973. TYPE: Malaya, Pahang, Cameron Highlands, Gunong Beramban, 5 June 1933, KEP 31007 coll. Symington (holotype, SING; isotypes, K, KEP).

Shrub or tree 2.5-15 meters tall, d.b.h. to 38 cm.; trunk (?)unbuttressed; outer bark yellowish to ochre, smooth at first, becoming fissured; inner bark red-brown; latex clear golden or opaque cream.

Twigs strongly flattened, 1.2-2.5 mm. across, 4-angled, drying dark brown, yellowish brown when much older, transiently subglabrous or farinose-puberulent; axillary innovations lacking basal scars; internodes 2-6.5 cm. long; uppermost pair of axillary buds pointed, 1.5-3.5 mm. long, erect; terminal bud narrowly conical to somewhat plump, (3.5-)4.5-6 mm. long, with subfur-furaceous grayish brown to subtomentose rufous indumentum (hairs, FIGURE 43, p), underdeveloped internode absent. Petiole 4.5-9.5 mm. long, concave above, convex below, glabrescent; lamina obovate (rarely subelliptic), 2-5 by 1.3-3.6 cm., retuse (very rarely rounded) at apex, cuneate to acute at base, broadly undulate or not and not recurved to slightly so at margin, entire lamina drying \pm concave, coriaceous, sabelline-olivaceous above and sepia below, when young farinose on midrib below, the midrib above abruptly narrowed at base, raised to subdepressed, with raised margins, 0.15-0.25 mm. wide at midpoint, disappearing just short of apex or not, below raised, striate (subdepressed toward apex), the venation above apparent, below subobscure to apparent, raised to level, 12 to 19 veins/5 mm., angle of divergence (55-)65-75°. Inflorescences terminal (also from uppermost pair of foliate axils), with 7 to 13 flowers, often with 3-flowered branches to 1.5 cm. long, frequently flabellate, the axis to 4 cm. long, farinose to puberulent at least near base, lowest internode 1.5-3.2 cm. long; bracts foliaceous, to 2 cm. long, subsistent; pedicels 0.6-1.1 cm. long, glabrous (sparsely farinose toward base). Flower (?)hermaphroditic; tepals 8, the outer pair broadly ovate, 5.5-6.5 by 4.5-5.5 mm., the inner ones elliptic to obovate, 9-10 by 4-6 mm.; stamens ca. 150, the filaments to 4.5 mm. long, the anthers oblong, 1.2-1.5 mm. long, subacute to retuse at apex; ovary ca. 2 mm. long, the style ca. 3 mm. long, the stigma peltate, ca. 0.8 mm. across, 3- or 4-radiate. Immature fruit ovoid, ca. 1.8 by 1.4 cm., apiculate, drying brown, smooth; outer layer ca. 1.2 mm. thick; stone walls probably very thin.

DISTRIBUTION. Malaya, the Main Range (MAP 47).

SELECTED SPECIMENS SEEN. **Malaya.** PERAK: G. Korbu, 1524-2134 m., *KEP 32118* (K, KEP). PAHANG: Cameron Highlands, Bukit Mentigi, 1524 m., *Chew 860* (A, AAU, G, K, KEP, SING, UC), path to G. Beramban, 1494 m., *FRI 15675* (KEP, L); G. Benom, 1829 m., *FRI 3305* (KEP), Kluang Terbang, *Barnes s.n.* (SING). SELANGOR: Fraser's Hill, *KEP 11468* (KEP, SING); G. Bunga Bua, *FRI 307* (KEP, SING).

ECOLOGY. Lower montane forest (trees on ridges very stunted), 1490-2135 m. alt. Flowering June and October; flower cream, fragrant.

Barnes s.n. and *Chew 860* have leaves modified as bilabiate galls, perhaps caused by coccids.

Calophyllum aureum can be characterized by its uppermost pair of axillary buds, which are long and erect; its long internodes; its small, usually obovate and retuse lamina that dries grayish green above with the midrib brownish, and brown to golden brown below; and its relatively few-flowered, farinose-puberulent terminal inflorescences with widely spreading branches and persistent bracts. The epithet *aureum* ("gold") alludes to the yellowish bark.

Barnes s.n. was cited under *Calophyllum aureo-brunnescens* by Henderson and Wyatt-Smith (*op. cit.*); they thought that it was intermediate between that species and *C. aureum*. However, *Barnes s.n.* is merely a poor, galled specimen of *C. aureum*; *FRI 3305*, also from G. Benom, is more obviously this species. The fruits of both *C. aureum* and *C. aureo-brunnescens* are still unknown; the two species may not be closely related.

158. *Calophyllum rubiginosum* M. R. Henderson & Wyatt-Smith, *Gard. Bull. Singapore* 15: 308. *pl. 5*. 1956; Smythies, *Common Sarawak Trees*, 61. 1965; Kochummen, *Malayan Forest Rec. ed. 2*, 17: 215. 1965; T. C. Whitmore, *Tree Fl. Malaya* 2: 189. 1973; H. Keng, *Gard. Bull. Singapore* 28: 245. 1976; Corner, *Gard. Bull. Singapore Suppl. 1*: 104. 1978. **TYPE:** Malaya, Negri Sembilan, Berembun-Angsi Reserve, Bukit Tanga, 25 Feb. 1918, *KEP 1953* coll. *Kinsey* (lectotype, KEP; isolectotype, K, SING). FIGURE 40, i.

C. wallichianum auct., non Planchon & Triana; King, *Jour. Asiatic Soc. Bengal*, II. 59: 179. 1890, *quoad descr.*; Ridley, *Jour. Straits Branch Roy. Asiatic Soc.* 33: 48. 1900, *Fl. Malay Penin.* 1: 187. 1922, *pro parte*; M. R. Henderson, *Gard. Bull. Straits Settl.* 4: 224. 1938; Foxworthy, *Malayan Forest Rec.* 3: *fig. 1927*.

C. muscigerum Boerl. & Koord. ex Heyne, *Nutt. Pl. Nederl.-Indië. ed. 2*, 2: 1085. 1927, *ibid. ed. 3*, 1: 1085. 1950; Pukol & Ashton, *Checklist Brunei Trees*, 93. 1964. *Nomen*.

Calophyllum sp. *Koord.-Schum. Syst. Verzeich.* 2: 40. 1910.

Tree 7.5-39 meters tall, d.b.h. to 77 cm.; trunk without buttresses (with small spurs); outer bark brownish at first, becoming grayish to yellowish or ochre, with long, shallow fissures, or rugulose with minute cracks, flaking or scaling, hoop marked, the inner surface yellow to orange; under bark orange-straw to deep red; inner bark red; latex white, sticky or not.

Twigs flattened, 2-3.5 mm. across, strongly 2- or 4-angled, drying whitish

or yellowish, subsersistently brown-tomentose (rarely puberulent); axillary innovations lacking basal scars; internodes (1-)2-7 cm. long; uppermost pair of axillary buds pointed, 1-2 mm. long, erect; terminal bud plump, 4-8 mm. long, with brown, short-tomentose to puberulent indumentum (hairs, FIGURE 41, c-f), underdeveloped internode absent (-2 mm. long). Petiole 0.5-3 cm. long, slender, narrowly to broadly concave above, convex and \pm persistently short-tomentose below; lamina elliptic to suboblong or ovate, (4.5-)7-16 by (1.6-)2-5.7 cm., acute to acuminate at apex, acute to subdecurrent (rarely rounded) at base, distantly and \pm deeply undulate and plane to slightly recurved at margin, coriaceous, drying olivaceous to umber above and clay or cinnamon-sabelline to sienna-umber below, color often obscured by ferruginous indumentum, usually tomentose (rarely puberulent) on both surfaces initially, becoming glabrescent above, the midrib above narrowing gradually from base, sharply raised, 0.2-0.5 mm. wide at midpoint, below strongly raised, \pm striate, the venation subobscure on both surfaces, raised to depressed, latex canals as clear as veins, 8 to 14 veins/5 mm., angle of divergence 70-80°. Inflorescences terminal and from adjacent foliate axils, with 7 to 15 flowers (very rarely single, terminal flower), unbranched, often flabellate, the axis 2.5-7 cm. long, short-tomentose, lowest internode 0.5-1.7 cm. long; bracts \pm linear, to 3.2 cm. by 2 mm., soon deciduous; pedicels 3.5-16 mm. long, short-tomentose. Flower (?)hermaphroditic; tepals (4 or) 8, the outer pair ovate, 5.5-6.5 by 3.5-5.5 cm., tomentose on outer and inner surfaces, especially near apex, the next pair (broadly) elliptic, 7.5-9 by 4-5.5 mm., tomentose in band down back, the inner ones obovate to subelliptic, to 8 by 4 mm.; stamens 130 to 235, the filaments to 5.5 mm. long, the anthers suboblong, 0.6-1 mm. long, rounded to slightly retuse at apex, with subsistent hairs to 0.2 mm. long; ovary 1.5-1.7 mm. long, the style to 2.5 mm. long, the stigma subpellate, to 0.9 mm. across, 3-radiate. Fruit ovoid-ellipsoid, 2-2.2 by 1.4-1.8 cm., \pm acute at apex, drying brown, sharply and prominently wrinkled, furfuraceous; outer layer detaching cleanly from stone or not, ca. 1.5 mm. thick, compact; stone ellipsoid, ca. 1.7 by 1.4 cm., rounded at apex, the walls less than 0.2 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Southern Malay Peninsula to Sumatra and Borneo (MAP 47).

SELECTED SPECIMENS SEEN. **Malaya.** SELANGOR: Bukit Lagong F.R., 502 m., *KEP 83675* (KEP); Bangi F.R., *KEP 10974* (KEP, P); Rantau Panjang, *KEP 14772* (KEP, P); Kuala Lumpur, Jalan Rajah, *KEP 10470* (E, K, KEP, NY, SING); Kepong, F.R.I. plantation, *KEP 38507* (K, KEP, SING, US); Sungei Buloh F.R., 240 m., *KEP 99637* (A, KEP, SAR); Kuang F.R., *KEP 21962* (KEP, NY, P); Ayer Hitam F.R., *KEP 10903* (KEP); Kanching, *KEP 14782* (KEP); Weld Hills F.R., *KEP 2615* (KEP); Ulu Gombak F.R., *KEP 11645* (KEP, NY, SING); Bukit Cheraka F.R., *KEP 65567* (KEP); Bukit Tunggul F.R., *KEP 23644* (KEP); Ulu Langat F.R., *KEP 53604* (KEP); Ampang F.R., *FRI 16054* (KEP, SING); Kajang, *KEP 2649* (KEP); 12th mile Bentong road, *Samat bin Abdullah 174* (A, G, KLU). MALACCA: 15th mile Sungei Udang F.R., *Sinclair 8937* (B, E, K, SING); Ayer Panas F.R., *KEP 25253* (K, KEP); Batang Malaka F.R., *KEP 2063* (K, SING); Ramuan China F.R., *KEP 25257* (BO, KEP). NEGRİ SEMBILAN: Sungei Menyala F.R., *KEP 64654* (KEP, SING); Senawang F.R., *KEP 18505* (A, K, KEP, SING);

Gunong Angsi F.R., 457 m., *FRI 17332* (K, KEP, SAR, SING). PAHANG: ca. 10 km. S. of Kampong Aur, *FRI 15895* (KEP); Lesong F.R., 150 m., *FRI 19843* (KEP, SAR). JOHORE: Kluang Forest, *FRI 8709* (A, K, KEP, SAR, SING); Jemaluang F.R., *KEP 69995* (KEP); Sungei Kayu, *Kiah s.n.*, 28 Oct. 1936 (SING). SINGAPORE: Bukit Timah, *Ridley 6196* (A, E, K, NSW, P, SING); NE. end MacRitchie Reservoir, *SFN 39634* (BO, E, K, P, SING); Chua Chu Kang, *Ridley s.n.*, anno 1894 (SING); Botanic Gardens, *SGN 1668* (SING). SUMATRA. RIAU: Indragirische Bovenlanden, Danau Mengkoeang, 60 m., *bb 27550* (BO, L); Upper Riau, Pakanbaru, Tenajan R., *Soepadmo 86* (A, B, BO, C, E, LAE, NY, SING). SELATAN: Rawas, 100 m., *Grashoff 970* (BO, L). "Central, Nogul Droog." *Koorders 15779* (BO). BORNEO. SARAWAK. 3rd Division: Melinau, Ulu Selada, path to Bukit Mabong, 305 m., *S 24266* (L, SAN, SAR, SING). 4th Division: Baram, Sungei Beling, *FA 636* coll. *Egon*, 24 May 1948 (SAR); Poak, *Hose s.n.*, 8 Nov. 1911 (BM). BRUNEI: Kuala Beblong, 60 m., *Ashton s.n.*, Oct. 1959 (SAR). SABAH. Beaufort: Beaufort Hill, *SAN 36900* (SAN). KALIMANTAN. TIMUR: C. Kutei, Belajan R., G. Kelepok near Tabang, 250 m., *Kostermans 10584* (BO, CANB, K, KEP, L, NY, P, SING); W. Koetei, Long Bleh, 30 m., *bb 16059* (A, BO).

ECOLOGY. Lowland or colline forest, 30–500 m. alt. Flowering January to May, and July and August (flower scented); fruiting April to July, and October to December (fruit brownish green).

YOUNG PLANT. The young plant is erect, and the terminal bud is functional.

LOCAL USES. The wood, although susceptible to termite attack, is used in construction. The latex is very poisonous and, mixed with rice, is used to exterminate rats (Heyne, *loc. cit.*). It is also reportedly used as a poison to stun fish (*Kostermans 10584*, Kalimantan); in the 3rd Division of Sarawak the latex of *C. rubiginosum*, or another species with white latex, is placed in small dams and left overnight for this purpose (Banyeng ak Nudong, pers. comm.).

Calophyllum rubiginosum is a distinctive species characterized by its pale whitish yellow-drying twigs, its usually well-developed and persistent indumentum, its terminal inflorescences, and its ellipsoid, deeply wrinkled fruits with a furfuraceous surface and a very thin-walled stone. The epithet *rubiginosum* ("rusty") is very appropriate since the conspicuous, rusty brown indumentum persists so long.

Although *Calophyllum rubiginosum* is superficially similar to *C. molle*, the two species keying out adjacent to one another in Henderson and Wyatt-Smith (*op. cit.*), there are numerous differences between them, and they are probably not closely related. *Calophyllum molle* has yellow latex, clearer venation, a petiole less than 1 cm. long, axillary inflorescences, flowers with four tepals and at least 500 stamens, a densely tomentose ovary, and a spherical fruit that is finely wrinkled but not furfuraceous and that has a stone with walls about 1 mm. thick. However, *C. molle* and *C. rubiginosum* are, so far as is known, the only two large-leaved species of *Calophyllum* to have hairs on the anthers. (Hairy anthers are also found in a few specimens of *C. canum*.) *Calophyllum rubiginosum* has also been confused with *C. wallichianum* (= *C. rufigemmatum*) because both have conspicuous, reddish

brown indumentum; however, there is otherwise little similarity between the two.

There is relatively little variation within *Calophyllum rubiginosum*. Some specimens from Sumatra have somewhat smaller leaves that are more or less rounded at the base of the lamina, and strongly flattened, two-angled twigs; *C. rubiginosum* usually has four-angled twigs, and the base of the lamina varies from more or less rounded to decurrent. *Grashoff 970* (from Sumatra) has inflorescences that consist of a single, terminal flower, but in other characters it is unremarkable. Some specimens from Borneo, as well as *Sinclair 8937*, from Malaya, have indumentum that is shorter and less prominent and persistent than is typical for the species. The description of the rather remarkable linear bracts is taken from *KEP 38507* (Malaya); whether or not the bracts are always linear is unclear.

The type collection of *Calophyllum rubiginosum*, *KEP 1953*, consists of two sheets, one with flowers and the other with fruits; they were collected at different times but in the same area. *Calophyllum rubiginosum* has been lectotypified on the flowering collection; the fruiting collection was made on May 22, 1918.

159. *Calophyllum molle* King, Jour. Asiatic Soc. Bengal, II. 59: 177. 1890; Curtis, Jour. Straits Branch Roy. Asiatic Soc. 25: 78. 1894; Ridley, Fl. Malay Penin. I: 185. 1922; I. H. Burkill & M. R. Henderson, Gard. Bull. Straits Settl. 3: 347. 1925; M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore 15: 307. 1956; T. C. Whitmore, Tree Fl. Malaya 2: 188. 1973. TYPE: Malaya, Penang Hill, March (fl.) or June (fr.), 1888, *Curtis 1426* (syntypes, K, SING). FIGURE 40, h, j.

Tree 12-30 meters tall, d.b.h. to 50 cm.; trunk without buttresses or spurs; outer bark pale brown to gray-yellow, shallowly and distantly fissured or with vertical lines of lenticels, hoop marked, the inner surface orange; under bark dark brown; inner bark orange-red to dark reddish brown, fibrous; latex clear yellow, not sticky (dirty colored, nonresinous); wood white, radially flecked, soft.

Twigs slightly flattened, 1.7-2.2 mm. across, obscurely 4-angled, drying yellowish or whitish, densely and persistently brown-tomentose, hairs to 0.5 mm. long; axillary innovations lacking basal scars; internodes (1-)2-6 cm. long; uppermost pair of axillary buds rounded, 1-2 mm. long, spreading; terminal bud plump to elliptic, 4-10 mm. long, with dense, brown, tomentose indumentum (hairs, FIGURE 41, n, o), underdeveloped internode 1-2.5 mm. long. Petiole 5-9 mm. long, deeply concave above, convex below, subsersistently tomentose; lamina ovate to suboblong or subelliptic, 6-18.5 by (1.5-)2.2-5 cm., shortly acute to acuminate at apex, rounded to cuneate and subcucullate at base, undulate and narrowly recurved at margin, thinly coriaceous, drying cinnamon-drab-grayish sepia to vinaceous-hazel above and sabelline to fulvous-umber below, rather persistently tomentose on midrib above and on entire lower surface, the midrib above narrowing near base, or already narrow at base and further narrowing gradually, raised, 0.15-0.3(-0.6) mm. wide

at midpoint, below raised, rounded to striate, the venation apparent above, slightly less so below, raised, (8 to) 11 to 17 veins/5 mm., angle of divergence 70-75(-80)°. Inflorescences from foliate axils along stem, with 3 to 5 flowers, unbranched, the axis 0.5-2.9 cm. long, persistently tomentose, lowest internode 0.5-1.8 cm. long; bracts narrowly ovate, ca. 4 mm. long, soon deciduous; pedicels 4-12 mm. long, tomentose, in fruit to 1.4 cm. long and 3.5 mm. thick. Flower (?) hermaphroditic; tepals 4 (rarely 6 in terminal flowers), the outer pair ovate-oblong, 7-8.5 by 4-6 mm., short-tomentose on back (also on inner surface, at least near apex), the inner ones \pm obovate-elliptic, 7.5-9.5 by 5-6.5 mm., nearly always tomentose in band down back; stamens 510 to 580, the filaments to 5 mm. long, connate for ca. 0.4 mm., the anthers suboblong, 0.4-0.7 mm. long, rounded to subretuse at apex, with rather dense, persistent hairs to 0.3 mm. long; ovary 2-3 mm. long, tomentose, the style 2.5-3 mm. long, the stigma peltate, ca. 0.9 mm. across, 3-radiate. Fruit subspherical to ellipsoid, 2.2-3.4 by 2-2.1 cm., apiculate to acute at apex, pubescent, drying brown to orange-brown, shallowly wrinkled; outer layer detaching cleanly from stone, 2.3-3.5 mm. thick, compact; stone spherical to ellipsoid, 1.4-2.9 by 1.3-1.5 cm., \pm obtuse at apex, the walls 1-1.3 mm. thick, sometimes with 3 shallow, longitudinal depressions running from apex, otherwise smooth, discolored area at base 5.5-7 mm. across; spongy layer thin.

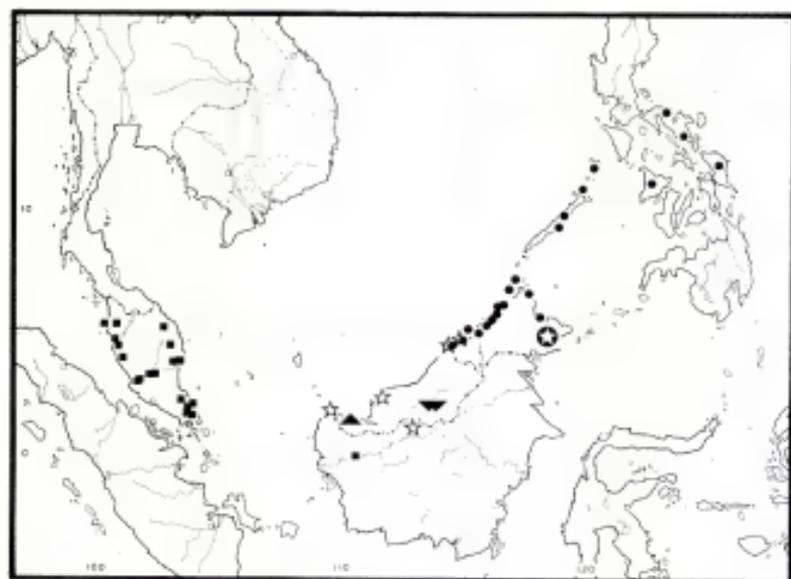
DISTRIBUTION. The Malay Peninsula, possibly also western Borneo (MAP 48).

SELECTED SPECIMENS SEEN. **Malaya.** KEDAH: Gunong Inas F.R., 60 m., *KEP* 79265 (*KEP*). Pinang: Pulau Penang, back of W. Hill, 610 m., *Curtis* = 1426, March 1901 (*K*, *SING*). PERAK: Larut, 310-465 m., *King's collector* 6724 (*BM*, *FL*, *K*, *P*, *SING*); Sg. Merbau, Tapah Road, *KEP* 4563 (*K*, *SING*); Tronoh, *KEP* 12022 (*KEP*); Ulu Piah, *KEP* 11970 (*KEP*); Sungai Pangkor F.R., 36 m., *KEP* 75968 (*KEP*). SELANGOR: Kuang, *KEP* 14776 (*KEP*, *P*); Bukit Lagong F.R., 457 m., *KEP* 52233 (*KEP*, *SING*); Kanching F.R., *KEP* 21975 (*KEP*); Panjang Rawang, *KEP* 24931 (*KEP*). TRENGGANU: Ulu Besut, near Bukit Jebak Puyoh, 150 m., *FRI* 8285 (*A*, *K*, *KEP*); Ulu Sungai Loh below E. face G. Mandi Angin, 701 m., *FRI* 12135 (*K*, *KEP*). PAHANG: G. Tapis, 610 m., *FRI* 10903 (*A*, *KEP*, *SAR*, *SING*); Raub, Bilut F.R., *KEP* 23353 (*KEP*); Kuantan, Baloh F.R., 15 m., *KEP* 77971, *pro parte* (*KEP*); Temerloh, *KEP* 5458 (*SING*). JOHORE: Renggam F.R., 45 m., *KEP* 71274 (*KEP*); Mersing F.R., 15 m., *KEP* 77929 (*A*, *BO*, *K*, *KEP*, *SING*); Labis F.R., Ulu Endau, *FRI* 7878 (*A*, *K*, *KEP*, *SAR*, *SING*); NW. G. Blumut, 427 m., *FRI* 8757 (*A*, *K*, *KEP*, *SAR*, *SING*); Kola Tinggi, Panti F.R., *KEP* 53935 (*KEP*, *SING*). **Borneo.** KALIMANTAN, Barat: Sanggau, G. Keramas, 75 m., *bb* 14405 (?) (*BO*).

ECOLOGY. Mixed dipterocarp forests, often on ridges and hillsides; 15-701 m. alt. Flowering March (most) and August (once); fruiting June, July, and September to November (fruit brown).

GERMINATION AND YOUNG PLANT. The young plant is erect, and the terminal bud is functional.

Calophyllum molle can readily be recognized by its well-developed, tomentose indumentum; its leaf blades, which are often slightly cucullate at the



MAP 48. Distribution of *Calophyllum molle* (squares), *C. ardens* (stars), *C. aurantiacum* (erect triangle), *Calophyllum* sp. 163 (inverted triangles), *C. obliquinervium* (circles), and *C. sakarium* (star in solid circle) in Malaysia.

base; its axillary inflorescences; its flowers, which have four tepals and anthers that are more or less covered by short hairs; and its large, shallowly wrinkled fruits with a thick outer layer and a thick-walled, triradiately marked stone. The soft, tomentose indumentum of this species presumably suggested the epithet *molle* ("soft").

Calophyllum molle is superficially similar to *C. rubiginosum*, and both species have hairs on their anthers. However, the two are not otherwise very similar; for the differences separating them, see *C. rubiginosum*.

The report of *Calophyllum molle* from Sumatra (Ridley, *loc. cit.*; Beccari, *PS* 953—see *Calophyllum* sp. 54) is incorrect. However, *bb* 14405, from western Kalimantan, is possibly to be referred to *C. molle*. It has a terminal bud up to 1.5 cm. long, its stems dry mid-brown, its petiole is broad, and its lamina is up to 14.5 by 6.5 cm. However, in general leaf and indumentum type it is similar to *C. molle*, and its flowers have four tepals, hairy anthers, and a densely tomentose ovary.

Henderson and Wyatt-Smith (*loc. cit.*) suggested that *Calophyllum molle* was typified by *Curtis* 1426; this number and several (unspecified) numbers of King's collector (Kunstler) had been mentioned in the protolog. In the Kew and Singapore herbaria there are some specimens of *Curtis* 1426 with flowers that were collected in March (the year is not mentioned), and others

with fruits that were collected in June, 1888. Not having seen material from Calcutta, I have not designated a lectotype.

160. *Calophyllum obliquinervium* Merr. Philip. Jour. Sci. **20**: 409. 1922, Enum. Philip. Fl. Pl. **3**: 30. 1923; Keith, N. Borneo Forest Rec. ed. 2. **2**: 314. 1952; J. Anderson, Gard. Bull. Singapore **20**: 154. 1963, *pro minore parte*; Pukul & Ashton, Checklist Brunei Trees, 93. 1964, *pro parte*; Meijer, Bot. Bull. Herb. Forest Dept. Sabah **7**: 15. 1967, Field Guide Trees W. Malesia, 161. 1974. TYPE: Philippine Islands, Palawan, Feb. 1920, *FB 27929* coll. *Cenabre, Paras, & Gellidon* (isotypes, BM, UC).

C. benjamina Ridley, Kew Bull. **1938**: 119. 1938; Masamune, Enum. Phanerog. Born. 475. 1942; Keith, N. Borneo Forest Rec. ed. 2. **2**: 313. 1952. TYPE: Brunei, Limbang, *Haviland 505* (holotype, K; isotypes, SAR, SING).

C. pseudotacamahaca vel. aff. auct., non Planchon & Triana; Keith, N. Borneo Forest Rec. ed. 2. **2**: 313. 1952.

Tree 4-20(-30) meters tall, d.b.h. to 64.5 cm.; without buttresses; outer bark yellowish to grayish brown at first, with diamond-shaped fissures, becoming brown to blackish with reddish or brownish tinge, cracked or fissured, scaling, the inner surface dirty brown-greenish; under bark dark red; inner bark reddish brown to yellow; latex clear yellow (white—*SAN 33639*), very sticky.

Twigs slightly flattened, 1.2-3 mm. across, 4-angled to 4-angled, drying blackish brown, glabrous or sparsely farinose when young; axillary innovations lacking basal scars; internodes 0.5-3(-5) cm. long, terminal internode of innovation usually $\frac{1}{2}$ or less length of others; uppermost pair of axillary buds rounded, ca. 0.5 mm. long, obscured by petiole bases; terminal bud plump, 1.5-2.5 mm. long, with rufous to pale brown, puberulent to subadpressed indumentum (hairs, FIGURE 41, k-m), underdeveloped internode not apparent. Petiole (0.3-)1-2.3 cm. long, flat to concave above, convex below, glabrous; lamina elliptic to subobovate, (3.8-)5.7-14.5 by (1-)1.2-6.5 cm., acute to acuminate and recurved at apex, decurrent to cuneate (rarely rounded) at base, slightly undulate and not recurved at margin, coriaceous, drying umber to olivaceous above, umber to fulvous below, glabrous or very nearly so, the midrib above narrowing gradually from base, margins slightly raised, adjacent midrib often slightly raised, center slightly depressed, 0.1-0.3 mm. wide at midpoint, usually disappearing ca. 1 cm. short of apex, below not much raised, rounded or \pm striate, the venation above and below subobscure, raised, 9 to 19 veins/5 mm., angle of divergence 30-50°. Inflorescences terminal and from adjacent foliate axils (rarely 2 per axil), with 7 to 13 flowers, usually unbranched, the axis 3.5-9 cm. long, glabrous, or puberulent near base when young, lowest internode 1.7-3.5 cm. long; bracts 1.5-3(-8) mm. long, soon deciduous; pedicels 0.5-1.9 cm. long, to 2.5 cm. long in young fruit, glabrous. Flower (?)hermaphroditic; tepals 8 or 10, the outer pair suborbicular, (2.3 (when 10 tepals)-)3-3.7 mm. long and across, the next pair, when 10 tepals, \pm ovate, ca. 4.5 by 3.2 mm., the inner ones obovate

to elliptic, 5–8.5 by 2.5–4.5 mm. (rarely ca. 6 by 1.5 mm.); stamens 55 to 125, the filaments to 4 mm. long, connate for up to 0.5 mm., the anthers suboblong, 0.5–1.5 mm. long, truncate to retuse at apex; ovary 1–1.5 mm. long, the style 2–4 mm. long, the stigma excentrically peltate, 0.5–0.8 mm. across, infundibular. Fruit spherical to ellipsoid, 0.9–1.3 by 0.75–1.1 cm., apiculate or not, drying dark brown, \pm smooth when ripe, strongly wrinkled when young; outer layer not detaching cleanly from stone, less than 0.5 mm. thick, air spaces developing; stone \pm spherical to ellipsoid, 6–8.5 by 5.5–7.5 mm., rounded at apex, the walls 0.2–0.3 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Northeastern Borneo, never far inland, and the northern and western Philippine Islands (MAP 48).

SELECTED SPECIMENS SEEN. **Borneo and adjacent islands.** BRUNEI: Tutong, Kg. Danau, *van Niel* 3453 (L); Bukit Pasir Puteh, *BRUN* 5020 (BO, BRI, K, KEP, L, SAR, SING); Belait, mouth R. Lumut, *van Niel* 4046 (L); Lumapas, *KEP* 37223 (A, K, KEP, SING); Berakas, *KEP* 37212 (K, KEP, SING). SABAH: Sipitang: 2.4 km. NE. of Sipitang, 6 m., *SAN* 15191 (A, BO, K, KEP, SAN, SING); Kuala Mengalong F.R., 30 m., *SAN* 73151 (K, L, SAN, SING); Sungei Buntoh, 3 m., *SAN* 27978 (L, SAN, SAR); Marantaman, *SAN* 2492 (A, BO, K). PAPUA: Kawang F.R., *SAN* 30271 (K, KEP, L, SAN, SAR, SING); Kimanis F.R., 6 m., *A* 301 (K, KEP, SING); Kg. Padawan, *SAN* 30311 (K, KEP, L, SAN, SAR, SING); Bongawan F.R., 4.5 m., *SAN* 2316 (A, BO, K). Kota Kinabalu: Pulau Gaya F.R., 6 m., *SAN* 41303 (K, L, SAN, SING); Putatan, 1 m., *SAN* 33639 (KEP, L, SAN, SAR, SING); Penampang, *SAN* 2813 (BO, K); Bukit Padang, *SAN* 19940 (SAN). Tuaran: Lumas F.R., 180 m., *SAN* 33837 (K, L, SAN, SAR). Kota Belud: Kelawat F.R., 120 m., *SAN* 33644 (K, KEP, L, SAN, SAR, SING). Kudat: Marudu, Kitaku F.R., *A* 1199 (A, BO, K, KEP, SING, US); Kadayan F.R., *A* 3181 (BO, BRI, KEP, L, P, SING, US); Loto F.R., 150 m., *SAN* 51054 (BISH, NY, SAN); Balembangan B., 6 m., *SAN* 69604 (SAN). Labuk & Sugut: Jembongan Is., *SAN* 18956 (A, BO, K, KEP, L, SAN, SAR, SING). Sandakan: Leila F.R., Water Works, *SAN* 48174 (K, KEP, L, SAN, SAR, SING); Sepilok Trig. Hill, 90–150 m., *SAN* 24904 (K, L, SAN); Bukit Luku, Buli, *SAN* 20553 (BO, L, SAR, SING). **Philippine Islands.** PALAWAN: Aborlan, Malasgao R., *PNH* 14132 (A, BO, UC, US); Tapul Mt., vicinity of Puerto Princesa, *Ebalo* 534 (A, BISH, NY, UC); Silanga, *BS* 9585 (?) (K, US). CALAMIAN, Culion: sine loco, *Herre* 1087 (A, NY, UC). LUZON. Camarines Norte: Paracale, *FB* 27096 (A, K, P, US). Albay: sine loco, *FB* 20108 (BO). SAMAR: sine loco, *Philippine Plants* 1630 (BM, BO, G, GH, MO, NSW, NY, P, SING).

ECOLOGY. Rather variable in Borneo, although favoring poorer (acid) soils (in kerangas vegetation and similar places), by seashore, in swamps (at Kimanis), in primary forest with nibong (*Oncosperma* Blume), in secondary forest, in mixed dipterocarp forests on hillsides; to 180 m. alt. In Philippine Islands also with wide ecological range (Merrill, 1923, *loc. cit.*). Flowering December, February, and March (flower scented, petals often notably reddish or purplish—e.g., *BRUN* 5020); fruiting March to May, July, and December (fruit bluish, or reddish black).

GERMINATION AND YOUNG PLANT. The radicle probably breaks through the stone to one side of the base. The seedling has two pairs of leaves separated

by a well-developed internode. Subsequent growth is rather slow, but the young plants seen were growing on a dry ridge, which may have made their growth slower than normal. The young plants are erect, and the terminal bud is functional. Young plants 30 cm. tall lacked the characteristic short terminal internode on each innovation, but this was present on innovations of plants about 1.6 meters tall. (Stevens 702, from Sabah.)

LOCAL USE. The timber is used for building.

Calophyllum obliquinervium is a distinctive species. Its twigs dry dark brown, the terminal internode of each innovation is notably shorter than the others, its leaf blades have steeply ascending venation, its inflorescences are terminal and usually unbranched, and its fruits are fairly small. The epithet *obliquinervium* ("oblique nerves") was suggested by the characteristic venation of this species.

Anderson felt that *Calophyllum benjamina* and *C. obliquinervium* could be separated on bark characteristics: the bark of specimens from kerangas vegetation is gray and fissured (see his notes on S 27681 at Kew), while that of specimens from peat swamps is yellow. Although his later reduction of *C. benjamina* to synonymy under *C. obliquinervium* (Anderson, *loc. cit.*) is correct, he included specimens of *C. ardens* in *C. obliquinervium*. *Calophyllum ardens* is a characteristic peat swamp species that apparently always has yellow bark; the numerous differences between it and *C. obliquinervium*, a species usually of drier ground, are discussed under *C. ardens*.

The similarity between *Calophyllum obliquinervium* and *C. sakarium* is only superficial, as the discussion after the latter species indicates.

Specimens of *Calophyllum obliquinervium* from Borneo are similar to those from the Philippine Islands, although the Bornean specimens have slightly smaller flowers. Herre 1087, from Culion Island, in the Philippines, has pedicels only 3-5 mm. long and a leaf blade that is rounded at the base; it is not otherwise different from specimens collected in the Philippine Islands.

161. *Calophyllum sakarium* P. F. Stevens

FIGURE 42, d-f.

A speciebus aliis Calophylli in lamina mediocra obovata nervis lateralibus 3 usque ad 7 per 5 mm. (in pagina superiore ut videtur 6 usque ad 14 per 5 mm.), inflorescentiis terminalibus, floribus cum 8 tepalis, et fructu 1.1-1.3 cm. longo, differt.

Tree 12-24 meters tall, d.b.h. to 65 cm.; outer bark yellowish green to yellowish white, scaly or fissured; inner bark pale red or red-brown; latex yellow.

Twigs flattened, 2-3(-3.5) mm. across, \pm strongly 4-angled, drying brown, soon glabrescent; axillary innovations lacking basal scars; internodes 1.5-3 (-4.5) cm. long, becoming shorter toward apex (uppermost internode less than $\frac{1}{2}$ length of others); uppermost pair of axillary buds rounded, ca. 1 mm. long, spreading; terminal bud bluntly conoid, 1.4-2 mm. long, with short, brown, tomentose indumentum (hairs, FIGURE 41, h-j), underdeveloped internode 0.5-1.5 mm. long. Petiole 0.6-1.7 cm. long, shallowly concave above,

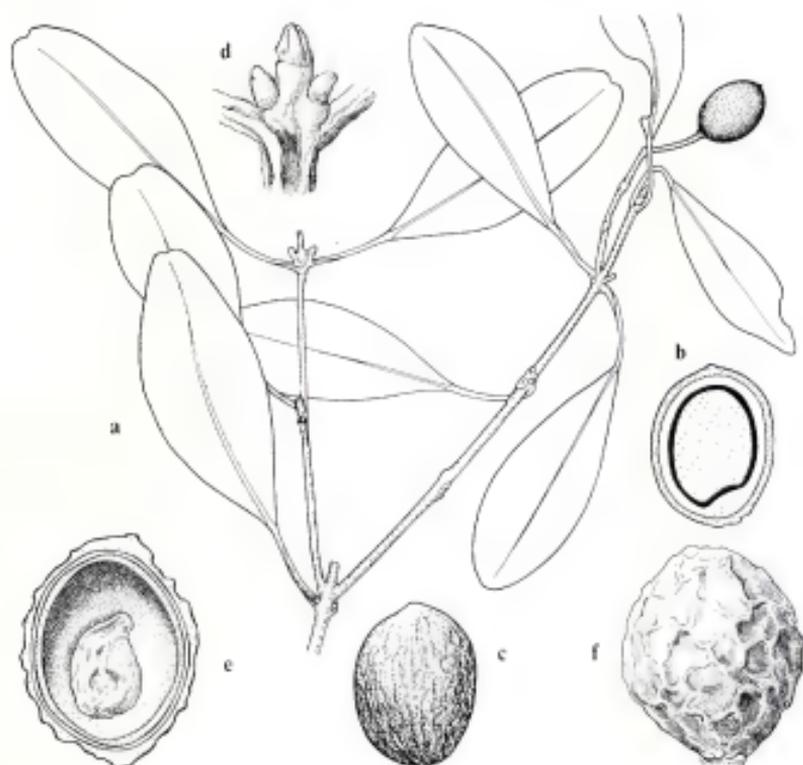


FIGURE 42. a-c, *Calophyllum ardens* (BRUN 297). a, habit, $\times 0.5$. b, c, fruit $\times 0.75$: b, longitudinal section; c, from outside. d-f, *C. sakarium*. d, SAN 57404, terminal bud, $\times 3$. e, f, SAN 21622, fruit, $\times 3$: e, longitudinal section; f, from outside.

convex below, glabrescent; lamina obovate, 4-9 by 1.7-4.7 cm., rounded to shallowly retuse at apex, cuneate to acute at base, distantly undulate but not recurved at margin, coriaceous, drying olivaceous above and sabelline below, often with grayish covering, soon glabrescent or sparsely and persistently puberulent on midrib below, the midrib above narrowed gradually from base, flat to slightly raised, 0.3-0.7 mm. wide at midpoint, below slightly raised, striate or not, the venation subobscure above and below, latex canals as prominent as veins above, 3 to 7 veins/5 mm., angle of divergence 40-55°. Inflorescences terminal and from adjacent foliate axils, with 7 to 25 flowers, terminal inflorescences flabellate and/or with branches up to 5 cm. long and with 7 flowers, axillary inflorescences unbranched, the axis (1.5-)3-9 cm. long, puberulent at base, lowest internode 1.5-4.6 cm. long, frequently only 0.3 mm. in terminal inflorescences; bracts unknown; pedicels 0.7-2.5

cm. long, glabrous. Flower (?)hermaphroditic; tepals 8 (or 9), the outer pair suborbicular, ca. 3 by 3 mm., when 8 the inner ones obovate to suborbicular, 5-11 by 4-7 mm., when 9 innermost one ca. 6.5 by 3 mm.; stamens 105 to 160, the filaments to 4 mm. long, the anthers suboblong, 1.2-1.7 mm. across, retuse at apex; ovary ca. 1.5 mm. long; style ca. 3 mm. long; stigma peltate, (?)1-1.5 mm. across, 2-radiate. Fruit ellipsoid, ca. 1 by 0.8 cm., apiculate, drying vinaceous-brown, wrinkled; outer layer detaching from stone only with difficulty, 0.2-0.3 mm. thick, compact, (?)air spaces developing at maturity; stone ellipsoid, ca. 0.8 by 0.7 cm., rounded at apex, the walls 0.2-0.3 mm. thick, smooth, unmarked; spongy layer initially thick.

TYPE. Sabah, Lahad Datu, V.J.R. Silam, 240 m., 12 Dec. 1966, SAN 57404 coll. *Sinanggol* (holotype, L; isotypes, K, SAN).

DISTRIBUTION. Borneo (southeastern Sabah), local (MAP 48).

ADDITIONAL SPECIMENS SEEN. Borneo, SABAH. Lahad Datu: Pulau Sakar, 60 m., SAN 21612 (K, KEP, L, SAN), 75 m., SAN 21613 (K, KEP, L, SAN, SAR, SING), 6 m., SAN 21622 (A, K, KEP, L, SAN, SAR, SING), SAN 24569 (K, KEP, L, SAN, SING), 36 m., SAN 26993 (A, K, KEP, L, SAN, SAR, SING); Silam, ca. 36 m., SAN 29384 (K, KEP, L, SAN, SAR, SING); Mile 1, Silam Road, 90 m., SAN 47686 (A, K, L, SAN); Mile 13, base of Mt. Silam, 75 m., SAN 73422 (SAN).

ECOLOGY. Well-drained ridges or slopes, once in soil derived from ultramafic rock (SAN 21612); 6-240 m. alt. Flowering December, and February to April; submature fruit in April.

Calophyllum sakarium can be readily distinguished by its obovate leaf blades that are rounded at the apices; its steeply ascending, rather distant venation that appears to be twice as dense on the upper surface of the blade as on the lower; its terminal inflorescences; and its small, ellipsoid fruits. The specific epithet is taken from the name of an island, Pulau Sakar, where this species has been collected.

There is considerable variation in internode length along both vegetative and inflorescences axes. Although the terminal two pairs of leaves are never pseudovercillate, as in *Calophyllum obliquinervium*, the uppermost internode may be less than half the length of the penultimate one. In addition, there is a tendency for the first internode of the axillary innovations to be notably longer than the rest. However, the basal internode of terminal inflorescences varies greatly in length and is frequently much shorter than subsequent ones.

The relationships of *Calophyllum sakarium* are obscure. Although both *C. ardens* and *C. obliquinervium* have medium-sized leaves with steeply ascending venation, and *C. obliquinervium* has terminal inflorescences, the two species are readily distinguished by the characters given above. In addition, both species have denser venation (apparently equally dense on both surfaces of the lamina); *C. obliquinervium* has leaf blades that are usually acuminate at the apices; and *C. ardens* has much larger fruit. An anatomical feature that readily distinguishes *C. sakarium* is the presence of a large latex canal replacing most of the vascular tissue in alternate vascular bundles; each

normal vascular bundle is separated by three latex canals. This feature has not been observed in any other species.

Calophyllum sakarium is possibly closer to *C. pentapetalum*, which also often has terminal inflorescences and small fruits. However, the latter species has an often smaller lamina that is rarely obovate in shape, denser venation (the same density on both surfaces), and hairs that are usually strongly papillate or even branched at the base.

162. *Calophyllum ardens* P. F. Stevens, sp. nov.

FIGURE 42, a-c.

C. obliquinervium auct., non Merr.; J. Anderson, Gard. Bull. Singapore 20: 154. 1963, *pro majore parte*; Pukul & Ashton, Checklist Brunei Trees, 83. 1964, *pro parte*; Smythies, Common Sarawak Trees, 61. pl. 21. 1965. *Calophyllum* sp. nov. J. Anderson, Trees Peat Swamp Forest Sarawak, 86. pl. 27c. 1972.

A speciebus aliis *Calophylli* in foliis patentibus, lamina elliptica valde coriacea margine plana nervis lateralibus sub angulo 25-35° e costa abeuntibus, et fructu magno circa 3 cm. longo putamine parietibus circa 1.2 mm. crassis, differt.

Tree 15-30 m. tall, d.b.h. to 45 cm.; trunk without buttresses, numerous knee roots present; outer bark ochraceous, smooth, hard, with thin, curved scales; inner bark reddish brown, lamellate, or in transverse section bright yellow with dark brown lamellae; latex bright yellow, opaque, or brown, very viscous.

Twigs flattened, 2.5-3 mm. across, not angled or obscurely so, drying brown to blackish, glabrous at maturity; axillary innovations lacking basal scars, such scars perhaps present in young plants; internodes 1.5-4.5 cm. long; uppermost pair of axillary buds rounded, to 1 mm. long, spreading; terminal bud plump, 4.5-6 mm. long, with crustaceous, brown indumentum (hairs, FIGURE 41, aa), underdeveloped internode absent. Petiole 2-2.8 cm. long, broadly concave above, convex below, glabrous; lamina elliptic or cuneiform to obovate, 4.5-8.5(-10.7) by 1.7-4.6 cm., retuse or rounded to acute at apex, narrowly cuneate at base, quite flat at margin, very coriaceous, drying honey above and sabelline below, glabrous, midrib above narrowing gradually from base, flat to slightly depressed, surrounding lamina obscurely raised, (0.25-)0.4-0.6 mm. wide at midpoint, disappearing ca. 1.2 cm. below apex, below \pm flat, not conspicuous, the venation inconspicuous on both surfaces, slightly raised, 5 to 10 veins/5 mm., angle of divergence 25-35°. Inflorescences from foliate axils, with scars of 7 to 14 flowers, sometimes with 3-flowered branches to 1.6 cm. long, the axis 3.5-6 cm. long, glabrous, lowest internode 0.7-2 cm. long; bracts unknown; pedicels in fruit (0.2-)1.5-2 cm. long, glabrous. Flower not known. Fruit ellipsoid, 2.7-3 by 2-2.2 cm., subrounded at apex, drying brown, inconspicuously striate; outer layer detaching cleanly from stone, ca. 0.8 mm. thick, compact, hard; stone ellipsoid, ca. 2.6 by 1.95 cm., obtuse at apex, the walls ca. 1.2 mm. thick, smooth, unmarked, paler area ca. 6 mm. across at base; spongy layer thin.

TYPE: Brunei, Tutong, Bukit Pasir Puteh, 1.5 m., 25 July 1957, *BRUN* 297 coll. *Ashton* (holotype, L; isotypes, BO, BRI, KEP, SAR, SING).

DISTRIBUTION. Northern and western Borneo, scattered (MAP 48).

ADDITIONAL SPECIMENS SEEN. **Borneo.** SARAWAK. 3rd Division: Loba Kabang South Protected Forest, S 659 coll. *Anderson*, 12 Jan. 1954 (KEP, SAR, SING), KEP 79327 (A (frag.), KEP). BRUNEI: Telamba, KEP 37081 (KEP); Badas, KEP 48498 (KEP). KALIMANTAN. Barat: Kenepai, *Teysmann*, HB 8050 (BO); Sambas, Paloh, 5 m., bb 13885 (BO).

ECOLOGY. Low-altitude peat swamps; rare in alan forest (*Shorea albida*-*Gonostylus*-*Stemonurus* association), more common in *Shorea albida*-dominated forest, locally abundant in *Shorea albida*-*Litsea*-*Parastemon* association (*Anderson*, 1963, *op. cit.*); below 5 m. alt. Fruiting in July.

LOCAL NAME AND USE. An Iban name, "kayu api," means "firewood." "The yellow exudate of the tree is richly secreted into the outer bark, imparting to it its color, and the flakes infused with dry sap ignite easily, burning with a smoky yellow flame. Hence its use in firelighting" (*BRUN* 297).

Calophyllum ardens is a very distinctive species, immediately recognizable even when sterile by its spreading leaves and by its very coriaceous leaf blades that dry quite flat and have steeply ascending venation. The epithet *ardens* ("burning") is appropriate since the bark is used to start fires.

Although both *Calophyllum ardens* and *C. obliquinervium* have been collected at Bukit Pasir Puteh in Brunei (the latter as *BRUN* 5020) and have been much confused in the literature, they are easily separable. The leaf blades of *C. obliquinervium* have steeply ascending veins similar to those of *C. ardens*, but they are less coriaceous, and the leaves themselves are more or less ascending on the twigs. *Calophyllum obliquinervium* has terminal, not axillary, inflorescences; its fruits are about one-third the size of those of *C. ardens* and have a thin-walled stone. *Calophyllum ardens* is a characteristic tree of peat swamps, but *C. obliquinervium* is very rare there; references to the latter occurring in peat swamps (e.g., Whitmore, 1975, p. 153) usually refer to *C. ardens*. There are anatomical differences, the most obvious being the thickness of the cuticle/epidermal cell wall complex; 25-35 μ m. on both leaf surfaces in *C. ardens*, and less than 10 μ m. in *C. obliquinervium*.

The leaves from apparently young plants are narrowly elliptic and measure up to 12.5 by 2 cm. Axillary innovations in such specimens appear to have basal scars. (*Teysmann*, HB 8050.)

163. *Calophyllum* sp.

FIGURE 40, m-o.

Tree 4.5-25 meters tall, d.b.h. to 48 cm.; outer bark shallowly fissured and flaked.

Twigs flattened, 1.8-2.5 mm. across, 4-angled, drying dark brown, transiently subfarinose; axillary innovations lacking basal scars; internodes (0.5-)1.2-3.5 cm. long; uppermost pair of axillary buds \pm rounded, ca. 1 mm. long, spreading; terminal bud plump to conical, 3-4.5 mm. long, with grayish brown, subcrusta-

ceous indumentum (hairs, FIGURE 43, v-x), underdeveloped internode to 3(-7) mm. long. Petiole 0.8-1.3 cm. long, deeply concave above, convex below, glabrous; lamina elliptic to suboblong, 4.8-12.5 by 1.8-4 cm., acute to subacuminate at apex, acute to attenuate at base, undulate and slightly recurved at margin, coriaceous, drying hazel to olive above and fulvous below, sparsely farinose-puberulent on midrib below when young, the midrib above narrowing gradually from base, raised, 0.12-0.2 mm. wide at midpoint, below raised, \pm angled to substriate, the venation subapparent above and below, raised, latex canals sometimes subimpressed on both surfaces, 6 to 11 veins/5 mm., angle of divergence 70-80°. Infructescences from foliate axils, with scars of 7 to 11 flowers, unbranched, the axis 2-4.7 cm. long, glabrous, lowest internode (0.2-)0.4-1.2 cm. long; bracts unknown; pedicels 0.7-1.8 by 1.2-1.5 mm., glabrous. Flower unknown. Fruit spherical, ca. 1.2 by 1.2 cm., apiculate or not, drying kaiser brown, sharply wrinkled; outer layer detaching cleanly from stone, 1.3-2 mm. thick, compact; stone subspherical, ca. 10 by 9 mm., rounded at apex, the walls ca. 0.15 mm. thick, smooth, unmarked; spongy layer thick at first.

DISTRIBUTION. Northeastern Sarawak, (?)Brunei (MAP 48).

SPECIMENS SEEN. **Borneo**, SARAWAK. 3rd Division: Balleh, Ulu Mujong, Temiai/Temalad watershed, 1100 m., *S* 13399 (A, K, KEP, SAN, SAR, SING); Carapa Pila, Ulu Mujong, Balleh, 900 m., *SAN* 19958 (A, BO, K, KEP, SAN, SAR, SING); Ulu Pila/Mujong watershed, 850 m., *S* 19612 (A, K, KEP, SAN, SAR, SING); Kapit, Melinau, Bukit Mabong area, 1006 m., *S* 25796 (SAR). **BRUNEI**: G. Pagon Periok, 1500 m., *BRUN* 1372 (?) (SAR). *Sine loco*: *S* 10634 (SAR).

ECOLOGY. Locally common in lower montane forest on basalt or dacite, 900-1500 m. alt. Fruiting in April; fruit green.

Calophyllum sp. 163 can be recognized by its short, subconoid terminal bud often with an obvious underdeveloped internode; its inconspicuous indumentum; its more or less elliptic leaf blades that dry bicolored (hazel to olivaceous above, fulvous below); and its spherical, wrinkled fruit with a compact outer layer 1.3-2 mm. thick.

Because of the way it dries, *Calophyllum* sp. 163 is superficially similar to some members of the *C. blancoi* complex, but its short terminal bud and unbranched hairs readily distinguish it. *Calophyllum incumbens* also tends to dry a similar color to *Calophyllum* sp. 163, but that species has a different terminal bud and fruit (cf. FIGURES 40, m-o, and 32, a, b). *Calophyllum tetrapterum* var. *obovale* may have a terminal bud somewhat similar to that of *Calophyllum* sp. 163, but its obovate leaves have an obvious thickened margin, and the fruits are usually smaller and have a much thinner outer layer.

BRUN 1372 possibly does not belong here; it is a sterile specimen, and the terminal bud does not have an obvious underdeveloped internode. On the sheet of *S* 10634 at Kuching the number and other data are in Brunig's handwriting, but the adjacent numbers were collected by Smythies on Mt. Kinabalu, Sabah.

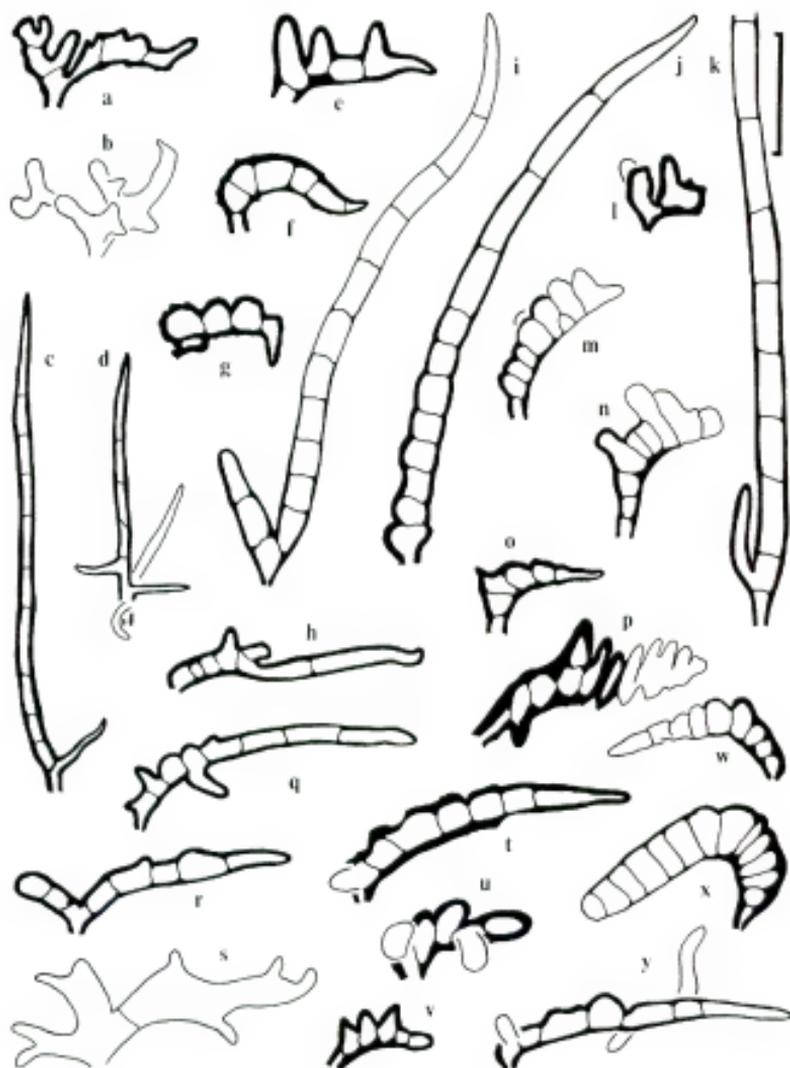


FIGURE 43. Hairs (from terminal bud, unless otherwise noted). a, b, *Calophyllum piluliferum* (LAE 51772). c, d, *C. acutiputamen* (Brass 28325). e-h, *C. leptocladum*: e, f, A. C. Smith 7874; g, h, FDA 142. i, j, *Calophyllum* sp. 151 (Stevens et al. 112). k, *C. gracillimum* (SFN 28998), base of hair ca. 600 μ m. long. l, *C. aureo-brunnescens* (Ridley 16015). m-o, *C. griseum*: m, o, S 24648; n, S 15872. p, *C. aureum* (Chew 860). q-s, y, *C. whitfordii*: q, r, y, Williams 639, large hairs; s, PNH 39394, from inflorescence axis. t, u, *C. rigidulum* (BS 45686). v-x, *Calophyllum* sp. 163: v, w, S 19612; x, S 13999. Scale = 60 μ m. (in c, d, scale = 120 μ m.).

164. *Calophyllum* sp.

Tree ca. 10.5 meters tall, d.b.h. ca. 28 cm.; trunk and bark unknown.

Twigs flattened, 1–1.3 mm. across, 4-angled, drying brown, farinose when young; axillary innovations lacking basal scars; internodes 0.5–3 cm. long; uppermost pair of axillary buds rounded, ca. 0.5 mm. long, spreading; terminal bud plump to narrowly conical, 1.3–2 mm. long, with subcrustose to subpuberulent, brown indumentum, underdeveloped internode 1–6 mm. long. Petiole 4–6.5 mm. long, deeply concave above, convex below, glabrous; lamina elliptic, 4.1–6.7 by 1.3–2.7 cm., acuminate at apex, cuneate at base, slightly undulate and barely recurved at margin, thinly coriaceous, drying ± sabelline above and below, glabrous when mature, the midrib above gradually narrowed from base, raised, strongly sulcate at first, ca. 0.2 mm. wide at midpoint, below raised, rather inconspicuous, obscurely angled, the venation apparent above, subobscure below, raised, 13 to 18 veins/5 mm., angle of divergence 65–70°. Inflorescences from foliate axils, with 5 to 7 flowers, unbranched, the axis 0.3–1.2 cm. long, glabrous, lowest internode 1.5–7 mm. long; bracts unknown; pedicels 7–8 mm. long, glabrous. Flower (?) hermaphroditic; tepals 8, glabrous, the outer pair suborbicular to broadly ovate, 4–4.5 mm. long and across, only slightly concave, inner ones obovate, 6–7 by 2.5–3.5 mm.; stamens ca. 230, the filaments to 5 mm. long, the anthers elliptic, 0.25–0.3 mm. long, subapiculate to subretuse at apex; ovary ca. 1 mm. long, the style ca. 3.7 mm. long, the stigma peltate, ca. 0.7 mm. across, (?) radiate. Immature fruit ovoid, 7 mm. by 4 mm., apiculate.

DISTRIBUTION. Sarawak (MAP 47); known only from a single specimen.

SPECIMEN SEEN. Borneo. SARAWAK. 3rd Division: Anap, Bukit Mersing, 800 m., S 22125 (K, SAR).

ECOLOGY. Mixed dipterocarp forest on basalt hillside, ca. 800 m. alt. Flowering in September.

Calophyllum sp. 164 can be recognized by its small, slender terminal bud, which may be nonfunctional, and its almost equally long and slender underdeveloped internode. Its elliptic leaves have fairly dense venation more prominent above than below, and its flowers have very small anthers.

165. *Calophyllum gracilipes* Merr. Philip. Jour. Sci. C. 5: 197. 1910, Enum. Philip. Fl. Pl. 3: 79. 1923. TYPE: Philippine Islands, Mindanao, Zamboanga Province, Port Banga, 600 m., 3 Feb. 1908, FB 9405 coll. Whitford & Hutchinson (isotypes, K, LY, US).

C. tetragonum Merr. Univ. Calif. Publ. Bot. 15: 199. 1929; Masamune, Enum. Phanerog. Born. 476. 1942; Keith, N. Borneo Forest Rec. ed. 2. 2: 315. 1952 ("C. sp. cf. *tetragonum*"); Meijer, Bot. Bull. Herb. Forest Dept. Sabah 7: 15. 1967. TYPE: Borneo [Sabah], near Sandakan, Sapajaya River, 10 m., 21 March 1923, D. D. Wood 1312 (holotype, UC; isotypes, A, BO).

C. tetragonum Merr. var. *parvifolium* Merr. Univ. Calif. Publ. Bot. 15: 199. 1929; Masamune, Enum. Phanerog. Born. 476. 1942. TYPE: Borneo

[Sabah], Elphinstone Province, Tawao, *Elmer 21577* (lectotype, UC; isolectotypes, A, BISH, BM, C, F, G, GH, K, M, MO, NY, P, SING, U).

C. cuspidatum Ridley, *Kew Bull.* 1938: 119. 1938; Masamune, *Enum. Phanerog. Born.* 475. 1942. TYPE: Sarawak [4th Division], Baram, March 1895, *Hose 37* (holotype, K; isotypes, BM, L).

C. pulcherrimum auct., non Wall. ex Choisy; Merr. *Bibl. Enum. Born. Pl.* 393. 1921; Masamune, *Enum. Phanerog. Born.* 476. 1942.

Tree (rarely shrub), 3.7–24 meters tall, d.b.h. to 30(?–60) cm.; trunk without buttresses (rarely with short, spreading spurs); outer bark yellowish or orange-brown (brown), smooth or finely cracking and scaling, hoop marked or not, the inner surface bright orange (rarely blackish or reddish (in Sabah)); under bark red; inner bark red to pale red; latex whitish- or grayish-brown to lemon yellow, not very sticky (rarely clear yellow, sticky).

Twigs somewhat flattened, 0.6–2.5 mm. across, strongly 4-angled when young, soon becoming rounded (rounded), often with obscure horizontal lines at nodes, drying yellowish, greenish, or brown, glabrous or transiently farinose to puberulent; axillary innovations lacking basal scars; internodes 0.5–4 cm. long; uppermost pair of axillary buds rounded to pointed, to 1 mm. long, erect to spreading, often inconspicuous; terminal bud narrowly conical, 1–6 mm. long, with brownish, crustaceous to adpressed (short-tomentose) indumentum (hairs, FIGURE 41, p–r, bb, cc), underdeveloped internode to 1 mm. long. Petiole (0.2–)0.35–1.4(–2.4) cm. long, deeply concave above, convex beneath, usually glabrous; lamina narrowly elliptic or elliptic to ovate (subobovate), (2.5–)4–14(–16) by (0.75–)1.3–5.4(–6.2) cm., acuminate to long-acuminate at apex, narrowly to broadly cuneate (rarely acute) at base, strongly and closely undulate and narrowly recurved at margin, thinly coriaceous, drying umber to sepia above and fulvous to grayish below, midrib often yellowish, glabrous or shortly and subpersistently brown-pubescent on midrib below, the midrib above narrowing gradually from base, raised, center often \pm sulcate, 0.15–0.3 mm. wide at midpoint, below raised to almost flat, rounded to striate, the venation subapparent above and obscure to subapparent below, raised, latex canals below raised or depressed (additional obliquely ascending latex canals near base), 6 to 12 veins/5 mm., angle of divergence 50–70(–75)°. Inflorescences from foliate axils (sometimes 2 together), with 3 (to 9) flowers, unbranched, the axis 0.5–3(–5) cm. long, farinose to subtomentose near base, lowest internode 0.3–1 cm. long; bracts not seen, apparently caducous; pedicels 0.5–1.5 cm. long, glabrous, in fruit to 4.3 cm. by 1.5 mm. Flower (?)hermaphroditic; tepals (?4 to) 8 (to 10), glabrous or almost so, the outer pair ovate, 4.5–5.5 by 3–4.3 mm., the inner ones oblong, elliptic, or obovate, 6.5–8 by 3.5–6 mm.; stamens 60 to 110, the filaments to 5.5 mm. long, connate for up to 0.75 mm., the anthers suboblong, 0.4–0.9(–1.2) mm. long, shallowly retuse at apex; ovary 1.3–2 mm. long, the style 4.5–6 mm. long, the stigma subpeltate, apparently asymmetrical, 0.5–0.8 mm. across. Fruit subspherical, 1.3–2 cm. by 1.2–2 cm., apiculate or not, furfuraceous, drying \pm brown, broadly wrinkled; outer layer detaching cleanly from stone, 0.6–1.5 mm. thick, air spaces developing under skin and next to stone, otherwise compact; stone subovoid to ellipsoid, 1–1.4 by 0.8–1.15 cm., rounded to

apiculate at apex, the walls less than 0.2 mm. thick, smooth, unmarked; spongy layer thin.

DISTRIBUTION. Borneo and Mindanao (MAP 46).

SELECTED SPECIMENS SEEN (for explanation of letters, see text). **Borneo.** SARAWAK. 1st Division: G. Gading, 640 m., *S* 34645 (A, SAN, SAR); G. Buri, 75 m., *S* 36700 (SAR); Sabal Tapang, 175 m., *Stevens et al.* 179 (A); G. Matang, 610 m., *Stevens et al.* 270 (A). 3rd Division: Kapit, Bukit Raya, 600 m., *S* 23910 (A, BO, K, SAR, SING); Kapit, Balleh, Sungei Mengiong, *S* 29682 (A, E, K, SAR, SING); Bukit Goran, 420 m., *S* 36259 (SAR); Bukit Bukar, near Takalit, Katibas, 740 m., *S* 36398 (SAR). 4th Division: Ulu Mayeng, Kakus, 60 m., *S* 21841 (y) (A, BO, KEP, P, SAN, SAR, SING); Bukit Mersing, Anap, 150 m., *S* 21903 (y) (A, K, KEP, SAN, SAR, SING). 5th Division: Limbang, Ulu Medamit, 305 m., *S* 32327 (BO, K, SAN, SAR, SING). BRUNEI: Labi Hills, F.R., *KEP* 48124 (KEP). SABAH. Sipitang: Mensapol, *SAN* 65998 (L, SAN). Kota Kinabalu: Gaya Is. below trig., Jesselton side, 60 m., *SAN* 33559 (K, KEP, SAN, SAR, SING). Kota Belud: Bukit Matindok, 12.6 km. from Kota Belud, 310 m., *SAN* 32182 (L, SAN, SAR); Mt. Templer F.R., SW. of Sungei Talupit, 457 m., *SAN* 76245 (K, SAN, SAR). Tenom: G. Lumaku F.R., W. of Sapong Est, *SAN* 43154 (K, KEP, L, SAN, SAR, SING); Pangi, 8 km. WNW. of Tenom, 579 m., *SAN* 15115 (A, BO, KEP, SAN, SING); Mile 79, Pangi, 150 m., *SAN* 50471 (SAN). Ranau: Mt. Kinabalu, E. shoulder, 762 m., *RSNB* 209 (A, B, BO, CANB, K, L, SAN, SING); Lohan, 1372 m., *SAN* 44653 (K, L, SAN, SAR, SING); half way between Tambunan and Keninguan, 732 m., *KEP* 80422 (KEP); along Mamut road, E. of Mamut camp, 900-1400 m., *Kokawa & Hotta* 5943 (SAN). Labuk & Sugut: Telupid, S. of Agricultural Station, 60 m., *SAN* 53625 (SAN); Ulu Sungei Segualid Lokan F.R., mile 41 Labuk Road, *SAN* 72628 (K, SAN). Sandakan: Sepilok F.R., 10 m., *SAN* 16206 (A, KEP, SING); Sekong Kechil, Sepagaya, Sandakan Bay, 27 m., *SAN* 38239 (K, L, SAN, SAR, SING); Talong Tingod, Lagsikan F.R., 90 m., *A* 3409 (K, KEP, L, SING); Dusun, 60 m., *SAN* 77366 (SAN). Kinabatangan: Lamag, Bukit Garam, 36 m., *SAN* 36563 (K, L, SAN, SING); Sungei Pin V.J.R., *SAN* 52041 (SAN). Lahad Datu: Bukit Pintasan, Ulu Segama, *SAN* 79109 (SAN); near Kuala Sungei Beruang, *SAN* 71040 (SAN); Mostyn, Madai F.R., 45 m., *SAN* 67748 (SAN). Tawau: near Tawau, *Elmer* 21121 (A, BISH, BM, BO, C, F, G, GH, K, M, MO, NY, P, SING, U, UC, US); Kelumpang, Balong, 30 m., *SAN* 17342 (K, KEP, L, SAN, SAR, SING); Gemok Hill, 180 m., *SAN* 39219 (K, L, SAN); Ulu Sungei Apas, *SAN* 32955 (K, L, SAN); Membalu F.R., 60 m., *SAN* 22770 (A, BO, K, KEP, SAN, SAR, SING); [Sungei] Umas-Umas, 6 m., *SAN* 4575 (K, SING). KALIMANTAN. TIMUR: Kabiran, Sungei Bengaloen, 100 m., *bb* 11657 (BO). BARAT: Liang Gagang, *Hallier* 2992 (?) (A, BO, K, L); Sekadau, Pait, 250 m., *bb* 8029 (y) (BO), Tamang, 50 m., *bb* 8027 (y) (BO). **Philippines.** MINDANAO. Zamboanga: Sax R., *Williams* 2193 (GH, K, NY, US).

ECOLOGY. Mixed dipterocarp forest, to 1372 m. alt. Flowering February (Philippines), March, and July to September (flower really stamens?) sometimes yellowish or greenish; fruiting January, February, and May to November (fruit yellow to olive or brownish).

GERMINATION AND YOUNG PLANT. The radicle breaks the stone just to one side of the base. The seedling has two pairs of leaves separated by an internode to ca. 5 mm. long. Subsequently produced internodes are a little longer;

the terminal bud is functional; the stem is initially arched and only later straightens. (*Stevens et al.* 159, 179A, 360.)

Calophyllum gracilipes can be recognized by its thinly coriaceous leaf blades that are more or less undulate but slightly recurved at the margin, its few-flowered inflorescences, and its subspherical, furfureaceous fruits. The epithet *gracilipes* ("slender foot") was chosen because of the distinctive long, slender pedicels.

Calophyllum gracilipes is closely related to *C. aurantiacum* and *C. recurvatum*; for differences that separate *C. gracilipes* from these species, see *C. aurantiacum* and *C. recurvatum*.

Calophyllum gracilipes has been confused with *C. tetrapterum* var. *tetrapterum*, but the two are not closely related. In *C. tetrapterum* var. *tetrapterum* the lamina is a darker color when dry, and the margin is less prominently undulate. The flowers of the two species are similar, although *C. tetrapterum* var. *tetrapterum* has more profuse inflorescences. In fruit the two are quite different: the fruits of *C. tetrapterum* var. *tetrapterum* are about half the size of those of *C. gracilipes*, they lack a furfureaceous surface, and they have a thinner outer layer.

There is a considerable amount of vegetative variation within *Calophyllum gracilipes*, and field work is needed to understand it; ecological collections of P. S. Ashton suggest that on Bukit Raya there are two forms of this species. Specimens in the list above that are denoted by "y" have a fairly large lamina (toward the upper limits of the measurements given), the midrib on the lower surface is rather strongly raised and yellowish in color, and the veins appear to be dense because of the prominence of the latex canals. However, these characters vary individually between other specimens.

The indumentum on the terminal bud is quite variable in its development: although normally subcrustaceous to very short-tomentose, it is sometimes tomentose (e.g., S 36700, *Stevens et al.* 159; see also *Calophyllum recurvatum*).

The specimens of *Calophyllum gracilipes* from Brunei and the 3rd Division of Sarawak have slender twigs 0.6–1 mm. across, petioles 2–5 mm. long, and narrowly ovate to elliptic leaf blades 2.7–6.6 by 0.75–2(–2.7) cm. that are long-acuminate at the apex. These specimens include the type of *C. cuspidatum*, but they cannot be clearly distinguished from other specimens with larger leaves and a coarser facies.

Hallier 2992 is included only with hesitation. It has leaf blades that are rounded at the base and flowers with only four tepals. Another noteworthy specimen is SAN 33559, which has very small leaves less than 3.5 cm. long; this merely represents the lowermost extreme of great variation in leaf size within *Calophyllum gracilipes*.

The specimens determined by E. D. Merrill as *Calophyllum gracilipes* and *C. tetragonum* are very similar; in his description of the latter species, Merrill noted that its alliance was clearly with *C. gracilipes*. When described, *C. tetragonum* var. *parvifolium* was distinguished from var. *tetragonum* by small differences in leaf size; it is clear from the preceding discussion that it is impossible to recognize variants in *C. gracilipes* based on leaf size. *Calophyllum*

tetragonum var. *parvifolium* has been lectotypified on the sheet of *Elmer 21577* at UC. *Elmer 21577* and the syntype, *Elmer 21751*, are almost identical; they both agree with the protolog and have been widely distributed.

166. *Calophyllum recurvatum* P. F. Stevens, sp. nov. FIGURE 44, a, b.

A *Calophyllo gracilipes*, quo aliter simile est, in gemma terminali indumento tomentosum praedita, ramulis subulatis, ramulis, foliis, floribus et fructibus grandioribus, et lamina margine valde recurvato pagina inferiore venulis lateralibus haud conspicuis, differt.

Tree 3-20 meters tall, d.b.h. to 23 cm.; trunk without buttresses; outer bark reddish brown, brown-yellow, or grayish, sometimes mottled, with lines of lenticels, the inner surface bright orange to orange-red; under bark pale red to reddish; inner bark rose; latex yellow or clear yellow-brown, not viscous, or almost colorless and watery.

Twigs slightly flattened, 2.5-3.7 mm. across, strongly 4-angled to subulate, often with obscure horizontal lines at nodes, drying brown, glabrous or sparsely tomentose when young; axillary innovations lacking basal scars; internodes 1.5-7 cm. long; uppermost pair of axillary buds rounded, ca. 1 mm. long, erect, inconspicuous; terminal bud broadly conical, 3-6.5 mm. long, with brown, tomentose indumentum (hairs, FIGURE 41, v, w), underdeveloped internode absent. Petiole 0.8-2.2 cm. long, narrowly concave above, convex below, sometimes transiently tomentose below; lamina elliptic to suboblong, (9-)12-24 by (2.6-)3.7-9.8 cm., gradually acuminate at apex, cuneate to acute at base, rather distantly undulate and strongly but narrowly recurved at margin, coriaceous, drying sepia to gray-olivaceous above and sepia to wood-brown below, glabrous or transiently tomentose on midrib below, the midrib above narrowing gradually from base, raised, 0.2-0.35 mm. wide at midpoint, below raised, angled, the venation apparent and slightly raised above, subobscure below, 5 to 9 veins/5 mm., angle of divergence 70-80°. Inflorescences from foliate axils, with 3 to 9 flowers, unbranched, flabellate, the axis (0.3-)2-6.2 cm. long, sparsely tomentose, at least at base, lowest internode 0.3-2(-4.3) cm. long (exceptionally terminal, with up to 13 flowers, branched, axis to 8.5 cm. long); bracts ovate to elliptic, 5-7 mm. long, deciduous; pedicels (0.5-)1-2.2 cm. long, glabrous, incrassate in fruit, to 3.5 mm. thick, flattened. Flower (?) hermaphroditic; tepals 8 to 12, the outer pair ovate, 5-9 by 5-7 mm., the next pair broadly elliptic, 11-12 by 8.5-9.5 mm., the inner ones narrowly elliptic to obovate, 10-12 mm. by 3.5-5 mm.; stamens ca. 125, the filaments up to 3.5 mm. long, \pm connate, the anthers oblong, 1.5-2.1 mm. long, rounded to subretuse at apex; ovary ca. 2.5 mm. long, the style 4-5.7 mm. long, the stigma asymmetric, ca. 1 mm. across. Fruit subspherical, ca. 2.3 by 2 cm., apiculate, furfuraceous, drying brown, broadly wrinkled; outer layer detaching cleanly from stone, ca. 0.7 mm. thick, large air spaces developing; stone spherical, ca. 1.3 by 1.3 cm., rounded at apex, the walls ca. 0.25 mm. thick, smooth, unmarked; spongy layer thin.

TYPE: Sarawak, 1st Division, Kuching District, 12th mile, Penrissen Road,

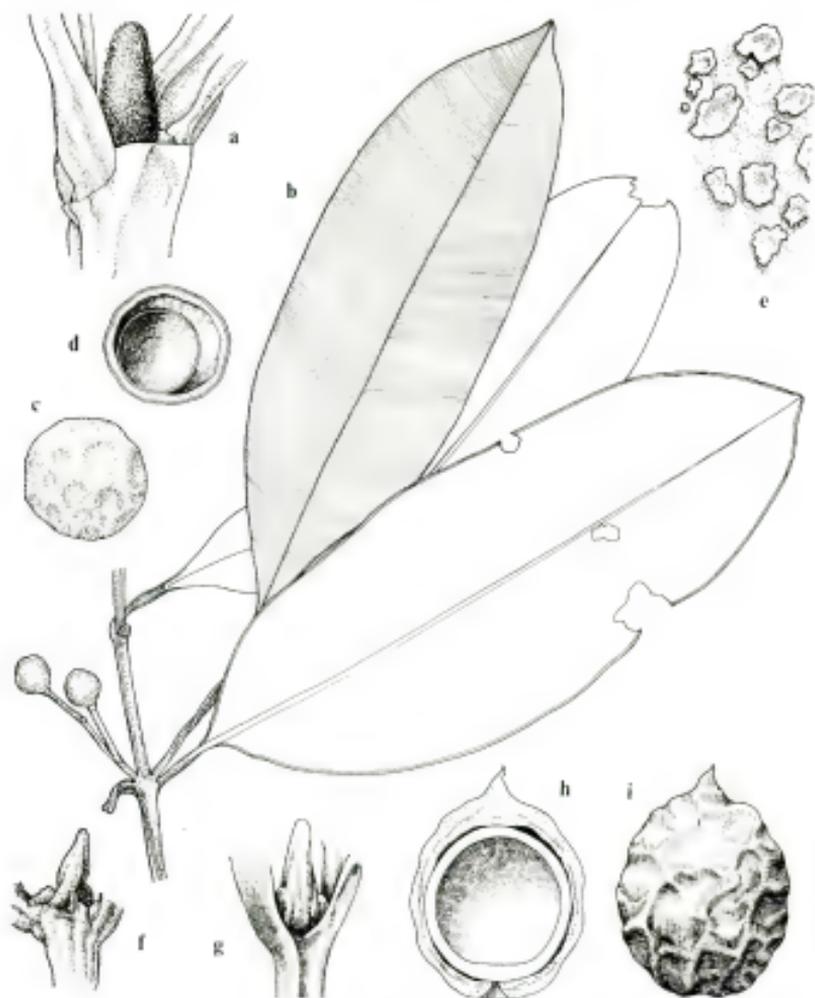


FIGURE 44. a, b, *Calophyllum recurvatum* (S 26205): a, terminal bud, $\times 3$; b, habit, $\times 0.5$. c-f, *C. aurantiacum* (Stevens et al. 195). c-e, fruit: c, from outside, $\times 1$; d, transverse section, $\times 1$; e, surface, $\times 25$. f, terminal bud, $\times 3$. g, *C. rigidulum* (BS 45686), terminal bud, $\times 6$. h, i, *Calophyllum* sp. 170 (Chevalier 38909), fruit, $\times 1$: h, longitudinal section; i, from outside.

19 Oct. 1966, S 26205 coll. ak Nudong & ak Bubong (holotype, a; isotypes, K, L, SAN, SAR).

DISTRIBUTION. BORNEO (MAP 47).

ADDITIONAL SPECIMENS SEEN. **Borneo and adjacent islands.** SARAWAK. 1st Division: Semengoh Arboretum, S 24338 (K, L, SAN, SAR, SING), S 25370 (K, KEP, L, SAN, SAR, SING), 90 m., S 7737 (BO, K, L, SAR, SING), *Stevens et al.* 143 (A); Lundu, Bukit Jebong, 60 m., *Stevens et al.* 212 (A), 90 m., *Stevens et al.* 218 (A), 120 m., S 15450 (BO, K, L, SAR); G. Gading, 686 m., S 35069 (SAR). Sine loco: *Native collector for Bur. Sci. Philip.* 641 (A, P, US), *Beccari, PB 2304* (FI). KALIMANTAN. Timur: Bukit Liang Karing, *Jaheri 1224* (BO); Lilibloelan Tepoetsy, *Jaheri 882* (BO). Barat: G. Sendjudjul, 80 m., *Hamzah 11* (BO).

ECOLOGY. Mixed dipterocarp forest, sometimes over limestone; 40-686 m. alt. Flowering August and September; fruiting September and December (fruit greenish yellow or pale green).

GERMINATION AND YOUNG PLANT. The radicle probably breaks through the stone to one side of the base. The seedling has two pairs of leaves separated by an internode less than 5 mm. long. Subsequent growth is slow, a young plant 22 cm. tall having 14 internodes in 12 cm., and although the terminal bud is functional, the stem is initially curved and straightens only after some time. (*Stevens et al.* 143.)

Calophyllum recurvatum can be recognized by its tomentose indumentum, subulate twigs, fairly large leaf blades with sharply recurved margins, flowers with eight to twelve tepals, and subspherical, furfuraceous fruits. The filaments are connate for much of their length; as a result, the androecium may remain on the old flower after the tepals have fallen—an unusual condition in the genus. The epithet *recurvatum* ("recurved") was chosen because of the sharply recurved edges of the leaf blades.

Although *Calophyllum recurvatum* is a distinct taxon, it is not easy to decide at what rank it should be recognized. The similarity between *C. recurvatum* and *C. gracilipes* extends to the young plant (in both, the main shoot is initially curved, only later straightening) and to their somewhat similar yellowish bark. Moreover, there are three specimens more or less intermediate between the two. S 36700 (Sarawak, 1st Division, G. Buri, 75 m.) has a densely tomentose terminal bud and a sparsely tomentose stem and inflorescence axis, an elliptic leaf blade the size of that of *C. gracilipes* (up to 9 by 2.8 cm.) that is subpruinose below, and rather large flowers. *Stevens et al.* 159 is a sterile specimen from Gunong Matang (1st Division) with the vegetative characters of S 36700. *Kostermans 6013* (Kalimantan, E. Kutei, Menubar R., NE. of Sangkulirang, 100-200 m.) has well-developed, tomentose indumentum, but in other vegetative characters (except its more or less oblong lamina) it is like *C. gracilipes*. Further collections from southwestern Sarawak and northwestern and northern Kalimantan are needed to enable a better understanding of the relationships between the two taxa.

167. *Calophyllum aurantiacum* P. F. Stevens, sp. nov.

FIGURE 44, c-f.

A *Calophyllum gracilipes* et *C. recurvatum*, quibus fructibus furfuraceis similibus habent, in ramulis mox demum teretibus, et folio parvo coriaceo costa supra leviter vel haud elevata et ante apicem evanescenti, differt.

Sprawling shrub or tree ca. 4.5 meters tall; trunk without buttresses; outer bark yellowish (small plants) or grayish and pale brown mottled, smooth, the inner surface bright orange; under bark bright orange; inner bark pale red; latex sparse.

Twigs flattened, 1.2–2.5 mm. across, slightly 4-angled or -striate, soon becoming rounded, drying brown, soon becoming dark brown or blackish, puberulent when young; axillary innovations lacking basal scars; internodes 0.4–3.5 cm. long; uppermost pair of axillary buds rounded, to 1 mm. long, erect; terminal bud plump or conical, 1.8–3 mm. long, with short, tomentose, brown indumentum (hairs, FIGURE 41, s, y), underdeveloped internode absent. Petiole 4–11 mm. long, deeply concave above, convex below, glabrous; lamina elliptic to obovate, (2.5–)3.4–6.5(–7.7) by (1.1–)1.8–3.5 cm., rounded to subretuse at apex, cuneate toward and shortly and abruptly rounded at base, slightly to broadly and distantly undulate and recurved at margin, coriaceous, drying fulvous to olivaceous above and fulvous below, glabrous, the midrib above gradually narrowed from base, not very evident, at first subdepressed, becoming elevated, 0.05–0.15 mm. wide at midpoint, disappearing 2–4 mm. before apex, below raised, \pm angled, the venation subevident (rarely obscure) on both surfaces, slightly raised, 5 to 9 veins/5 mm., angle of divergence 50–60°. Infructescences from foliate axils, with scars of 5 to 7 flowers, not branched, the axis 0.8–1.3 cm. long, sparsely puberulo-tomentose toward base, lowest internode (0.25–)0.6–1.1 cm. long; bracts unknown; pedicels in fruit 0.6–1.1 cm. by 1.5 mm., glabrous. Flower unknown; old tepal persisting at base of fruit obovate, ca. 5 mm. by 3.5 mm. Submature fruit subspherical, 1.2–1.6 by 1–1.6 cm., rounded at apex, furfuraceous, drying brown, smooth or broadly corrugated; outer layer detaching cleanly from stone, 0.7–1 mm. thick, subcompact; stone spherical, 0.9–1.3 by 0.8–1.2 cm., rounded at apex, the walls up to 0.2 mm. thick, smooth, unmarked; spongy layer at first well developed.

TYPE: Sarawak, 1st Division, Bau, Tai Ton, ca. 105 m., 12 December 1975, Stevens *et al.* 195 (holotype, A; isotypes, SAR and to be distributed).

DISTRIBUTION. Sarawak, local (MAP 48).

ADDITIONAL SPECIMEN SEEN. **Borneo.** SARAWAK. 1st Division: Bau, Tai Ton, Bukit Numpang, 165 m., S 22784 (SAR).

ECOLOGY. Small bush or tree of limestone hills, 105–165 m. alt. Submature fruit in December.

Calophyllum aurantiacum can be recognized by its more or less terete twigs; its short terminal bud; its small, elliptic to obovate, rather coriaceous leaf blades; and its furfuraceous fruits. The midrib on the upper surface of the lamina is at most slightly elevated and disappears short of the apex. The epithet *aurantiacum* ("orange") was suggested by the bright orange color of the inner surface of the outer and under bark.

Calophyllum aurantiacum is related to *C. gracilipes* and *C. recurvatum*, two species that also have furfuraceous fruits; in all three the venation on

the underside of the fresh leaf is practically invisible. *Calophyllum aurantiacum* can be distinguished from these other species by the characters given above.

The narrow but abrupt basal rounding of the lamina develops during the drying of the specimen—living leaves of *Calophyllum aurantiacum* are cuneate at the base.

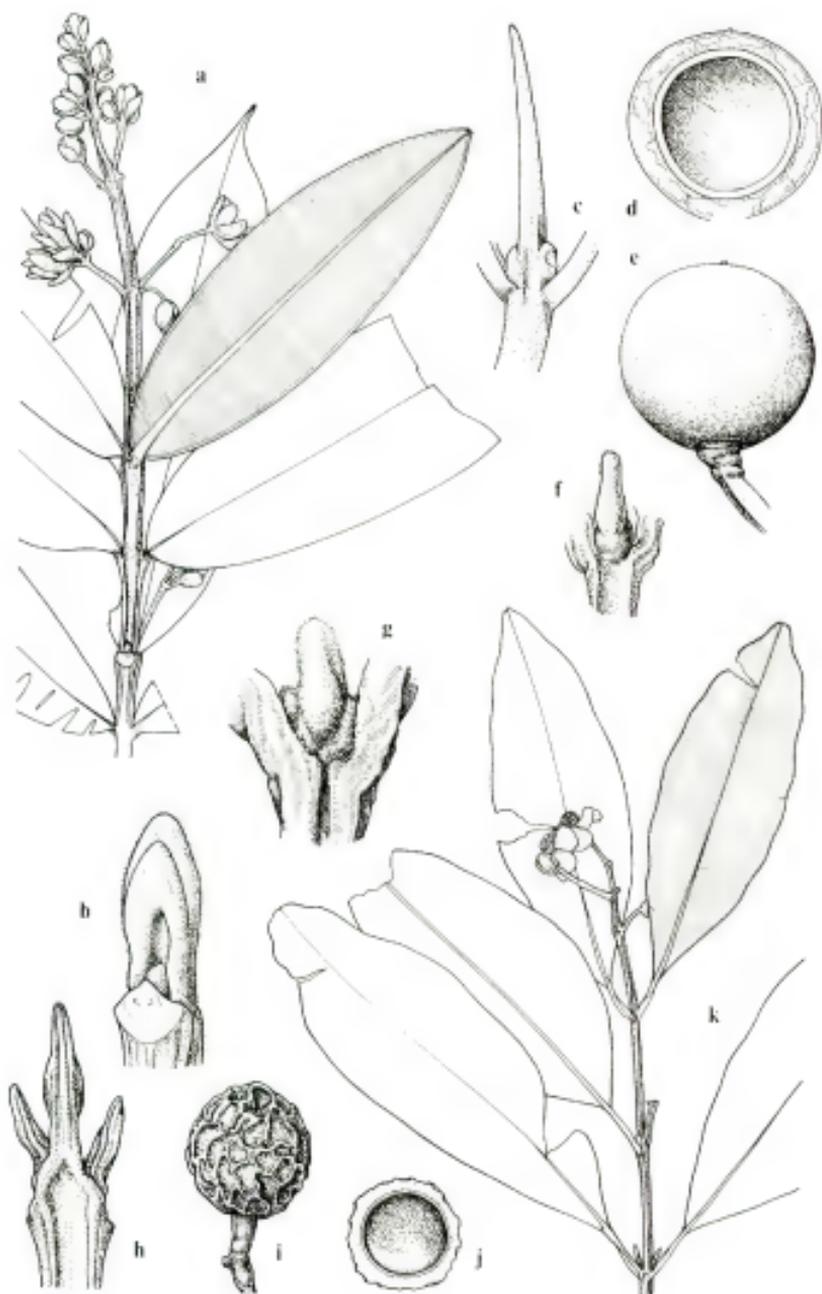
168. *Calophyllum griseum* P. F. Stevens, sp. nov.

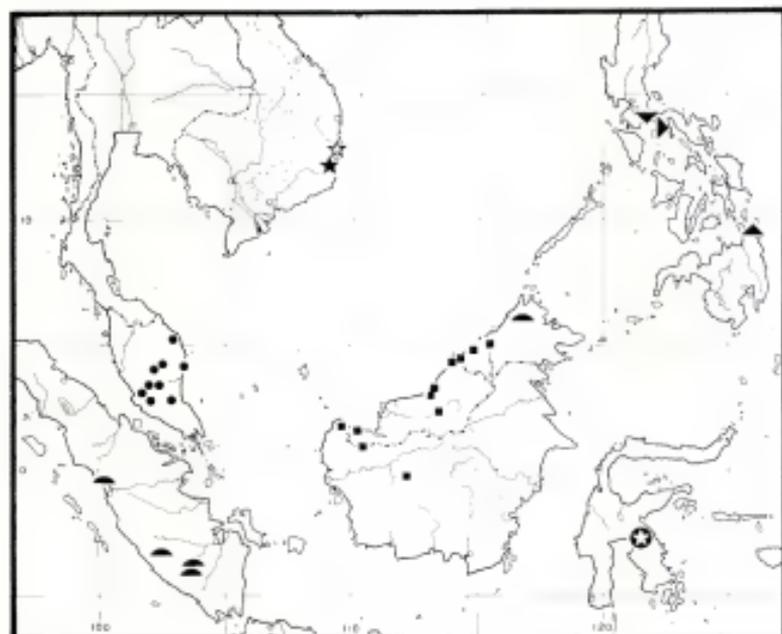
FIGURE 45, h-k.

A specibus aliis Calophylli in lamina mediocra coriacea in siccitate supra saepe cinerascenti venulis lateralibus manifestis, inflorescentia terminali indumento farinoso-puberulento praedita, et in fructu sphaerico in siccitate rugoso putamini parietibus minoribus quam 0.2 mm. crassis, differt.

Tree 12–30 meters tall, d.b.h. to 40 cm.; trunk without buttresses; outer bark grayish brown, scaly, with scales yellowish brown and newly exposed bark dark brown (pale citrine), or deeply (shallowly—*BRUN 670*) fissured, or cracked, inner surface bright orange; under bark brownish red or dark red; inner bark brownish red or pale reddish; latex yellow, clear (yellow-green—*BRUN 670*).

Twigs slightly flattened, 1.7–3(–3.5) mm. across, usually strongly 4-angled, drying brown to yellow, brown-farinoso at first; axillary innovations lacking basal scars; internodes 1.5–5.5 cm. long; uppermost pair of axillary buds \pm pointed, 2–3.5 mm. long, spreading; terminal bud plump, 4.5–7 mm. long, with grayish, subcrustaceous indumentum (hairs, FIGURE 43, m–o), underdeveloped internode absent to 4(–7) mm. long. Petiole 0.8–1.6 cm. long, broadly concave above, convex below, glabrous; lamina ovate or suboblong to elliptic, 8.5–16 by 3.5–6.2 cm., subrounded or acute to acuminate at apex, acute to cuneate at base, broadly and deeply to barely undulate and slightly recurved at margin, coriaceous, drying sepia to gray-olivaceous above and sepia to hazel below, glabrous at maturity, the midrib above narrowing fairly quickly near base, raised, 0.2–0.4 mm. wide at midpoint, below raised, angled toward apex, striate toward base, venation \pm apparent on both surfaces, raised, 4 to 8 veins/5 mm., angle of divergence 70–80(–85) $^\circ$. Inflorescences terminal and from adjacent foliate axils, with up to 20 flowers, branched, sometimes flabellate, the axis 2–4 (axillary inflorescences) or up to 9 (terminal inflorescences) cm. long, puberulent, lowest internode 1–2 cm. long; bracts unknown; pedicels 2.5–10 mm. long, puberulent, stout. Flower (?)hermaphroditic; tepals 8, the outer pair broadly ovate, 5–5.5 by ca. 4.5 mm., short-puberulent on back, the next pair subelliptic, 7.5–10 by 4–7.5 mm., sometimes puberulent toward base, inner ones oblong to elliptic, 7.5–11 by 2.5–5.5 mm.; stamens 190 to 265, the filaments to 7 mm. long, connate basally for up to 1.2 mm., the anthers oblong, 0.6–1 mm. long, apiculate to retuse at apex; ovary 1.3–2 mm. long, the style ca. 4 mm. long, the stigma peltate, ca. 0.9 mm. across, (?)4-radiate. Fruit spherical to ellipsoid, 1.7–2.2 by 1.2–1.7 cm., rounded at apex, drying dark brown; broadly wrinkled; outer layer detaching cleanly from stone, 1.7–3.2 mm. across, thick, subcompact, air spaces developing under skin; stone subspherical, 1.4–1.8 by 1–1.5 cm., rounded at apex, the walls less than 0.2 mm. thick, smooth, unmarked; spongy layer thin.





MAP 49. Distribution of *Calophyllum poilanei* (open star), *Calophyllum* sp. 170 (solid star), *C. subhorizontale* (circles), *C. exittcostatum* (half-circles), *C. griseum* (squares), *C. echinatum* (star in solid circle), *C. rigidulum* (inverted triangle), *Calophyllum* sp. 178 (side-facing triangle), and *C. brachyphyllum* (erect triangle) in Southeast Asia-Malesia.

TYPE: Sarawak, 4th Division, Bintulu, Nyabau catchment area, 100 feet [30 m.], 22 June 1966, S 24614 coll. *ak Luang* (holotype, α ; isotypes, κ , KEP , L , SAN , SAR , SING).

DISTRIBUTION. Northwestern Borneo (MAP 49).

ADDITIONAL SPECIMENS SEEN. **Borneo.** SARAWAK. 1st Division: Semengoh Arboretum, 40 m., *Stevens et al.* 131 (α); Lundu, Sungei Arok, S 9624 (no , κ , L , SAR , SING); G. Santubong, 90 m., *Stevens et al.* 302 (α). 3rd Division: Ulu Rejang, FA 515 coll. *Egon*, 4 Aug. 1938 (KLU , SAR). 4th Division: Miri,

FIGURE 45. a, b, *Calophyllum poilanei* (Poilane 6572): a, habit, $\times 0.5$; b, terminal bud, $\times 3$. c, *C. echinatum* (Cel./II-215), $\times 1.5$ (axillary buds knocked off). d-f, *C. exittcostatum* (bb 31756). d, e, fruit, $\times 3$: d, longitudinal section; e, from outside. f, terminal bud, $\times 6$. g, *Calophyllum* sp. 178 (FB 30772), terminal bud, $\times 3$. h-k, *C. griseum*. h, S 15872, terminal bud, $\times 3$. i, j, S 15872, fruit, $\times 1$: i, from outside; j, transverse section. k, S 25802, habit, $\times 0.5$.

near Sungei Dalau F.R., *KEP 80069* (KEP); Bintulu, Simalajau F.R., *S 15872* (A, BO, K, L, SAN, SAR, SING); Nyabau catchment area, 120 m., *S 24648* (A, K, KEP, L, NY, SAN, SAR). BRUNEI: Berakas F.R., 60 m., *S 2035* (?) (SAR); Anduki F.R., 3 m., *S 2243* (SAR); Labi Hills, Bukit Teraja, Mile 19 $\frac{1}{4}$, 150 m., *BRUN 670* (BO, BRI, K, KEP, L, SAR, SING); Labi, *KEP 30474* (A, KEP, SAR). SABAH. Beaufort: Lumat, *SAN 25802* (BO, K, KEP, L, SAN, SAR, SING). KALIMANTAN. Barat: Melawi Tjatit, B. Bansa, 400 m., *bb 26445* (BO, L); Melawi, B. Watas Emang nabij Ng. Betoeng, 175 m., *bb 26869* (?) (L).

ECOLOGY. Well-drained mixed dipterocarp forest, 3–400 m. alt. Flowering March, June, July, and September (flower scented); fruiting December, January, and August (fruit pale grayish brown).

GERMINATION AND YOUNG PLANT. Young plants about 1 meter tall are erect and have a functional terminal bud; the internodes are well developed. The young plants are conspicuous because of their pale, yellowish white bark.

Calophyllum griseum is a distinctive species. The upper surface of the lamina often has a grayish, waxy covering that is later rubbed off; this grayish covering suggested the specific epithet. The lamina is fairly coriaceous, with distinct and rather distant venation; the inflorescence is terminal and puberulent, and the pedicels and the backs of the outer tepals are also puberulent; the flower has eight tepals; and the broadly wrinkled fruits have a thick, subcompact outer layer and a thin-walled stone.

169. *Calophyllum subhorizontale* M. R. Henderson & Wyatt-Smith, Gard. Bull. Singapore **15**: 325, pl. 11. 1956; T. C. Whitmore, Tree Fl. Malaya **2**: 170. 1973. **TYPE:** Malaya, Pahang, Kuala Lipis, 500 feet [150 m.], *KEP 658* coll. Carroll (holotype, SING; isotype, KEP).

Tree 6–8 meters tall, d.b.h. to 29 cm.; outer bark ochre, smooth, to purplish or yellowish, fissured; inner bark reddish to white; latex yellow, sticky.

Twigs flattened, 3.5–7 mm. across, with (2 or) 4 (or 6) prominent rounded lines, drying shiny, brown when young (yellowish when older), at first puberulent; axillary innovations (?) lacking basal scars; internodes (0.5–)1–5 (–7.5) cm. long; uppermost pair of axillary buds rounded, ca. 1 mm. long, suberect; terminal bud plump to conical, 4–7 mm. long, with brown, short, tomentose indumentum (hairs, FIGURE 46, l, m), underdeveloped internode absent. Petiole 0.5–1.6 cm. long, broadly concave above, convex below, glabrous when mature; lamina elliptic to suboblong or obovate, 10.5–27 by 5.5–9 cm., obtuse to acute at apex, acute at base, distantly undulate and slightly recurved at margin, coriaceous, drying sepia above and amber to sabelline below, \pm puberulent on midrib below when young, the midrib above narrowing gradually from or rather quickly near base, raised, 0.3–0.7 mm. wide at midpoint, below raised, angled, the venation above \pm apparent, finely raised, below \pm apparent to subobscure, broadly raised, 3 to 6 veins/5 mm., angle of divergence 65–85°. Inflorescences from foliate axils, with 7 to 9 flowers, unbranched, the axis (1–)2–4 cm. long, sparsely tomentose near base, lowest internode (0.3–)1–1.7(–2.5) cm. long; bracts ovate, to 4 mm.

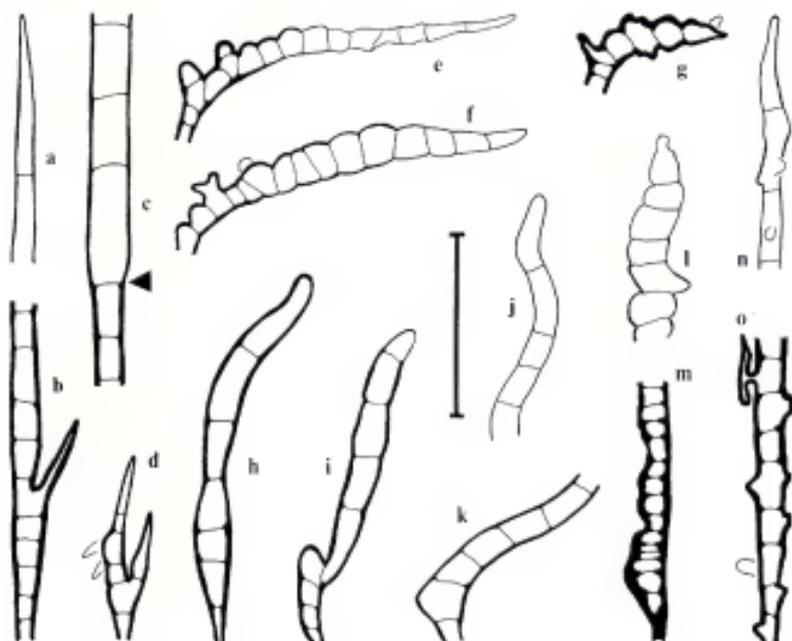


FIGURE 46. Hairs (from terminal bud, unless otherwise noted). a-d, *Calophyllum insularum*. a-c, bb 30965: a, b, apex and base of hair ca. 780 μ m. long; c, base of hair ca. 420 μ m. long, arrow marks abrupt transition in cell type. d, bb 30937. e-g, *C. exiticostatum*: e, g, bb 2299; f, Stevens et al. 559, slight birefringence. h, i, *C. membranaceum* (Wang 449). j, k, *C. poilanei* (Poilane 6572), apex and base of hair ca. 780 μ m. long. l, m, *C. subhorizontale* (KEP 94773), apex and base of hair ca. 720 μ m. long. n, o, *Calophyllum* sp. 170 (Chevalier 38909), apex and base of hair ca. 780 μ m. long. Scale = 120 μ m.

long, caducous; pedicels 1-3.5 cm. long, glabrous, in fruit to 4 cm. by 3 mm. Flower (?)hermaphroditic; tepals (8 to) 12, sometimes glabrous, the outer pair orbicular to broadly elliptic, 7-12 by 7-10 mm., the inner ones elliptic to oblong, 13-17 by 4.5-11 mm.; stamens (?)150 to 260, the filaments 4-7.5 mm. long, connate for up to 0.7 mm., the anthers oblong, 1-1.9 mm. long, rounded to slightly retuse at apex; ovary ca. 2 mm. long, the style ca. 7 mm. long, the stigma peltate-infundibular, ca. 1.7 mm. across, obscurely radiate. Fruit ovoid, ca. 4.3 by 2.5 cm., acute at apex, drying vinaceous-brown, wrinkled; outer layer not detaching cleanly from stone, 1.5-3 mm. thick, compact; stone ellipsoid, ca. 2.4 by 1.9 cm., rounded at apex, the walls ca. 1 mm. thick, smooth, unmarked; spongy layer (?)thin.

DISTRIBUTION. Malay Peninsula (MAP 49).

SELECTED SPECIMENS SEEN. **Malaya.** SELANGOR: Sungei Buloh F.R., *KEP 5315* (KEP, SING). NEGERI SEMBILAN: G. Angsi F.R., *KEP 23817* (KEP, SING). TRENGGANU: Sungei Tong F.R., *KEP 94773* (A, KEP, L, SAN, SING); Kemaman, Bukit Kajang, 150 m., *Corner s.n.*, 25 NOV. 1935 (SING). PAHANG: Sungei Tembeling, near Kuala Kenyum, Sungei Redab, 240 m., *FRI 8584* (K, KEP, L, SING); Bukit Goh F.R., *KEP 17316* (KEP); Raub, Bilut Reserve, *KEP 23381* (KEP, SING); Kuala Lipis, *KEP 1267* (KEP, SING); Lesong F.R., 45 m., *FRI 19825* (K, KEP); sine loco, *KEP 1151* (KEP).

ECOLOGY. Sometimes in rocky stream beds (*FRI 8584*), 45–240 m. alt. Flowering March and August (flower scented); fruiting March and December.

Calophyllum subhorizontale is a distinctive species that can be recognized by its relatively small, tomentose terminal bud; stout, more or less shining twigs; large, coriaceous leaf blades with distant venation; large flowers usually with more than eight tepals; and ovoid fruits. The tepals tend to persist at the base of the fruit. The fruit dries wrinkled and has a moderately thick outer layer and a well-developed stone. The epithet *subhorizontale* was suggested by the clear and widely ascending venation of this species.

An incomplete specimen from Vietnam, *Chevalier 38909*, has fruits superficially similar to those of *Calophyllum subhorizontale*, but the leaf blades, with their fine venation, are reminiscent of those of *C. soulattri*. At least the outer pair of tepals is densely puberulent on the back, and the outer layer of the fruit is only ca. 1.2 mm. thick and is notably fibrous (see *Calophyllum* sp. 170).

The data for the type locality and collector were kindly confirmed by K. M. Kochummen; the collector's name on the Singapore sheet is given as Phillips.

170. *Calophyllum* sp.

FIGURE 44, h, i.

(?) Tree; details of trunk and bark unknown.

Twigs strongly flattened, 2–3 mm. across, persistently 4-subalate, drying brown, subsersistently tomentose; axillary innovations lacking basal scars; internodes (1.3–)2–7 cm. long; uppermost pair of axillary buds rounded, ca. 2.5 mm. long, suberect; terminal bud bluntly conical, 3 to ca. (?)5 mm. long, with brown, tomentose indumentum (hairs, FIGURE 46, n, o), underdeveloped internode absent. Petiole 1.1–2 cm. long, broadly concave above, convex below, glabrous when mature; lamina oblong to elliptic, 9–13 by 5.8–7 cm., retuse to shortly and abruptly acuminate at apex, acumen ca. 4 mm. long, acute at base, undulate and slightly recurved at margin, coriaceous, drying near sabelline above and below, subsersistently tomentose on midrib below, the midrib above narrowing quickly near base, raised, 0.3–0.4 mm. wide at midpoint, below raised, \pm angled, the venation above and below subapparent, raised, 10 to 16 veins/5 mm., angle of divergence 70–75°. Inflorescences unknown; pedicel in fruit 4–7 by ca. 2 mm., short-tomentose. Flower known only from remains at base of fruit; tepals ca. 16, the outer pair broadly ovate, 4.5–8 by 6–7.5 mm., puberulent on back, the next pair subelliptic, 7–12 by 7–11 mm., \pm puberulent on back, the inner ones obovate to elliptic,

to 18 by 11 mm., sometimes puberulent in strip down back; stamens numerous, the filaments to 10 mm. long, connate for up to 2.3 mm., the anthers ellipsoid, ca. 1 mm. long, retuse at apex; ovary, style, and stigma unknown. Fruit ovoid to ellipsoid, 2.5-3 by 2.1-2.5 cm., sharply pointed at apex, beak ca. 7 mm. long, drying brown, with rather distant and shallow wrinkles; outer layer detaching \pm cleanly from stone, ca. 1.2 mm. thick, compact except for air spaces under skin, fibrous; stone ellipsoid, 2-2.4 by 1.8-2.1 cm., rounded at apex, the walls 1.1-1.4 mm. thick, at base 2.2-3 mm. thick and slightly fibrous, smooth, obscurely triradiate at apex, basal (?) plug ca. 6.5 mm. across; spongy layer thin.

DISTRIBUTION. Vietnam (MAP 49); known only from a single collection.

SPECIMEN SEEN. **Vietnam:** Nhatrang, entre Suối Ca et Suối Giầu, *Chevalier* 38909 (A, P).

Calophyllum sp. 170 can be recognized by its bluntly conical, tomentose terminal bud, very strongly and persistently angled twigs, rather large leaf blades with close venation, tomentose pedicels, flowers with twelve tepals (outer ones tomentose on back), and large, ovoid, beaked fruits with thick stone walls.

Calophyllum sp. 170 is similar in fruit to *C. subhorizontale*, although it differs in terminal bud, twig, and leaf. In leaves it resembles *C. soulattri* but differs in terminal bud, flower, and fruit.

Although the fruits are not attached to the shoots, they nevertheless appear to belong to the specimen.

171. *Calophyllum brachyphyllum* Merr. *Philip. Jour. Sci.* **17**: 290. 1920, Enum. *Philip. Fl. Pl.* **3**: 78. 1923. TYPE: Philippine Islands, Mindanao, Surigao Province, Hegapit River, ca. 350 m., 25 April 1919, *BS* 34482 coll. *Ramos & Pascasio* (isotypes, A, K, P, US).

Small tree; trunk and bark not known.

Twigs slightly flattened, 1-1.5 mm. across, obscurely 4-angled, drying brown when young, grayish when older, sparsely farinose when young; axillary innovations lacking basal scars; internodes 0.8-3.5 mm. long; uppermost pair of axillary buds pointed, ca. 1.5 mm. long, erect; terminal bud narrowly conical, 3-4 mm. long, with dense, adpressed, grayish indumentum (hairs, FIGURE 41, x, z), underdeveloped internode absent. Petiole 1-2 mm. long, concave above, convex below, glabrous; lamina broadly ovate to elliptic, 1.3-2.7 by (0.85-)1-2 cm., retuse at apex, rounded to shallowly cordate at base, quite flat at margin, coriaceous, drying sepia to near sabelline above to sepia below, minutely puberulent on midrib above and below when young, the midrib above narrowing near base, becoming flat to slightly raised, margins at first \pm raised, center sulcate, less than 0.2 mm. wide at midpoint, below raised, striate, conspicuous, the venation above and below subobscure, very slightly raised, 13 to 17 veins/5 mm., angle of divergence 55-70°. Inflorescences from uppermost or adjacent axils, with scars of 3 to 5 flowers, unbranched, the axis 0.5-1.8 cm. long, glabrous, lowest internode ca. 5 mm.

long; bracts unknown; pedicels 1-2.5 cm. by 2 mm., glabrous. Flower unknown. Fruit spherical, to 1.3 by 1.3 cm., rounded at apex, drying dark brown, smooth; outer layer detaching \pm cleanly from stone, 1.5-1.8 mm. thick, compact; stone spherical, ca. 1 by 1 cm., rounded at apex, the walls 0.5-0.6 mm. thick, smooth, unmarked; spongy layer at first thick.

DISTRIBUTION. Philippine Islands; known only from a single collection from Mindanao (MAP 49).

ECOLOGY. Stream-side forest, ca. 350 m. alt. (Merrill, 1920, *loc. cit.*).

Calophyllum brachyphyllum can be recognized by its small, coriaceous leaf blades that are retuse at the apex and more or less cordate at the base; the venation is dense. The small fruit, with its relatively very thick outer layer and stone wall, is also distinctive. The epithet *brachyphyllum* ("short leaf") alludes to the short leaves of this species.

Calophyllum brachyphyllum is apparently a rather isolated species. It is not close to any of the cordate-leaved taxa centered on *C. venulosum*, nor is it close to *C. pentapetalum* as Merrill originally suggested. It has small leaves and dense venation like *C. exiticostatum*, but it differs from that species in its more coriaceous leaves that have a much stronger midrib, and in its fruit (that of *C. exiticostatum* is smaller, has a thin outer layer that is disorganized by air spaces, and has thin stone walls).

172. *Calophyllum rigidulum* P. F. Stevens, sp. nov.

FIGURE 44, g.

A speciebus aliis Calophylli in lamina parva percoriacea marginibus planis costa supra subplana infra lata versus basem leviter elevata versus apicem (sub)depressa, differt.

Shrub ca. 1 meter tall; trunk and bark not known.

Twigs flattened, 1-1.5 mm. across, 4-angled, drying dark brown when young, yellowish when older, sparsely farinose-puberulent; axillary innovations lacking basal scars; internodes 0.7-2.5 cm. long; uppermost pair of axillary buds subacute, 0.5-1.5 mm. long, erect; terminal bud plump, 3-4 mm. long, with brown, crustaceous indumentum (hairs, FIGURE 43, t, u), underdeveloped internode absent. Petiole 2-5 mm. long, strongly concave above, convex below, glabrous; lamina elliptic to subobovate, 1.4-3 by 0.75-1.8 cm., rounded to slightly retuse at apex, cuneate at base, quite flat at margin, very coriaceous, drying dust color above and fulvous-umber below, when young subfarinose on and near midrib on both surfaces, the midrib above narrowed at base, at first depressed, becoming level, ca. 0.2 mm. wide at midpoint, below broad, \pm depressed toward apex, raised at base, the venation obscure on both surfaces, subdepressed below, 13 to 16 veins/5 mm., angle of divergence 55-60°. Infructescences from foliate axils along twig, with scars of 3 to 11 flowers, sometimes with 3-flowered branches ca. 4 mm. long, the axis 0.6-1.4 cm. long, sparsely puberulent, lowest internode 4-7 mm. long; bracts ovate, ca. 1.6 mm. long, deciduous; pedicels 3-6 mm. long, glabrous. Flower not known; outer pair of tepals persisting at base of immature fruit suborbicular,

ca. 2 by 2 mm., thick. Young fruit ovoid, ca. 8 mm. long, apiculate, drying brown; outer layer less than 0.3 mm. thick.

TYPE: Philippine Islands, Luzon, Tayabas Province, Mt. Alzapan, 6000 feet [1829 m.], 7 June 1925, BS 45686 coll. Ramos & Edaño (holotype, A; isotypes, B, K, UC, US).

DISTRIBUTION. Philippine Islands (MAP 49); known only from the type locality.

ECOLOGY. Shrub in mossy forest, ca. 1830 m. alt.

Calophyllum rigidulum is a distinctive, albeit poorly known, species. The leaf blades are small, very coriaceous, and rounded to shallowly retuse at the apex, and the venation is fairly dense. On the upper surface of the blade the midrib is rather narrow and indistinct, while on the lower surface it is broad but more or less depressed. The epithet *rigidulum* means "rather rigid"—appropriate for this rigid-leaved species.

173. *Calophyllum insularum* P. F. Stevens, sp. nov.

FIGURE 40, d.

Calophyllum sp. A, aff. *C. caudatum* Kanchira & Hatusima, P. F. Stevens, Austral. Jour. Bot. 22: 362. 1974.

A speciebus aliis *Calophylli* in lamina chartacea 4.9–10 cm. longa et 1.1–2.5 cm. lata venatione densa, ramulo, gemma terminali, costa laminae, inflorescentia et tepalis exterioribus utrinque indumento tomentoso subpersistenti praeditis, et inflorescentiis axillaribus singulifloribus, differt.

Tree to 33 meters tall, d.b.h. 40 cm.; trunk without buttresses; outer bark dark brown, with numerous shallow fissures; inner bark brown; latex yellow, clear.

Twigs slightly flattened or not, 0.9–1.3 mm. across, not 4-angled to obscurely so, with obscure horizontal line at nodes, drying blackish, subpersistently tomentose; axillary innovations frequently with scars within 6 mm. of base; internodes 1–3.5(–7) cm. long; uppermost pair of axillary buds subacute, ca. 1.5 mm. long, erect; terminal bud narrowly conical, 5–8(–9.5) mm. long, shape obscured by dense, reddish brown, tomentose indumentum (hairs, FIGURE 46, a–d), underdeveloped internode to 1 mm. long. Petiole 0.7–1.3 cm. long, deeply concave above, convex below, subpersistently tomentose; lamina narrowly ovate to elliptic, 4.9–10 by 1.1–2.5 cm., acuminate at apex, cuneate at base, undulate and slightly recurved at margin, coriaceous, drying olivaceous to amber above and sepia to gray-sepia below, ± tomentose on midrib, margin, and lower surface when young, persistently so on midrib below (and margin), the midrib above abruptly narrowed at base, flat to slightly raised, 0.15–0.4 mm. wide at midpoint, sometimes sulcate, below raised, slightly angled or rounded, venation evident on both surfaces, raised, (13 to) 16 to 19 (to 22) veins/5 mm., angle of divergence 70–80°. Inflorescences from foliate axils near ends of twigs, with 1 flower, unbranched, the axis 3–5 mm. long, tomentose, lowest internode 3–5 mm. long; bracts not known; pedicels 5.5–8 mm. long, tomentose. Flower known only in late bud, (?)hermaphroditic;

tepals 8, the outer pair triangular, 7.5–8.5 by 4–5 mm., concave, tomentose outside and sericeous inside, the next pair elliptic to obovate, to 7.5 by 4 mm., thinner; stamens 80 to 100, the anthers oblong, 1.3–2.3 mm. long, subtense to apiculate at apex; ovary 1.5–2 mm. long, the style 1.5–3.5 mm. long, the stigma peltate, ca. 1.3 mm. across. Fruit not known.

TYPE: Eil. Meos Noem [Irian Jaya], Seroei, 200 m., 5 Oct. 1939, *bb 30941* (holotype, L; isotypes, A, NY, SING).

DISTRIBUTION. Papuaia, known only from islands in Geelvink Bay (MAP 45).

ADDITIONAL SPECIMENS SEEN. **PAPUASIA.** IRIAN JAYA. Geelvink Bay: Meos Noem, Seroei, 200 m., *bb 30937* (A, L), *bb 30944* (A, L, NY, SING), *bb 30959* (A, L), *bb 30965* (A, L), *bb 30967* (L, SING); Japen Is., Aisao, 200 m., *BW 10569* (L, LAE), *BW 10585* (L, LAE).

ECOLOGY. Colline rainforest, ca. 200 m. alt. Late bud in October.

Calophyllum insularum can be recognized by its tomentose indumentum, its narrowly ovate to elliptic leaf blades with dense venation, its single-flowered, axillary inflorescences, and its flowers. The flower buds are bilabiate, with the tips of the outer tepals separating early (perhaps due to the way that the specimens were dried). The outer pair of tepals has hairs on both surfaces. The epithet *insularum* ("of the islands") was chosen because this species has so far been collected only on islands.

Calophyllum insularum can be distinguished from *C. trachycaule*, with which some of the specimens cited above had been confused, by its more delicate facies (thinner twigs, and narrower, thinner, more pointed leaves), its solitary flowers with eight tepals, the outer two of which are hairy on both surfaces (the inflorescences of *C. trachycaule* have five or more flowers, each with four subglabrous tepals), and its anthers, which are two to three times the size those of *C. trachycaule*. There are also anatomical differences between the two (Stevens, *loc. cit.*).

The indumentum on the petiole often consists of rather scattered long hairs mixed with short ones (FIGURE 46, a–d).

174. *Calophyllum poilanei* Gagnep. ex P. F. Stevens, sp. nov.

FIGURE 45, a, b.

C. poilanei Gagnep. in Humbert, Fl. Gén. Indo-Chine Suppl. 1: 269. 1943; Pham & Nguyễn, Cây-Cổ Miền Nam Việt-Nam, 179. *bang 62bis* F. 1960; Pham, Cây-Cổ Miền Nam Việt-Nam. ed. 2. 2: 299. *fig.* 1970. *Nomen invalidum.*

A speciebibus aliis Calophylli in ramulis crassis nitidis 4-subalatis, nodis defoliatis prominentibus, et inflorescentiis terminalibus axillaribusque floribus pedicellis brevibus (usque ad 10 mm. longis) vel nullis, differt.

Small tree 3–4 meters tall, d.b.h. to 7 cm.; bark not known.

Twigs slightly flattened, 4–5 mm. across, strongly 4-angled to winged, drying

brown, shiny, sparsely tomentose when young; axillary innovations with basal scars; internodes 0.7-3.5(-5) cm. long; upper pair of axillary buds rounded, ca. 1 mm. long, spreading, not conspicuous; terminal bud conical, ca. 4 mm. long, with brown, tomentose indumentum (hairs, FIGURE 46, j, k), underdeveloped internode absent. Petiole 2-5 mm. long, broadly concave above, convex below, glabrescent; lamina oblong to subobovate, 11.7-21 by 3.7-6 cm., acuminate at apex, broadly rounded to shallowly cordate at base, slightly undulate and strongly recurved at margin, marginal thickening 0.5 mm. wide, coriaceous, drying cinnamon above and fulvous below, glabrous at maturity, the midrib above abruptly narrowed near base, becoming \pm raised, 0.2-0.5 mm. wide at midpoint, below strongly raised, angled toward apex, striate toward base, venation prominent on both surfaces, raised, 6 to 12 veins/5 mm., angle of divergence ca. 80° . Inflorescences terminal and from adjacent foliate axils, with numerous flowers, often flabellate, branched, branches to 2.5 cm. long, the axis to 10 cm. long, tomentose when young, 4-alate, lowest internode 1-2 cm. long; bracts ovate, ca. 7 mm. long, soon deciduous; pedicels to 5(-10) mm. long, tomentose. Flower (?) hermaphroditic; tepals 10 (rarely 11), the outer pair ovate, ca. 8 by 5-6 mm., short-tomentose on back, the inner ones elliptic to oblong, 10-15 by 3.5-7 mm., outer two with strip of indumentum down back, next two with tuft of hairs near apex; stamens 130 to 180, the filaments to 9 mm. long, the anthers oblong, 1-1.3 mm. long, \pm rounded at apex; ovary 1.2-1.4 mm. long, the style 6-8 mm. long, the stigma subexcentrically peltate, ca. 1 mm. across, 3- or 4-lobed. Fruit not known.

TYPE: Vietnam, Prov. Nhatrang, nord de Ninh-Hoa, massif de la Mère et l'Enfant, 1300 m., 18 May 1934, *Poilane 6572* (holotype, ν ; isotype, ν).

DISTRIBUTION. Central Vietnam (MAP 49).

ADDITIONAL SPECIMEN SEEN. **Vietnam:** Nhatrang, nord de Ninh-Hoa, massif de la Mère et l'Enfant, 1300 m., *Poilane 6454* (ν).

ECOLOGY. Stony ground, ca. 1300 m. alt. Flowering in May; flower scented.

Calophyllum poilanei is one of the most distinctive species of *Calophyllum*, with its shiny, little-branched, more or less four-alate twigs that have very prominent leaf scars. The lamina is rounded to shallowly cordate at the base, the inflorescence is terminal, and the flowers usually have ten tepals. The flowers have short pedicels or are sessile; this gives the inflorescence a distinctive appearance. Although the twigs, leaves, and flowers are very robust, the plant itself is reported to be small. The epithet commemorates E. Poilane.

Gagnepain (*loc. cit.*) seems to have been somewhat confused over the flower. He referred to bracteoles, borne just under the flower, which were ca. 12 by 5 mm. The measurements of "outer sepals" were given as 8 by 4 mm. It is possible that Gagnepain's "bracteoles" were bracts (these fall off very early—only a single one was seen) or the outer pair of tepals (in which case he may have confused their measurements with those of the next pair of tepals).

The description given above is needed because Gagnepain's description (*loc. cit.*) is in French and invalid.

175. *Calophyllum membranaceum* Gard. & Champ. Jour. Bot. Kew Misc. 1: 309. 1849; Choisy, Descr. Guttif. Inde, 43. 1849, Mém. Soc. Phys. Hist. Nat. Genève 12: 423. 1851; Walp. Ann. Bot. Syst. 2: 191. 1851; Seem. Bot. Voy. H.M.S. Herald, 368. 1857; Planchon & Triana, Ann. Sci. Nat. Bot. IV. 15: 290. 1862; Bentham, Fl. Hongkong. 25. 1861; Forbes & Hemsley, Jour. Linn. Soc. Bot. 23: 75. 1886; Vesque, Epharמוש 2: t. 4. 1889, in C. DC. Monogr. Phanerog. 8: 551. 1893; Gagnep. in Humbert, Fl. Gén. Indo-Chine Suppl. 1: 275. 1943; Auct. Ic. Corm. Sin. 2: 883. 1972. TYPE: Hongkong [Mt. Victoria], *Champion s.n.* (holotype, ♀).
- C. bonii* Pitard in Lecomte, Fl. Gén. Indo-Chine 1(4): 317. 1910; Gagnep. in Humbert, Fl. Gén. Indo-Chine Suppl. 1: 268. 1943. TYPE: Tonkin [Vietnam], Ninh Thai, Muong Lang, 23 April 1889, *Bon 4136* (lectotype, ♀).
- C. tonkinense* Pitard in Lecomte, Fl. Gén. Indo-Chine 1(4): 317. 1910. TYPE: Tonkin [Vietnam], Ninh Thai, Muong Lang, 17 March 1890, *Bon 4301* (lectotype, ♀; isoelectotype, ♀).
- C. spectabile* auct., non Willd.; Hooker f. & Arnott, Bot. Beechey Voy. 174. 1883.

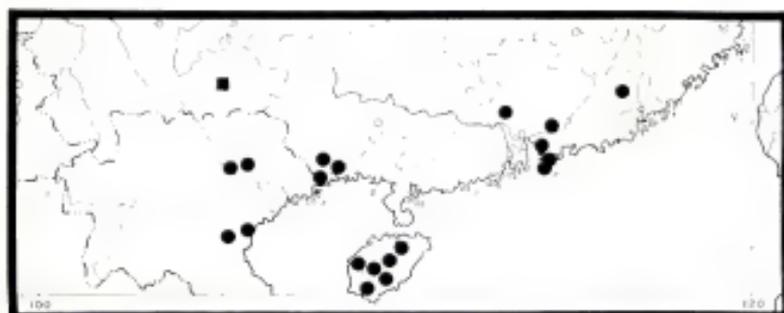
Shrub or small tree 1-5 meters tall, d.b.h. to 10 cm.; details of bark unknown.

Twigs slightly flattened, 1.3-2.5 mm. across, strongly 4-angled to subulate (with 2 additional raised lines decurrent from petiole), drying brown, glaucous when older, sparsely puberulent when young; axillary innovations lacking basal scars; internodes (0.5-)1.5-7 cm. long; uppermost pair of axillary buds pointed, to 1.5 mm. long, erect; terminal bud narrowly conical, 3.5-7 mm. long, with dense, brown, subadpressed indumentum (hairs, FIGURE 46, h, i), underdeveloped internode 0.1 mm. long. Petiole 0.4-1.4 cm. long, very deeply concave above and convex below, sparsely puberulent when young; lamina oblong to elliptic, 4.2-13.1 by 1.4-4.6 cm., acuminate at apex, cuneate at base, slightly undulate and recurved at margin, coriaceous, drying umber to olivaceous above and below, glabrous or sparsely and subsersistently puberulent on midrib below, the midrib above gradually narrowing from base, sharply raised, 0.1-0.35 mm. wide at midpoint, below raised, angled to striate, the venation on both surfaces apparent, raised, (5 or) 6 to 11 (or 12) veins/5 mm., angle of divergence 70-80°. Inflorescences axillary or terminating short axillary shoots, with (1 to) 3 to 9 flowers, sometimes flabellate, unbranched, the axis (0.1-)0.35-2.7(-5) cm. long, sparsely to subdensely puberulent, lowest internode (0.1-)0.3-1.5(-3.4) cm. long; bracts elliptic, 1-8 mm. long, ± deciduous, or foliaceous, to 5.2 by 2.3 cm., subsistent; pedicels 3-9 mm. long, sparsely puberulent. Flower (?)hermaphroditic; tepals 8 (to 12), the outer pair suborbicular, 3-4.5 by 3-4 mm., sometimes puberulent on back near base, the next pair broadly elliptic, 5.5-8 by 3.5-4.5 mm., the inner ones elliptic to obovate, 5.5-10 by 2-4.5 mm.; stamens 125 to 250, the filaments 1.5-4 mm. long, connate for up to 1.5 mm., the anthers suboblong to elliptic,

0.4–0.9 mm. long, \pm retuse at apex; ovary 1.2–1.8 mm. long, style 4.5–5.5 mm. long, stigma obscure. Fruit ellipsoid (rarely ovoid), 1.4–1.8 by 0.9–1.15 cm., minutely apiculate or not, drying pale brown, wrinkled; outer layer not detaching cleanly from stone, 0.4–1 mm. thick, compact; stone ellipsoid, 1.3–1.7 by 0.8–1 cm., rounded at apex, the walls ca. 0.1 mm. thick, smooth, (?)unmarked; spongy layer thin.

DISTRIBUTION. Southern China (Kwangtung, Kwangsi; reported also from Yunnan (Auct., Ic. Corm. Sin., *loc. cit.*)), Hong Kong, and northern Vietnam (MAP 50).

SELECTED SPECIMENS SEEN. **China:** KWANGTUNG: Pok Lor, *Fung Hom A-548* (NY); Yam na Shan (Yit Nga Shan), Mei (Kaying) Distr., *W. T. Tsang 21525* (A, K, NY, P); Ting Wu Shan, *W. Y. Chun 6406* (A, E, K, US, W); San-on Distr., Ng-Tung Shan, 940 m., *T. M. Tsui 230* (F, K, MO, NSW); Lofoushan, *Ying 1714* (SING). KWANGSI: Sehfengdarshan, S. Nanning, 762 m., *R. C. Ching 8086* (A, NY, US); Shap Man Taai Shan, near Ping Hoh village, SE. of Shang-sze, Kwangtung Border, *W. T. Tsang 22047* (A, BM, P); Hainan, Mochung Mt., Tingkap, Tingan, *S. P. Ko 52238* (NY), Yaichow, *H. Y. Liang 61994* (E, M, NY), Five Finger Mt., 500 m., *CCC 8495* (A, BM, C, E, G, K, MO, P), Dung Ka to Wen Fa Shi, *N. K. Chun & C. L. Tso 43684* (NY), Ka Chik Shan & vicinity, Ch'ang Kiang Distr., *S. K. Lau 1633* (A, BM, NY, P), Ng Chi Leng, Fan Yah, 914 m., *N. K. Chun & C. L. Tso 44133* (A, E, F, NY), Kan-en Distr., Chim Fung Ling, near San Mo Watt village, *S. K. Lau 3856* (A, P), Ngai Distr., Yeung Ling Shan, *S. K. Lau 86* (A, B, BM, E, G, K, MO, NY, P, US, W), Po Ting, 365 m., *F. C. How 71875* (A, BM). **Hong Kong:** Aberdeen, *Y. S. Lau 47* (A); Kowloon, Wong Keng Tsai, Shatin, *Y. W. Taam 2298* (G, NY, US); Wong Kum Cha, *Y. K. Chan 3043* (NY); Pic Victoria, *Bodinier 1450* (E, P); Ma On Shan, *S. Y. Hu 9329* (A); ravine leading to Pok-foo-lum, *Lamont 43* (BM); Kadoorie Farm, Kuan Yin Shan, *S. Y. Hu 12014* (A); Tai Mo Shan, *S. Y. Hu 11274* (A). **Vietnam:** Tam Dao, 850 m., *Petelot 4241* (A, BO, NY, P, US); Nin Thai, Muon Long, *Bon 3955* (P); Quombi, *Balansa 1504* (G, P); station experimental de Phu Tho, *Chevalier 41053* (P); Ha Coi, Tuai Wong Mo Shan, near Chuk Phai, *W. T. Tsang 29024* (A, BO, C, E, G, K, P, SING).



MAP 50. Distribution of *Calophyllum membranaceum* in Asia (circles, localized; squares, unlocalized).

ECOLOGY. Locally common, lowland or (usually) colline forest, sometimes in rocky places; 50–915 m. alt. Flowering April and May, rarely in March; (flower scented); fruiting October to December, rarely September or January (fruit yellow to orange—those reported as black seem to be immature).

LOCAL USES. Used in Yunnan to reduce the inflammation around bruises and to kill pain (Auct., Ic. Corm. Sin., *loc. cit.*)

Calophyllum membranaceum can be easily recognized, even when sterile, by its strongly angled twigs, its suboblong, thinly coriaceous lamina that often dries greenish and has prominent veins leaving the midrib at 70–80°, and its deeply concave petiole. The inflorescence is somewhat variable. There are sometimes fully developed leaves in the lower part of the inflorescence axis so that the inflorescence appears to be terminal. The asymmetrical, nonpeltate stigma of the flower and the thin outer and woody layers of the fruit are also distinctive. The epithet *membranaceum* ("membranaceous") was presumably suggested because of the texture and thinness of the dry leaf blades.

There is relatively little variation in flower and fruit, but specimens of *Calophyllum membranaceum* from Hong Kong frequently have more than eight tepals. In all other respects they agree with specimens from other parts of the range of the species.

Calophyllum bonii was based on specimens with very small inflorescences—this was the key character used by Gagnepain (*loc. cit.*) to separate it from the other species of *Calophyllum* growing in Indochina. However, as mentioned above, inflorescences in *C. membranaceum* are variable in appearance, and *C. bonii* has been reduced to synonymy under *C. membranaceum* without hesitation. *Bon 4136* is designated the lectotype of *C. bonii*; the original description was also based on *Balansa 1504*.

Calophyllum tonkinense was based on three numbers collected by the Abbé Bon (*Bon 3159, 3282, and 4301*) that are indistinguishable from other specimens assigned to *C. membranaceum*. *Calophyllum tonkinense* has been lectotypified on *Bon 4301*, a specimen with flowers.

176. *Calophyllum echinatum* P. F. Stevens, sp. nov. FIGURE 45, c.

A speciebus aliis *Calophylli* in gemma terminali longa, pari superiore gemmarum axillarum conspicuo patentique, lamina plerumque saltem 9 cm. longa margine arcte undulata costa supra lamina elevata circumcincta venulis lateralibus 15 usque ad 22/5 mm., et fructu strato exteriori fibroso fibris putamine confluentibus, differt.

Tree to 26 meters tall, d.b.h. to 75 cm.; details of bark not known.

Twigs slightly to strongly flattened, 2.5–3 mm. across, 2-, 4-, or 6-angled, soon becoming rounded, drying yellowish, farinose-puberulent when young; axillary innovations lacking basal scars; internodes (1–)2–6.5(–10) cm. long; uppermost pair of axillary buds ± acute, 1.5–7 mm. long, spreading to suberect; terminal bud narrowly conical, (0.7–)0.9–1.7 cm. long, with brown, subcrustaceous indumentum (hairs, FIGURE 41, t, u), underdeveloped internode 3.5–9

mm. long. Petiole 1.7–2.4 cm. long, strongly concave above, convex below, drying blackish, glabrous; lamina ovate or elliptic to suboblong, (5.2–)9–13.5 by (2.2–)3.2–5.2 cm., acute to short-acuminate at apex, acute to cuneate at base, closely and strongly undulate and slightly recurved at margin, coriaceous, gray- to green-olivaceous above and sepia-olivaceous-sabelline below, subsersistently puberulent on midrib below, the midrib above abruptly narrowed near base, raised, surrounding lamina also raised, 0.3–0.55 mm. wide at midpoint, below strongly raised, angled, the venation subobscure on both surfaces (subapparent above), slightly raised, 15 to 22 veins/5 mm., angle of divergence 70–80°. Inflorescences from uppermost foliate axils, with ca. 11 flowers, the branches 3-flowered, to 1.3 cm. long, the axis 4–6 cm. long, puberulent, lowest internode 1–3.5 cm. long; bracts not known; pedicels ca. 2.8 cm. long, puberulent. Insect-damaged flowers only known; tepals 4, the outer pair broadly ovate, ca. 6 by 5 mm., puberulent on back, the inner pair obovate, ca. 9.5 by 6 mm.; stamens and ovary not known. Fruit ellipsoid, ca. 5.3 by 3 cm., obtuse at apex, drying vinaceous-brown, deeply and distantly wrinkled; outer layer not clearly distinguishable from stone, fibrous, large air spaces developing; stone ellipsoid, ca. 2.7 by 1.7 cm., rounded at apex, the walls to 0.8 mm. thick, in places only 0.1 mm. thick, not marked, rough, with branched, anastomosing fibers arising from stone; spongy layer (?) thin.

TYPE: Celebes, Malili, Oesoe, *Cel./II-407* coll. *Waturandang* (holotype, no).

DISTRIBUTION. Known only from the Celebes (MAP 49).

ADDITIONAL SPECIMENS SEEN. **Celebes:** Malili, Oesoe, 50 m., *bb 32596* (no, l), 200 m., *Cel./II-215* (A, no, l); Thawatta, 200 m., *Cel./II-407* coll. *Gonggrijp* (A, no, l); Lingkomomo, Timampoe, 300 m., *bb 8566* (no).

ECOLOGY. Forest, 20–300 m. alt.

The fruits of *Cel./II-407* coll. *Gonggrijp* appear to be galled; they are flattened-ellipsoid structures ca. 6 by 2.3 cm. that are open on one side.

Calophyllum echinatum is a distinctive species that is easily recognizable, even when sterile. The terminal bud is rather long (usually over 9 mm.) and narrow, and the uppermost pair of axillary buds is conspicuous and spreading. The black-drying petiole contrasts strongly with the yellowish stem. The elliptic to oblong lamina is closely undulate at the margin, the midrib on the upper surface is surrounded by raised blade, and the venation is very fine and dense (15 to 22 veins/5 mm.). The ellipsoid fruit is large (ca. 5.3 cm. long), with the outer layer much disorganized by air spaces and containing fibers continuous with the stone; the stone is about 2.7 cm. long. The fibers arising from the stone give it a spiny appearance, hence the epithet *echinatum* ("prickly").

Although some specimens of *Calophyllum soulattri* from the Celebes (e.g., *Cel./III-63*) have a midrib similar to that of *C. echinatum*, they do not otherwise approach that species. In *C. soulattri* the uppermost pair of axillary buds

is usually erect (rather than spreading), the lamina is thinner, the lowest internode of the inflorescence is shorter, the pedicels and outer tepals are nearly always glabrous, and the tepals are smaller. The fruit of *C. soulattri* is quite different from that of *C. echinatum*: it is about one-quarter the length and has a compact, slightly fibrous outer layer.

177. *Calophyllum exiticostatum* P. F. Stevens, sp. nov. FIGURE 45, d-f.

A speciebus aliis *Calophylli* in lamina parva 2-5(-7.5) cm. longa basi plerumque rotundata venulis lateralibus densis et costa infra apicem evanescenti, petiolo brevi 1.5-4 mm. longo, et fructus circa 7 mm. longo strato exteriori forte proviso, differt.

Large tree 30-45 meters tall, d.b.h. to 140 cm.; trunk without buttresses; outer bark yellowish, with shallow, diamond-shaped fissures, the inner surface orange; under bark dark red; inner bark pale red; latex at first yellow, clear, becoming opaque.

Twigs slightly flattened, 1-1.5 mm. across, strongly 4-angled (with obscure horizontal lines at nodes), drying blackish brown, puberulo-tomentose when young; axillary innovations lacking basal scars; internodes 0.5-3 cm. long; uppermost pair of axillary buds rounded, ca. 0.8 mm. long, erect; terminal bud plump to conical, 2.3-3 mm. long, with brown, subadpressed indumentum (hairs, FIGURE 46, e-g), underdeveloped internode absent. Petiole 1.5-4 mm. long, broadly concave above and convex below, subsersistently puberulent; lamina ovate to elliptic, 2-5(-7.5) by 0.9-2.6(-3.1) cm., rounded (rarely subretuse or subacute) at apex, broadly to narrowly rounded or cuneate at base, not undulate or slightly so and not recurved at margin, coriaceous, drying umber to fulvous above and cinnamon to sabelline below, subsersistently puberulent on midrib below, the midrib above gradually narrowed from or abruptly narrowed at base, flat to slightly raised, subsulcate at base, 0.05-0.2 mm. wide at midpoint, below \pm level or slightly raised, striate, generally disappearing 2-3 mm. below apex, the venation obscure to subapparent on both surfaces, slightly raised, 14 to 23 veins/5 mm., angle of divergence 40-60(-70) $^{\circ}$. Inflorescences axillary, with 5 to 7 flowers, unbranched, the axis 4-10 mm. long, densely pubescent, especially near base, lowest internode ca. 2 mm. long; bracts not known; pedicels 3.5-6.5 mm. long, pubescent. Flower (?)hermaphroditic; tepals 4, the outer pair ovate, 4-5 by ca. 2 mm., puberulent on back, the inner pair \pm elliptic, 3.5-4.5 by 1.5-3 mm., with strip of indumentum down back; stamens 40 to 50, the filaments to 2.5 mm. long, the anthers oblong, 1-1.2 mm. long, rounded to shallowly retuse at apex; ovary ca. 1.5 mm. long, the style ca. 2.2 mm. long, the stigma peltate, ca. 0.6 mm. across. Fruit spherical, ca. 7 by 7 mm., rounded or minutely apiculate at apex, drying vinaceous-brown, smooth; outer layer not detaching cleanly from stone, ca. 0.8 mm. thick, with large air spaces developing beneath skin; stone spherical, ca. 5.5 by 5.5 mm., rounded at apex, the walls ca. 0.15 mm. thick, smooth, unmarked; spongy layer thin.

TYPE: Sumatra, Palembang, Lematang Ilir, Semangoes Reserve, 75 m., 8 May 1940, *bb* 31756 coll. *Buwalda* (holotype, α ; isotypes, β , κ , ι , ν , σ).

DISTRIBUTION. Southern Sumatra and northern Borneo (MAP 49).

ADDITIONAL SPECIMENS SEEN. **Sumatra.** SELATAN: Lematang Oeloe, 110 m., *Grashoff 161* (BO), 150 m., *Grashoff 224* (BO, L); Pasemahlanden, Djangkar, 900 m., *bb 8118* (BO); Afd. Redjang, bij desa Loeboek binjai, Rimba Ketjau, *bb 2299* (BO, L). **BARAT:** [Barisan], Manindjau, Silajang, 500 m., *bb 3971* (BO). **Borneo.** SABAH. RANAU: Poring turn-off, Kota Kinabalu-Sandakan road, 640 m., *Stevens et al. 559* (A), *563* (A).

ECOLOGY. Colline rainforest, 75-900 m. alt. Flowering in March; fruiting in May.

GERMINATION AND YOUNG PLANT. The young plants grow erect, and the terminal bud is functional. The leaf blades are up to 11.5 by 3 cm.

Calophyllum exiticostatum is an easily distinguishable species. It has strongly four-angled twigs, a short terminal bud, and small, very densely veined leaves that are usually rounded at the base. The inflorescence axis is more or less puberulent, the flowers have four tepals, and the spherical, smooth fruit has large air spaces in the outer layer. The midrib, which disappears just below the apex of the blade, suggested the epithet *exiticostatum* ("going-out-midrib").

The closest relative of *Calophyllum exiticostatum* may be *C. calaba*, although the latter species has somewhat larger leaf blades with usually less steeply ascending venation and a midrib that continues to the apex of the blade. In addition, the fruit of *C. calaba* lacks the strong epicarp of *C. exiticostatum*. *Calophyllum brachyphyllum*, from the Philippine Islands, also has small leaf blades with dense venation, but this species has a much more coriaceous blade that is retuse at the apex, and larger fruits with both the outer layer and the stone thicker.

Despite the 1500 km. distance separating the localities of *Calophyllum exiticostatum* in Sabah (near Mt. Kinabalu) and Sumatra, the Bornean specimens are vegetatively similar to the Sumatran ones. The only differences seem to be that in the Sumatran specimens the midrib is a little more prominent, the lamina is a little larger (measurements in parentheses in the description above), and the horizontal lines at the nodes are more obvious (cf. also *C. gracilipes*). However, material in flower and fruit is needed to confirm this similarity; the description of the bark is taken from Bornean material.

178. *Calophyllum* sp.

Tree ca. 8 meters tall, d.b.h. to 6 cm.; trunk and bark unknown.

Twigs flattened, 3-3.5 mm. across, 4-angled, drying dark brown, tomentose when young; axillary innovations lacking basal scars; internodes 2.5-4 cm. long; uppermost pair of axillary buds subrounded, ca. 2 mm. long, erect; terminal bud bluntly conical, ca. 4 mm. long, tomentose, underdeveloped internode absent. Petiole 2.8-3.3 cm. long, rather narrowly concave above, convex below, glabrous when mature; lamina ovate-oblong, 16.5-18 by 6-6.5 cm., short-acuminate at apex, rounded to acute at base, distantly undulate and slightly recurved at margin, coriaceous, drying umber above and fulvous-

umber below, with sparse hairs persisting on midrib below, the midrib above gradually narrowing from base, raised, 0.3–0.4 mm. wide at midpoint, below raised, substrate to subangled, the venation above apparent, below subobscure, raised, latex canals impressed below, 5 or 6 veins/5 mm., angle of divergence 70–80°. Inflorescences from foliate axils, with ca. 5 flowers, unbranched, the axis 3–3.5 cm. long, puberulo-tomentose, lowest internode 0.6–1.1 cm. long; bracts unknown; pedicels 0.5–1.4 cm. long, puberulo-tomentose. Flower (?)hermaphroditic; tepals ca. 12, the outer pair subovate, ca. 1.5 by 1 cm., puberulent at base on back, the next pair suborbicular, ca. 1.3 by 1.3 cm., the inner ones oblong-obovate, 1.1–1.6 by 0.4–1 cm.; stamens ca. 410, the filaments to 8 mm. long, the anthers oblong, 1.2–1.6 mm. long, retuse at apex; ovary ca. 3 mm. long, the style ca. (?)6 mm. long, the stigma peltate, ca. 1.6 mm. across, 2-radiate. Fruit unknown.

DISTRIBUTION. Philippine Islands (MAP 49).

SPECIMEN SEEN. **Philippine Islands**. LUZON. Tayabas: Malbog, 100 m., *FB 30772* (NY).

ECOLOGY. Forest, ca. 100 m. alt. Flowering in February; flower scented.

Calophyllum sp. 178 can be recognized by its short, bluntly conical terminal bud, its long petioles, its relatively large, ovate-oblong leaf blades with the venation clearly raised on the upper surface but obscure and barely raised (with latex canals impressed) on the lower, and its few-flowered axillary inflorescences. The flowers are large and have about twelve tepals.

It is premature to describe this taxon in the absence of fruits, but its conical, rather short terminal bud and its distant venation suggest that it is not related to the variable *Calophyllum blancoi*.

179. *Calophyllum macrophyllum* Scheffer, *Natuurk. Tijdschr. Nederl.-Indië*, VII. 2: 405. 1873; Vesque in C. DC. *Monogr. Phanerog.* 8: 609. 1893; *Lauterb. Bot. Jahrb.* 58: 14. 1922; T. C. Whitmore, *Gard. Bull. Singapore* 22: 12. 1967; P. F. Stevens, *Austral. Jour. Bot.* 22: 377. 1974. TYPE: Gebeh [Irian Jaya], *Teysmann, HB 7574* (holotype, ♂; isotypes, c, K, L, MEL).

(?)Tree; details of trunk and bark unknown.

Twigs slightly flattened, 5–7 mm. across, strongly 4-angled to -alate, drying brown, glabrous at maturity; terminal bud ± conical, ca. 5 mm. long, with brownish indumentum, hairs adaxially curved and very papillate; other details of twigs and buds unknown. Petiole 1.3–1.7 cm. long, shallowly concave above, angled below, glabrous at maturity; lamina elliptic to suboblong, 32–45 by 9–11 cm., acute at apex, cuneate at base, barely undulate and slightly recurved at margin, coriaceous, drying olivaceous above and fulvous-umber below, glabrous at maturity, the midrib above rather quickly narrowed at base, raised, 0.3–0.4 mm. wide at midpoint, below strongly raised, angled, the venation obscure above, apparent below, raised, with 3 to 5 veins/5 mm., angle of divergence ca. 80°. Inflorescence, flower, and fruit not known.

DISTRIBUTION. Gebeh Island (MAP 45); known only from the type collection.

The very large leaf blades with distant venation and the relatively small terminal bud allow *Calophyllum macrophyllum* to be recognized readily, but it is still known only from the rather fragmentary sterile collection on which the original description was based. The epithet *macrophyllum* ("large leaf") was presumably suggested because of the size of the leaves.

Although it seems unlikely that *Teysmann*, HB 7574 was taken from a sapling (Stevens, *loc. cit.*), the leaves would be large even for a young plant of *Calophyllum*. Fertile collections of *C. macrophyllum* would be of considerable interest; it is possible that it is related to *C. celebicum*.

NOMINA NON SATIS COGNITA

Calophyllum cerasiforme Teijsm. & Binn. ex Koord.-Schum. Syst. Verzeich. 2: 7. 1910. *Nomen*.

I cannot identify the specimen on which this name is based (*Koorders 10623*, from Sumatra); see also *Calophyllum* sp. 9.

Calophyllum kunstleri King var. *longifolium* Boerl. Catal. Pl. Phanerog. Horto Bot. Bogor 2: 80. 1901; Koord.-Schum. Syst. Verzeich. 2: 58. 1910. *Nomen*.

I have been able to identify neither the specimens cited in the references above, nor that listed under *Calophyllum kunstleri* in Koorders-Schumacher (*loc. cit.*). The "*Calophyllum kunstleri*" currently grown at Bogor (plant VI C 237) is *C. calaba* var. *bracteatum*.

Calophyllum lonchophyllum O. Schwarz, Repert. Sp. Nov. 24: 89. 1927. TYPE: Australia, Northern Territory, Finniso River district, *Bleeser A22*.

Tree.

Branches terete, branchlets plicate-sulcate; buds with fuscous, adpressed, pubescent indumentum, the hairs contorted, unbranched. Petiole 5-9 mm. long; lamina long-lanceolate, 12-19 by 1.4-3.5 cm., long-acuminate at apex, narrowly acute (?and/or cuneate) at base, coriaceous, glabrous, the midrib above immersed-prominulous, below carinate, yellowish, the lateral nerves spreading horizontally, very close.

The description above is based on the protolog. *Bleeser A22*, from which Schwarz took his description, was apparently a sterile specimen and has since been destroyed, having been held in Berlin. It is impossible to tell to what species the name *Calophyllum lonchophyllum* should be referred.

Calophyllum minus Ridley, Dispersal Pl. World, 207. 1930. *Nomen*.

As noted by Ridley (*loc. cit.*), Guppy found that fruits of this species, which grew inland in the Solomon Islands, float. The name is not mentioned in Guppy, Solomon Is. 1867.

Calophyllum vanoverberghii Merr. Philip. Jour. Sci. C. 9: 454. 1915. TYPE: Philippine Islands, Luzon, subprovince of Bontoc, Bauco, ca. 1700 m., 12 Sept. 1918, *Vanoverbergh 1466* (PNH, destroyed).

Small tree ca. 3 meters tall.

Twigs drying grayish or olivaceous, sometimes slightly pubescent at tips; terminal bud ferruginous-pubescent. Petiole ca. 1 cm. long, slightly pubescent at first, otherwise glabrous; lamina oblong, 5-8 by 2-3 cm., obtuse at apex, acute or slightly decurrent at base, thickly coriaceous, drying concolorous, nitid, glabrous when mature, nerves very close. Inflorescences axillary and terminating short lateral branchlets, branched, with 3 short branchlets, often also with additional flowers, the axis 1.5-2.5 cm. long, the lowest internode very short, usually somewhat ferruginous-pubescent; pedicels 5-10 mm. long. Tepals 4, the outer pair broadly ovate, ca. 6 mm. long, sometimes glabrous, concave, the inner pair narrowly obovate, ca. 8 mm. long; stamens indefinite, the filaments to 3.5 mm. long, the anthers narrowly obovoid or oblong-obovoid, 1.5-2 mm. long; ovary glabrous, style ca. 2 mm. long. Fruit unknown.

Although Merrill's description of the inflorescence of *Calophyllum vanoverberghii* (translated above) reads somewhat like that of *C. soulattri*, a species which also has four-tepaled flowers, *C. soulattri* never has an oblong, very coriaceous lamina that dries concolorous and nitid. *BS 75484* (from Catanduanes, Luzon) may belong to *C. vanoverberghii*; the outer layer of the fruit of this specimen is not compact, unlike that of *C. soulattri*, although in inflorescence the two are similar.

Calophyllum sp. Merr. Jour. Arnold Arb. 19: 355. 1938.

Merrill (*loc. cit.*) noted that *Rheedia umbellata* Houtt. (Nat. Hist. II. 3: 3. 1774) was a new name for *R. javanica* Burman f. (Fl. Indica, 118. 1768) and that it might be a species of *Calophyllum*. I have not been able to identify *R. javanica* more precisely.

NOMINA EXCLUDENDA

Calophyllum acuminatum Lam. Encycl. Méth. Bot. 1: 553. 1785. TYPE: sine loco, anon. (lectotype, ♀).

The specimen that Lamarck had on hand consists of a fruiting element, referable to *Calophyllum tacamahaca*, and a leafy element, referable to a species of *Garcinia*. The name *C. acuminatum* was lectotypified on this latter element (see P. F. Stevens, Jour. Arnold Arb. 57: 181. 1976).

Calophyllum akara Burman f. Fl. Indica, 121. 1768. TYPE: based on Rheede, Hortus Malabar. 5: 15. t. 8. 1685 (*Akara patsjoti*).

According to Merrill (Philip. Jour. Sci. 19: 366. 1921), this is properly called *Tetracera akara* (Burman f.) Merr. (Dilleniaceae).

Calophyllum angustifolium Roxb. Fl. Indica, ed. 2 (W. Carey, ed.). 2: 608. 1832, Hortus Bengal. 41. 1814, *nomen*; Choisy, Descr. Guttif. Inde,

43. 1849, Mém. Soc. Phys. Hist. Nat. Genève **12**: 423. 1851; Planchon & Triana, Ann. Sci. Nat. Bot. IV. **15**: 293. 1862; T. Anderson in Hooker f. Fl. Brit. India **1**: 276. 1874; Vesque in C. DC. Monogr. Phanerog. **8**: 609. 1893. TYPE: Malaya, Penang, *Roxburgh s.n.* (lectotype, BM, *quoad Garcinia*).

The protolog to this species reads "Twigs cylindrical. Leaves short-petioled, lanceolate, with lengthened, somewhat obtuse points, lucid, finely veined. Flowers in axillary fascicles; pedicels with a cyatheiform apex. . . ." There are two elements on a sheet presumably of the type at the British Museum: a vegetative shoot of a species of *Calophyllum* with "*Calophyllum angustifolium*" written on one of the leaves, and a shoot of a species of *Garcinia* with pistillate flowers just past anthesis. The only part of the original description clearly referable to *Calophyllum* is the mention of the leaves being lucid and finely veined, although Roxburgh also says that "peon" (poon) spars for the masts of ships come from this species—probably also referring to this element. The mention of the leaves having somewhat obtuse points best fits the shoot of *Garcinia*, as does the description of the inflorescence and the pedicel.

Since most of the protolog of *Calophyllum angustifolium* seems to be based on the shoot of *Garcinia*, it is reasonable to lectotypify the name on this element. I do not know to which species of *Garcinia* this shoot belongs; the epithet *angustifolia* is already occupied in *Garcinia* (*G. angustifolia* A. C. Smith, from New Guinea). The shoot of *Calophyllum* is not complete enough for identification; the terminal bud is not properly developed.

Calophyllum augia Steudel, Nomencl. ed. 2. **1**: 260. 1840, *nomen illegitimum* for *Augia sinensis* Lour. Fl. Cochinch. **1**: 337. 1790, *ibid.* ed. Willd. **1**: 411. 1793.

Merrill (Trans. Am. Philos. Soc. n.s. **24**(2): 244. 1935) equated this name with *Rhus succedana* L. (Anacardiaceae). The only element in the original description that might refer to *Calophyllum* is the mention of the flower having 100 stamens.

"*Calophyllum chinense* Walp.? ex Seemann in Bonplandia"; T. Anderson in Hooker f. Fl. Brit. India **1**: 270. 1874. *Nomen*.

Anderson (*loc. cit.*) equated this name with *Ochrocarpus longifolius* (Wight) Benth. & Hooker f. (= *Mammea longifolia* (Wight) Planchon & Triana). I have been unable to find any other reference to *Calophyllum chinense* except that given by Anderson, but he may have meant to refer to *Calysaccion chinense* Walp. (see Seemann, *Bonplandia* **4**: 299. 1856). This name is not included in Kosterman's (1956, 1961) revisions of the Asiatic and Pacific species of *Mammea*, but from Seemann's discussion it seems to be a synonym of *Calysaccion longifolium* Wight (= *M. longifolia*).

Calophyllum dubium Steudel, Nomencl. ed. 2. **1**: 261. 1840. Based on *C. longifolium* Wall. Catal. **4851**. 1831. *Nomen*.

See *Calophyllum longifolium*, below.

Calophyllum excelsum Zoll. & Moritz, Nat. Geneesk. Arch. Neerl. Indië 2: 582. 1845.

As Merrill (Jour. Arnold Arb. 26: 94. 1945) noted, this name is to be referred to *Ochrocarpus odoratus* (Raf.) Merr., properly called *Mammea odorata* (Raf.) Kosterm.

Calophyllum hexapetalum Hooker f. Trans. Linn. Soc. 23: 163. 1860. TYPE: [In ora septentrionale insulae] Borneo, *Low s.n.* (holotype, κ).

This is certainly a species of *Mesua*, but was not included by Kostermans (1969) in his list of new combinations in the genus.

Calophyllum longifolium Wall. Catal. 4851. 1831. *Nomen.*

Wight took up Wallich's epithet when he described *Calysaccion longifolium* Wight. This is correctly to be called *Mammea longifolia*.

Calophyllum nagassarium Burman f. Fl. Indica, 121. 1768.

This name has usually been referred to *Mesua ferrea* L. (Steudel, Nomencl. ed. 2. 1: 260. 1840); however, type material of *M. ferrea* apparently belongs to the species hitherto called *M. thwaitesii* (Kostermans, 1976). The species of *Mesua* commonly cultivated must be called *Mesua nagassarium* (Burman f.) Kosterm. Kostermans (*loc. cit.*) typified *C. nagassarium* on Rumphius, Herb. Amboin. 7: pl. 2. 1750. However, Burman may well have received material of *C. nagassarium*, since he stated "habitat in Amboina & Java, unde anno 1759. missa." There are two sheets of *C. nagassarium* originally in Burman's herbarium that are now in Geneva.

Calophyllum neurophyllum Schlechter, Bot. Jahrb. 39: 193. 1906. TYPE: New Caledonia, Hügeln bei Noumea, 20 m., Oct. 1902, *Schlechter 15091* (isotypes, σ , ν).

This is correctly called *Mammea neurophylla* (Schlechter) Kosterm.

Calophyllum pustulatum Ridley, Kew Bull. 1938: 118. 1938; Masamune, Enum. Phanerog. Born. 476. 1942. TYPE: Sarawak, near Kuching, 23 Jan. 1893, *Haviland 2117* (holotype, κ ; isotype, ι).

This name is to be referred to *Mesua*, but it is not included in that genus by Kostermans (1969).

Calophyllum touriga C. T. White & Francis, Proc. Roy. Soc. Queensland 35: 63. 1923. TYPE: Australia, Queensland, Gourka pocket, Atherton Tableland, Jan. 1923, *Merrotsy s.n.* (lectotype, BRU, n.v.; see L. S. Smith, Proc. Roy. Soc. Queensland 68: 48. 1957).

This species is correctly called *Mammea touriga* (C. T. White & Francis) L. S. Smith.

Calophyllum vidalii F. Villar in Ceron, Catal. Pl. Herb. Manila, 229. plate. 1892. TYPE: Philippine Islands, Luzon, Camarines Sur Province, Mt. Isarog, [March 1886], *Vidal 2134* (isotype, λ).

This species is correctly called *Schuurmansia vidalii* (F. Villar) Merr., a member of the Ochnaceae. In the original publication of *Calophyllum vidalii*, the name "*C. cuneatum* Vidal" is mentioned in synonymy; the latter is invalid.

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ADDENDUM

Since this article went to press, an account of the genus *Calophyllum* in Sri Lanka has appeared (KOSTERMANS, A. G. J. H. 1980. Clusiaceae (Guttiferae). Pp. 72-110 in M. D. DASSANAYAKE, ed., A revised handbook to the flora of Ceylon. Vol. 1. Amerind, New Delhi). In this account, endosperm is said to be sometimes present as a thin, jellylike layer around the cotyledons; Thwaites (Jour. Bot. Kew Misc. 6: 72. 1854) noted that CP 2446 (*C. trapezifolium*) had a green embryo surrounded by abundant endosperm. These observations must be confirmed. Kostermans gives interesting information on the color and appearance of the young leaves. The species mentioned in his account are listed below; brief comments have been added so that Kostermans's account and the present one can be integrated.

1. *Calophyllum inophyllum*.
2. *Calophyllum tomentosum* (see also Thwaites, Enum. Pl. Zeyl. 51. 1858). Kostermans 24848 is considered to be a close match with material previously identified as *C. elatum*; reports of that species from Sri Lanka are included without hesitation in the synonymy under *C. tomentosum*.
3. *Calophyllum moonii*. The flowers are reported to have only four tepals.
4. *Calophyllum calaba*. Material assigned to *C. calaba* var. *worthingtonii* above is believed to represent the young stage of "typical" *C. calaba*.
5. *Calophyllum bracteatum*. The seedlings are noted as having very narrow, linear leaves; saplings 2 meters tall already show the leaf variation characteristic of this species.
6. *Calophyllum trapezifolium*. Galls are said not to occur on this species.
7. *Calophyllum zeylanicum*. This is included in *C. trapezifolium* in the present account.
8. *Calophyllum cuneifolium*.
9. *Calophyllum walkeri*.
10. *Calophyllum thwaitesii*. The conflicts with earlier descriptions of this species and its variation that Kostermans mentions are resolved by the description of *C. vergens*.
11. *Calophyllum cordato-oblongum*.

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NOTICE

Because of continually increasing production costs, the Editorial Committee of the *Journal of the Arnold Arboretum* is requesting authors to help defray publication expenses. Beginning with manuscripts received and accepted for publication as of March, 1980, a page charge will be levied. Acceptance of manuscripts for the Journal will, however, continue to be based solely on appropriateness and scientific merit, not on an author's ability to meet page costs. Information on page charges and general editorial policies can be obtained from the Managing Editor.

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COVER: The shoots and fruits (about natural size) and a single trichome (magnified nearly 160 times) of a Fijian endemic, *Calophyllum leucocarpum* A. C. Smith, form the basis of this year's stylized cover design. A row of trichomes is used in the device on the back cover, while a cluster of leaves appears on the offprints. As in recent years, the designs, based on holotype material in the herbarium of the Arnold Arboretum, were drawn by Karen Stoutsenberger.

Calophyllum L. (Guttiferae) is a wide-ranging genus of tropical forest trees in both the New and Old Worlds, and some species are of considerable economic importance as sources of valuable timber. Its use on the cover of this volume of the *Journal of the Arnold Arboretum* is appropriate since the April and July numbers are devoted to P. F. Stevens's revision of the Old World representatives of this genus.—S. A. S.

JOURNAL
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ARNOLD ARBORETUM

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TAXONOMY OF THE WEST INDIAN CYCADS

JAMES E. ECKENWALDER

TEN GENERA of Cycadales exist in world floras. Four genera, all members of the Zamiaceae, are natives of the Western Hemisphere, and two of these are found in the West Indian region. The monotypic *Microcycas* (Miq.) A. DC. is endemic to Cuba, while *Zamia* L. is found from Mexico south to Bolivia and Brazil, as well as in the West Indies (Schuster, 1932). Within the West Indian region, cycads are indigenous to all of the Greater Antilles, the Bahamas, Florida, and the southeastern coast of Georgia but are absent from the Lesser Antilles and the Virgin Islands. Because of its restricted distribution and seeming morphological isolation, *Microcycas* has heretofore caused little dispute, but the taxonomic history of West Indian zamias, like that of many other West Indian plant groups (Howard, 1977), has comprised a confusing array of divergent circumscriptions and delimitations, resulting in widely different species tallies (from one (present study) to 14 or more (de Candolle, 1868)) for the region. Altogether, some 35 entities have been described, accounting for about 40 percent of the names proposed in the genus.

Diverse taxonomic treatments can be ascribed to complex variation patterns and political fractionation of the region, as well as to differences in philosophy among taxonomists. Most previous workers have had a very narrow species concept and have acknowledged neither extensive variation within populations nor continuity between populations. Often species were described on the basis of single specimens—sometimes cultivated plants for which the original sources were unknown. Other than Schuster's (1932) synonymies, which are tortuous and partly invalid under the present *International Code of Botanical Nomenclature*, there has been little effort to consolidate nomenclature in different subregions, and nomenclatural and taxonomic chaos persist. This paper proposes a new taxonomy of West Indian cycads, based on field, herbarium, and garden studies; explains the contrast between this classification and those of previous workers; and accounts for most published names in the complex.

TAXONOMIC AND NOMENCLATURAL HISTORY

West Indian cycads were described by pre-Linnaean authors, usually as species of "Palma," and Linnaeus (1763, 1764) founded his genus *Zamia*, with its sole species, *Z. pumila* L., on their descriptions and illustrations. Smith (1961) raised an important question concerning the typification of *Z. pumila*. He correctly contended that the Linnaean protologue contained references to two currently recognized species of *Zamia*, and that correct application of the name depended upon lectotypification by subsequent authors. Most authors have either rejected *Z. pumila* because of this mixture (e.g., Schuster, 1932) or have used it for the West Indian cycad described and illustrated by Commelijn (de Candolle, 1868; Carabia, 1941). Smith, in contrast, argued that Miller (1768) had first lectotypified the name using the other references. Thus, he contended that *Z. pumila* L. should be applied to the Mexican species currently known as *Z. furfuracea* Aiton, and that the West Indian species that had almost universally borne the Linnaean epithet should be known as *Z. debilis* Aiton. This argument, which has largely been ignored, can be set safely aside within the framework of the ICBN. Miller's account need not be taken as a lectotypification of *Z. pumila* L. because it describes *Palma pumila* Miller and contains no reference to Linnaeus's combination. Nomenclaturally, it can be considered an independent publication of the epithet. The first post-Linnaean use of *Z. pumila* may be by Aiton (1789), who applied it (as a synonym) to a West Indian cycad. *Zamia pumila* L. may thus be retained for the common West Indian cycad that has traditionally been known (in part) by that name, and *Z. furfuracea* Aiton remains the correct name for a Mexican species.

Soon after the original description of *Zamia*, new West Indian species were added to the genus. Aiton (1789) contributed *Z. debilis* Aiton and *Z. integrifolia* Aiton, the latter a renaming of *Z. pumila* L. With *Z. media* Jacq. and *Z. angustifolia* Jacq., Jacquin (1791, 1798) created the narrow species concept, based on leaflet widths, in West Indian *Zamia*. Aiton and Jacquin set trends followed by many later authors dealing with the taxonomy of *Zamia* in the West Indies—purposeful or inadvertent renaming of previously described entities, and proliferation of described taxa based on slight differences in leaflet width. As an example of the former trend, cycads with narrow leaflets from the south coast of the former Oriente Province of Cuba have successively been named *Z. stricta* Miq., *Z. yatesii* Miq., *Z. angustissima* Miq., *Z. multifoliolata* A. DC., and *Z. guggenheimiana* Carabia. Many plants attributable to these taxa are virtually indistinguishable from cycads from Eleuthera in the Bahamas named *Z. angustifolia* Jacq., and from others from Mayagüez Province, Puerto Rico, named *Z. portoricensis* Urban. The second trend is reflected in such epithets as *Z. angustissima* Miq., *Z. angustifolia* Jacq., *Z. media* Jacq., and *Z. latifoliolata* Prenl. The tendency toward a narrow species concept defined on leaflet width is even reflected in treatments of fossils of *Zamia* from the West Indies (Hollick, 1932). Additional names proposed in the last 200 years are included later in the synonymy of *Z. pumila* subsp. *pumila*.

Dwarf cycads from western Cuba were first distinguished as *Zamia pygmaea* Sims (1815). Since these diminutive cycads also display variations in leaflet size comparable to those of the more widespread larger plants, they too have engendered numerous specific epithets based on local variants. These names are included in the

synonymy of *Z. pumila* subsp. *pygmaea* (Sims) Eckenw. in the taxonomic treatment presented below. The other Cuban endemic, *Microcycas calocoma* (Miq.) A. DC., was first described as a species of *Zamia* in 1851. De Candolle (1868) transferred it to a new monotypic genus because of its striking differences from the other species of *Zamia* then known. Its rarity and distinctiveness have inhibited recognition of segregates, and little controversy has attended taxonomic accounts of this species since its identity was firmly established (Caldwell & Baker, 1907).

Modern treatments of West Indian cycads adopt one of four differing points of view on the taxonomy of the *Zamia pumila* complex. 1) Each subregion has several species, which may or may not be shared between subregions (Schuster, 1932; Chamberlain, n. d.). This viewpoint is particularly attractive to botanists working within a single subregion and has characterized most treatments to date of West Indian cycads, including accounts for Florida (Small, 1933), the Bahamas (Britton & Millspaugh, 1920), Puerto Rico (Britton & Wilson, 1926), and Cuba (León, 1946; Liogier, 1969). It is less attractive when viewed against overall variation in the West Indian region. 2) Each subregion has a single endemic species (Read, 1967). This view ignores parallel variation in cycads of different subregions, particularly in Cuba, Puerto Rico, and the Bahamas. 3) The West Indian region has a single endemic species of *Zamia*. This is the viewpoint adopted here and rests on evidence presented below. It is more conservative than treatments such as that of Carabia (1941), which accept two or three species and are intermediate between viewpoints 1 and 2. 4) West Indian cycads are conspecific with those of the Central and South American mainland. W. C. Steward (pers. comm.) contends that *Zamia* is monotypic. This concept of *Z. pumila* ignores apparent discontinuities in variation to include a wide array of diversity in morphology, ecology, and chromosome number under one specific epithet. Since Steward's arguments are not yet published, they can not be examined in detail here. Of the four taxonomic viewpoints enumerated above, numbers 2 and 4 do not seem to accord with the facts of variation in West Indian zamias, as seen here. Based on information presented below, a treatment reflecting viewpoint 1 must embody great arbitrariness in delimitation of taxa. I favor a conservative approach (number 3) as most workable and most in accordance with present variation in these plants.

MATERIALS AND METHODS

Approximately 1500 herbarium specimens (including 33 holotypes and isotypes) of *Microcycas* and *Zamia* from throughout the West Indian region were examined in the following herbaria: A, AAH, BM, DAO, DAY, DUKE, F, FAU, FLAS, FSU, FTG, GA, GH, MICH, MO, MSU, NCU, NY, TEX, UC, UNC, US, USF, and the personal herbarium of Dr. J. de Js. Jiménez (Santiago, Dominican Republic). Over 500 living plants at Fairchild Tropical Garden, representing 34 accessions from known localities in all West Indian subregions and including a few interpopulational hybrids, were also studied. Field work in the Bahamas and throughout Florida complemented the herbarium and garden studies and provided information concerning the association of morphological variations with habitat differences. Occurrences were mapped, and leaflet length, width, and vein number (characteristics that dominated previous species delimitations) were

recorded. Variation in these characters is analyzed below. Additional morphological features, both vegetative and reproductive, were recorded; they also influenced taxonomic decisions. They are not specifically analyzed below but are summarized in the taxonomic descriptions presented. The short lists of representative specimens come from the full range of each taxon and emphasize morphological variation within those subregions in which each occurs.

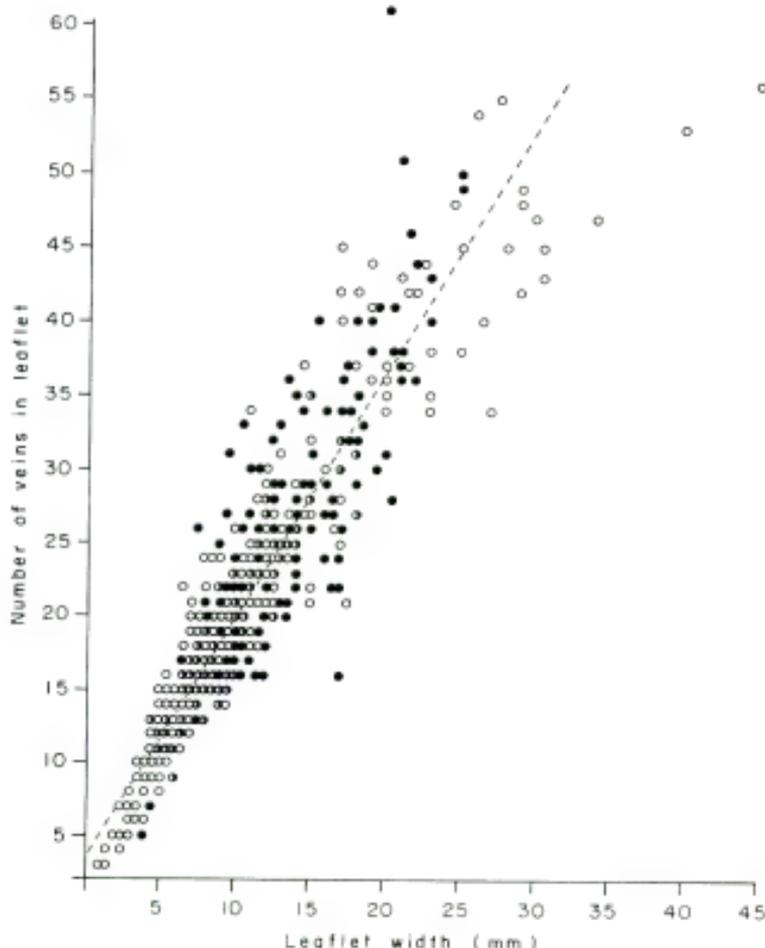


FIGURE 1. Regression of vein number on leaflet width of West Indian zamias: circles, *Zamia pumila* subsp. *pumila*; spots, subsp. *pygmaea*; mixed symbols, both subspecies; regression line dashed, $y = 1.66x + 3.29$, $r^2 = 0.88$, $n = 1111$.

RESULTS AND DISCUSSION

Previous workers, often lacking fertile material, emphasized leaflet characteristics in their specific delimitations of West Indian zamias. Because leaflet length, width, and vein number differ between populations, these (especially the latter two) are the features that were most often used to distinguish new species. Furthermore, since early workers had few specimens available to them, their descriptions included narrow ranges of variation in these characters, and later authors continued this tradition (Read, 1967). A scatter diagram of the two most frequently used distinguishing characters (leaflet width and vein number), based on a representative sample of 500 specimens, shows them to be closely associated (FIGURE 1). The correlation coefficient for these characters for all 1043 specimens measured is 0.94, and similar high correlations characterize plants from each of the West Indian subregions (TABLE 1). Thus, 88 percent of the variation in vein number in these cycad leaflets is accounted for by corresponding differences in leaflet width. It is not surprising, therefore, that authors could always find differences in vein number to reinforce differences in leaflet width. In fact, the features are structurally related; no matter

TABLE 1. Correlation coefficients of leaflet width with vein number and leaflet length for *Zamia* in the West Indian region.†

REGION	VEIN NUMBER	n	LEAFLET LENGTH	n
West Indies	0.94***	1043	0.07*	1083
Florida	0.93***	401	0.16**	345
Bahamas	0.97***	69	0.45***	106
Cuba	0.91***	364	0.10*	427
Jamaica	0.86***	11	0.24 n.s.	19
Dominican Republic	0.81***	31	0.31*	46
Puerto Rico	0.94***	167	0.21*	130

† Correlation coefficients significant at: * $p < .05$, ** $p < .01$, *** $p < .001$.

how wide or narrow the leaflets are, there are always about two veins per mm. of width. These veins arise by numerous dichotomies of two original traces from the rachis within the first 4 mm. after they enter the petiole. Rarely, dichotomies may occur before the traces enter the leaflet, so that three or four traces enter, but this is as frequent in narrow leaflets as in wide ones. Thus, two traces enter most leaflets, and these ramify to maintain a relatively constant relation of vascular tissue to other tissues of the blade. Cycad taxonomists were incorrect in using differences in these features as independent differences between West Indian *Zamia* species, and leaflet width will be emphasized in subsequent analyses in this paper.

In contrast to leaflet width and vein number, a scatter diagram of leaflet width vs. leaflet length (FIGURE 2) shows no obvious association, and the low, but mostly significant, correlation coefficients (TABLE 1) argue for the independence of these features within each subregion, as well as within the entire West Indian area. Leaflet length seems, instead, to reflect the general robustness of the plant. For instance, the correlation coefficient of leaflet length with total leaf length is 0.70, and other features are also associated in a loose group of "size" characters that are indepen-

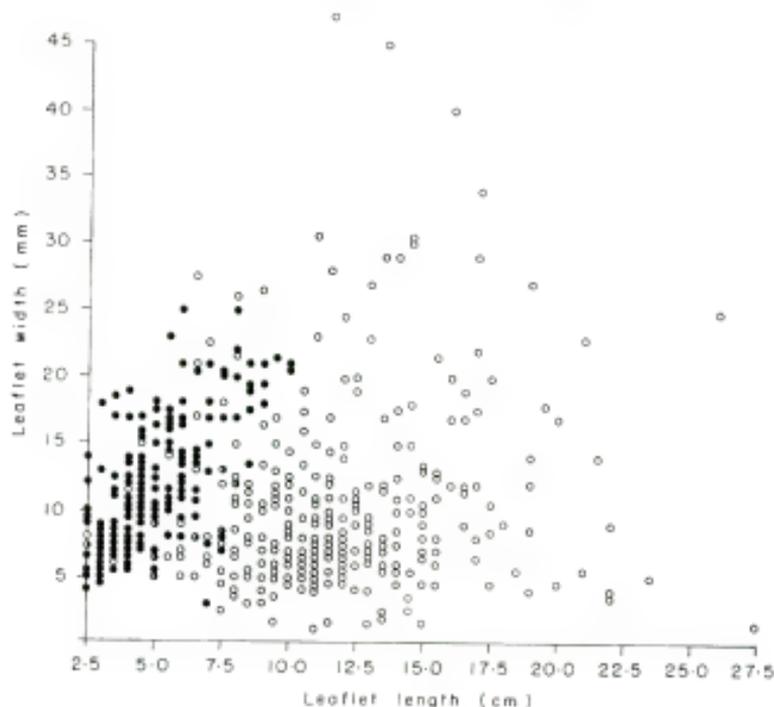


FIGURE 2. Scatter diagram of leaflet width vs. leaflet length of West Indian zamias: circles, *Zamia pumila* subsp. *pumila*; spots, subsp. *pygmaea*; mixed symbols, both subspecies; $n = 500$.

dent of a series of characters associated with leaflet width (Eckenwalder, in prep.). Therefore, leaflet length is used in addition to leaflet width to represent these two sets of vegetative characters in the analyses that follow.

When leaflet widths of individuals are plotted in frequency histograms for the West Indies and for each of its subregions (FIGURE 3), it is apparent that these frequencies follow smooth distributions within areas and sum to a smooth, unimodal distribution for the entire region. These frequency distributions provide little support for recognition of many taxa in the region, a point emphasized by superimposing ranges of leaflet width of species accepted for the West Indies by the most recent comprehensive monographs (Schuster, 1932; Chamberlain, n. d.) onto the overall West Indian histogram (FIGURE 4). Morphological boundaries between taxa accepted by these authors are clearly arbitrary, and the modal width for cycads of the region (6.5–7.5 mm.) is not even included in values for any of Chamberlain's species. If species boundaries are not recognizable in these data, Schuster's further segregation of these cycads among several subsections of the genus seems even less warranted.

Data on leaflet length show a similar trend of smooth distributions within subre-

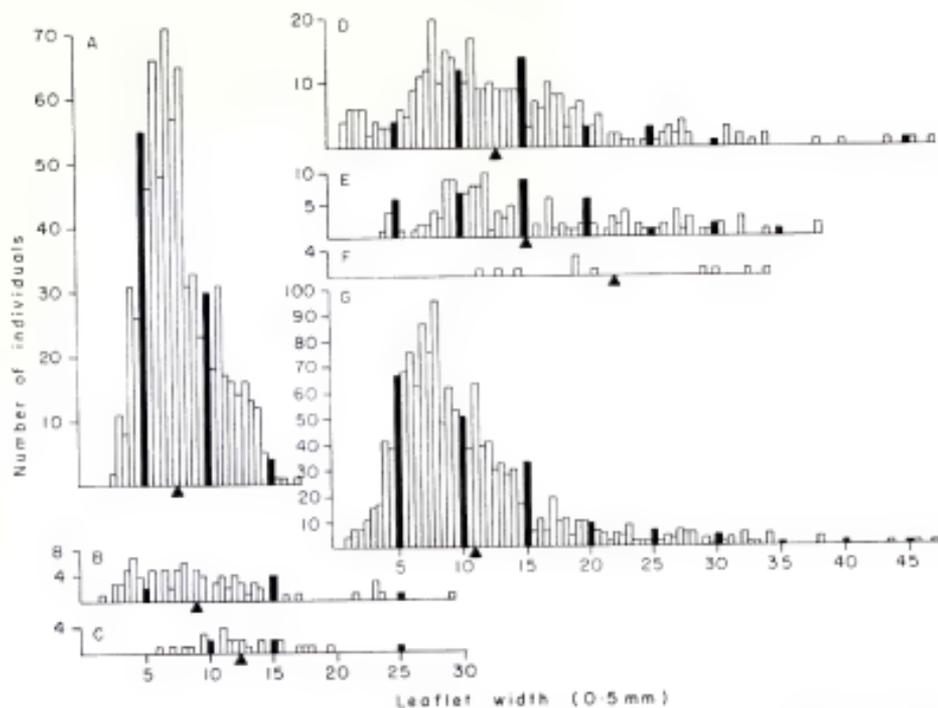


FIGURE 3. Histograms of leaflet widths of zamias of the West Indian region: A, Florida ($n = 754$, $\bar{x} = 7.8$); B, Bahamas ($n = 100$, $\bar{x} = 9.1$); C, Dominican Republic ($n = 31$, $\bar{x} = 12.7$); D, Cuba ($n = 364$, $\bar{x} = 13.1$); E, Puerto Rico ($n = 167$, $\bar{x} = 15.4$); F, Jamaica ($n = 11$, $\bar{x} = 22.4$); G, entire West Indian region ($n = 1427$, $\bar{x} = 10.5$); triangles mark locations of means.

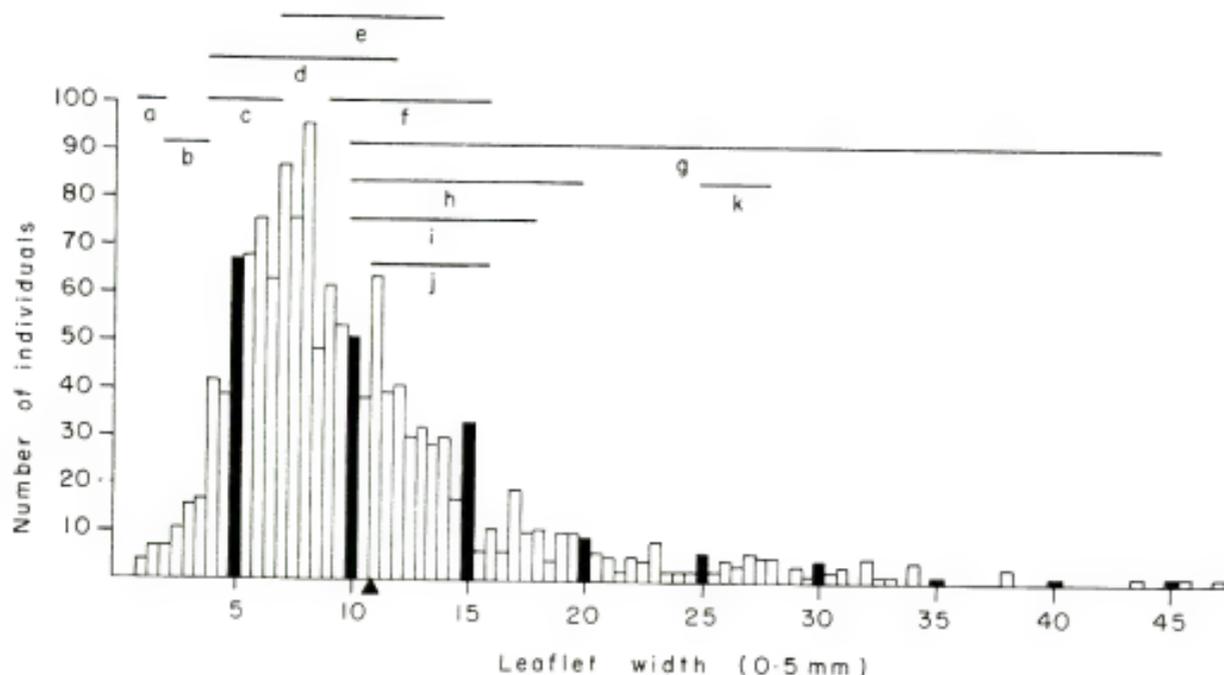


FIGURE 4. Ranges of leaflet width given by Chamberlain (n. d.) for West Indian species of *Zamia* superimposed on frequency histogram of leaflet widths for the entire West Indian region: a, *Z. angustissima*; b, *Z. angustifolia*; c, *Z. floridana*; d, *Z. pygmaea*; e, *Z. silicea*; f, *Z. media*; g, *Z. latifoliolata*; h, *Z. portoricensis*; i, *Z. kickxii*; j, *Z. pumila*; k, *Z. ottonis* (d, e, i, and k are synonyms of *Z. pumila* subsp. *pygmaea*; all others of subsp. *pumila*).

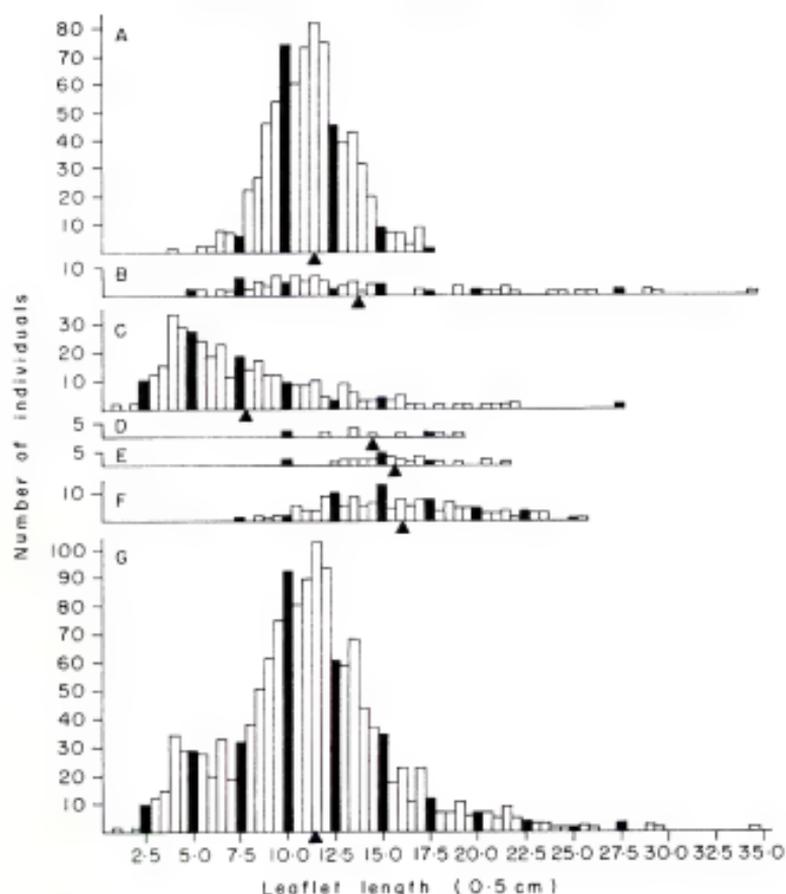


FIGURE 5. Histograms of leaflet lengths of zamias of the West Indian region: A, Florida ($n = 754$, $\bar{x} = 11.3$); B, Bahamas ($n = 100$, $\bar{x} = 13.5$); C, Cuba ($n = 364$, $\bar{x} = 7.6$); D, Jamaica ($n = 11$, $\bar{x} = 14.4$); E, Dominican Republic ($n = 31$, $\bar{x} = 15.5$); F, Puerto Rico ($n = 167$, $\bar{x} = 15.9$); G, entire West Indian region ($n = 1427$, $\bar{x} = 11.1$); triangles mark locations of means.

gions and overall for the West Indies (FIGURE 5). In Cuba, however, cycads I have distinguished as *Zamia pumila* subsp. *pygmaea* contribute to a bimodal distribution of leaflet length. In their extreme form in westernmost Cuba, these smaller plants appear strikingly different from individuals of subsp. *pumila* from eastern Cuba, but there is an uninterrupted cline of intergradation in robustness across the length of the island (FIGURE 6). This cline steepens at the border between the two subspecies in eastern Cuba (MAP 1), so that most individuals can be readily identified to subspecies. With this exception, leaflet length, like leaflet width, provides little evidence

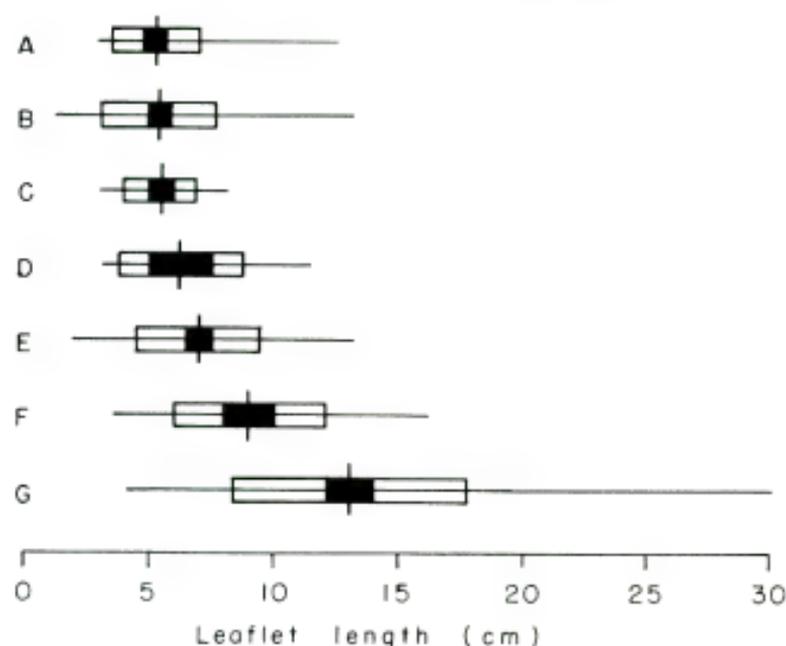
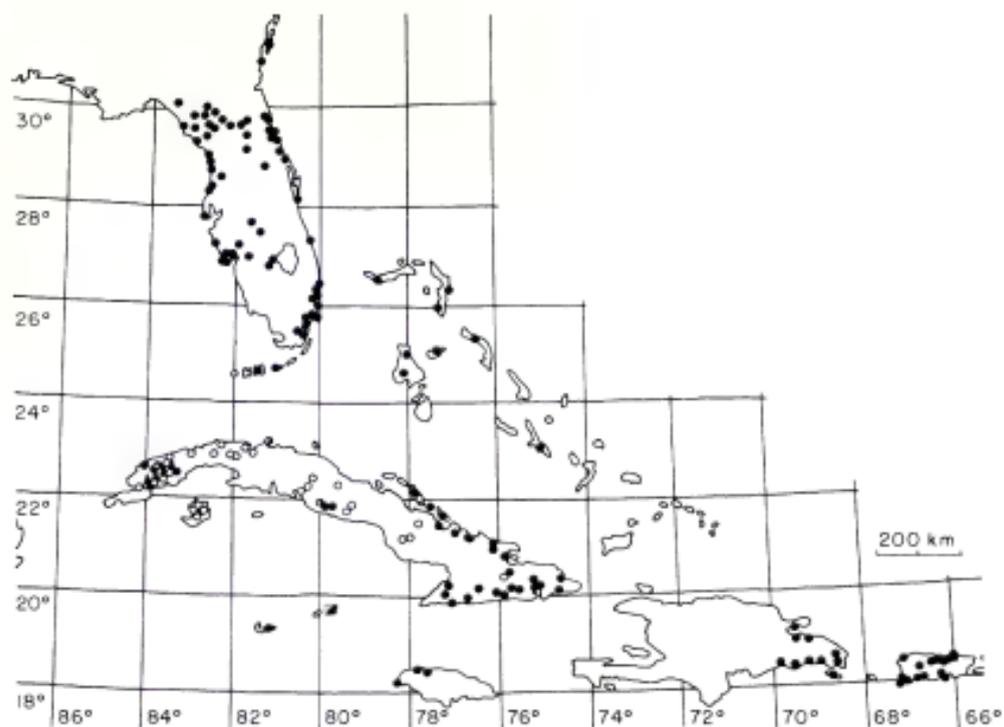


FIGURE 6. Dice-grams of leaflet lengths of Cuban zamias from west to east across island by old provinces: A, Isla de Pinos ($n = 61$, $\bar{x} = 5.2$); B, Pinar del Río ($n = 127$, $\bar{x} = 5.4$); C, Habana ($n = 34$, $\bar{x} = 5.4$); D, Matanzas ($n = 16$, $\bar{x} = 6.2$); E, Las Villas ($n = 130$, $\bar{x} = 7.0$); F, Camagüey ($n = 37$, $\bar{x} = 9.0$); G, Oriente ($n = 112$, $\bar{x} = 13.1$). Horizontal line = range; vertical line = mean; large rectangle = twice the standard deviation; small rectangle = four times the standard error, delimiting 98% confidence interval of mean.

favoring segregation of taxonomic entities among West Indian zamias.

Other characters examined, both vegetative and reproductive, also show continuous variation patterns that discredit the traditional recognition of numerous taxonomic segregates, but I have concentrated on those emphasized by previous workers. Particular combinations of features characterize many distinctive local populations that have been described as species in previous taxonomic treatments. For example, individual islands of the Bahamas have populations of *Zamia* differing markedly in appearance (FIGURES 7, 8; Eckenwalder, in press), and these populations were divided among four species by Britton and Millspaugh (1920). Similarly, Small (1933) recognized four species of *Zamia* in Florida, where plants of coastal hammocks in the northeast (*Z. umbrosa* Small) seem sharply distinct from those of the remainder of the peninsula (*Z. floridana* A. DC.). But distinctive local races that appear to maintain their integrity in particular subregions seem much less distinct in the context of total variation throughout the West Indies. Formal recognition of these variants would be difficult to achieve consistently without further multiplying de-



MAP 1. Distribution of native West Indian cycads: spots, *Zamia pumila* subsp. *pumila*; circles, subsp. *pygmaea* (Cuba only); mixed symbols, intermediates (Cuba only); triangles, *Microcycas calocoma* (Cuba only).

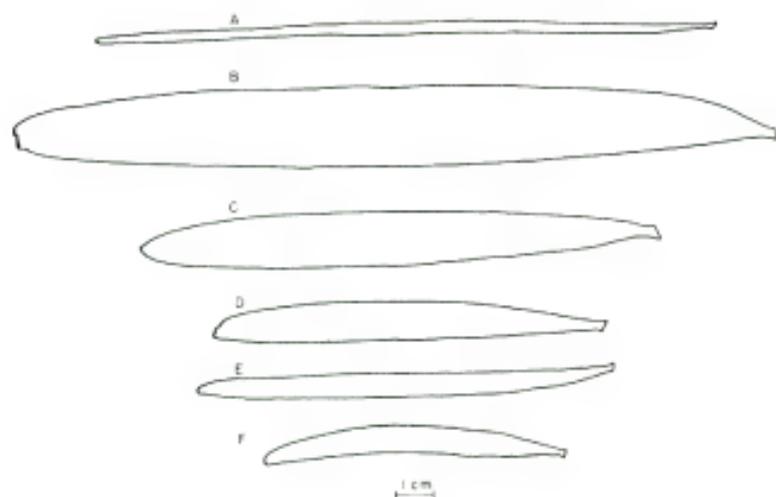


FIGURE 7. Outlines of representative leaflets of Bahamian zamias: A, Eleuthera (Correll & Hill 45240, no); B, Long Island (Britton & Millspaugh 6271, ca)—isotype of *Zamia lucayana*; C, Grand Bahama (Britton & Millspaugh 2576, f); D, Great Abaco (Correll et al. 42713, rTG); E, New Providence (Britton & Brace 704, NY); F, Andros (Brace 6990, f).

scribed entities and would not clarify the biological situation. The distribution of variants is complicated by effective dispersal by both birds and seawater (Eckenwalder, 1980), which has confused what may once have been a more straightforward situation. Now, however, the variation pattern within *Z. pumila* seems taxonomically irresolvable (making the species an ochlopecies, as described by White, 1962, and by Whitmore, 1975), and the course adopted here is to describe and accept variability without formalizing it in a necessarily arbitrary infraspecific hierarchy like that of Schuster (1932).

TAXONOMIC TREATMENT

KEY TO INDIGENOUS WEST INDIAN CYCADS

1. Stems erect, to 20 m. tall; leaves numerous, more than 10 per crown, 10 dm. or more long, with petiole ca. $\frac{1}{2}$ total length of leaf; leaflets drooping, lanceolate, pointed, entire, articulated to rachis by noncallose petiolule 5–8 mm. wide; male and female cones with tawny pubescence, massive, 4 dm. or more long, peduncle less than $\frac{1}{2}$ length of cone; scales of male and female cones with rounded, raised apex; fleshy layer of seed pink or peach. *Microcycas calocoma*.
1. Stems largely subterranean; leaves few, 3 to 12 per crown, 1–8(–15) dm. long, with petiole ca. $\frac{1}{2}$ total length of leaf; leaflets horizontally spreading or ascending, linear, oblong, oblanceolate to obovate, rarely lanceolate, usually blunt, usually with few to many callose teeth apically, articulated to rachis by callose

- petiole 2–5 mm. wide; male and female cones with purple or rusty pubescence, compact, 0.2–2.5 dm. long, peduncle at least $\frac{1}{2}$ length of cone; scales of male and female cones with flat, truncate apex; fleshy layer of seed orange or red. *Zamia pumila*.
2. Plants robust, stems 2.5 cm. or more in diameter; leaves 4–8(–15) dm. long; leaflets 5–25(–35) cm. long, usually linear or oblong, usually revolute with thickened margin, thick and leathery; cones 0.5–2.5 dm. long. *Z. pumila* subsp. *pumila*.
2. Plants dwarfed, stems 2.0 cm. or less in diameter; leaves 0.3–6(–10) dm. long; leaflets 2.5–7(–10) cm. long, often obovate, margin thin, thin and fragile; cones 0.2–1.0 dm. long. *Z. pumila* subsp. *pygmaea*.

Microcycas calocoma (Miq.) A. DC. Prodr. 16(2): 538. 1868.

Zamia calocoma Miq. in Van Houtte, Fl. Serres Jard. Eur. 7: 141. 1851. TYPE: Cuba, cult. Hort. Amstelod., *Miquel s.n.* (holotype, 1).

ILLUSTRATIONS: Caldwell, Bot. Gaz. (Crawfordsville) 44: figs. 10–14. 1907; Caldwell & Baker, Bot. Gaz. (Crawfordsville) 43: fig. 1. 1907; Schuster, Pflanzenr. 99: figs. 6P, 8K; pl. 5. 1932.

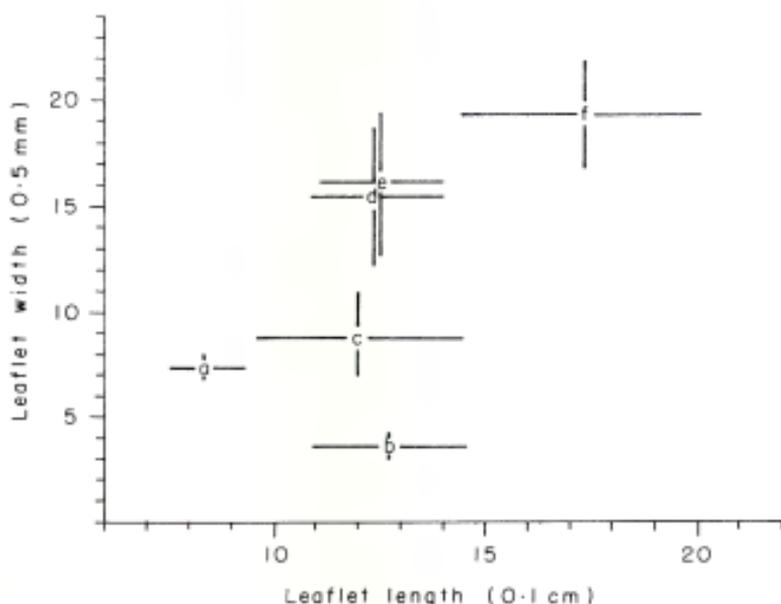


FIGURE 8. Plot of means of leaflet width (\bar{y}) vs. leaflet length (\bar{x}) for zamias from different Bahamian islands: a, Andros ($n = 27$, $\bar{x} = 8.4$, $\bar{y} = 7.3$); b, Eleuthera ($n = 24$, $\bar{x} = 12.7$, $\bar{y} = 3.6$); c, New Providence ($n = 9$, $\bar{x} = 12.0$, $\bar{y} = 8.8$); d, Great Abaco ($n = 11$, $\bar{x} = 12.4$, $\bar{y} = 15.4$); e, Grand Bahama ($n = 18$, $\bar{x} = 12.5$, $\bar{y} = 16.1$); f, Long Island ($n = 17$, $\bar{x} = 17.3$, $\bar{y} = 19.3$); horizontal and vertical lines represent twice the standard error on each side of mean.

Arborescent, sparingly branched cycads up to 20 m. tall; crown formed by 10 to 50 pinnate leaves; leaves 1–2 m. long, emerging in annual flushes, covered by transient, mealy, tawny pubescence; leaflets 50 to 80 pairs, 8–20 cm. long, lanceolate, reflexed, caducous after 1–3 years from more persistent rachis, the rachis falling after 4 or 5 years, leaving an armor of persistent leaf bases that eventually abscise, the older portions of trunk developing shallowly furrowed, thin bark; male and female cones annual, 1 or 2, emerging from among scale leaves of crown, massive, 4–7 dm. long, with 500 to 1500 peltate hexagonal scales in ca. 20 straight rows, the external face tawny-pubescent, with raised, rounded knob; outer fleshy layer of seed coat light pink, turning peach at maturity, seed 2.5–3 cm. long. $n = 13$ (Sax & Beal, 1934).

DISTRIBUTION. Endemic to woodlands of canyons and foothills of the Sierra del Rosario in Pinar del Río Province, western Cuba (MAP 1), where it is apparently rare (Caldwell, 1926). Although the species is in little immediate danger of extinction because it is not commercially exploited and because the slopes on which it grows are unsuitable for cultivation, it is listed in Appendix 1 of the International Convention on Trade in Threatened and Endangered Species (Ayensu & DeFilippis, 1978).

REPRESENTATIVE SPECIMENS. **Cuba.** PINAR DEL RÍO. Britton *et al.* 9637 (NY), Ekman 10845 (US), 18186 (NY), Shafer 13750 (NY, US), 13882 (NY, US), Van Hermann 3322 (NY, US).

Microcycas is scarcely differentiable from *Zamia*. When this Cuban endemic was first elevated to generic rank by de Candolle (1868), the majority of known species of *Zamia* were low, West Indian or Mexican plants that were superficially very different in stem, foliage, and cone from the massive *Z. calocoma*. Later, chromosome counts of $n = 8$ for species retained in *Zamia* seemed to confirm their isolation from the $n = 13$ *Microcycas* (Sax & Beal, 1934). Embryological features, as well as the greater number of both spermatozooids and archegonia, were unique to *Microcycas* among all cycads studied and also reinforced separation of the two genera (Chamberlain, 1935). The only character used to separate the two genera in generic keys to the cycads, however, has been the flattened knob of the male cone scales of *Microcycas*, compared to the truncate microsporophyll of *Zamia* (de Candolle, 1868; Schuster, 1932). In recent years, increasing access to arborescent species of *Zamia* from forests of Central and South America have eliminated many apparent differences between *Zamia* and *Microcycas*. Living plants of these formerly little-known species are becoming available for study at Fairchild Tropical Garden and other institutions. The taxonomy of these species is unresolved, but some of them have individual leaf and leaflet or cone characteristics of *M. calocoma*. None duplicates the combination of characters found in the Cuban cycad, but collectively they possess all of the gross morphological features formerly thought to distinguish *Microcycas* from *Zamia*. *Zamia*, formerly considered to be chromosomally uniform with $n = 8$, has been shown to have a diversity of chromosome numbers up to the $n = 13$ formerly thought to be confined among cycads to *Microcycas* (Norstog, 1974, and in press). Recent anatomical work has further shown that *Zamia* and *Microcycas* share an unusual branched hair type not found in other cycads, including the related genus *Ceratozamia* Brongn. (D. W. Stevenson, pers. comm.). The only features now

remaining that distinguish the two genera are the extreme proliferation of both archegonia and spermatozoids in *Microcycas*. Embryology of the arborescent zamias of Tropical America is virtually unknown (Norstog, 1977), and a decision to return *M. calocoma* to the genus *Zamia*, although likely in the future, should await embryological investigation of *Z. chigua* Seem. and its allies. *Microcycas calocoma* was probably isolated in the West Indies by the same events that isolated *Z. pumila*. It has probably diverged from Central American arborescent zamias just as *Z. pumila* diverged from its closest relatives in the Central American *Z. furfuracea* complex.

Zamia pumila L. subsp. *pumila*

- Zamia pumila* L. Sp. Pl. ed. 2: 2: 1659. 1763. LACTOTYPE: Palma prunifera humilis non spinosa, insulae hispaniolae, fructui jujubino similis, ossiculo triangulo, *J. Commelinj*, Horti Med. Amstelod. 1: t. 58. 1697 (lectotype, AMS; imprints, Hunt Inst., NY!). *Palmifolium pumilum* (L.) Kuntze, Rev. Gen. Pl. 2: 803. 1891. *Zamia debilis* Aiton, Hortus Kew. 3: 478. 1789. *nomen illegit.* *Palmifolium debile* (Aiton) Kuntze, Rev. Gen. Pl. 2: 803. 1891. *Zamia humilis* Salisb. Prodr. 400. 1796, *sphalm.* *Zamia media* var. *commeliniana* Schuster, Pflanzenr. 99: 155-157. 1932.
- Zamia integrifolia* Aiton, Hortus Kew. 3: 478. 1789. TYPE: Florida, cult. Kew, Aiton s.n. (holotype, BM; tracing, NY!). *Palmifolium integrifolium* (Aiton) Kuntze, Rev. Gen. Pl. 2: 803. 1891. *Zamia floridana* var. *purshiana* Schuster, Pflanzenr. 99: 151. 1932.
- Zamia angustifolia* Jacq. Ic. Pl. Rar. 3: t. 636. 1791. TYPE: Bahamas, cult. Hort. Vindob. (lectotype, pl. 636). *Palmifolium angustifolium* (Jacq.) Kuntze, Rev. Gen. Pl. 2: 803. 1891.
- Zamia media* Jacq. Pl. Rar. Horti Caes. Schoenbr. 3: 77, 78. tt. 397, 398. 1798. TYPE: West Indies, cult. Hort. Schoenbr. (lectotype, pl. 398). *Palmifolium medium* (Jacq.) Kuntze, Rev. Gen. Pl. 2: 803. 1891. *Zamia media* var. *jacquiniana* Schuster, Pflanzenr. 99: 157, 158. 1932, *nomen illegit.*
- Zamia tenuis* Willd. Sp. Pl. ed. 5: 4: 846. 1806. TYPE: Bahamas, cult. Hort. Berol., Willdenow s.n. (holotype, B; isotype (frag.), NY!). *Palmifolium tenue* (Willd.) Kuntze, Rev. Gen. Pl. 2: 803. 1891. *Zamia media* var. *tenuis* (Willd.) Schuster, Pflanzenr. 99: 158. 1932.
- Zamia dentata* Voigt, Syll. Pl. Nov. 2: 53. 1828.
- Zamia angustissima* Miq. Nieuwe Verh. Eerste Kl. Kon. Ned. Inst. Wetensch. Amsterdam, ser. 3: 4: 184. 1851. TYPE: trop. Amer. [Cuba], cult. Hort. Amstelod., Miquel s.n. (holotype, L). *Zamia angustifolia* var. *angustissima* (Miq.) Regel, Gartenflora 27: 13. 1878. *Palmifolium angustissimum* (Miq.) Kuntze, Rev. Gen. Pl. 2: 803. 1891.
- Zamia stricta* Miq. Nieuwe Verh. Eerste Kl. Kon. Ned. Inst. Wetensch. Amsterdam, ser. 3: 4: 183. 1851. TYPE: trop. Amer. [Cuba], cult. Hort. Amstelod., Miquel s.n. (holotype, L). *Zamia angustifolia* var. *stricta* (Miq.) Regel, Gartenflora 27: 13. 1878. *Palmifolium strictum* (Miq.) Kuntze, Rev. Gen. Pl. 2: 803. 1891.
- Zamia yatesii* Miq. Nieuwe Verh. Eerste Kl. Kon. Ned. Inst. Wetensch. Amsterdam, ser. 3: 4: 182. 1851. TYPE: trop. Amer. [Cuba], cult. Hort. Amstelod., Miquel s.n. (holotype, L). *Zamia angustifolia* var. *yatesii* (Miq.) Regel, Garten-

- flora 27: 13, 1878. *Palmifolium yatesii* (Miq.) Kuntze, Rev. Gen. Pl. 2: 803, 1891.
- Zamia floridana* A. DC. Prodr. 16(2): 544, 1868. LECTOTYPE: E. Florida, Fort Brooke, *Hulse s.n.* (holotype, G-DC; isotype, NY!). *Zamia angustifolia* var. *floridana* (A. DC.) Regel, Gartenflora 27: 13, 1878. *Palmifolium floridanum* (A. DC.) Kuntze, Rev. Gen. Pl. 2: 803, 1891.
- Zamia multifoliolata* A. DC. Prodr. 16(2): 545, 1868. TYPE: Cuba [Oriente], San Juan de Buenavista, *Wright 597* (holotype, G-DC; isotypes, GH!, MO!, NY!, US!). *Palmifolium multifoliolatum* (A. DC.) Kuntze, Rev. Gen. Pl. 2: 803, 1891.
- Zamia lauiifoliolata* Prenl. Bull. Soc. Vaud. Sci. Nat. 11: 278, 1872. TYPE: Republica Dominicana, road to Punto de la Torrecilla, *Prenleoup s.n.* (holotype, LAU).
- Zamia concinna* Hort. Booth ex Regel, Gartenflora 27: 9, 1878, *nomen inval.* (*pro syn.* *Z. pumila* L.).
- Zamia cylindrica* Hort. Booth ex Regel, Gartenflora 27: 9, 1878, *nomen inval.* (*pro syn.* *Z. pumila* L.).
- Zamia linifolia* Hort. Pawl. ex Regel, Gartenflora 27: 13, 1878, *nomen inval.* (*pro syn.* *Z. angustifolia* Jacq.).
- Zamia linearifolia* Linden, Ill. Hort. 28: 32, 1881, *nomen nudum*.
- Zamia portoricensis* Urban, Symb. Antill. 1: 291, 1899. TYPE: Puerto Rico, Mayagüez, prope Guanica in sylva ad Ensenada, *Sietenis 3782* (holotype, B, isotype (frag.), NY!). *Zamia media* var. *portoricensis* (Urban) Schuster, Pflanzenr. 99: 158, 1932.
- Zamia allison-armourii* Millsp. Publ. Field Columbian Mus., Bot. Ser. 2: 23, 1900. TYPE: Republica Dominicana, Distrito Nacional, near river flowing into Santo Domingo, *Millspaugh 817* (holotype, F!; isotype, NY!).
- Zamia erosa* Cook & Collins, Contr. U. S. Natl. Herb. 8: 267, 1903. LECTOTYPE (here designated): Puerto Rico, Ponce, Coamo Springs, *Cook s.n.* (lectotype, NY!; isolectotype, NY!).
- Zamia lucayana* Britton, Bull. New York Bot. Gard. 5: 311, 1907. TYPE: Bahamas, Long Island, Clarence Town and vicinity, *Britton & Millspaugh 6271* (holotype, NY!; isotypes, F!, GH!, NY!).
- Zamia umbrosa* Small, J. New York Bot. Gard. 22: 136, 1921. LECTOTYPE (here designated): Florida, Volusia, Daytona Beach, *Small 8679* (lectotype, NY!; isolectotypes, DUKE!, FLAS!, GH!).
- Zamia silvicola* Small, J. New York Bot. Gard. 27: 128, figs. 1, 2, 1926. TYPE: Florida, Citrus, "Spanish Mound" near Crystal River, *Small, Small, & DeWinkeler 10060* (holotype, NY!). *Zamia floridana* var. *purshiana* f. *silvicola* (Small) Schuster, Pflanzenr. 99: 152, 1932.
- Zamia brachyphylla* Hort. ex Schuster, Pflanzenr. 99: 159, 1932, *nomen inval.* (*pro syn.* *Z. angustifolia* Jacq.).
- Zamia linearis* Miq. ex Schuster, Pflanzenr. 99: 159, 1932, *nomen inval.* (*pro syn.* *Z. angustifolia* var. *yatesii* (Miq.) Regel).
- Zamia media* var. *guterrezi* f. *calcicola* Schuster, Pflanzenr. 99: 155, 1932. TYPE: Cuba, Pinar del Río, Baños de San Vicente, *Britton, Britton, & Gager 7392* (holotype, B, isotypes, CA!, NY!). *Zamia calcicola* Britton ex Schuster, Pflanzenr.

- 99:** 155. 1932, *nomen inval.* (*pro syn.* *Z. media* var. *gutierrezii* f. *callicola* Schuster).
- Zamia media* var. *jacquiniana* f. *brevipinnata* Schuster, *Pflanzenr.* **99:** 158. 1932. LECTOTYPE (here designated): Cuba, Oriente, Holguín to Myabe, *Shafer 1406* (lectotype, ♀; isolectotypes, ♂!, NY!).
- Zamia subcoriacea* Wendl. ex Schuster, *Pflanzenr.* **99:** 155. 1932, *nomen inval.* (*pro syn.* *Z. media* var. *commeliniana* Schuster).
- Zamia verbruggiana* Hort. ex Schuster, *Pflanzenr.* **99:** 159. 1932, *nomen inval.* (*pro syn.* *Z. angustifolia* var. *yatesii* (Miq.) Regel).
- Zamia guggenheimiana* Carabia, *Caribbean Forest.* **2:** 89. 1941. TYPE: Cuba, Oriente, Pílon, Ensenada de Mora, Manzanillo, *Carabia 1403a* (holotype, NY!; isotype, F!).

ILLUSTRATIONS: Small, *J. New York Bot. Gard.* **27:** *figs. 1, 2.* 1926; Victorin & León, *Itin. Bot. Cuba, figs. 33-37, 283, 284.* 1942.

Cycads with short, preponderantly underground stems, 2.5-6 cm. in diameter, these often highly branched in apparent dichotomies; crown formed by (1 to) 4 to 8 (to 12) pinnate leaves; leaves (1-3-7(-16) dm. long, emerging in annual or irregular flushes, covered by transient, rusty, filamentous pubescence; the leaflets (2 to) 10 to 30 (to 45) pairs, (4-)8-20(-35) cm. long, linear, lanceolate, oblong, or oblanceolate, horizontally spreading to secund, caducous after 1 or 2 years, only shortly before rachis, rachis abscising with leaf bases to leave smooth stem; male and female cones annual, long peduncled, with peltate, hexagonal scales in vertical files, the external face of scales rusty or dark purple pubescent, faceted, with flat center, the male cones 1 to 8 (to 63), emerging from among inner leaves of crown, 4-6.5(-13) cm. long, with 9 to 15 scales in each of 6 to 11 rows, the female cones solitary, terminal, more massive than males, 6-10(-20) cm. long, with 3 to 5 scales in each of 5 or 6 rows; outer fleshy layer of ovular seed coat pink, turning bright orange or red at maturity, seed 1-2.5 cm. long. *n* = 8 (Sax & Beal, 1934).

DISTRIBUTION. Found sporadically throughout the native range of cycads in the West Indian region, but absent from Haiti and many of the Bahamas and rare in western Cuba, where it is replaced by subsp. *pygmaea* (see MAP 1). It occurs in a variety of habitats ranging from open sea bluffs and sand dunes, through pine and oak savannas, to closed-canopy oak hammocks and tropical forests. It is most common near sea level on limestone and sand but also occurs on other substrates. Morphological features of leaflet width, attitude, and thickness are associated with habitat differences, apparently affected by both genetic and environmental components (Eckenwalder, unpubl. data). The plants are frequently cultivated for ornament in their native regions and were formerly the basis of a starch-extraction industry (Small, 1921). Habitat destruction is the major current threat to them, especially in Florida, where residential development is leading to a drastic decline in number. The subspecies is listed as threatened in Florida (Ward & Pritchard, 1979).

REPRESENTATIVE SPECIMENS. **Florida.** ALACHUA: *Small 8450* (MO, NCU, NY), *D. & S. Ward 1838* (FLAS, FSU, NCU, US, USF), *Weber S.H.* (F, NY, US). BROWARD: *Moldenke 504*

(DUKE, MO, NY), *Sandler s.n.* (FAU), *Seibert 1168* (A, MO), *Citrus Baltzell 4724* (FLAS), *Lakela 26820* (USF), *Small 10387* (NY), DADE: *Beckner 1775* (FLAS, FSU, USF), *Curtiss 2676* (A, GA, GH, MD, NY, US, USF), *Demaree 10237* (MO, UC, US), *Tracy 9265* (F, GH, MO, NY, TEX, US), *Dixie Harbison 57* (A, NCU, US), *Gilchrist Ward & Ford 3588* (FLAS, NCU, USF), GLADES: *Ward et al. 2423* (FLAS, GH, USF), HERNANDO: *Small et al. 10067* (DUKE, MO, NCU, NY), HILLSBOROUGH: *Blanton 6921* (F, MO, US), *Levy: Evers s.n.* (FLAS), *Godfrey & Redfearn 52834* (DUKE, FSU, GH, NY, USF), *Miller 339* (US), *Murrill s.n.* (MO), MARION: *Mather M-172* (FLAS, GA), *Norstog s.n.* (NY, USF), *Schuster A-258-a* (DUKE, FSU), ST. JOHN'S: *Smith 522* (F, GH, US), *Ward & Moore 2362* (FLAS, FSU, NCU, USF), SARASOTA: *Simpson 394* (F, GH, NY, US), SEMINOLE: *Beckner 884* (FLAS, FSU, GA), TAYLOR: *Godfrey & Redfearn 52817* (DUKE, FSU, GH, NCU, NY, UC, USF), VOLUSIA: *Brown s.n.* (NCSC), *Curtiss 2676b* (F, GA, MO, NY, US, USF), *Read 1046* (A, FTG), *Small 8679* (DUKE, FLAS, GH, NY), **Georgia**, *Camden Proctor s.n.* (GA), *Glyn Duncan 23659* (GA), **Bahamas**, GREAT ABACO: *Brace 1746* (F, NY), *Correll et al. 42577* (FTG), ANDROS: *Brace 6990* (F, NY), *Hill 3183* (F, FTG, NY), ELEUTHERA: *Britton & Millspaugh 5418* (F, NY, UC, US), *Correll & Hill 45240* (F, FTG, LL, MO, NY), GRAND BAHAMA: *Brace 3693* (F, GH, MO, NY, US), *Britton & Millspaugh 2576* (F, NY, US), LONG ISLAND: *Hill 828* (F, GH, MO, NY, US), *2334* (FTG, NY), NEW PROVIDENCE: *Britton & Brace 704* (F, NY), **Cuba**, CAMAGUEY: *Shafer 679* (F, NY, US), *793* (F, NY, US), *2659* (F, NY, US), ISLA DE PINOS: *Carabia 1190* (F), LAS VILLAS: *Britton & Wilson 5443* (F, NY), *Gonzales 381* (A), *León & Carabia 19074* (F), *Shafer 12198* (NY, US), MATANZAS: *Carabia 1992* (F), ORIENTE: *Britton & Cowell 12742* (MO, NY, US), *Carabia 3523* (F), *Hioram 4924* (F, GH, NY), *León & Alain 18934* (F, GH), *Pollard & Palmer 141* (F, GH, MO, NY, US), *382* (F, GH, MO, NY, US), *Shafer 1406* (F, NY, US), *Victorin 60037* (GH, MO, NY, US), *Wright 1463* (F, GH, MO), PINAR DEL RIO: *Baker 28944* (NY), *Carabia 3189* (F), *Van Hermann 7153* (F, GH), **Jamaica**, ST. ANN: *Clift s.n.* (FTG), *Howard & Proctor 15114* (A), TRELAWNY: *Proctor 31556* (F, GH, LL), WESTMORELAND: *Britton & Hollick 2070* (NY), *Clift s.n.* (FTG), *Harris 10229* (NY, US), **Cayman Islands**, GRAND CAYMAN: *Kimbe s.n.* (FTG), *Osment s.n.* (FTG), **Dominican Republic**, ALTAGRACIA: *R. & E. Howard 9774* (GH, NY, US), *Logier 12341* (GH, NY, US), DISTRITO NACIONAL: *Allard 13572* (US), *Ekman 5800* (GH, US), *Rose et al. 3783* (NY, US), ROMANA: *Crafts 115* (DAV), *Miller 1001* (US), *Taylor 352* (F, NY), SAMANA: *Abbott 1158* (US), *Logier 14383* (NY, US), SAN PEDRO DE MACORIS: *Augusto 691* (NY), *R. & E. Howard 9494* (GH), *Rose et al. 3707* (F, NY, US), SEIBO: *Jiménez 5052* (NY), *Miller 1014* (US), *Taylor 112* (NY), **Puerto Rico**, AGUADILLA: *N. & E. Britton 9282* (NY), ARECIBO: *Blomquist 11984* (DAV, DUKE, MO, TEX), *Stimson 3816* (DUKE, MICH, MO, NY), *Underwood & Griggs 847* (F, MICH, NY, US), MAYAGUEZ: *Britton & Shafer 1832* (F, MO, NY, US), *Chamberlain s.n.* (F), *Sintenis 763* (GH, US), *Stimson 3272* (DUKE), PONCE: *Britton et al. 1768* (NY, US), *Britton 8557* (F, GH, MO, NY, US), *Heller s.n.* (US), SAN JUAN: *Britton et al. 2855* (F, NY, US), *Goll 857* (NY, US), *A. & G. Heller 397* (F, NY, US).

Zamia pumila is distinguished from other species of the genus by its low stature, underground stems, unarmed petioles, sparsely toothed, often rounded leaflets, small, long-peduncled cones with rusty or purple pubescence, and low-faceted cone scales. Although all of these features are found individually in other species of the genus, the combination is unique to the West Indian plants. This species is most closely related to the Mexican and Central American *Z. furfuracea*, which differs in being more robust and in having larger, spiny-petioled leaves, tougher, more serrate leaflets, longer-peduncled cones with tawny pubescence, and smaller red seeds.

As noted above, *Zamia pumila* subsp. *pumila* is very variable in leaflet form both within and between West Indian subregions. It was initially expected that varieties

would be recognized within the subspecies. This would give some taxonomic recognition to the diversity, which is particularly troublesome in an area such as the Bahamas, where individual islands have distinctive, relatively homogeneous populations (FIGURES 7, 8; Eckenwalder, in press). This expectation was abandoned because of lack of morphological discontinuities in specimens of the subspecies from throughout its range. No coherent system of varieties could be devised that was not as arbitrary and as typological (in the perjorative sense) as the earlier systems of species here replaced with the present broadened concept. Local botanists are thus left with the somewhat unsatisfactory circumstance of not being able to give taxonomic recognition to distinctive variants that occur in their region and that intergrade only in some less familiar ground. The capacity for long-distance dispersal by seawater has evidently aggravated this situation (Eckenwalder, 1980).

Zamia pumila L. subsp. **pygmaea** (Sims) Eckenwalder, stat. et comb. nov. BASIONYM. *Zamia pygmaea* Sims, Bot. Mag. **43**: t. 1741, 1815. TYPE: W. Indies [Cuba], cult. Hort. Loddiges, Salisbury s.n. (holotype, BM!). *Palmifolium pygmaeum* (Sims) Kuntze, Rev. Gen. Pl. **2**: 803, 1891.

Zamia kickxii Miq. Monogr. Cycad. **71**, t. 8, fig. A, 1842. TYPE: Cuba, cult. Hort. Ghent, *Kickx s.n.* (holotype, G). *Palmifolium kickxii* (Miq.) Kuntze, Rev. Gen. Pl. **2**: 803, 1891. *Zamia pygmaea* var. *kickxii* (Miq.) Schuster, Pflanzenz. **99**: 152, 1932.

Zamia ottonis Miq. Linnæa **17**: 740, 1843. TYPE: Cuba, Matanzas, San Antonio Fundador de Caminar, *Otto 36* (holotype, L; isotypes, B, SV (frag.)). *Palmifolium ottonis* (Miq.) Kuntze, Rev. Gen. Pl. **2**: 803, 1891. *Zamia pygmaea* var. *ottonis* (Miq.) Schuster, Pflanzenz. **99**: 153, 1932.

Zamia pygmaea var. *wrightii* A. DC. Prodr. **16**(2): 543, 1868. TYPE: Cuba, Sabanas Chirigati, *Wright 3192* (holotype, G DC; isotypes, BM!, GH!, MO!). *Zamia chamberlainii* Schuster, Pflanzenz. **99**: 153, 1932.

Zamia silicea Britton, Bull. Torrey Bot. Club **43**: 462, 1916. TYPE: Cuba, Isla de Pinos, vicinity of Los Indios, Britton, Britton, & Wilson 14166 (holotype, NY!; isotypes, F!, GH!, US!). *Zamia media* var. *commeliniana* f. *silicea* (Britton) Schuster, Pflanzenz. **99**: 157, 1932.

Zamia rotundifolia Hort. ex Schuster, Pflanzenz. **99**: 152, 1932, *nomen inval.* (pro syn. *Z. pygmaea* var. *kickxii* (Miq.) Schuster).

ILLUSTRATIONS: Victorin & León, Itin. Bot. Cuba, figs. 113, 114, 173, 181, 189, 1942.

Cycads differing from subsp. *pumila* primarily in smaller stature, with few differences of proportion; stems 0.5–2 cm. in diameter; leaves (0.5–)1–4(–7) dm. long; leaflets 1–7(–10) cm. long, narrowly oblong to obovate, typically shorter and more numerous with respect to total leaf length than in subsp. *pumila*, much thinner in texture and more fragile; male cones 1.5–5 cm. long; female cones 2.5–7 cm. long; seeds 1–1.5 cm. long. *n* = 8 (Norstog, in press).

DISTRIBUTION. Dwarf cycads are endemic to western Cuba and Isla de Pinos (MAP 1) and intergrade with subsp. *pumila* eastward across the main island (FIGURE 6). These cycads typically occur in open limestone and serpentine communities, but the most robust individuals grow in moist forests of ravines on isolated mogotes (limestone

hills) from Pinar del Río Province to Las Villas Province. Here they may be replaced by subsp. *pumila*. They are uncommon in cultivation and are apparently relatively little affected by human activities.

REPRESENTATIVE SPECIMENS. **Cuba.** CAMAGÜEY: Britton 2386 (NY), Britton et al. 13166 (NY), *Carabia* 3405 (f). HABANA: Britton et al. 638 (f, NY), 6267 (NY), *Carabia* 1869 (f). ISLA DE PINOS: Britton & Wilson 14877 (NY, US), *Carabia* 983 (f), Killip 42674 (GH, US). LAS VILLAS: Britton et al. 10233 (NY, US), Combs 647 (GH), Howard et al. 290 (A. LL. MICH. NY. UC), Luna 585 (f, NY). MATANZAS: Britton & Wilson 420 (NY), *Carabia* 1591 (f), Van Hermann 913 (f, NY). PINAR DEL RÍO: Britton et al. 9664 (NY, US), Shafer & León 13713 (f, GH, NY), Van Hermann 2652 (f, NY, UC).

Zamia pumila subsp. *pygmaea* is the smallest living cycad. Although the largest individuals overlap subsp. *pumila* in total leaf length, the leaflets are proportionately shorter and broader than on corresponding plants of the more widespread subspecies, the stems are more slender, and the male and female cones and seeds are somewhat smaller. Chamberlain apparently crossed the two subspecies and obtained hybrids, some of which reached Fairchild Tropical Garden during the dispersion of his living collection after his death. These uncertainly documented plants appear intermediate, normal, and fertile. In all respects, plants of subsp. *pygmaea* resemble miniature versions of subsp. *pumila*. The differences are preserved after twenty years of cultivation at Fairchild Tropical Garden, so they are presumably genetically based. The evident similarity of the dwarf plants to subsp. *pumila* and their intergradation with the more robust plants argue against their recognition at a higher taxonomic rank.

INTRODUCED CYCADS

Zamia furfuracea Aiton. Hortus Kew. 3: 477. 1789.

- Zamia gutierrezii* Sauvalle. Anales Acad. Ci. Méd. Habana 5: 54. 1868. TYPE: Cuba, Pinar del Río, cult. Hort. Blain, Rangel (holotype, n.v.; isotypes, f!, NY!).
Zamia media var. *gutierrezii* (Sauvalle) Schuster. Pflanzenz. 99: 154. 1932.
Palma pumila Miller. Gard. Dict. ed. 8, no. 9. 1768. LECTOTYPE: Palma fructu clavato polypreno. C. J. Trew. Pl. Selec. t. 26. 1752?

As noted both by *Carabia* (1941) and in correspondence associated with herbarium specimens at GH, this Mexican and Central American species has been cultivated for more than a century in the West Indian region. Plants growing in what was once a botanic garden in Cuba were renamed by Sauvalle and were considered as a West Indian endemic. Schuster (1932) incorrectly believed that these represented the widespread, particularly robust phase of *Zamia pumila* subsp. *pumila* (called *Z. latifoliolata* Prenl. by many authors) and made a combination appropriate to that view. *Zamia furfuracea* is contrasted with *Z. pumila* in the discussion of subsp. *pumila*. The two species may hybridize when brought together, and putative hybrids of this parentage can be found at Fairchild Tropical Garden.

Cycas circinalis L. Sp. Pl. 2: 1188. 1753.

Cycas revoluta Thunb. Fl. Japon. 229, 1784.

Cycas rumphii Miq. Bull. Sci. Phys. Nat. Néerl. 2: 45, 1839.

The familiar Asiatic sago palms are widely cultivated in the West Indies, as in all tropical and subtropical regions. They are arboresecent cycads readily distinguished from the native plants by their leaflets with a midrib, and by their large seeds borne on elongate sporophylls not aggregated into compact cones but appearing in flushes alternating with flushes of foliage leaves. These most-isolated cycads are often retained as the sole extant genus of Cycadaceae, while other genera with distinct, pedunculate, megasporangiate strobili (Johnson, 1959) are segregated to the Zamiaceae (and Stangeriaceae).

ACKNOWLEDGMENTS

I thank the curators and directors of institutions whose living and preserved specimens I examined. I also thank my former colleagues at Fairchild Tropical Garden for numerous and varied contributions. A National Science Foundation grant to D. S. Correll supported some field work in the Bahamas. Financial support from Fairchild Tropical Garden contributed to extensive field work in Florida. Jack, Spencer, Susan, and others cracked the whip.

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DEPARTMENT OF BOTANY
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 CANADA

DICOTYLEDONOUS WOOD FROM THE UPPER CRETACEOUS
OF CENTRAL CALIFORNIA, II

VIRGINIA M. PAGE

THE PRESENT REPORT is the second in a series describing the results of an investigation of an assemblage of woods from the Upper Cretaceous of central California. As reported in the first paper (Page, 1979), most of the fossil specimens were collected from three localities, considered to be Maastrichtian in age, situated in the foothills of the Mt. Diablo Range, west of the town of Patterson in Stanislaus County: locality 1 (Del Puerto Creek); locality 2a (Black Gulch); and locality 2b (an unnamed site near locality 2a). Pertinent information about these sites was presented in the earlier paper. Chmura (1973) places locality 1 stratigraphically above locality 2a; localities 2a and 2b are essentially time equivalent (Stein, pers. comm.).

In the present report, two additional localities are represented:

Locality 3. Cache Creek; R4W, T12N, Sec. 2, SE $\frac{1}{4}$, Morgan Valley 15' quadrangle.

Locality 4. $\frac{1}{2}$ mile north of Pigeon Point, San Mateo County.

Locality 3 is an exposure of the Sites Formation along Cache Creek, in Yolo County on the western side of the Sacramento Valley. Douglas (1969) and Passagno (1974) consider the Sites Formation as Coniacian in age, but correlations based on Goukoff's (1945) foraminiferal zones place the locality in the G-2 zone, or middle to late Turonian (Popenoe *et al.*, 1960). Locality 4 lies west of the Coast Ranges in an outcrop of the Pigeon Point Formation along the San Mateo County coast one-half mile north of Pigeon Point. Although numerous faults hamper stratigraphic work in this area, Hall *et al.* (1959) and Wentworth (1960 and pers. comm.) agree that the age of the formation is Campanian.

All thin sections described here are deposited in the California Academy of Sciences Geological Collections in San Francisco (CASG), and reference to these specimens is by accession number. The term "pore" is used in reference to the vessel as it appears in transverse section. The term "fiber" is used in its generic sense as defined in the *Multilingual Glossary of Terms Used in Wood Anatomy* (1964). Omission of an important feature in a description indicates that it was not possible to observe it due to poor preservation of the specimen. Growth rings are mentioned only if they are present, and pore frequency has been omitted because distortion of the grain in most specimens did not allow statistically significant measurements. In a general way the relative frequency can be inferred from the illustrations. The specimens are classified according to a system presented in the form of a synoptic key in the first paper of this series. The system is artificial and is merely a practical way to handle the structural patterns found among the fossil woods

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under study that can not, for reasons discussed at length, be assigned to modern genera or families. The characters used in the classification are those most likely to be preserved; hence, groupings are defined according to distribution of pores and of axial parenchyma, and to type of perforation plate and of intervessel pitting. With reference to distribution of axial parenchyma, the intent was to separate specimens that have paratracheal parenchyma from those that do not. It is, however, necessary to reserve a category for those in which no axial parenchyma could be observed. The notion of frequency was inadvertently interjected into the classification by the designation of an alternative ("sparse or absent") to the categories "parenchyma apotracheal only" or "paratracheal parenchyma present." For the sake of consistency, the word "sparse" should be removed from the synoptic key. Axial parenchyma cells, whatever their frequency, either are or are not associated with vessels. If the parenchyma cells are sparse and are consistently associated with vessels, they are considered paratracheal; if they are sparse and are not consistently associated with vessels, they are considered apotracheal. It should be mentioned that axial parenchyma cells are often difficult to recognize in sectioned (particularly in transversely sectioned) material. In fossilized woods the problems are more severe: such cells are often obscured by grain distortion; in transverse section they can be confused with fibers in which the secondary walls have been destroyed. Furthermore, mineral deposits within a cell may simulate the secondary thickening of fibers. Because of the difficulties in recognizing axial parenchyma in transverse section, it is important not to rely solely on such sections for determining its presence.

SYSTEMATIC DESCRIPTIONS

The first four specimens—*CASG* 60133, *CASG* 60420, *CASG* 60421, and *CASG* 60422—are classified in Group III. This group is characterized by mostly solitary pores and by perforation plates with fewer than 50 bars. Several specimens belonging to this group were described earlier (Page, 1979). *CASG* 60133 represents section B2 (parenchyma apotracheal, intervessel pits opposite), and *CASG* 60420, *CASG* 60421, and *CASG* 60422 represent section C (paratracheal parenchyma present).

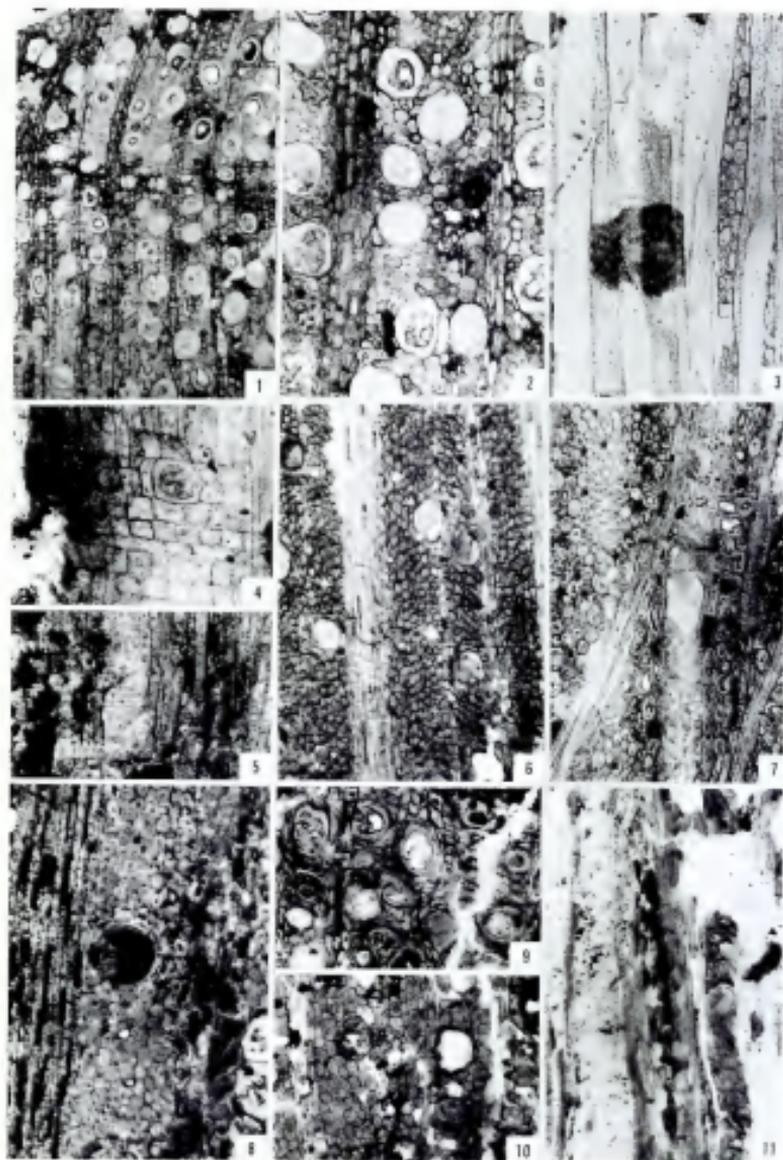
CASG 60133

FIGURES 1-4.

MATERIAL. Branch 2.5 cm. in diameter.

Secondary xylem. Diffuse porous, the pores solitary, numerous, average radial diameter 86 μm . (70-99), average tangential diameter 96 μm . (86-116). Perforation plates scalariform, slightly oblique, with less than 10 widely spaced bars. Intervessel pits small, round, opposite; pits to ray cells oval to almost scalariform; pits to parenchyma oval; average vessel element length 681 μm . (580-812). Parenchyma

FIGURES 1-11. 1-4, *CASG* 60133: 1, transverse section (note growth ring), $\times 53$; 2, transverse section, $\times 75$; 3, tangential section, $\times 75$; 4, radial section showing enlarged ray cell, $\times 75$. 5-8, *CASG* 60420: 5, perforation plate, $\times 80$; 6, transverse section, $\times 40$; 7, tangential section (note broad rays and small intervessel pits), $\times 70$; 8, transverse section, $\times 80$. 9-11, *CASG* 60422, $\times 75$: 9, 10, transverse sections showing pore distribution variants; 11, tangential section.



apotracheal diffuse. Rays 2 to 6 cells wide, numerous, the cells variable in size and shape, some much enlarged; uniseriate 1 to 6 cells high, heterocellular. Fiber pits on all walls small, bordered.

Pith. Large, 1 cm. in diameter; primary xylem points numerous, separated by multiseriate rays.

LOCALITY. Del Puerto Creek, locality 1.

Poor preservation obscured intervessel pits in all but a few vessels. Because of distortion, the uniseriate rays could not be counted; however, they do not seem to be numerous. Multiseriate rays are in various stages of dissection, and the lower rays have only one marginal row of square cells. Many are joined vertically by their uniseriate margins. The enlarged ray cells appear to have been crystalliferous (FIGURE 4). The pith is filled with convoluted, thick-walled tubules resembling hyphae of certain fungal pathogens.

Type IIB2 modern woods most similar to CASG 60133 include certain members of the Ericaceae, Escalloniaceae, Cunoniaceae, and Myricaceae. Solitary crystals have been reported in the Myricaceae (Metcalfe & Chalk, 1950).

CASG 60420

FIGURES 5-8.

MATERIAL. Fragment of mature secondary xylem.

Secondary xylem. Pores solitary, angular, some in radial pairs, average radial diameter 120 μm . (87-145), average tangential diameter 102 μm . (81-127). Perforation plates scalariform, 10 to 15 bars. Intervessel pits numerous, small to minute, opposite; pits to parenchyma similar, some elongated horizontally; average vessel element length 725 μm . (580-880); tyloses common. Parenchyma sparse, apotracheal diffuse and paratracheal as uniseriate sheath around some vessels. Multiseriate rays frequent, up to 15 cells wide and 2.7 mm. high, some dissected, the cells varying greatly in shape and size in no particular pattern, those in center mostly procumbent; uniseriate infrequent, 3 to 5 cells high. Fibers thick walled. Most elements containing dark, amorphous inclusions.

LOCALITY. Cache Creek, locality 3.

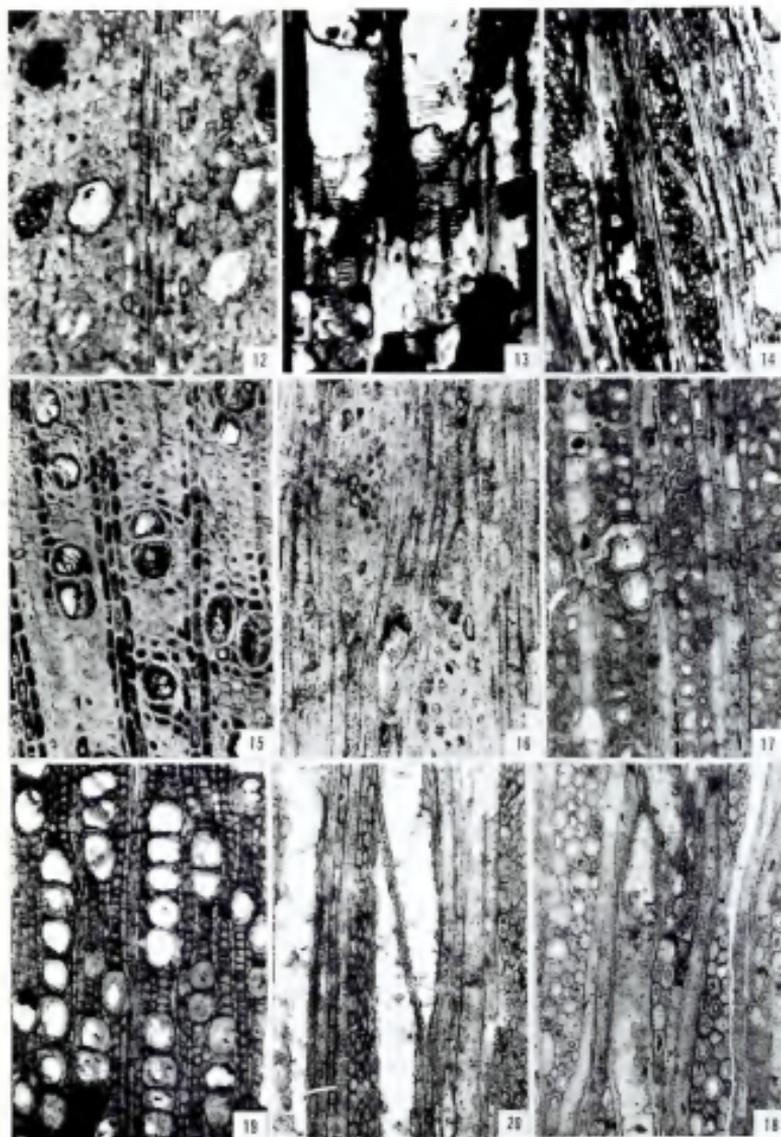
The amorphous inclusions and the tyloses obscure the end walls of many vessels; therefore, it is not certain whether all end walls are multiperforate.

Similar wood patterns can be observed in genera of the Araliaceae and Dilleniaceae. According to Dickison (1967), apotracheal parenchyma predominates in the Dilleniaceae, and paratracheal parenchyma is of a diffuse nature. Fibers are septate in most species of the Araliaceae. Although fiber septae were not observed in the fossil, their presence could be obscured by the amorphous inclusions in the very narrow cell lumens.

CASG 60421

FIGURES 12-14.

MATERIAL. Stem or root with what appears to be only secondary xylem, in one radial section with some evidence of primary xylem. Grain much distorted. Specimen probably from fork of a branch.



FIGURES 12-20. 12-14, CASG 60421: 12, transverse section, $\times 50$; 13, longitudinal section showing wall pitting of ray and axial parenchyma cells, $\times 70$; 14, tangential section, $\times 28$. 15, 16, CASG 60423: 15, transverse section, $\times 40$; 16, tangential section, $\times 70$. 17, 18, CASG 60425: 17, transverse section, $\times 55$; 18, tangential section, $\times 63$. 19, 20, CASG 60424: 19, transverse section, $\times 42$; 20, tangential section, $\times 70$.

Secondary xylem. Pores solitary, angular, average radial diameter 139 μm . (102–203), average tangential diameter 171 μm . (87–232). Perforation plates scalariform, 40 to 50 bars. Intervessel pitting not observed; pits to ray cells and axial parenchyma scalariform or large and oval; average vessel element length 1413 μm . (1160–1624); tyloses common. Parenchyma paratracheal, apotracheal diffuse, and in uniseriate tangential lines. Rays up to 15 cells wide, averaging 1.7 mm. (1–2.7) high, heterocellular, the cells of central portion of large rays long procumbent, others short procumbent or square; uniseriate margins 1 to 5 cells high; sheath cells present; uniseriate numerous, up to 20 cells high, cells upright; rhomboidal crystals common. Fibers thick walled, the pits large, bordered, apertures small.

LOCALITY. Del Puerto Creek, locality 1.

Similar wood patterns occur in *Dillenia* (Dilleniaceae), *Saurauia* (Saurauiaceae), and *Kaunbachia* (Canoniaceae).

CASG 60422

FIGURES 9–11.

MATERIAL. Piece of secondary wood. Mostly compressed; grain distorted and cells crushed.

Secondary xylem. Observable pores solitary, differing in size and frequency in various areas of undamaged section where not compressed (difference possibly represents either various portions of growth ring or early- and later-formed wood), average radial diameter 86 μm . (58–104), average tangential diameter 78 μm . (58–93). Perforation plates scalariform, with ca. 15 coarse, widely spaced bars. Intervessel pits appear to be opposite, pits to ray cells and parenchyma scalariform; vessel elements ca. 770 μm . long; tyloses thick walled. Parenchyma appears to be mostly paratracheal. Rays 2 or 3 cells wide, the cells large, occasional larger ones may have been crystalliferous; sheath cells occasional; uniseriate appear to be infrequent. Fibers very thick walled, pit apertures small and slitlike.

Phloem. Patches of fibers alternating radially with enlarged thin-walled cells and crushed cells. Fibers small in diameter, thick walled. Large, thin-walled cells becoming stone cells in outer layers. Cells of rays not preserved, but no perceptible broadening of ray tissue in outer layers.

LOCALITY. Del Puerto Creek, locality 1.

The next two specimens, CASG 60423 and CASG 60424, are classified in Group VA. Members of this group have scalariform perforation plates with fewer than 50 bars, both solitary and multiple pores, and little or no parenchyma. Examples of modern woods of this type with opposite and/or scalariform intervessel pits and with vessel elements that average more than 900 μm . in length include *Meliosma* (Sabiaceae), *Paypayrola* and *Leonia* (Violaceae), and several members of the Flacourtiaceae and Araliaceae. Those with opposite and/or scalariform intervessel pits and with vessel elements averaging less than 900 μm . in length include certain genera of the Staphyleaceae, Dichapetalaceae, Rhizophoraceae, and Araliaceae.

CASG 60423

FIGURES 15, 16.

MATERIAL. Small branch 4.5 cm. in diameter. Grain distorted.

Secondary xylem. Diffuse porous, pores solitary and in clusters and radial chains of 3 to 5, average radial diameter 98 μm . (58–128), average tangential diameter 81 μm . (46–104). Perforation plates scalariform, up to 18 coarse bars. Intervessel pits opposite, at least in part; pits to axial parenchyma large, oval; average vessel element length ca. 580 μm .; tyloses abundant. Parenchyma sparse, paratracheal. Rays 3 to 5 cells wide, over 1 mm. high, the cells large, mostly square or short procumbent; uniseriate margins 1 or 2 cells high, cells upright; uniseriates not numerous. Fibers septate in part.

Pith. Small, round; cells rounded, thin walled.

LOCALITY. Black Gulch, locality 2a.

The secondary xylem pattern is similar to some observed in the Araliaceae and the Rhizophoraceae. Fiber septae are difficult to find in the fossil, but some can be observed; since there is no evidence of fungal hyphae, it is reasonably certain that they are truly septae. The nature of the perforation plates is also difficult to discern in many vessels; many are unquestionably multiperforate, but it is possible that simple ones are also present.

This specimen is somewhat similar to *CASG* 60420, except that in *CASG* 60423 the rays are much narrower, no apotracheal parenchyma was observed, and pore multiples are present.

CASG 60424

FIGURES 19, 20.

MATERIAL. Small portion of mature secondary xylem.

Secondary xylem. Pores solitary and in radial rows of 3 to 5, average radial diameter 97 μm . (70–139), average tangential diameter 100 μm . (70–145). Perforation plates scalariform, bars averaging 35 (28 to 46). Intervessel pits small, opposite to laterally elongated; average vessel element length 1310 μm . (1160–1740). Parenchyma absent. Rays heterocellular, the cells mostly square, short procumbent, and upright, with some low procumbents; uniseriate margins 1 to 10 cells high, cells upright; many multiseriates connected vertically by margins; sheath cells occasional; uniseriates up to 14 cells high, cells upright. Fibers septate.

LOCALITY. Black Gulch, locality 2a.

Type VA woods, characterized by long vessel elements, opposite intervessel pits, and high heterocellular rays, occur in some of the more primitive members of the Violales. End walls in the vessels of the fossil have more bars than is characteristic of even the most primitive members of the Flacourtiaceae, and the intervessel pits are much smaller. There are numerous bars in the perforation plates in woods of the Violaceae, but intervessel pitting is scalariform or transitional. The family Lacistemaceae has small, opposite intervessel pits, but parenchyma in the four species examined is abundant.

Pollen attributable to the Lacistemaceae has been described from locality 1 (Chmura, 1973).

The next two specimens, CASG 60425 and CASG 60426, are classified in Group VB, which comprises woods with scalariform perforation plates with fewer than 50 bars, and pores both solitary and in multiples. Woods of this type occur in at least 23 families.

CASG 60425

FIGURES 17, 18.

MATERIAL. Stem or root 4 cm. in diameter.

Secondary xylem. Pores solitary and radially aligned in groups of 3 or 4, with some clusters, average radial diameter 93 μm . (72–114), average tangential diameter 81 μm . (64–107). Perforation plates scalariform, bars 10 to 15. Intervessel pits appear to be scalariform, average vessel element length 760 μm . (870–1100). Parenchyma abundant, apotracheal diffuse. Rays 2 to 4 cells wide, cells variable in size but mostly large and procumbent; uniseriate margins 1 or 2 cells high, cells square; uniseriates 3 to 10 cells high, the cells variable in size, mostly square.

LOCALITY. Del Puerto Creek, locality 1.

The wood anatomy of CASG 60425 is much like that of *Magnolioxylon panochensis*, a specimen described from locality 2a (Page, 1970), except that all the cells are larger, and the vessel elements are significantly shorter. CASG 60425 may represent a root or a stem of the same species or, since it was collected from a slightly younger locality, a different species altogether.

Few Group V woods have scalariform intervessel pits. Among those that do are *Hibbertia* (Dilleniaceae), and certain members of the Hamamelidaceae and the Magnoliaceae.

CASG 60426

FIGURES 21–23.

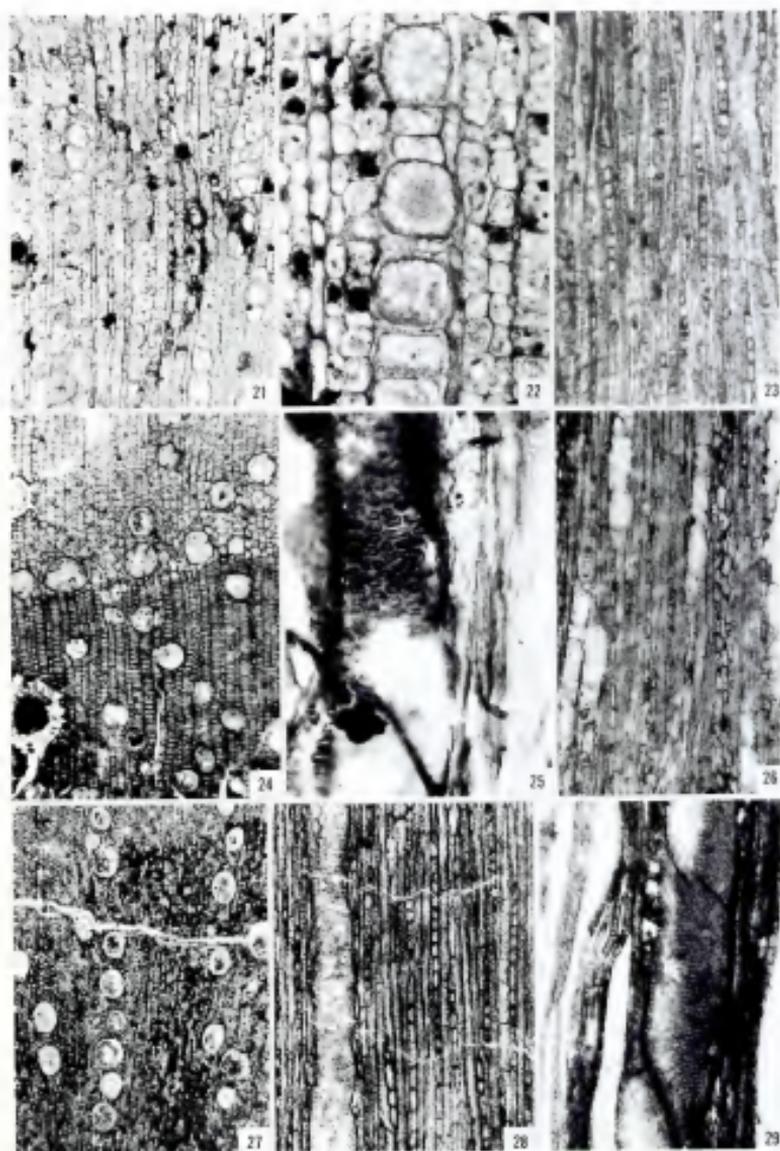
MATERIAL. Small stem 3 cm. in diameter.

Secondary xylem. Growth rings indistinct. Diffuse porous, pores solitary and in short chains and clusters, average radial diameter 58 μm . (46–80), average tangential diameter 46 μm . (40–58). Perforation plates scalariform, with up to 50 or more fine bars. Intervessel pits small, opposite transitional; pits to ray cells small, numerous; average vessel element length 748 μm . (580–870). Parenchyma abundant, apotracheal, diffuse and in tangential pairs. Rays numerous, uniseriate, up to 23 cells high, heterocellular. Fibers thick walled.

Pith. Small; cells small, rounded in transverse section.

Phloem. About 3 mm. thick, cells in no particular pattern, walls of parenchyma

FIGURES 21–29, 21–23, CASG 60426: 21, transverse section, $\times 62$; 22, transverse section, $\times 200$; 23, tangential section, $\times 60$. 24–26, CASG 60427: 24, transverse section, $\times 67$; 25, longitudinal section showing bordered pits on vessel wall, $\times 250$; 26, tangential section, $\times 60$. 27, 28, CASG 60428: 27, transverse section, $\times 28$; 28, tangential section, $\times 80$. 29, CASG 60429, longitudinal section showing vessel wall pitting, $\times 70$.



cells and ray cells highly thickened and tangentially elongated in outer layers. Rays continuous from xylem.

LOCALITY. Black Gulch, locality 2a.

Because preservation is poor, an accurate assessment of the number of end plate bars was not possible. It appears that most plates contain fewer than 50 bars; therefore, the fossil is placed in Group V.

Type VB woods, with vessel elements averaging less than 900 μm . in length, abundant parenchyma, and transitional to opposite intervessel pits, occur in such genera as *Ilex* (Aquifoliaceae), *Strombosia* (Olacaceae), and *Clethra* (Clethraceae). Except for its more numerous end plate bars, the fossil is similar to the wood of *Strombosia*.

Pollen attributable to both the Aquifoliaceae and the Olacaceae has been described from Black Gulch and Del Puerto Creek (Chmura, 1973).

The following specimen, CASG 60428, is classified in Group VIB. Members of this group have both simple and scalariform perforation plates, mostly solitary pores, and apotracheal parenchyma.

CASG 60428

FIGURES 27, 28.

MATERIAL. Small stem 3 cm. in diameter.

Secondary xylem. Pores ovoid, solitary, in slightly oblique arrangement, very small pores mixed with large ones, average radial diameter 121 μm . (70–153), average tangential diameter 104 μm . (87–157). Perforation plates simple and scalariform with up to 30 bars; intervessel pits alternate or slightly elongated horizontally, occasionally almost scalariform near pith; pits to ray cells similar, apertures coalescing obliquely in some cells; pits to parenchyma large; average vessel element length 551 μm . (406–696); tyloses occasional. Parenchyma abundant, apotracheal diffuse. Rays numerous, mostly uniseriate, some with biseriate centers, homogeneous to partly heterogeneous, up to 40 cells high, cells mostly procumbent, occasional marginal cells containing a single crystal. Fiber pits bordered; vasicentric tracheids occasional.

Pith. Cells large, thin walled.

Phloem. Alternating zones of fibers and stone cells separated by tangential rows of crushed thin-walled cells; cuboidal crystals occasional in parenchyma.

LOCALITY. Black Gulch, locality 2a.

Possibly because of poor preservation, vasicentric tracheids are discernible in only a few small areas in the two specimens with this pattern. All cells (except vessels) contain brown inclusions.

Patterns similar to the above occur in *Castanopsis* (Fagaceae), *Casuarina* (Casuarinaceae), and *Engelhardtia* (Juglandaceae). Abundant apotracheal parenchyma and an oblique arrangement of solitary pores form a common pattern in these families. According to Moseley (1948), no species of *Casuarina* has only diffuse axial

parenchyma. Although metatracheal bands of parenchyma are characteristic of most species of Juglandaceae and Fagaceae, there are some genera in which parenchyma is only diffuse. Vasicentric tracheids are characteristic of some genera of Fagaceae and at least one species of *Casuarina*. Scalariform perforation plates with few bars occur in species of some genera of the Juglandaceae including *Engelhardtia*, occasionally in small vessels in species of *Casuarina*, and in species of *Nothofagus* and *Fagus*. It is interesting to note that the three orders represented by these families are depicted by Cronquist (1968, p. 159) as closely related.

Pollen attributable to the Fagaceae and the Juglandaceae has been described from both Black Gulch and Del Puerto Creek (Chmura, 1973).

Group VIII, which includes woods with both simple and scalariform perforation plates, pores in multiples as well as solitary, and some paratracheal parenchyma, is represented by specimen CASG 60427.

CASG 60427

FIGURES 24-26.

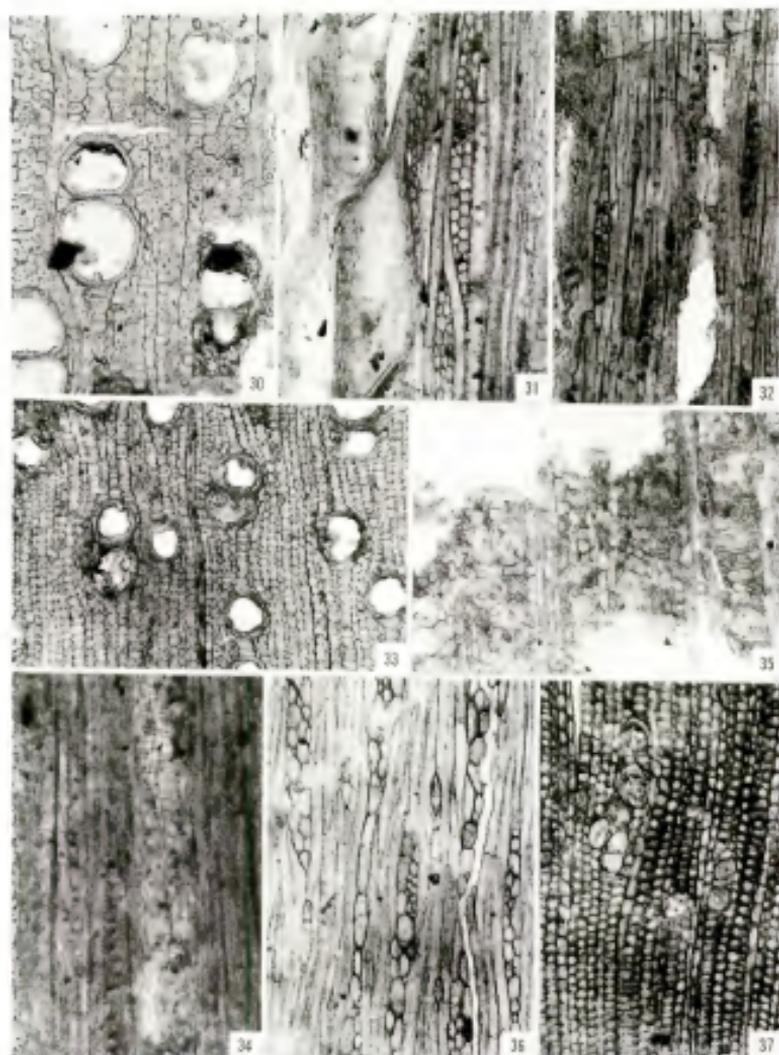
MATERIAL. Stem 2 cm. in diameter.

Secondary xylem. Semi-ring porous, the pores small, isodiametric, angular, solitary with some clusters and radial groups of 3, average radial diameter 49 μm . (43-58), average tangential diameter 52 μm . (35-70). Perforation plates simple, a few scalariform, usually with 3 or 4 bars. Intervessel pits scalariform and transitional to alternate, large, bordered; pits to axial parenchyma large, round, almost scalariform; average vessel element length 464 μm . (406-520); tyloses abundant. Parenchyma terminal and sparse paratracheal. Multiseriate rays infrequent, 3 cells wide, the cells upright, walls thick; uniseriate rays low, the cells upright, square. Fibers septate near vessels; long, narrow, scalariform-pitted, tracheidlike elements associated with some vessels.

Pith. Large, 7 mm. in diameter; cells small, more or less isodiametric, round in transverse section.

LOCALITY. Del Puerto Creek, locality 1.

Loss of material during preparation of the thin section destroyed portions of the single growth ring, and grain distortion obscures much of what remains. Most of the axial parenchyma is associated with the larger vessels at the inner edge of the outer ring. Because the ring is incomplete and distorted, it is impossible to be certain that what can be observed represents the normal structure of the stem. The scalariform pitting and abundant tyloses make it difficult to determine the nature of the end walls, although most appear to be simple. There is a progression from scalariform intervessel pitting to transitional alternate between the primary xylem and the outer portion of the stem, where a mixture of the two types occurs. The rays are of the kind generally considered juvenile. These factors indicate that the mature secondary xylem of the plant may have had wider multiseriate rays and a mixture of scalariform or transitional and alternate pits. Since the wood was in a state of transition, comparison with modern mature woods is valueless. All that can be said is that the fossil may be a transitional stage of mature patterns such as can be observed in some



FIGURES 30-37. 30, 31, CASG 60429: 30, transverse section, $\times 60$; 31, tangential section, $\times 70$. 32-34, CASG 60430: 32, tangential section, $\times 75$; 33, transverse section, $\times 75$; 34, longitudinal section showing vessel wall sculpturing, $\times 95$. 35-37, CASG 60432: 35, transverse section near periphery of stem, $\times 75$; 36, tangential section, $\times 73$; 37, transverse section near pith, $\times 75$.

Araliaceae and in *Leea* (Leeaceae); scalariform tracheids are characteristic of *Leea*; terminal or initial parenchyma is uncharacteristic of both *Leea* and the Araliaceae.

Group VIII is represented by specimens CASG 60429 and CASG 60430. Members of this group have simple perforations and scalariform, opposite, or transitional intervessel pits. This combination of characters is uncommon among modern woods but occurs in some Araliaceae, Cunoniaceae, Elaeocarpaceae, Fagaceae, Guttiferae, Leeaceae, Melastomataceae, Olacaceae, and Schisandraceae.

CASG 60429

FIGURES 29-31.

MATERIAL. Mature secondary wood.

Secondary xylem. Diffuse porous, the pores in multiples of 2 to 4, numerous, average radial diameter 143 μm . (100-174), average tangential diameter 110 μm . (75-156). Perforation plates simple, slightly oblique. Intervessel pits opposite, horizontally elongated to almost scalariform; pits to ray cells scalariform; average vessel element length 591 μm . (464-696). Parenchyma absent. Rays up to 3 cells wide, the cells mostly procumbent, varying in size; uniseriate margins 1 to 3 cells high, cells upright or square; uniseriates low, cells square or upright.

LOCALITY. Black Gulch, locality 2a.

Type VIII woods with little or no parenchyma have been observed in the Vitaceae, Melastomataceae, and Fagaceae (*Nothofagus*). According to Metcalfe and Chalk (1950), paratracheal parenchyma is always present in the wood of Melastomataceae and Vitaceae. Some Magnoliaceae have wood patterns similar to that of the fossil, but at least some vessels in these woods have scalariform perforations, and all have apotracheal parenchyma (mostly terminal).

CASG 60430

FIGURES 32-34.

MATERIAL. Secondary wood 2 cm. in diameter.

Secondary wood. Pores solitary and in radial rows of 2 to 4, rounded, but flattened in areas of contact, average radial diameter 69 μm . (52-81), average tangential diameter 64 μm . (46-75). Perforation plates simple. Intervessel pits scalariform; average vessel element length 350 μm . (286-394). Parenchyma apotracheal. Rays mostly 2 or 3 cells wide, averaging less than 500 μm . high, cells mostly procumbent; uniseriate margins 1 or 2 cells high; uniseriates infrequent, 1 to 9 cells high, cells square or upright.

LOCALITY. Locality 2b.

It is not certain that intervessel pits are scalariform in all vessels. Axial parenchyma is present, but it is not possible to determine its amount or distribution, except that no paratracheal parenchyma was noted. A very similar stem, CASG 60431, consisting of a pentagonal pith nearly 1 cm. in diameter surrounded by a layer of secondary xylem 13 mm. thick, was also collected at locality 2b. Near the pith there are a few scalariform perforation plates with four or fewer bars. The rays are higher

and more heterogeneous than are those in CASG 60430. The differences observed in the secondary wood of the two specimens are of the kinds that exist between early- and later-formed increments in the same plant.

Type VIII B woods with diffuse apotracheal parenchyma occur in species of the Cunoniaceae, Fagaceae (*Nothofagus*), and Olacaceae.

Group IX, which includes woods with simple perforations, alternate intervessel pits, and no parenchyma, is represented by two specimens, CASG 60432 and CASG 60433. This pattern occurs in many families.

CASG 60432

FIGURES 35-37.

MATERIAL. Stem 4.5 cm. in diameter.

Secondary xylem. Pores solitary, in clusters, and in radial multiples of 3 to 6, average radial diameter 86 μ m. (69-104), average tangential diameter 87 μ m. (70-110), smallest near pith. Perforation plates simple, oblique. Intervessel pits alternate, crowded, minute; pits to ray cells similar; average vessel element length 301 μ m. (261-406). Parenchyma absent. Rays numerous, 3 to 7 cells wide, heterocellular, the cells variable in size and shape, large, square, or short procumbent, very irregularly organized; sheath cells common; uniseriate infrequent, 1 to 4 cells high. Small elements resembling tracheids present (no perforations observed). Fibers very short.

LOCALITY. Del Puerto Creek, locality 1.

It is difficult to determine whether the irregular ray structure was characteristic of the plant as a whole since the only specimen collected represents the fork of a branch. Because this irregularity is consistent in the many sections cut from the sizeable specimen, however, I assume that it is typical of the plant. It appears that many rays that are uniseriate in tangential section may be radial uniseriate extensions of multiseriate rays in the process of reduction in width. Preservation is poor, and the grain is often distorted; therefore, the total absence of parenchyma is not certain. It could not have been abundant, for it would surely have appeared in one of the sections. Some members of the Compositae and Solanaceae have similar woods.

Pollen attributable to the Solanaceae has been described from locality 1 (Chmura, 1973).

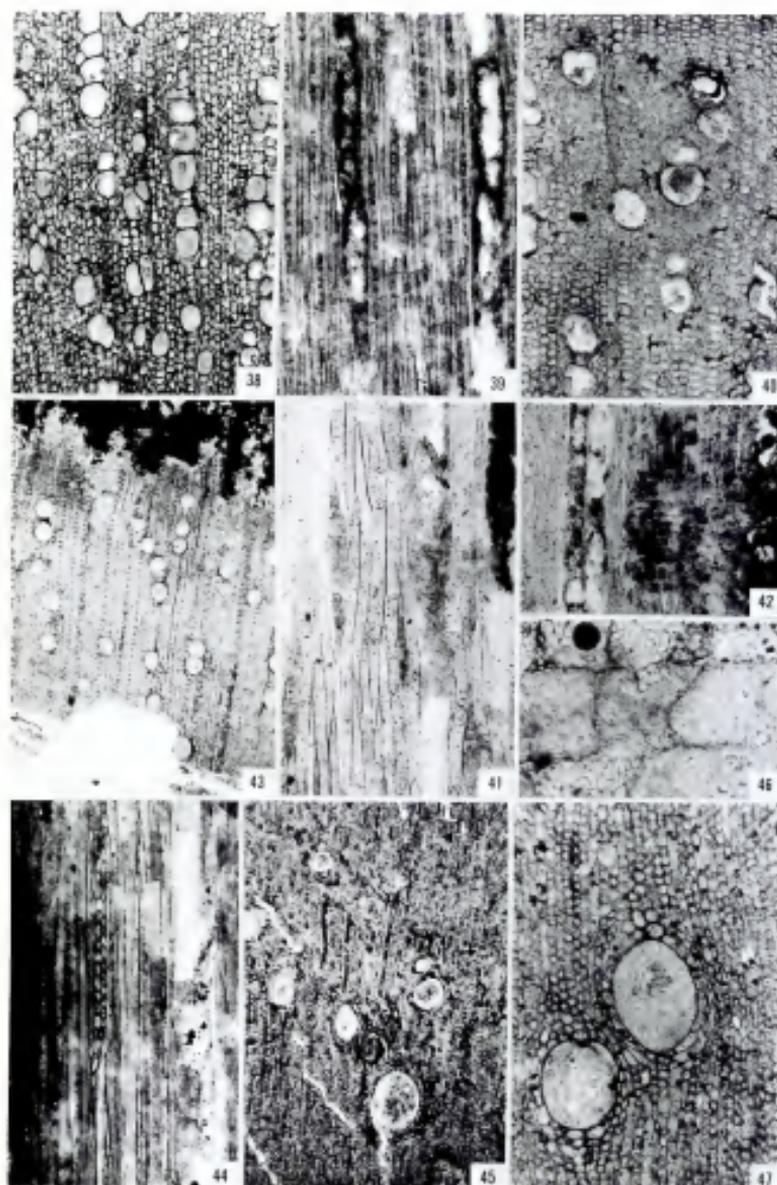
CASG 60433

FIGURES 38, 39.

MATERIAL. Small stem 17 mm. in diameter.

Secondary xylem. Pores small, angular, mostly in radial multiples of 2 to 4,

FIGURES 38-47. 38, 39, CASG 60433, $\times 63$: 38, transverse section; 39, tangential section. 40-42, CASG 60434; 40, transverse section, $\times 72$; 41, tangential section, $\times 70$; 42, radial section, $\times 70$. 43, 44, CASG 60435; 43, transverse section, $\times 42$; 44, tangential section, $\times 75$. 45-47, CASG 60419; 45, transverse section, $\times 45$; 46, radial section showing pitting on wall of ray cell, $\times 300$; 47, transverse section, $\times 80$.



clusters occasional, average radial diameter 69 μm . (34–87), average tangential diameter 50 μm . (29–58). Perforation plates simple, angle acute. Intervessel pits alternate, crowded, minute; average vessel element length 398 μm . (377–464). No parenchyma observed. Rays numerous, low, uniseriate, some biseriate, the cells small, square or short procumbent, some upright.

Pith. Almost 2 mm. in diameter; cells large, thin walled.

LOCALITY. Del Puerto Creek, locality 1.

Wood patterns similar to that of the fossil can be observed in certain members of the Euphorbiaceae, Moraceae, Punicaceae, Sonneratiaceae, and Rubiaceae.

Group XA, which includes woods with simple perforations, alternate intervessel pits, and diffuse apotracheal parenchyma, is represented by specimens CASG 60434, CASG 60435, and CASG 60419. Genera of many modern families are included in this group.

CASG 60434

FIGURES 40–42.

MATERIAL. Stem 2 cm. in diameter.

Secondary xylem. Growth rings apparent with magnification. Pores small, rounded, numerous, solitary and in radial pairs or triplets (occasional), average radial diameter 63 μm . (41–87), average tangential diameter 70 μm . (46–87). Perforation plates simple. Intervessel pits small, mostly alternate, some opposite, apertures sometimes horizontally elongated; vessel element length ca. 412 μm . Parenchyma sparse, apotracheal. Rays mostly low, average height 335 μm . (203–580), 1 to 3 cells wide, the cells square and short procumbent; uniseriate margins absent or up to 5 cells high, cells square or upright.

Pith. Small, round.

Phloem. Poorly preserved except for scattered stone cells and nests of fibers.

LOCALITY. Del Puerto Creek, locality 1.

Some fibers appear to be septate, but there is some doubt about this interpretation. In many fibers extremely fine fungal hyphae follow the contours of the inner wall, at intervals crossing the lumen and continuing along the wall in the opposite direction. Unless the cells are carefully examined, the hyphae can easily be mistaken for septae. It is possible that passage along the full length of the fiber was obstructed by septae, and that hyphae crossings thus actually indicate the presence of septae.

CASG 60435

FIGURES 43, 44.

MATERIAL. Stem 1.5 cm. in diameter.

Secondary xylem. Growth rings distinct, demarcated by tangential pore clusters. Pores mostly solitary, occasionally in clusters or radial files, average radial diameter 65 μm . (41–98), average tangential diameter 63 μm . (35–98). Perforation plates simple. Intervessel pits alternate, minute, the apertures narrow, extending beyond

borders; average vessel element length 423 μm . (3 measurements). Parenchyma apotracheal diffuse. Rays mostly biseriate, some 3 cells wide, up to 12 cells high, the cells small, square and short procumbent. Ground tissue mostly fibers, some with conspicuously bordered pits, mainly in vicinity of vessels.

Pith. Cells small, thick walled, round in transverse section.

Phloem. Groups of stone cells alternating with thin-walled cells; multiseriate rays flaring out and forming conspicuous wedges in outer portion; vertical files of "beaded" cells resembling chambered parenchyma, containing what appear to be remnants of polyhedral crystals.

LOCALITY: Del Puerto Creek, locality 1.

Due to poor preservation, the characteristics of the fibrous elements in the vicinity of vessels are not always clear. Those with conspicuous pits are not consistently associated with vessels.

The specimen is closely similar to *Carpinioxylon ostryopsoides* (Page, 1970). There are a few multiperforate vessels in *C. ostryopsoides*, the rays are wider, and the parenchyma is more abundant. Aggregate rays are also present. Among modern forms with aggregate rays, there is wide variation in the age at which these rays are initiated. Since CASG 60435 is half the diameter (3.0 cm.) of the specimen of *C. ostryopsoides* (mistakenly described as 1.5 cm.), and aggregate rays were observed in only the outer portion of the section, it is possible that these rays did not normally develop in early-formed wood. A specimen (CASG 60436) collected at an earlier date but from the same locality (2a) as *C. ostryopsoides* is quite similar, although it lacks aggregate rays. Close similarities were also observed in pith and bark among the three specimens, although only CASG 60435 has both tissues. *Carpinioxylon ostryopsoides* has a pith but no bark; CASG 60436 has bark but no pith. These two specimens are probably from the same kind of plant, while CASG 60435 may be a different species of either the same genus or a closely related one.

Although all three specimens compare favorably with the *Coryleae* of the *Betulaceae* (except for the smaller pits in the fossils), there are no modern genera that bear a close resemblance. There is some similarity to *Castanopsis* of the *Fagaceae*, but here the intervessel pits are also large, the vessel-ray pits are even larger, and the pores are exclusively solitary.

CASG 60419

FIGURES 45-47.

MATERIAL: Fragment of mature wood.

Secondary xylem. Pores solitary, rounded, ovoid, widely spaced in oblique radial arrangement, tangential clusters occasional, small pores mixed with large, average radial diameter 150 μm . (87-232), average tangential diameter 116 μm . (69-174). Perforation plates simple, horizontal or slightly oblique. Intervessel pits small, alternate, the apertures narrow, sometimes coalescent; pits to ray cells similar, apertures sometimes coalescing obliquely; average vessel element length 494 μm . (435-696); tyloses occasional. Parenchyma abundant, mostly apotracheal diffuse, but some paratracheal. Rays numerous, mostly uniseriate, up to 20 cells high, the cells

square, upright, or short procumbent; multiseriate infrequent, up to 4 cells wide, cells mostly procumbent; all ray cells containing dark brown substance. Fiber pits round, bordered, crowded.

LOCALITY. $\frac{1}{2}$ mile north of Pigeon Point, locality 4.

Axial parenchyma cells vary in diameter. It is sometimes difficult to distinguish between axial and ray parenchyma in radial section because the cells associated with vessels are small and frequently square or rhomboidal as in the rays. In transverse section, however, many large pores appear to have at least a partial sheath of parenchyma. Both rays and axial parenchyma are abundant; therefore, the association of either with vessels may be fortuitous.

There is a general similarity between this specimen and CASG 60428, but the cells in the rays of the latter are mostly procumbent, occasional cells contain crystals, and there is some evidence of vasicentric tracheids. Although scalariform perforation plates are present in CASG 60428, this may not be a significant difference since a stem collected at Black Gulch (CASG 60437) with secondary xylem identical to that of CASG 60419 has a few vessels with scalariform perforations in the early-formed wood.

CASG 60419 has many characteristics of some woods of the Myrtaceae and is also similar to *Licania* and *Parinari* (Rosaceae), and *Monetes* and *Marquesia* (Dipterocarpaceae); however, some paratracheal parenchyma is typical of the latter two genera.

Group XIA is represented by 12 specimens consecutively numbered from CASG 60438 through CASG 60449. This group is distinguished by simple perforations, alternate intervessel pits, and vasicentric parenchyma—a pattern common among modern woods. A discussion of the relationship between the fossils and modern woods is presented following the descriptions of the specimens.

CASG 60438

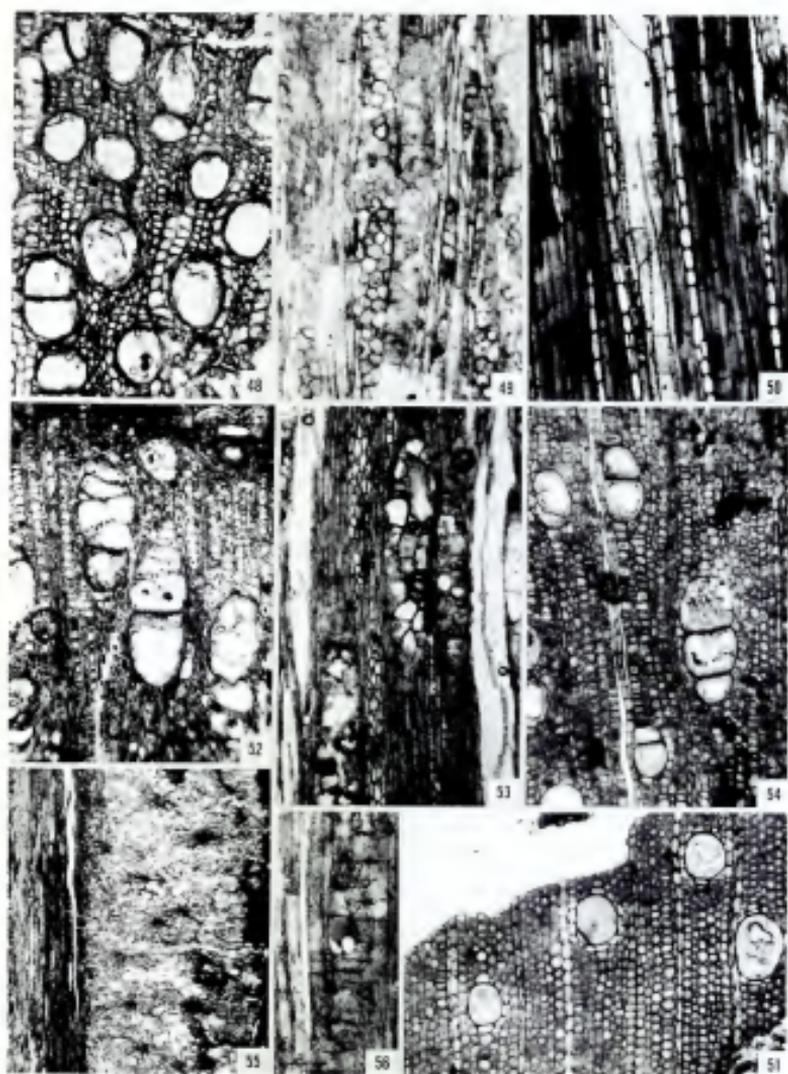
FIGURES 48, 49.

MATERIAL. AN AXIS 2 cm. in diameter. The center is not preserved; therefore, it is not possible to determine whether the specimen is a stem or a root.

Secondary xylem. Pores large, solitary and in radial or tangential multiples of 3, average radial diameter 202 μm . (174–232), average tangential diameter 161 μm . (145–191). Perforation plates simple. Intervessel pits alternate, crowded, apertures narrow; pits to parenchyma large; average vessel element length 383 μm . (261–522). Parenchyma paratracheal. Rays 3 to 9 cells wide, up to 2 mm. high, the cells large, square or short procumbent; uniseriate margins lacking; uniseriate low, heterocellular; occasional cells with opaque, amber-colored inclusions. Fibers short, average length similar to that of vessel elements.

Phloem. Thick in proportion to amount of xylem; rays flaring out in cross section due to tangential expansion of cells; stone cells or other sclereids absent; many cells containing amber inclusions.

LOCALITY. Del Puerto Creek, locality 1.



FIGURES 48-56. 48, 49, CASG 60438: 48, transverse section, $\times 38$; 49, tangential section, $\times 54$. 50, 51, CASG 60440, $\times 80$: 50, tangential section; 51, transverse section. 52, 53, CASG 60439: 52, transverse section, $\times 38$; 53, tangential section, $\times 24$. 54-56, CASG 60442: 54, transverse section, $\times 70$; 55, longitudinal section through pith showing nests of sclereids, $\times 6$; 56, radial section showing enlarged secretory cell, $\times 85$.

The large, numerous vessels and the high rays indicate that the plant may have been a liana. Inclusions such as those in the ray cells and bark may have been secretions of oil. The cells, however, are not especially enlarged. A proper radial section was not obtained.

CASG 60439

FIGURES 52, 53.

MATERIAL. Stem or root. Secondary xylem 1 cm. in diameter with bark 2.5 mm. thick.

Secondary xylem. There appear to be 13 or 14 faint growth rings. Pores large, solitary and in radial multiples, average radial diameter 232 μm . (128–365), average tangential diameter 174 μm . (116–232). Perforation plates simple. Intervessel pits small, alternate, apertures narrow; pits to rays variable, mostly large; pits to axial parenchyma large, oval; average vessel element length 548 μm . (464–638); tyloses abundant. Parenchyma paratracheal. Rays variable, some very high, 2 to 4 cells wide, heterocellular; uniseriate up to 6 cells high, cells variable; many cells containing amber-colored inclusions. Fibers short.

Phloem. Rays numerous, the cells enlarged tangentially, particularly at periphery of axis; scattered cells containing amber-colored inclusions; all cells thin walled, some parenchyma cells enlarged but lacking inclusions.

LOCALITY. Del Puerto Creek, locality 1.

This specimen is somewhat similar to CASG 60438, although in that specimen the pores are more numerous, there are far fewer pore multiples, and tyloses are lacking. The presence of growth rings in CASG 60439 suggests that if it is a root, it may not have been subterranean.

CASG 60440

FIGURES 50, 51.

MATERIAL. Small stem 1.5 cm. in diameter.

Secondary xylem. Pores mostly solitary, some radial multiples of 2 to 4, slightly angular, average radial diameter 100 μm . (58–121), average tangential diameter 80 μm . (58–98). Perforation plates simple, slightly oblique. Intervessel pits large, crowded, alternate; pits to ray cells large, oval, irregularly oriented; average vessel element length 399 μm . (343–445). Parenchyma paratracheal, sheaths 1 or 2 cells thick. Rays mostly uniseriate, occasionally bi- or triseriate, the cells mostly square or upright, with numerous small pits on tangential and horizontal walls, occasionally slightly inflated and containing amber-colored inclusions. Some fibers septate.

Pith. 0.5 cm. in diameter; nests of sclereids numerous; protoxylem points numerous; pith cells in vicinity of primary xylem small, thick walled, other cells large.

LOCALITY. Del Puerto Creek, locality 1.

A specimen (CASG 60441) collected at locality 2b and nearly identical in every way contains numerous inflated cells, which are interpreted to be secretory cells.

CASG 60442

FIGURES 54-56.

MATERIAL. Stem 22 mm. in diameter.

Secondary xylem. Pores solitary with occasional radial files of 2 to 5, average radial diameter 106 μm . (70-128), average tangential diameter 85 μm . (52-104). Perforation plates simple. Intervessel pits small, alternate, crowded, pits to ray cells large, oval; average vessel element length 365 μm . (290-435). Parenchyma sparse, paratracheal. Rays 1 to 3 cells wide, the cells short procumbent or upright, often enlarged and containing amber-colored inclusions.

Pith. Large, round; cells very large except in vicinity of primary xylem where small and thick walled. Nests of cells resembling potential sclereids common.

LOCALITY. Black Gulch, locality 2a.

CASG 60443

FIGURES 57-59.

MATERIAL. Mature secondary wood.

Secondary xylem. Pores solitary and in occasional radial multiples of 2 to 4, rounded, average radial diameter 118 μm . (93-139), average tangential diameter 92 μm . (81-104). Perforation plates simple. Intervessel pits small, alternate; pits to ray cells large; length of vessel elements ca. 765 μm .; tyloses occasional. Parenchyma sparse, paratracheal. Multiseriate rays 4 or 5 cells wide, cells mostly procumbent; uniseriate margins 1 to 3 cells high, cells upright; uniseriates infrequent, 2 to 4 cells high, cells upright; rays widely spaced; some enlarged cells may have been crystaliferous. Fibers frequently septate.

LOCALITY. Black Gulch, locality 2a.

CASG 60444

MATERIAL. Fragment of stem with pith and a small amount of secondary xylem.

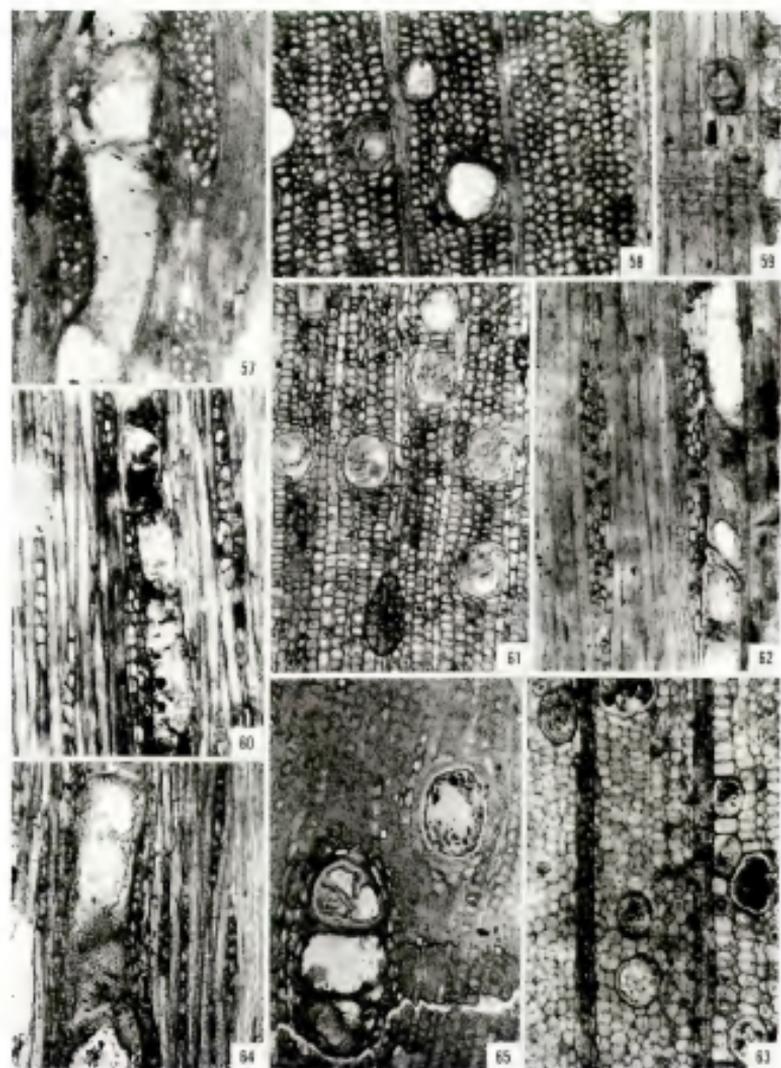
Secondary xylem. Pores mostly solitary and widely spaced with occasional radial multiples of 3, average radial diameter 129 μm . (104-174), average tangential diameter 115 μm . (93-145). Perforation plates simple, slightly oblique. Intervessel pits alternate, crowded; pits to parenchyma oval; length of vessel elements ca. 300 μm . Parenchyma paratracheal. Multiseriate rays mostly 3 cells wide, the cells mostly procumbent with 1 or 2 marginal rows of square cells, nearly homogeneous; uniseriates infrequent.

Pith. 1 cm. in diameter, with large, mostly peripheral cavities.

Primary xylem. Protoxylem points conspicuous, extending deep into pith, the adjacent pith cells very small, thick walled; average vessel diameter 79 μm . (63-93). Multiseriate rays extending into secondary xylem.

LOCALITY. Del Puerto Creek, locality 1.

The nature of the peripheral pith cavities is difficult to determine. There is no structural evidence to indicate whether they were a functional part of the stem or



FIGURES 57-65. 57-59, *CASG* 60443: 57, tangential section, $\times 78$; 58, transverse section, $\times 52$; 59, radial section showing enlarged ray cell with contents resembling a crystal, $\times 80$. 60, 61, *CASG* 60445: 60, tangential section, $\times 64$; 61, transverse section, $\times 57$. 62, 63, *CASG* 60448: 62, tangential section, $\times 78$; 63, transverse section, $\times 70$. 64, 65, *CASG* 60447: 64, tangential section (note small intervessel pits), $\times 78$; 65, transverse section, $\times 75$.

whether they were formed by some foreign agent. Vertical extent of the cavities is minimal.

CASG 60445

FIGURES 60, 61.

MATERIAL. Fragment of mature secondary wood, diameter 2.2 cm.

Secondary xylem. Diffuse porous, pores solitary with some radial pairs, radial files of 3, and occasional clusters of 3 or 4, average radial diameter 112 μm . (87-145), average tangential diameter 82 μm . (70-99). Perforation plates simple. Intervessel pits large, alternate; pits to ray cells large; vessel element length ca. 464 μm .; tyloses occasional. Parenchyma sparse, paratracheal. Rays up to 4 cells wide, irregular in height (0.58-3.1 mm.), some in process of dissection, the cells square and short procumbent, with tangential walls often inclined from vertical in radial section; uniseriate margins absent or up to 3 cells high, cells upright; uniseriates 1 to 4 cells high, cells variable in size and shape. Fibers thick walled.

LOCALITY. Locality 2b.

CASG 60446

MATERIAL. Small stem 1.5 cm. in diameter.

Secondary xylem. One distinct growth ring present. Pores mostly solitary, radial pairs numerous, clusters of 3 occasional, average radial diameter 88 μm . (73-102), average tangential diameter 80 μm . (58-102). Perforation plates simple. Intervessel pits alternate, fairly large, particularly in ligule; pits to ray cells large, oval; average vessel element length 406 μm . (348-464); tyloses abundant. Parenchyma sparse, paratracheal. Rays mostly 2 or 3 cells wide, cells of multiseriate portion mostly procumbent; uniseriate margins 1 to 5 cells high, the cells square or upright, uprights more common toward center of stem; uniseriates mostly 5 cells high, cells square; some cells containing dark globules.

Pith. Small.

Phloem. Appears to have checkered pattern of groups of thin- and thick-walled cells.

LOCALITY. Locality 2b.

CASG 60447

FIGURES 64, 65.

MATERIAL. Mature secondary xylem.

Secondary xylem. Pores mostly solitary with some radial multiples, average radial diameter 154 μm . (116-191), average tangential diameter 116 μm . (87-145). Perforation plates simple. Intervessel pits very small, alternate, apertures coalescent; pits to parenchyma oval; average vessel element length 407 μm . (314-515). Parenchyma paratracheal, sheaths 1 to 3 cells thick. Rays numerous, uniseriate or biseriate, 3 to 18 cells high, cells procumbent, some with one row of square cells at margins.

LOCALITY. Del Puerto Creek, locality 1.

CASG 60448

FIGURES 62, 63.

MATERIAL. Mature secondary wood.

Secondary xylem. Growth rings indistinct, defined by few rows of radially flattened fibers and somewhat smaller pores. Diffuse porous, pores mostly solitary or in radial pairs, average radial diameter 103 μm . (75–127), average tangential diameter 81 μm . (58–104). Perforation plates simple, angle acute. Intervessel pits alternate, large, apertures small; average vessel element length 412 μm . (406–580); tyloses thin walled. Parenchyma sparse, paratracheal. Multiseriate rays widely spaced, variable in height from 174 μm . to 1 mm., mostly 3 or 4 cells wide, cells low procumbent; uniseriate margins 1 to 3 cells high, cells square; uniseriates infrequent; all cells containing dark globules. Fibers large in diameter, average 29 μm .

LOCALITY. Locality 2b.

CASG 60449

MATERIAL. Stem 2 cm. in diameter.

Secondary xylem. Pores solitary, in short radial files and in clusters, average radial diameter 52 μm . (29–75), average tangential diameter 53 μm . (29–81). Perforation plates simple. Intervessel pits not observed; pits to parenchyma large; average vessel element length ca. 500 μm .; tyloses abundant. Parenchyma paratracheal. Rays low (about 12 cells high), 2 (or 3) cells wide, cells square or short procumbent; uniseriates about 10 cells high, heterocellular. Fibers large in diameter, some septate.

Pith. 3 mm. in diameter, prominently 6-lobed in transverse section; cells small.

LOCALITY. Del Puerto Creek, locality 1.

Except for its smaller pores and lower rays, CASG 60449 is very similar to CASG 60448. Since one would not expect to find higher rays in mature wood than in the juvenile wood of the same plant (see Bailey & Howard, 1941), it is unlikely that the two specimens represent the same natural species. The mature wood was collected from locality 2b, and the small stem from locality 1, a stratigraphic distance representing an estimated time interval of approximately one million years. Although there is a general similarity between these specimens and CASG 60430 and CASG 60434, no paratracheal parenchyma was observed in the latter two. In addition, intervessel pits in CASG 60430 appear to be scalariform, whereas those in CASG 60434 are opposite or alternate.

Among the many families with type XIA wood patterns, woods with little or no apotracheal parenchyma occur in at least eight. Special features, when present, serve to differentiate the various families. For example, secretory cells are characteristic of the Lauraceae, while radial canals and crystalliferous ray cells are found in the Anacardiaceae and Burseraceae. Canals also occur in the Araliaceae, and vested intervessel pits are characteristic of the Leguminosae and the Combretaceae. Of the fifteen type XIA fossil woods described, CASG 60438, CASG 60439, CASG 60440, CASG 60442, and two specimens described earlier (*Ulmium patersonensis* and *U. mulleri* (Page, 1967)) contain a few parenchyma cells that appear to have been oil or

secretory cells of some sort. In some specimens these cells are slightly inflated (FIGURE 56), but in others they are distinguished only by the presence of amber-colored inclusions. Pith sclereids such as those described in CASG 60442 and CASG 60440 occur in several members of the Lauraceae.

Infrequent rays, mostly solitary pores, and large vessel-ray pits as described in CASG 60443, CASG 60444, CASG 60445, and CASG 60446 are characteristic of families such as the Anacardiaceae, Burseraceae, and some genera of the Araliaceae. Crystalliferous cells (FIGURE 59) in the rays of CASG 60443 indicate a possible alliance with the Anacardiaceae and/or Burseraceae.

Pore multiples and low, numerous, mostly uniseriate rays composed of procumbent cells as described in CASG 60447 occur in some Combretaceae and Leguminosae. The presence of the vested intervessel pits characteristic of these families is almost impossible to establish in fossil material.

There are no distinguishing features in CASG 60448 and CASG 60449; however, the six-lobed pith of the former is uncharacteristic of the Lauraceae.

CONCLUSIONS

Remains of leaves and pollen of Cretaceous angiosperms are sufficiently abundant to provide an adequate source of information for the study of pre-Cenozoic angiosperm history. By contrast, angiosperm wood is sparsely represented. Until the discovery of the suite of dicotyledonous woods from central California, only a few isolated specimens had been described. Very little, therefore, could be learned of the evolutionary history of the dicot stem. The number of specimens is still small, but we now have some evidence of the diversity of wood patterns that existed in the Upper Cretaceous, as well as some bases for observations with respect to the level of specialization displayed by these woods as compared with those described from later periods. Of special interest is the lack of highly specialized characters in the specimens of the collection studied. Such features have not been convincingly described in any other pre-Cenozoic woods of unquestioned provenance. There is, for example, no evidence of complex pore arrangements, storied elements, resin canals, or tile cells, and while axial parenchyma occurs in a variety of conditions, there is no evidence of multiseriate bands or aliform sheaths. Furthermore, there is a high proportion of specimens with scalariform perforation plates and medium or long vessel elements. The most highly specialized pattern is that of CASG 60432, which has infrequent uniseriate rays, highly disorganized multiseriate rays with the cells variable in size and shape, very short fibers, and no observable parenchyma. The wood, in fact, resembles the secondary xylem of certain members of the Compositae. Although a discussion of some of the above observations was presented in an earlier paper (Wolfe *et al.*, 1975), a more extensive treatment will be presented in a forthcoming report.

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THE POST-ERUPTIVE VEGETATION OF LA SOUFRIÈRE,
GUADELOUPE, 1977-1979

RICHARD A. HOWARD, JACQUES PORTECOP, AND PIERRE DE MONTAIGNAC

BETWEEN July 8, 1976, and March 1, 1977, a series of phreatic eruptions occurred from three fracture zones at the summit (ca. 1400 m.) of La Soufrière, a volcano on the island of Guadeloupe in the West Indies. Forceful ejections of gas, water vapor, mud, dust, and boulders, but no lava, destroyed the vegetation of the southeastern, southern, and southwestern slopes of the mountain from the summit to beyond the Savane à Mulets and Piton Tarade, a distance of approximately one kilometer (FIGURE 1). The eruptions were accompanied by increased fumarole activity, resulting in toxic gas emissions from other summit vents and from those in the Col de l'Échelle (ca. 1200 m.).

The present study concerns the nature of the destruction of the vegetation; it reports on the recovery of certain taxa and details the early stages of revegetation of the affected area.

The history of seismic-volcanic activity of La Soufrière is incomplete. The age of the present pumice deposits near the current town of Basse-Terre is estimated at approximately 27,000 years. There are records of the ejection of incandescent material from the volcano in 1590 and of fumarole activity in 1635. In 1797-98 an important radial fracture to the north-northwest of the summit ejected vapor, dust, and rivers of mud; this was repeated in 1836-37. In 1892 fumaroles opened in the Col de l'Échelle. No major events on Guadeloupe were associated either with the classic eruptions in 1902 of Mt. Pelée, Martinique, and La Soufrière, St. Vincent, or with the activity of the latter in 1972 and 1979. On La Soufrière of Guadeloupe, a new radial fracture developed on the southeastern flank in 1956, with the projection of vapor and dust in a seismic crisis lasting about four months; after this the volcano was quiet until the tremors of late 1975. The fracture that formed in 1956 reopened on July 8, 1976, with significant projections of vapor and dust, the formation of a geyser at the Col de l'Échelle, and a river of mud and boulders that descended the Carbet Valley. Ejections of dust continued on July 25 and August 9 and 10. On August 30 the abyss of Tarrisan, a summit crater, ejected rocks and dust, while new fissures appeared on the south flank of the mountain. Another event on September 14 blew out the newly opened fissure of August 30 with the ejection of boulders and a cascade of mud and rocks in the direction of the Gallion River valley. On September 22 a plume of gas and dust reached an estimated altitude of 1500 meters above the crater. Ejections of dust occurred again on October 2 and between the 10th and the 30th. The summit fissure La Croix erupted on January 14 and 15, 1977, projecting boulders and producing mud rivers on several slopes. After a month of relative quiet, the last ejections of dust and boulders took place on February 28 and March 1, 1977.

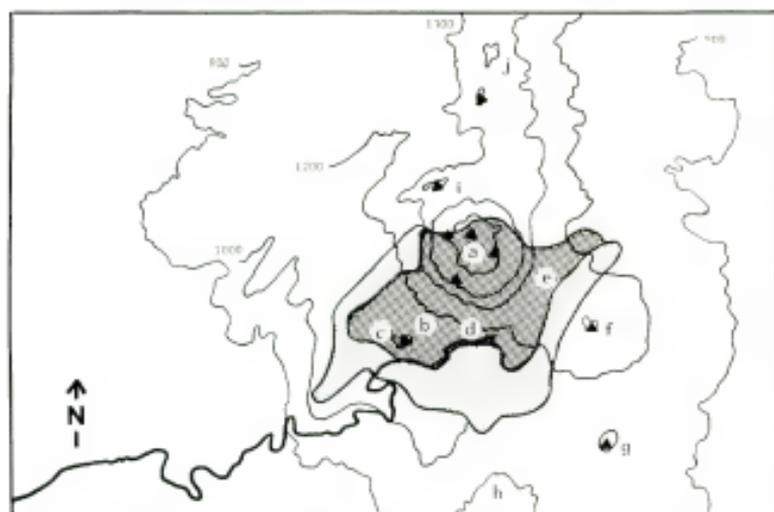


FIGURE 1. Map of summit of La Soufrière, Guadeloupe. Area of complete destruction of vegetation shown in dark dots; area of partial recovery in lighter dots. a, summit of volcano and sources of phreatic emissions, 1456 m.; b, Savane à Mulets, 1142 m.; c, Piton Tarade; d, parking area; e, Col de l'Échelle; f, L'Échelle; g, La Citerne; h, Gallion River valley; i, Morne Amic, 1390 m.; j, Morne Carmichael, 1414 m.

Since then all fissures and craters have been relatively quiet, with only casual emissions of steam from vents on the northern edge of the summit and near the Col de l'Échelle.

An ascent to the summit of La Soufrière is not a difficult climb. During the nineteenth century there were several trails from the southwest, one from the east, and another from the north. A cobblestone carriage track ascended from St. Claude to Bains Jaunes, where hot baths had been created using drainage from mountain streams. Although the area was easily accessible for over a century, collections of plant material remain inadequate, and nearly a dozen species reported from Bains Jaunes and the Soufrière have not been re-collected. Henri Stehlé (1935) published excellent, although brief, descriptions and enumerations of the vegetation around Bains Jaunes and the slopes and summit of La Soufrière. The illustrations presented in his paper, especially the double-faced pages between text pages 208 and 209, 224 and 225, and 240 and 241 (FIGURE 2), serve well for comparison with the recent and present conditions on the approach and summit of La Soufrière (FIGURE 3). In 1965 the government of Guadeloupe built a vehicular road to the area called Savane à Mulets and created a parking area in that location so that tourist buses could take groups of visitors to the area. An easy trail (Trace des Dames, FIGURE 7) ascends clockwise from the south to the north around the flank of La Soufrière, with a moderately steep climb to the summit. An undated (pre-1976) photograph (FIGURE 4) in a recent paper by Sastre (1978) shows the undisturbed vegetation at the Savane à

Mulets, currently the parking lot area. Neither the illustrations of Stehlé nor the photo by Sastre shows any plants killed by gases from fumaroles. When R. A. and E. S. Howard first climbed La Soufrière in 1950 (Howard, 1962, *fig. 9*), they found indications that fumarole emissions had had an effect on the woody vegetation even before the seismic activity of 1956.

Stehlé (1935) described a plant association on the slopes of La Soufrière that he



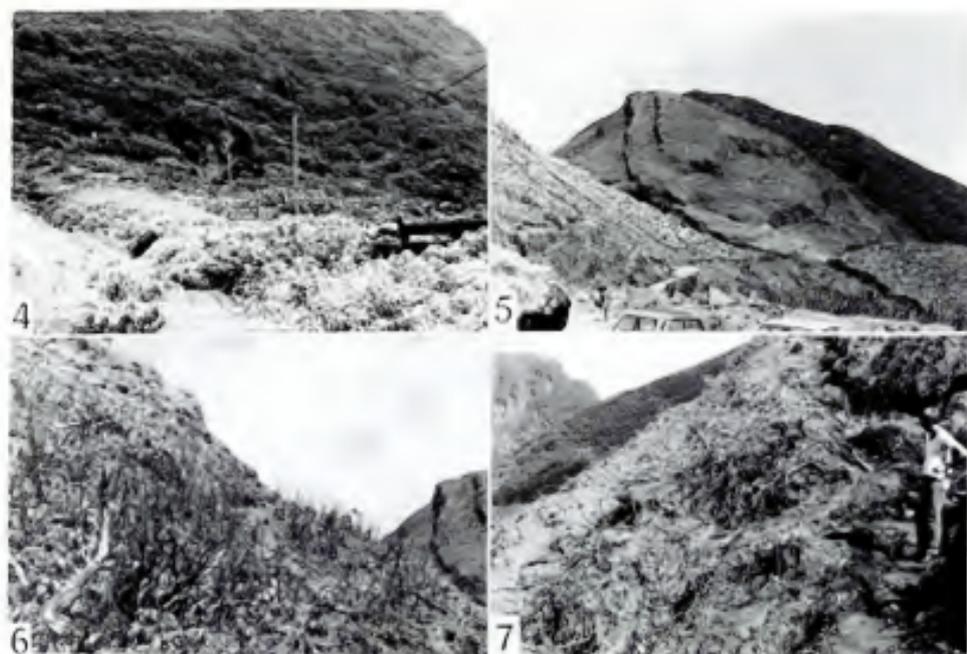
FIGURES 2, 3. 2, view of "Clusietum guadelupense" and summit of La Soufrière from south (reproduced from Stehlé, 1935). 3, view of summit of La Soufrière from south (1979): complete destruction of *Clusia* formation evident in foreground.

called a "Clusietum guadelupense"—a transition forest between the taller primary forest of more diverse composition in the area of Bains Jaunes and the stunted forests of the slopes at 1000 meters elevation. The size and dominance of *Clusia* is well shown in his plate reproduced here as FIGURE 2. Between 1150 and 1250 meters, a shrubby growth—a "Lobelietum guadelupense"—dominates the area, although trees reduced in stature persist in depressions and valleys on the lee face of the mountain. Rocky areas near the summit are covered with bromeliads, forming a "Pitcairnetum guadelupense," and on the summit Stehlé recognized swampy areas as "Eleocharidetum guadelupense," with the cliff faces having a "Sphagnetum guadelupense."

The southern and western flanks of La Soufrière affected by the recent volcanic activity are today a lahar, a volcanic desert of boulders, mud flats, and the debris of dead plants (FIGURES 3, 6). The original vegetation of this area can be identified by comparison with areas on the northwestern flank of the volcano at comparable elevations. Trees of *Clusia mangle* Rich. (Guttiferae) dominate and form a tangle of spreading branches supported by adventitious or prop roots. Specimens of *Cyrilla racemiflora* L. (Cyrillaceae), *Weinmannia pinnata* L. (Cunoniaceae), *Hex macfadynii* (Walp.) Rehder (Aquifoliaceae), *Myrsine coriacea* (Sw.) R. Br. (Myrsinaceae), *Hedyosmum arborescens* Sw. (Chloranthaceae), and *Dalymopanax attenuatus* (Sw.) Marchal (Araliaceae) are common, interspersed in the *Clusia* thickets. All are much-branched specimens, with the branching usually occurring from the base. Occasionally large, single-trunked trees of *Richeria grandis* Vahl (Euphorbiaceae) and *Myrcia platyclada* DC. (Myrtaceae) are found, and these are sparsely branched. Shrubs within the *Clusia* associations include *Chorizanthe alpinus* (Sw.) Howard (Melastomataceae), *Freziera undulata* (Sw.) Sw. (Theaceae), *Besleria lutea* L. (Gesneriaceae), and *Palicourea crocea* (Sw.) Roemer & Schultes (Rubiaceae). *Philodendron giganteum* Schott (Araceae) sprawls through the *Clusia*. Plants of *Norantea spiciflora* (Juss.) Krug & Urban (Marcgraviaceae) and *Hillia parasitica* Jacq. (Rubiaceae) may be woody at the base, and their scrambling branches appear vinelike from a distance. A few plants of *Prestoea montana* (Graham) Nicholson (Palmae) are found but rarely reach the canopy of *Clusia*. Two ferns, *Dicranopteris pectinata* (Willd.) Underw. and *Histiopteris incisa* (Thunb.) J. Sm., are relatively common but not abundant in the dense growth.

Between the swaths of the *Clusia* on slopes or flat areas is a shrub tangle that appears windswept and smooth. Although only 1–2 meters tall, the tangle is impenetrable from the ground and nonsupportive of any attempt to cross on top. Epiphytic masses of *Guzmania plumieri* (Griseb.) Mez. their rosettes filled with water, and soggy accumulations of *Sphagnum* and leafy liverworts cause a collector to become soaked while gathering specimens. The shrub association is of heterogeneous composition; the principal plant species are *Baccharis pedunculata* (Miller) Cabrera (Compositae), *Besleria lutea* L. (Gesneriaceae), *Chorizanthe alpinus* (Sw.) Howard (Melastomataceae), *Chorizanthe corymbosus* (Rich.) Cogn. (Clidemia guadalupensis Griseb. (Melastomataceae), *Freziera undulata* (Sw.) Sw. (Theaceae), *Miconia coriacea* DC. (Melastomataceae), *Miconia vulcanica* Naudin, *Psychotria aubletiana* Steyerf. (Rubiaceae), *Rondeletia parviflora* Rich. (Rubiaceae), and *Ternstroemia elliptica* Rich. (Theaceae).

Psychotria guadalupensis (DC.) Howard (Rubiaceae) is an epiphytic shrub, while *Norantea spiciflora* (Juss.) Krug & Urban (Marcgraviaceae) and *Symphysia racemosa*



FIGURES 4-7. 4, Savane à Mulets area prior to 1965. 5, parking area at Savane à Mulets, 1979; slope of La Soufrière on left, cascade of boulders evident in Col de l'Échelle; L'Échelle mountain in center. 6, dead shrub area on slopes of La Soufrière. 7, Trace des Dames in area of mud slides on western slope of mountain; unaffected *Chocia* formation evident in upper left, with Nez Cassé mountain shown in profile.

(Vahl) Stearn (Ericaceae) are scandent woody plants.

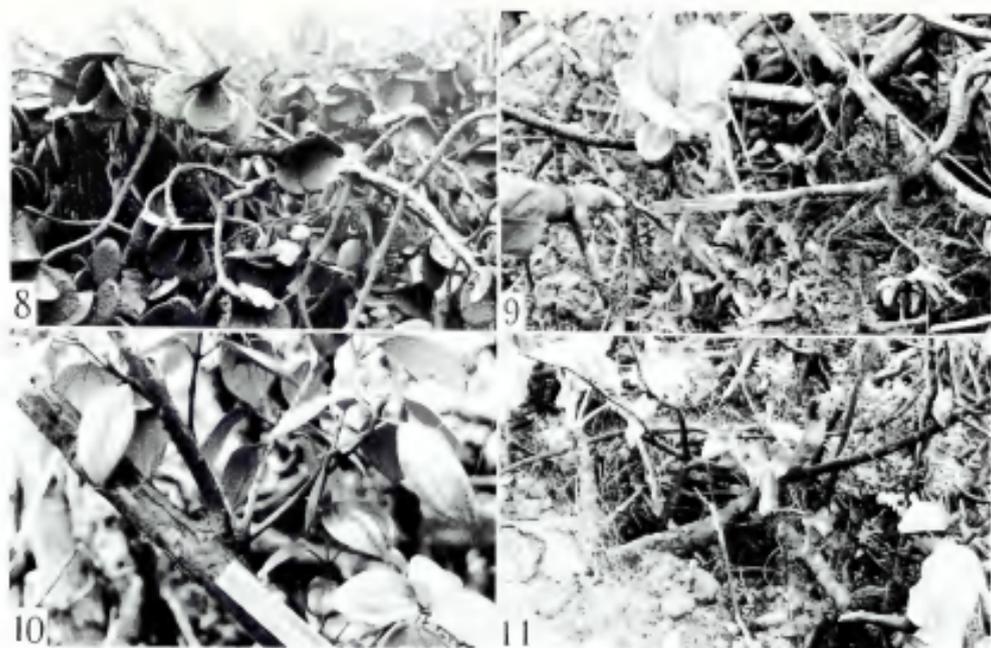
The herbaceous species scattered throughout the shrub zone include *Blechnum violaceum* (Fée) C. Chr. (Polypodiaceae), *Calolisianthus frigidus* (Sw.) Gilg (Gentianaceae), *Guzmania dussii* Mez and *G. plumieri* (Griseb.) Mez (Bromeliaceae), *Juncus guadeloupensis* Buch. (Juncaceae), and *Lobelia digitatifolia* (Griseb.) Urban (Lobeliaceae). The single scandent herbaceous or subwoody vine present is *Mikania ovalis* Gilg (Compositae).

On rock outcrops, cliff faces, or occasional boulders, there are woody and herbaceous plants of various habits: *Gaultheria swartzii* Howard (Ericaceae), *Isachne rigidifolia* (Poir.) Urban (Gramineae), *Lycopodium clavatum* L. (Lycopodiaceae), *Machaerina restioides* (Sw.) Vahl (Cyperaceae), *Peperomia hernandifolia* (Vahl) Dietr. and *P. tenella* (Sw.) Dietr. (Piperaceae), *Pilea parietaria* (L.) Blume (Urticaceae), *Pitcairnia bifrons* (Lindley) Read (Bromeliaceae), *Pityrogramma chrysophylla* (Sw.) Link (Polypodiaceae), *Pterolepis glomerata* (Rottb.) Miq. (Melastomataceae), *Rhynchospora polyphylla* (Vahl) Vahl (Cyperaceae), *Sauvagesia erecta* L. (Ochnaceae), *Tibouchina ornata* (Sw.) Baillon (Melastomataceae), and *Viola stipularis* Sw. (Violaceae). When *Calolisianthus frigidus* (Sw.) Gilg (Gentianaceae) is found in this area, the plants are dwarfed and often flower when less than a foot tall.

Following the eruption of July 8, 1976, Portecop made some observations on the initial effects of the volcanic activity. On August 15, 1976, Basse-Terre (the capital city) and surrounding areas were evacuated of 74,000 people; travel to the area was considered dangerous and was controlled. In October of 1976, Claude Sastre climbed La Soufrière. His observations are included in a brief appendix to his paper (1978). On December 8, 1976, Henri Stehlé ascended the volcano, and he has recently (1979) published the first part of his observations. Portecop returned to the mountain on December 20, 1976, and Howard and Portecop examined the slopes and summit in March, 1978, and again in April, 1979. The present report expands the brief published reports and extends the period of observation of lahars.

The climate at the summit and on the upper slopes of La Soufrière is harsh. Under normal circumstances the mountaintop is cloud covered; it is estimated to be completely free of clouds only five or six days a year. The heavy morning cloud cover is generally dissipated briefly during part of the day, but it reassembles quickly, producing heavy showers and dangerously reduced visibility. By mid-afternoon the cloud cover is solid again. Rainfall is estimated at 10 meters annually, but mist accumulation is nearly continuous. Before the eruptions runoff of rainfall was controlled by the dense cover of vegetation, but both sheet and channel erosion are now apparent in the decimated areas. The original cover of volcanic dust on the vegetation has been washed off by rain, and the mud flows have been reduced in thickness on the flanks, resulting in deep accumulations of sediment in many valleys and depressions. The winds on the summit, classified as fresh (19–30 m.p.h.), reach gale force (30–65 m.p.h.) in gusts. Changes in temperature of 20°C. have been recorded between the occasional full sun break in the clouds and the next passing mist.

The normal emission of acid gases from the summit fumaroles has had a cumulative effect in recent years on the flank vegetation on the western and southern slopes of La Soufrière. The current surface runoff and standing water show a pH of 4.5.



FIGURES 8-11. 8, 9, *Clusia mangle*. 8, leaves coated with acid mud (1976). 9, branch that survived eruption by natural layering (1979): adventitious roots formed below leaves at ruler (left), again at junction with dead area of stem at sheath knife (right). 10, *Charianthus alpinus*, multiple adventitious shoots formed below dead branch. 11, *Philodendron giganteum* recovering after eruption: plant at left intact and developing new leaves from apex; Dr. Portecop's hand indicates broken end of large stem with apex developing new leaves of normal size.

Drip from leaves, trunk water, and water held by the rosettes of leaves of bromeliads gave pH measurements of 4 to 5. R. M. Chevrier reported in 1976 that pH recordings taken at the level of l'Échelle during the eruption of July 14-16 went from 1.1 to 3.4. An unusually acid environment prevailed during the period of volcanic activity.

The dust ejected during the volcanic activity was soon converted into mud, which coated the leaves of all plants and compacted and smothered the lesser vegetation. However, not one of the plants reported from the slope and summit vegetation has a completely deciduous habit. The vegetation is evergreen, and leaves persist for several years since apparently no abscission layer is developed. Portecop observed coatings 5-10 mm. thick on the leaves of *Clusia* (FIGURE 8) on July 26, 1977, after the first eruption. The acidity of this mud mass was certainly a factor in the defoliation and subsequent death of the plants.

Heavy rains during the eruptions caused tremendous mud flows on the flanks of the volcano. At the present time many slopes of 30-45° have accumulations 1 meter thick, as revealed in profile in ravines where the old surface, compacted dead vegetation, and the new accumulations can be observed. The mud surface may have a rigid layer to 1 cm. thick, and transects of the flow show stratifications of silt and gravel. We observed that some plants of *Pitcairnia*, *Anthurium*, and *Philodendron* were exposed at the edges of ravines, where they were covered with layers of mud but were developing new growth on the ravine edge. A few plants of *Machaerina* that showed only the tips of leaves through the mud layer were excavated and found to be developing new rhizome offshoots that might in time penetrate the mud cover. However, in a flat area northwest of Savane à Mulets, Howard sank nearly three feet into a mire of mud when crossing a seemingly hard surface. In comparable open areas the current surface is depressed and is resilient underfoot as the mud-covered shrub layer, particularly the rhizomes of *Philodendron* and *Guzmania*, decays. Subsequent rainfall and surface runoff have sorted out areas of silt, gravel, and boulders. Hard-crusts resist colonization by plants, but silt and gravel zones now support seedlings that have germinated recently.

There were no firsthand observations of the rain of boulders ejected during the eruption. In the Col de l'Échelle the former trail area is covered with piles of boulders and massive rocks, and the area is passable only by scrambling over and around the fallen rock (FIGURE 5). To the south and west of the volcano summit, few new boulders can be observed, yet the effects of falling rocks are evident on the trees still standing. The tops of most woody plants are broken, and branches to 10 cm. in diameter are seen broken at their junction with the trunk. Some horizontal branches

FIGURES 12-15. 12, *Didymopanax attenuatum*, two adventitious shoots developing from marginal callus of injured stem, both shoots showing unusual bulbous development at base; 13, *Chorizanthe alpina*, adventitious shoot development from base; upper branches have been killed, adventitious shoots have flowered and produced fruit; 14, *Richeria grandis*, trunks with multiple adventitious shoots of varying sizes developed from uninjured sections of trunk; 15, *Ilex macfadynii*, multiple adventitious shoots developed from base of unbranched plant; leaves of these shoots abnormal in shape and thickness.

are without bark on the upper surface. Bark damage is greatest on the side toward the mountain, indicating that the rain of rocks was directional. The bark may be stripped away for several decimeters. A few angular rocks, some to 24 cm. in diameter and



one estimated as weighing 4 kg., were found wedged in branches or in the crotches of standing trees.

THE DEVELOPMENT OF ADVENTITIOUS SHOOTS

From the combined effects of gas, acid, mud, and injury, the woody vegetation appeared to be completely dead, and the herbaceous vegetation eliminated. At present this is true of all plants of *Clusia mangle*; a number of other dead woody plants are unidentifiable. However, a few individual plants have had renewed growth after a period of leaflessness. Apical growth is infrequent and is restricted to plants of single stem habit (e.g., *Philodendron*). Rhizomatous plants or those forming clumps may have lost their original shoot apices when covered with mud and then developed new shoots from the base after being washed clean.

Some trees and shrubs have developed adventitious shoots, but the variation in the patterns observed was not expected. Certain species developed adventitious shoots only near the apex of the broken shoots (FIGURE 14). Others developed the shoots only at or near the base of the plant (FIGURE 15). The areas of injury where bark was removed (presumably by falling rocks) have, on some plants, begun to develop callus tissue although no adventitious shoot development has occurred. Other plants have developed adventitious shoots above the injury, below the injury (FIGURE 10), or on areas not associated with injury (FIGURES 13, 14). Some woody species produce multiple adventitious shoots from a restricted area, suggesting the activity of multiple buds; others produce only solitary adventitious shoots. Regrettably, it is impossible to determine the age of the trunks or branches that develop adventitious shoots, and it is not known if these are latent buds of considerable age that have been released. The multiple shoots may be of varying sizes. In some cases all shoots have developed equally in length and thickness, while in other cases a few of the multiple shoots have already exceeded the others in size. Examples were seen where the smaller or thinner shoots had begun to die.

Horizontal branches or trunks that had extensive bark injury on the upper surface have often developed many adventitious shoots from the lower surface, opposite the injury, and a lesser number from the upper side in areas away from the injury. There seemed to be a tendency for the adventitious shoots from the lower surface (which had to curve around the trunk to assume an upright position) to branch from the base. This is in contrast to the unbranched adventitious shoots that developed on the upper surface.

Species also varied in the nature of the growth and branching of the adventitious shoots. *Didymopanax attenuatus* was characterized by the development of swollen, almost subbulbous, bases to the adventitious shoots (FIGURE 12). Leaf scars were no more frequent in these swollen areas than farther up the stem. The lower internodes of some adventitious shoots were short, while in other species the first-formed internodes were contrastingly longer than later ones. Abnormal leaves with thickened petioles and blades of other than normal shape were found only on some specimens of *Ilex macfadyenii*. However, there were contrasts in the type of leaf produced from the first or lower nodes. Smaller leaves (cataphylls with an early leaf fall) characterized some species, while other species had normal leaves from the beginning of shoot development.

In some species the growth of adventitious shoots is continuous, while in others it appears to be in units or flushes indicated either by sympodial apical growth below a dead bud or by longer internodes above a region of shorter internodal development with more proximate leaves (Howard, 1974). As many as three to five growth units were recorded for some adventitious shoots that had been produced within the past twelve months.

REGROWTH OF SINGLE-STEMMED PLANTS

The bromeliad *Guzmania plumieri*, the palm *Prestoea montana*, and the fern *Blechnum violaceum* all have tightly arranged leaves forming a rosette or crown. In the *Guzmania* this rosette normally holds water. During the volcanic eruption plants of all three species accumulated near the growing point quantities of acid mud that appears to have had lethal effects. Many plants are now seen without life and with the rosette of leaves well above the ground but still tightly packed with mud. Palms also have retained masses of mud in the apex and are dead, with only one seen in which the mud had been mostly washed away and new leaves were developing.

A taxonomic problem remains regarding the bromeliad called *Guzmania plumieri*. Young epiphytic plants of this species do not develop a long stem system, but terrestrial plants of the same species seem to have been long lived and to have developed a leafy rhizome. In some plants this rhizome has been recorded over two meters in length; however, none of these plants was seen in flower, and no herbarium record of *G. plumieri* refers to such growth forms. One long stem was washed clear of mud. Although the apex was dead, two adventitious shoots (small rosettes) had developed 17 and 32 cm. from the apex; these were green and were developing without evidence of adventitious roots. Climbing or rhizomatous bromeliad stems normally branch only immediately below a flower-producing rosette. This unusual example was marked and will be the subject of continued observation.

Philodendron giganteum also produces a thick, climbing or scrambling stem several meters in length. Normally, it branches infrequently but develops feeding or holding roots along its entire length. Long stems of some plants of *P. giganteum* observed were broken as a result of the eruption; the upper detached end was observed to be living (FIGURE 11). Although the plant may have lost all its leaves, the renewal growth at its apex produced leaves of mature size. Many cases were seen where subapical fragments of stems, with roots, did develop adventitious shoots. These adventitious shoots were a fraction of the diameter of the original shoot and had produced leaves of reduced size, comparable to those of very young plants. No examples were found of new apical shoot development from rooted basal sections of an older plant.

NOTES ON THE REGROWTH OF VARIOUS TAXA

TREES

Clusia mangle. The death of all individuals of this seemingly sturdy plant in the affected area was not expected. The standing trunks examined have no living bark, and no development of adventitious shoots is expected. The only example of survival

was a single shoot that had been depressed beneath a large stem of a *Philodendron* and protected by a mass of bromeliad rosettes. Green leaves attracted our attention, and upon excavation there appeared an example of natural layering. The stem system entering the ground was dead, but the apex had recently developed four pairs of leaves and emerged from the debris. Of interest was the development of adventitious roots immediately below the leaves as well as at the junction of the living and dead tissue, but with none for a distance of 30 cm. between (FIGURE 9).

Cyrilla racemiflora. Trunks to 3 meters with a d.b.h. of 10.5 cm. were seen. Many adventitious shoots were observed; they developed from single buds from the base to a height of 2 meters on the trunk. Several adventitious shoots were producing flowers from the upper portions of a growth unit. Lateral branching had occurred from nodes immediately above the flowering area, while nonflowering shoots were unbranched.

Didymopanax attenuatus. Standing trunks up to 3 meters tall with a d.b.h. of 8 cm. were found. Stems of this plant seemed to be vulnerable to injury by falling rocks, suggesting a soft or succulent bark. Callus was developing rapidly and conspicuously around the injured areas, and the development of adventitious shoots was primarily adjacent to these areas. The shoots had conspicuously swollen bases and generally thin stems without growth units (FIGURE 12). One young inflorescence was developing.

Ilex macfadyenii. This species, represented mostly by shrubs of less than 3 meters, is second to *Clusia* in frequency. However, two trees (4 and 6 meters tall) had diameters at breast height of 10 and 20 cm., respectively. Broken areas of bark were common, but callus formation was not conspicuous. Adventitious shoots were plentiful, primarily from the basal zone of even the largest trees (FIGURE 15). Many of the slender young shoots had retained cataphylls or reduced leaves at the first six or seven nodes. Abnormal leaves seen on several plants exhibited wider petioles, broader cuneate bases, and thicker blades than normal leaves. The shoots revealed three, four, and five growth units, the last in all cases being shorter than the others, with reduced leaf size near the apex and minute terminal buds. Adventitious shoots, which developed from the lower surface of damaged horizontal branches, were branched. Individual plants bore only staminate or pistillate flowers, but flowering on adventitious shoots was copious. The staminate flowers occurred in the axils of even the reduced leaves near the shoot apex. Pistillate flowers were not formed so close to the apex of the shoots. Only immature fruits were observed.

Myrcia platyclada. Only one tree of this species was encountered. Truncated 6 meters above the ground and with a d.b.h. of 34 cm., it may have originally exceeded 10 meters in height. Adventitious shoots developed singly from supra-nodal areas at mid-height of the existing stem. The largest shoots seen were 14 cm. long, without growth units, but with the younger leaves brightly colored, as is common in the Myrtaceae. The shoots were branched, but there was no evidence of flowering.

Myrsine coriacea. Few trees have survived. The largest living tree was 2.5 meters in height; it had previously branched from the base and appeared shrublike. Adventitious shoots were clustered, developing from multiple buds at the base to a height of

30 cm. The lower nodes of the adventitious shoots had cataphylls, and the basal internodes were shorter than the upper ones. Sympodial branch development was observed on two shoots that had not yet flowered.

***Prestoea montana*.** Only one living plant of this palm was seen; it was 1 meter tall and had a flush of young green leaves. All other palms were dead, with the crowns and persistent leaf bases solidly packed with mud.

***Richeria grandis*.** Several large but badly broken trees remained standing; the largest remnant was 3 meters tall with a d.b.h. of 21 cm. Adventitious shoot development was abundant in the basal meter of the plants. Buds were multiple, but the shoots varied in size and smaller ones were dying (FIGURE 14). Some adventitious shoots were produced singly near injured and callused areas.

***Weinmannia pinnata*.** This species is the third most common plant in the *Clusia* association. Trees generally were branched from the base, with the stems clustered. The largest plant still standing was 5 meters tall with a d.b.h. of 14 cm. Adventitious shoots were strongly developed from the current ground level but also occurred to a height of 3 meters. This was the only species that was developing adventitious shoots when we studied this area in 1978. The adventitious shoots were all clustered and of contrasting thickness. Areas of future shoot development along the stem were indicated by bright-colored multiple buds. Adventitious shoots showed three growth units; shoot growth is apparently halted by a resting terminal bud before development continues. The nodes at the immediate base of a growth unit were leafless, and the leaf scars were smaller than the bases of existing leaves. Several adventitious shoots were seen in flower, and young fruits were developing.

SIRIUS

***Chorizanthe alpinus*.** One plant 3 meters tall with a d.b.h. of 6.8 cm. was seen. Others located were less than 2 meters tall and badly broken. Clustered adventitious shoots appeared to develop immediately below old and dead branches (FIGURE 10). No growth units were observed, although several shoots were in flower. Flowers were normally produced in cymes from the two apical nodes and also terminated the growth of the shoot. Subsequent branching developed from shoots produced in the two or three nodes below those that were flowering. The adventitious shoots had four or five short basal internodes, with the subsequent ones considerably longer.

***Palicourea crocea*.** Most existing plants were badly broken, suggesting that this is a plant of weak structure. Nevertheless, all plants of this species freely developed adventitious shoots, and all shoots were of one growth unit terminated by an inflorescence. Subsequent, seemingly dichotomous branching resulted from the growth of axillary buds at the base of the inflorescence or at an additional node immediately below.

SCANDENT PLANTS

***Hillia parasitica*.** Only one recognizable plant was encountered. It had a stem diameter of 2.6 cm. and was dead to near the base, where one adventitious shoot was developing. This shoot had a conspicuously swollen base similar to that of *Didymopanax*, and no growth units had been established.

Norantea spiciflora. Plants of this semiscandent species seemed to have been buried in avalanches of mud but have recovered with remarkable frequency. One green shoot appeared to have developed adventitious roots above a dead area and was continuing growth. Other stems, 1–2 cm. in diameter, had sparse and scattered single adventitious shoots. The apices of all adventitious shoots showed the colorful flush growth of an elongated bud. The internodes of the adventitious shoots appeared to be shorter than those of undamaged plants, and the majority of adventitious shoots had developed clusters of adventitious roots from the lowest two nodes and internodes. It appears that the rapid shoot development awaits the establishment of this new root system.

Philodendron giganteum. This is a very abundant plant with thick, scrambling or trailing stems, some to 15 cm. in diameter. The stems are apparently fragile, since most plants were broken. The apical meristem was not destroyed in the loss of leaves during the eruption, and new leaves have developed and produced blades of normal size (FIGURE 11). Sections of the stem without the terminal bud have developed slender axillary adventitious growth that produced leaves of smaller than normal size. No new root development was observed on the adventitious shoots.

Symphysis racemosa. The majority of these scrambling plants had stems to 3.2 cm. diameter and were killed back to the current ground level. Adventitious shoots developed from the base of the plant from undamaged tissue. Scarred areas along the branches were developing callus but without indication of shoot production. The shoots had an average of six cataphyll units at the base, then abruptly large leaves, but ending with a series of much-reduced leaves. One shoot had three growth units recognizable by leafless areas presumably associated with cataphylls. Terminal growth was a flush of leaves, usually brightly colored, and normal stem extension was sympodial following the production of a terminal inflorescence. Several adventitious shoots had developed short lateral branches.

SEEDLING INVADERS

Volcanic activity of La Soufrière ceased in March, 1977. There are nonspecific reports of "seedlings present" for December, 1977. In March, 1978, we observed small but nonflowering plants of *Ischaemum*, *Machaerina*, *Pityrogramma*, *Sauvagesia*, and *Viola*. In April, 1979, we could recognize as invading plants mature, flowering, and fruiting specimens of *Erechtites hieracifolia* (L.) Raf., *Ischaemum latifolium* (Sprengel) Kunth, *Phytolacca icosandra* L., *Sauvagesia erecta* L., *Tibouchina ornata* (Sw.) Baillon, and *Viola stipularis* Sw., as well as spore-producing plants of *Histiopteris incisae* (Thunb.) J. Sm. and *Pityrogramma chrysophylla* (Sw.) Link. We have no recollection from 1978 of *Phytolacca* or *Erechtites* in the area now devastated, although both occurred occasionally as weedy plants near the parking area and along the trail. *Phytolacca* has multiseeded, fleshy fruits that might be transported by birds or on the shoes of visitors, while *Erechtites*, a composite, has plumed, wind-dispersed fruits. *Eleocharis maculosa* (Vahl) Roemer & Schultes (Cyperaceae), which was observed in fruiting condition, currently occurs in stream beds within the devastated area but probably existed there prior to the eruption. Seedling plants of *Charianthus alpinus* were seen flowering precociously with only two pairs of leaves and a total of four nodes present above the persistent cotyledons. *Calolisianthus*

frigidus was also seen flowering as a very small plant. In the undisturbed shrub zone this species may reach 1.5 meters when in flower, while on rock cliffs the plants are known to flower when only 12 cm. tall.

Didymopanax attenuatus seedlings occurred in clumps, due in some cases to the germination of several seeds in one fruit or the result of many fruits having been deposited in one place. Other species present as single plants—not clumps of seedlings—were *Anthurium*, *Ilex*, *Palicourea*, *Sauvagesia*, *Viola*, and *Weinmannia*. Seedlings of *Miconia* were infrequent but could not be determined to species. A myriad of seedling rosettes of *Guzmania* could be distinguished from the less frequent seedlings of *Pitcairnia*. Only *Guzmania* has wind-dispersed seeds. Young sporophytes of *Pityrogramma* of both silver and gold color forms were more numerous than those of *Blechnum violaceum*. Young plants of *Machaerina* may develop only one distichous fan of leaves or proliferate early from the base, forming several fans of equal size.

Of the nine taxa of woody plants normally associated in the area dominated by *Clusia*, only two were represented in the seedling populations. These—*Ilex* and *Didymopanax*—have fleshy fruits. Although *Clusia*, *Hedyosmum*, *Myrcia*, and *Myrsine* have a fleshy fruit structure that would presumably aid distribution, they were not found as seedlings. *Cyrilla* and *Weinmannia* (both with small, dry seeds) and *Richeria* (with explosive fruits and large seeds) were not present. *Clusia*, *Hedyosmum*, and *Richeria* are dioecious taxa. The palm *Prestoea montana* has not been seen in fruit in the flank area of the volcano, and it is possible that existing plants are from past casual introductions of the fleshy fruits by birds. No seedlings have been seen.

The shrubby species outside the *Clusia* associations include two species of *Charianthus*, two of *Miconia*, and one each of *Besleria*, *Freziera*, *Norantea*, *Psychotria*, *Symphysia*, and *Ternstroemia*; all of these taxa have fleshy and many-seeded fruits commonly red or blue in color. Only *Miconia* sp. and *Charianthus alpinus* are among the invading species of open areas. *Rondeletia* has small, light seeds, and *Baccharis*, a composite, has wind-dispersed fruits, but neither was found as a seedling.

Of the epiphytes of the flank areas, *Hillia parasitica* has comose seeds, and *Psychotria guadalupensis* has black, fleshy fruits. Neither species was encountered as a seedling.

Of the herbs, only *Guzmania* (with plumose seeds) seems to have a specialized dispersal mechanism. *Calolisianthus*, *Isachne*, *Machaerina*, *Sauvagesia*, *Tibouchina*, and *Viola*, as well as *Juncus*, *Lobelia*, and *Pterolepis*, have numerous small, dry seeds. *Viola* seeds may be holoblastic, but for short distances only. The first six genera were represented by seedlings in mud flat areas open to colonization, often considerable distances from the nearest mature plants.

The dominant plant of the "Pitcairniectum guadelupense" (*Pitcairnia latifolia*) has red-colored fruits that do not detach readily and that presumably are not distributed by animal vectors. Its abundance at the exposed higher elevations suggests that any seeds freed from the fruits could be carried by the wind to the mud flats where seedlings are now found. The dispersal of the very light spores of *Blechnum*, *Histiopteris*, and *Pityrogramma* is also easily understood. *Gaultheria swartzii*, found on rocky areas, has fleshy, black, many-seeded fruits but has not yet established itself as a colonizing plant.

The slopes of La Soufrière are within the Parc Naturel de Guadeloupe and are under the care of the Office National des Forêts. Additional study plots have been established, and future changes will be observed and reported.

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THE SOUFRIÈRE PLANT OF ST. VINCENT

RICHARD A. HOWARD AND KRISTIN S. CLAUSEN

THE SOUFRIÈRE PLANT (*Spachea elegans* (Meyer) Juss.; originally *S. perforata* Juss.) was collected by Alexander Anderson along the Essequibo River in British Guiana in 1791 and introduced into cultivation in the botanical garden of St. Vincent. The following notes should end the saga of a species considered extinct in the wild but preserved in a botanical garden. How the story became a legend of the Caribbean area is not clear.

For many years the tale has been repeated that *Spachea perforata* had been a native of the slopes of the Soufrière on St. Vincent, and that all native plants had been destroyed by the eruption of that volcano in 1902. A single plant supposedly remained under cultivation in the botanical garden near Kingstown. When the senior author visited St. Vincent in 1950, the location of the plant in the garden was not known, for most specimens in the garden were without labels. Two trees belonging to the Malpighiaceae were found in flower; herbarium specimens were made and determined, and the garden plants were again labeled. In a history of the St. Vincent Botanic Garden (Howard, 1954) the tale was published that, according to the records of the garden, these plants had been grown from seed obtained in the mountains.

Extensive general collecting on St. Vincent by H. H. and G. W. Smith, John and Pamela Beard, Conrad Morton, George Proctor, R. A. Howard, and Keith and Elizabeth Laidler has not turned up a single native specimen of the Soufrière tree.

More recently, Keith and Elizabeth Laidler (1975, 1978) became interested in propagating and reestablishing the species in the mountains of St. Vincent. These authors (1975) stated, "The eruption of Mt. Soufrière in the last century practically wiped out this arboreal species, which used to grow in relative abundance on the slopes of the volcano. The mature thirty-foot specimen now thriving in the Gardens is the only cutting that grew successfully from the single sapling which was discovered on the mountain after the catastrophe." The Laidlers sent flowering specimens to Kew to verify that the plant was hermaphroditic. They also rooted cuttings of the tree, planted them in several places on the island of St. Vincent, and speculated on the possibility that the plant might still be discovered in the remote areas of the northwestern corner of the island. In the final report of their work it is admitted that, lacking care, the transplants all died.

During the summer of 1979, Gavin Bridson, Librarian of the Linnean Society in London, called to the attention of the senior author a large and unappreciated manuscript of a "Hortus" of the West Indies written by Alexander Anderson in approximately 1803. Anderson, whose life story is being compiled by the senior author, was appointed director of the St. Vincent Botanic Garden in 1783 and served

in this capacity until ill health forced his resignation in 1811, a few months before his death. It was he who received and nurtured the plants, including several varieties of breadfruit, delivered from the South Seas by Capt. William Bligh. With William Lochhead, who was to succeed him as director of the Garden, Anderson made expeditions to Trinidad and Guiana to secure plants for the Botanic Garden. Anderson's manuscript described in detail the plants under cultivation in the garden and their sources, uses, and culture; it included many descriptions of plants new to science, as well as numerous exquisite drawings. The manuscript was sent to William Forsyth at Kensington Gardens and was intended for publication. Among the drawings was a colored plate of "*Cullenia malpighioides*," supplemented in the text by a complete Latin description of the new genus and species. The name honored a Dr. Cullen of Edinburgh, who was the first in Scotland to use the Linnaean system in his teaching. Anderson reported that in 1791 he saw the plant some 200 miles up the Essequibo River, collected seeds, and secured some small plants to return to the garden on St. Vincent. When they flowered, he prepared the description and had the plant sketched. Although "*Cullenia malpighioides*" antedates the genus *Spaethea*, the name was never validly published.

In 1818 G. F. W. Meyer described *Malpighia elegans* as new, based on an E. K. Rodschied specimen collected on the shores of the island of Arowabisch in the Essequibo River. The original specimen is preserved at Göttingen. In 1824 de Candolle transferred the species to the genus *Byrsonima*, and in 1838 A. Jussieu created the new genus *Spaethea* and published an illustration. Both de Candolle and Jussieu cited a collection of Leschenault from Surinam, now preserved in Paris and there indicated incorrectly as the type.

In 1840 Jussieu added to the genus *Spaethea parviflora* and *S. ossana*, from Cuba; *S. perforata*, from St. Vincent; and *S. tricarpa*, from Brazil. All of the species were described, but without the citation of specimens. Longer descriptions were published in 1843 (Jussieu, 1843), and collections were cited. Most critical characteristics used by subsequent scholars seem to be derived from Jussieu's descriptions. *Spaethea parviflora*, based on a specimen in "herb. DC," was credited as "In insula Cubae juxta Habannam legit cl. de la Ossa." *Spaethea ossana*, based on specimens in "herb. DC, Hook.," was described with the note "In Ins. Cubae juxta Habbannam legit cl. de la Ossa (herb. DC), et alterum specimen ex Ins. S. Vincentii exhibet herbarium Hookerianum cum *S. perforata* confusum." *Spaethea littoralis* ("herb. Mus. Par.") was attributed thus: "Ad littora maris in Insulâ S. Thomae legit cl. Finlay." Finally, *S. perforata* (herb. Hooker) was reported as "Specimen in Ins. S. Vincentii lectum communicavit cl. Hooker.—Adsunt in herb. Lessert specimen ibidem a cl. Caley lecta, foliis paulo majoribus, tenuioribus et omnino membranaceis, minus manifeste punctatis paulisper distincta." Each of these species requires a comment for clarification.

José Antonio de la Ossa became the first director of the Jardín Botánico de la Habana on May 30, 1817. León (1918) referred to the fact that Ossa had prepared a work listing the uses of plants and their common names and had also included plants recently introduced from other countries and acclimatized there. The death of Ossa, which occurred shortly afterwards, frustrated the publication of his work. This manuscript has not been studied in detail, and it is not known if it exists in Cuba

today. It is clear that *Eupatorium ossaeianum* DC. (de Candolle, 1836), with a type "de la Ossa, Havana, Cuba," is an endemic species of St. Vincent. It is probable that *Spachea parviflora* and *S. ossana*, attributed to Cuba, are plants obtained from the botanical garden of St. Vincent. A similar error was made by Jussieu in reporting *Spachea littoralis* was collected by Finlay from St. Thomas. Britton and Wilson (1924) noted that "*Spachea littoralis* A. Juss., described by A. Jussieu as from St. Thomas, collected by Finlay, was really collected in Trinidad." R. O. Williams (1947), who with the critical help of N. Y. Sandwith prepared the treatment of the Malpighiaceae for the *Flora of Trinidad and Tobago*, accepted only *S. elegans* and stated, "*S. perforata* Juss. recorded from St. Vincent and cultivated in the Royal Botanic Gardens, Trinidad, appears to be the same species." In a later section Cheesman (1947) referred to Niedenzu's work but noted, "A synonym of the latter [*S. parviflora* Juss. var. *perforata* (Juss.) Niedz.] is *S. littoralis* Juss., which was based on *Finlay 198* from Trinidad, but this collection may have been from a cultivated plant."

The collectors of the material Jussieu cited for *Spachea perforata* were Guilding (for the specimen sent to Hooker and now in the herbarium at Kew) and Caley (for the specimen in the Lessert Herbarium (p). Reverend Lansdown Guilding wrote a history (1825) of the botanical garden of St. Vincent that included Anderson's list of the plants growing in the garden in 1806. "*Cullenia malpighioides*" is not included in this list, but neither is any species of *Spachea*. According to Guilding's letters now in the archives at Kew, Guilding did send many specimens and drawings of plants in the St. Vincent Botanic Garden to Hooker for identification. George Caley, the director of the Garden from 1816 to 1819, commented in letters also preserved at Kew that Anderson neither numbered nor labeled the plants of the garden, making it necessary to send specimens to various people for identification.

Grisebach (1859) recognized both *Spachea elegans*, from Trinidad (Purdie) and Guiana, and *S. perforata*, from St. Vincent (Guilding). In the synonymy of *S. perforata*, Grisebach listed "Ossana Vincentiana, Juss." with an exclamation mark, indicating that he had seen material. This name has not been published.

Two monographs of the Malpighiaceae that treated the genus *Spachea* were published subsequently by Small (1910) and Niedenzu (1928). Small recognized four species: *S. parviflora*, from Cuba and St. Vincent; *S. littoralis*, from St. Thomas; *S. perforata*, from St. Vincent; and *S. ossana*, from Cuba and St. Vincent. No specimens are cited in treatments for *North American Flora*, and the lack of representative material in the herbarium of the New York Botanical Garden, where Small worked, suggests the descriptions and distinguishing characteristics were derived from the literature. Niedenzu treated these four species in a different manner. He accepted *S. elegans*, including his previously established forma *ossana* (Juss.) Niedz. (1914) (typified by the Ossa collections "ca. 1825: Havana"), and *S. parviflora* Juss. (typified by Ossa "ca. 1825: Havana"), consisting of varieties *typica* and *perforata* (Juss.) Niedz. (1914). He cited *S. littoralis* in the synonymy of the species *S. parviflora*, but not under either variety *typica* or variety *perforata*. Niedenzu did cite *Finlay 198*, from Trinidad, along with material of Caley and Guilding from St. Vincent under his variety *perforata*. Recent collections from Trinidad and northern South America, as well as six different collections from the

trees in the botanical garden on St. Vincent, reveal that the distinctions between *S. elegans* and *S. parviflora* as used by previous workers are not reliable, and that only one species is represented.

There remains a problem of the fertility or sex of the flowers of *Spachea* and particularly the "*Spachea perforata*" of the St. Vincent Botanic Garden. William Anderson, of the University of Michigan, a current specialist on the Malpighiaceae, states (pers. comm.), "Most Malpighiaceae have monotonously bisexual flowers, so it was a great surprise to discover that *Spachea* does not. Some plants are functionally pistillate, while the flowers on plants that produce pollen are morphologically perfect but perhaps functionally staminate, i.e., they do bear ovule-containing carpels, but I suspect that those carpels do not set seed, since I have found no enlarging fruit on old inflorescences of those plants. These observations are based only on material of *S. elegans* and *S. tricarpa*." An examination of six collections of "*Spachea perforata*" made between 1825 and 1980 from the botanical garden in St. Vincent, as well as some collections from plants in Trinidad propagated from the St. Vincent plant, reveals anthers with pollen and carpels with ovules, but no specimen has fruit. The records of the St. Vincent Botanic Garden were examined by Dr. George Cooley in 1962. He noted the entry for 1912: "A large number of cuttings made of the old *Spachea perforata*, about a dozen appear to have rooted. These will be distributed when strong enough. No recent record of seed produced though it flowers profusely." An entry for 1915-16: "*Spachea perforata* showed signs of decay. A limited number of young plants have been raised, one of which was planted out in the Garden." In 1918-19: "*Spachea perforata*. Young specimen to replace old dying tree making good growth. No seeds produced in recent years." In 1929: "The old plant of *Spachea perforata* which was regarded as dead nine months ago produced a strong shoot from its base during the year. Probably planted by Anderson 130 years ago. In 1912 rooted cuttings from this tree were sent to various botanical establishments in the West Indies. One was planted in that part of the St. V. gardens known as Nutmeg ground. Now a healthy tree, 20 ft. in height." These records certainly suggest that the St. Vincent plants are functionally staminate and perhaps date the cultivated plants in Trinidad from which specimens in various herbaria have been taken.

Small (1910), in a key to the species, distinguished *Spachea parviflora* as having "stigmas truncate" and noted "fruits not seen." According to Small, *S. littoralis*, *S. perforata*, and *S. ossana* have "stigmas slightly 2-lobed or reniform-capitate." He did not see the fruits of *S. littoralis* but did record fruit size for *S. perforata* and *S. ossana*. The lobed stigma characteristic may well be correlated with functional carpels. As we have indicated, no existing specimen of *S. perforata*—considered to be endemic to St. Vincent and known only from the plants in the botanical garden—is known in fruit, and the source of Small's descriptive detail of the fruit is a mystery. However, examination of the type material of *S. ossana* Juss. (DC.) reveals one sterile, leafless shoot, one leafless shoot with an inflorescence, and one leafless shoot with a small, unattached leaf trapped in a fruiting inflorescence. It is possible that Anderson sent to Ossa in Cuba some plants of the original 1791 introduction of his "*Cullenia malpighioides*," one of which was functionally pistillate, while retaining only functionally staminate plants on St. Vincent. The material of *S. parviflora*

Juss. (DC.) attributed to "La Havanna, de la Ossa 1825" is a leafy shoot with functionally staminate flowers, the anthers of which bear pollen. With regard to both *S. parviflora* and *S. ossana*, León and Alain (1953) stated, "No observada por los botánicos modernos."

The legend of the Soufrière tree must be discounted, and the plant in the St. Vincent Botanic Garden must be recognized as *Spachea elegans* (Meyer) Juss., with the other taxa considered in this paper as synonyms. The synonymy of *S. elegans* is presented below.

Spachea elegans (Meyer) Juss. in Delessert, Ic. Selec. Pl. 3: 19. t. 31. 1838.
BASIONYM: *Malpighia elegans* Meyer, Prim. Fl. Esseq. 178. 1818.

Byrsonima elegans (Meyer) DC. Prodr. 1: 580. 1824.

Spachea parviflora Juss. Ann. Sci. Nat. Bot. ser. 2. 13: 326. 1840; Monogr. Malpigh. 72. 1843. TYPE: *Ossa s.n.*, Cuba (G DC).

Spachea ossana Juss. Ann. Sci. Nat. Bot. ser. 2. 13: 326. 1840; Monogr. Malpigh. 72. 1843. TYPE: *Ossa s.n.*, Cuba (G DC).

Spachea perforata Juss. Ann. Sci. Nat. Bot. ser. 2. 13: 326. 1840. TYPE: St. Vincent (Herb. Hooker, K).

Spachea littoralis Juss. Arch. Mus. Paris 3: 328. 1840. TYPE: *Finlay s.n.*, "St. Thomas" (in error, really Trinidad) (P).

Ossana vincentiana Juss. ex Griseb. in Griseb. Fl. Brit. W. Indian Is. 116. 1859. in synon.

Spachea elegans f. *ossana* (Juss.) Niedz. Arbeit Bot. Inst. Lyc. Hosianum 5: 18. 1914.

Spachea parviflora var. *typica* Niedz. *Ibid.* 19. 1914.

Spachea parviflora var. *perforata* (Juss.) Niedz. *Ibid.*

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